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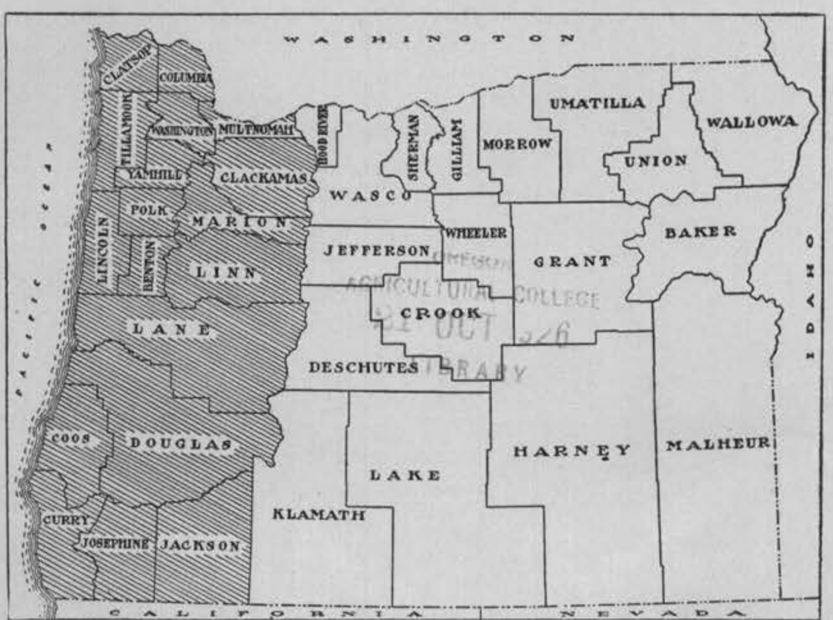

Sketch map of Oregon. Shaded portion covered in the oil and gas investigation.

REPORT ON

Investigation of Oil and Gas Possibilities of Western Oregon

By HARRISON and EATON, Consulting Petroleum Geologists

Forty Pages Six Illustrations

STATE OF OREGON

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ILLUSTRATIONS

FOREWORD

It has been a matter of common knowledge among geologists for many years that western Oregon is largely made up of rock formations of similar geologic age to those of the great oil producing districts of southern California. Early in 1919 the Oregon Bureau of Mines and Geology planned as one of its important projects for the year the geologic examination of all the sedimentary areas of western Oregon to determine whether in any sections conditions are favorable to the occurrence of commercial quantities of oil and gas.

It was especially desired that the quality of the investigation be the same as that demanded by any of the big oil producing companies. Harrison and Eaton, Consulting Petroleum Geologists, of Denver, Colorado, and Fort Worth, Texas, was employed to make the investigation. This firm was selected after careful inquiry into the experience records of many prominent oil geologists of the country. The inquiry showed that the members of this firm are men of unquestioned integrity who are held in high regard by those prominent in their own profession, as well as by leading oil producing companies of the country. The Bureau was fortunate in securing the services of men who have proved themselves so eminently successful as oil geologists in the commercial industry.

Close touch with the progress of the work was maintained throughout the season and it is my belief that the actual geologic conditions in the field were correctly interpreted, and that the conclusions reached are logically founded upon these conditions. Particular effort was made to render available all the geologic information accumulated by the Bureau during past years, as well as all possible data from other sources, for the purpose of this investigation. I regard the report in its entirety as a faithful presentation of fact followed by logical conclusions.

HENRY M. PARKS, Director.

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A Periodical Devoted to the Development of All Her Minerals

PUBLISHED AT PORTLAND BY
THE OREGON BUREAU OF MINES AND GEOLOGY
HENRY M. PARKS, Director

REPORT ON INVESTIGATION OF OIL AND GAS POSSIBILITIES OF WESTERN OREGON

By HARRISON AND EATON, Consulting Petroleum Geologists

Following is our report on the investigation of oil and gas possibilities in Western Oregon, conducted during the field season of 1919 in accordance with our contract with the Oregon Bureau of Mines and Geology.

Mr. Clarence B. Osborne, one of our geologists, was placed in active charge of the field work for the Oregon Bureau and the compilation of the data and preparation of this report have been largely entrusted to him. Mr. Osborne was assisted throughout the work by Ewart G. Sinclair and during part of the work by Dr. Warren D. Smith of the University of Oregon. These geologists are all graduates of American universities and their combined experience includes commercial investigations for oil in the fields of California, Texas, Wyoming, Oklahoma, Philippine Islands, South America, Canada, Cuba and China. Mr. Frank Kelsey was employed as field assistant during most of the work and rendered valuable and efficient service.

Upon the completion of the gathering of the field data, one of the members of the firm of Harrison and Eaton, Arthur Eaton, reviewed the work in the field, visiting the localities where sections had been measured and examining all of the regions that had furnished geologic information of importance in this investigation.

ACKNOWLEDGMENTS

Throughout the investigation, the geologists received most hearty and helpful assistance from the people in all parts of the State where work was carried on. It would not be possible to list the names of all

who have assisted the field men with helpful advice and information as to exposures of rock, road conditions and supposed oil indications, but mention should be made of the assistance given by Mr. W. D. Dement and Mr. Windgate of Astoria, Mr. Herbert Nunn, State Highway Engineer, Mr. Pyle of Lacomb, Mr. Spencer of Bandon, Arthur Noah of the Libby Mine, Mr. Anderson of Nehalem, Mr. Lane of Manzanita, Mr. Barlow of Warrenton, Dr. Goucher of McMinnville, Roderick Macleay of Portland, F. W. Strake of Waldport, George W. Neilson of Medford, and Dr. Earl L. Packard and Hubert Schenck of the University of Oregon. Acknowledgment should also be made of the geologic assistance in the office and field rendered by Director Henry M. Parks, Ira A. Williams, Geologist, and Arthur M. Swartley, Consulting Mining Engineer, of the Bureau of Mines and Geology.

AREA EXAMINED

The area under investigation included all of Oregon north of the California line and west of the Cascades mountain range.

During the past twenty years there has been from time to time a number of small oil "booms" in western Oregon and, all told, a considerable sum of money spent in actually trying out some of the regions by drilling. The desire that the people of Oregon have more definite knowledge as to the oil possibilities, based on a connected and general study of the geology of the state, led the Oregon Bureau of Mines and Geology to have such an investigation made that any future expenditures of money in oil prospecting in western Oregon might be spent in regions offering some promise, if such regions could be found to exist.

TOPOGRAPHY

On Plate 1 is shown a relief map of the state. The vertical scale of this map is approximately five times the horizontal scale, and for this reason, the land surface seems more rugged than is actually the case. In traveling throughout western Oregon, one is impressed with the fact that the topography is fairly old or well developed erosionally. The two important features are the Coast and Cascade ranges of mountains. From the California line to about the north line of Douglas county, there is a widening of both the Coast Range and the Cascade Range, making that part of western Oregon seem almost all made up of low ranges of hills and mountains with no great valleys or basins. As we go north of Douglas county, we find the main ranges are separated by the broad Willamette valley.

The drainage of western Oregon is interesting in that the great Rogue, Umpqua, Siuslaw, Yaquina, and Trask rivers with their sources east of the Coast Range cut their way through that range to empty into the Pacific Ocean. These rivers are now tide-flooded for a distance of from 10 to 30 miles up-stream, their deep channels having been cut at a time when this portion of the Pacific Coast was at a higher elevation than now.

This matured topography has made the gathering of geologic data difficult, because when stream erosion becomes slow there is more and more time for all rock surfaces to decay and become soil covered and thereby hide the geologic evidence. Where the new highways have been cut across the Coast Range, many good exposures are seen. During the low water in summer the larger rivers expose in their channels much of the rock that makes up the Coast Range. The wave-cut cliffs along the Pacific Coast also display the geology along much of the coast and very valuable data have been gathered from these rocky points.

VEGETATION

The equable climate and the very heavy annual rainfall have made the greater part of western Oregon almost a jungle of forests and dense brush and vines. This is especially true in the Coast Range mountains. Here the undergrowth is often impassable except along the main highways and trails. The brush, vines, low clinging shrubs, and moss cover with a dense blanket much of the underlying geology. This vegetation really presents a very expensive difficulty to be met where any careful detailed geologic survey is to be made in western Oregon. Once away from the graded roads on the west slope of the Coast Range, a geologist might spend days fighting his way through the vegetation to obtain enough data to accurately map the surface geology of one square mile of territory.

GEOLOGY

The careless observer traveling through western Oregon might easily get the impression that the geology of the entire area is a mixture of different kinds of shales, sandstones and volcanic rocks in a sort of hodge-podge, having no definite relation. But the same traveler would, upon making a more careful study of the region, find that the state is built up of a series of layers of rocks and these layers, like the pages of a book, each tells its story of what was happening throughout Oregon at the time that layer was being deposited.

The story or geologic history of Oregon would be more easily read if the layers of rock had all remained smooth and flat as when deposited, but due to great movements and strains of the earth's surface, these pages of history have been badly wrinkled by folding. They have been torn by big fault movements and some pages removed by erosion, so that today the pages have to be pieced together in order that we may read what has happened during each big geologic measure of time in the past.

TABLE OF STRATIGRAPHY WEST

To Accompany Report on Oil and Gas

Period	Formation	Type Locality	California Equivalent	Lithology	Thickness	Typical Fossils
Recent	Terrace	Bandon coast		Sands, clays, gravels, marine sands, black magnetic beach sands, varicolored sands.	25′-50′	
Pleistocene				Loose sands and gravels and shell beds.	100′-300′	Saxidomus giganteus Paphia staminea.
Pliocene	Coos	Fossil Point Coos Bay	Merced	Conglomerate.	30′	Mixed fauna of living, Pliocene and Miocene.
	Empire	Coos Bay Empire		Sandstone. Light and colored shales.	400′-500′	Pecten coosensis. Chione securis, etc.
Miocene		Newport	?	Tuffaceous sandstones and shales.	500′-800′	Pecten propetulus. Cardium coosensis. Arca devincta. Desmostylus hesporus. Desmatophoca oregonensis.
Oligocene	Acila Shales (Astoria Shales?)	Newport (May include part of Astoria Shales.)	San Lorenzo?	Dense dark-gray shales, very fine-grained.	2100′	Acila Shumardi. Acila gettysburgensis. Fish scales. Agasoma gravidum.
	Yaquina	Yaquina	?	Lower 1000′ coarse-grained sandstone buff-colored with a slight showing of coal in lower part. Upper 1300′ fine-grained, bluish colored, quite micaceous.	2300′	Acila thracia. Aturia angustata. Phaecoides, Spisula.
	Toledo	Toledo	?	Tuffaceous sandstones and shales, green-gray in color when fresh.	3000′	Not found.
Eocene	Coaledo	Coaledo, Coos Bay	Ione	Thinly bedded sandstones and shales of fresh and brackish water deposition with number of coal beds near top.	4000′	Ostreas, Modiolus, Mytilus. Brackish and fresh water fossils in beds near coal measures.
	Tyee	Tyee Mountain	Tejon	Rather porous sandstone generally heavily bedded with thin separations of muddy gray shale. The sandstone is bluish-gray in color and very micaceous.	2500′ Roseburg. 5000′+ Florence. 4000′+ Newport.	Generally lacking in fossils. Sandstone and shale often carry small fragments of carbonized wood. Venericardia planicosta found in Tyee.
				Basal conglomerate largely made up of Cretaceous and metamorphic pebbles 2000′. About 3000′ of dark muddy sandstones and brown shale beds overlie the conglomerate.	5000′	Turritella uvassana.
Cretaceous	Not found in Oregon	Chico, California	Chico			
	Upper Myrtle Lower Myrtle	Myrtle Cr., Ore. Myrtle Cr., Ore.	Horsetown Knoxville	Conglomerate, sandstone and sandy shales.	10,000′	Aucella crassicollia. Aucella piochii.
Pre-Cretaceous Metamorphics	Curry Co.	Curry Co.	Metamorphics	Schists, cherts quartzite and slaty shales.	5000′	Radiolaria.

INVESTIGATION OF WESTERN OREGON.

ABUNDANCE OF LIFE	STRUCTURE	IGNEOUS ACTIVITY	REMARKS
Relatively scarce.	Weakly cemented deposits, little disturbed.	None.	
Life abundant.	Gentle dips.	None.	
Rich in fossils.	Firmly cemented and little disturbed.	Post-Empire intrusives and flows.	Most of western Oregon was above sea level and was heavily eroded.
Mollusca, abundant in sandy strata.	Gently folded.	Tuffaceous deposits.	
Life not very abundant.	Coastal deposits. Monoclinal dipping to west 10°-20°.	Basaltic intrusions and flows and tuffaceous deposits.	Coastal deposits are dense and not of good character as petroleum reservoir.
Very rich in organic animal life.	Open gentle plunging anticlines and monoclinal in west coastal region. Gentle west dips.	?	Acila shales near Newport give petroleum odor when freshly fractured. Astoria formation seems to be of same horizon as Acila shales but only near Newport were these shales found to be favorable as possible source of petroleum.
Abundant molluscan life in some horizons.	In coastal regions monoclinal dips to west.	?	Not of satisfactory character as source of petroleum products.
Quite barren of evidence of life.	Same as Yaquina.	Pyroclastic.	Very unsatisfactory as a possible source of petroleum products.
Some horizons rich in brackish water fossils. Plant remains from which coal was formed.	Large gentle folds in Coos Bay region with some faulting and igneous intrusions.	Probably the main intrusive masses such as Mary's Peak, Granite Mt. and other Coast Range volcanic peaks were formed during Coaledo or early Oligocene time.	Lacking in evidence of being a possible source of petroleum products.
Quite barren of life.	Folded and faulted and cut by volcanic intrusions.	Basaltic intrusions and pyroclastics near crest of Coast Range mountains.	The Tyee of Florence and east of Newport doubtless includes the same horizon as the Coaledo of Coos Bay. Not favorable as source of petroleum.
All but a few horizons are barren of evidence of life.	Folded and faulted.	Basaltic intrusions.	Contains nothing to produce commercial quantities of petroleum products.
			During Chico period, western Oregon was above sea level and subject to heavy erosion.
Lacking in much evidence of life except plant remains.	Folded, faulted and somewhat altered by dynamic action.	Granodiorite, batholiths, serpentine, etc.	Not of favorable character as possible source of oil and is badly folded and faulted.
Highly metamorphosed.	Altered by excessive dynamic action.		Too badly changed by dynamic action to be of any value as producer of oil.

The lover of geology could spend a lifetime in the Coast Range and Cascades, always finding new bits of information to add to the geologic history. This investigation, however, was made for a very practical purpose and neither time nor funds would permit a study of many of the very interesting problems of a purely geologic nature. The aim was to find if western Oregon offered possibilities as a producer of petroleum or gas in commercial quantities and the study of the geology was largely controlled by this problem. For this reason, fossils were collected only where they were needed in furnishing additional help to correlate the different horizons.

The beds making up the different geologic ages were studied as to their being a possible source or container of oil. The measurements of thickness of beds were made to determine how deep wells would have to be drilled to pass through from one period of deposition to the next.

The Cascade Range of mountains is made up largely of igneous flows, intrusions and interbedded tuffaceous sediments. Although interesting geologically, this great thickness of igneous rocks has no petroleum possibilities. For this reason no attempt has been made in this report to consider the detailed geology of this range, though the outline map herewith covers to its summit line.

The Table of Stratigraphy accompanying this report (pages 6-7) has been prepared to summarize the principal geologic events that have taken place in western Oregon. In the preparation of this table, most of the works of previous Oregon geologic investigations have been studied and made use of insofar as they were of importance to this report. The compiling of this information and the preparation of this table are largely the work of Dr. Warren D. Smith of the University of Oregon.

A study of this table will show that since Jurassic time western Oregon has been subjected to long periods of subsidence below the level of the ocean and during these periods great thicknesses of marine sandstones and shales were deposited. These today are the great layers of rocks of which western Oregon is composed.

These beds have been uplifted into a few big major folds, one of which with axis in a general north and south direction follows the Coast Range region, although the crest of this fold does not conform to the top of the ridge nor can it be said to have any very great effect in having produced the present topography or relief of this part of the state. East of this upward fold is a great synclinal trough in which the strata dip to the eastward beneath the Willamette valley, and so far as observed, the inclination is continued beneath the west slopes of the Cascade Range. These major folds are gentle in slope but there is much minor folding in the strata which is more noticeable due to steeper dips and sharper folding.

PRE-CRETACEOUS

The geologic history of western Oregon is of interest in this investigation only back to the beginning of the Cretaceous age. The rocks laid down before Cretaceous time in Oregon have all been so badly altered by earth movements that they are now almost completely metamorphosed to mica schists, slates with highly-developed cleavage, and cherts, the more basic igneous rocks having altered to serpentine. This alteration is so great that the Pre-Cretaceous, even if it ever were a source of petroleum, could not today be regarded with any hopes of its being a source of a commercial producer of oil in western Oregon.

A well anywhere in western Oregon, if it could be drilled deep enough, would eventually reach Pre-Cretaceous rock. So we might regard the Pre-Cretaceous as the bedrock or floor upon which the sediments since that time have been deposited. This Pre-Cretaceous floor is found exposed in Jackson, Josephine, Curry, southern Coos and Douglas counties. As one goes north, this bedrock is covered by an increasing thickness of younger deposits of conglomerates, sandstones, shales, lava flows and intrusions. When the north end of the state is reached, if one were to drill to find this bedrock, the hole would probably have to go to a depth of more than three miles below the surface.

CRETACEOUS

Before the beginning of the Cretaceous deposition and extending into the early part of the Cretaceous age, there were great movements in the earth's crust in the lands bordering the Pacific. There were extensive intrusions of granodiorite that played their part in the mountain-making of southwestern Oregon.

From the geologic evidence all of the northern and central parts of western Oregon during Cretaceous time lay below sea-level, and the land area included only a small part of southern Coos and Douglas counties and the counties south of this line. All of the north was covered by the Pacific Ocean. The great lava flows cover and hide so completely the Cretaceous of the Cascades and of eastern Oregon that it is a question as to how far east one would have to go to find what part of eastern Oregon was above sea-level during the Cretaceous period. Identified Cretaceous sediments are found as far east as the John Day valley.

The Cretaceous of western Oregon as found exposed in the southwestern counties, is made up of conglomerates, shales and sandstones, lenses of limestone and many igneous intrusions. These beds have been subjected to sharp folding and such extreme stresses and strains that their material is greatly altered and as a possible source or retainer of petroleum products offer nothing encouraging. This feature of the Cretaceous will be treated in more detail in the discussion of Economic

Geology. These conglomerates and sandstones were found to be largely made up of the erosional material of the older metamorphic rocks.

As far as the Cretaceous could be studied from exposures in the southern counties of western Oregon, it marks a depth below which it would be useless to drill in the hope of producing oil or gas. For this reason, it was discarded early in the investigation and time was not spent in attempting to make a measurement of its thickness or in any detailed description of the different exposures. As it now exists in southwestern Oregon, it is an erosional remnant, and a great amount of time would be necessary to piece together the lower Cretaceous deposition, while much of the upper portion would still be missing as it has been removed by the long erosional period at the end of the Cretaceous and before the beginning of Tertiary deposition.

The fossil life found in the Cretaceous of western Oregon indicates that the lower part would correspond to the Knoxville of California, a period of rather cold climatic conditions. The upper Cretaceous of Oregon is richer in fossil life of a more tropical nature and has been classed with the Horsetown of California. These warmer water conditions continued throughout the remainder of the Cretaceous, and in relation to higher beds part of the upper Cretaceous beds of Oregon are correlated with the Chico of California.

TERTIARY

At the close of the Cretaceous, and extending into the early Eocene in western Oregon, there was an elevation of the surface and a long period of erosion during which period much of the upper layers of Cretaceous sediments were carried away. It was during this time that the Cretaceous of Oregon was badly faulted and subjected to heavy stresses and strains which resulted in the sharp folding and alteration of the deposits as now seen in the exposed Cretaceous of southwestern Oregon. The Tertiary will be treated under the three great main divisions—Eocene, Oligocene, and Miocene.

Eocene

As has been stated, during the early Tertiary western Oregon stood as a land surface, but during the latter part of the Eocene it was once more submerged and subjected to a building up of sedimentary beds. The whole of the north and central parts of western Oregon were once more below sea-level. The shoreline was near the south end of Coos and Douglas counties, with a long extension or bay extending almost to the southern end of Jackson county.

The Eocene of western Oregon has as its equivalent in California the Tejon and Ione sediments. While it represents only the last part of the Eocene age, it makes up a very formidable thickness of the sedimentary rocks of western Oregon and where complete would measure more than ten thousand feet thick. It has been separated into a number of divisions by the different geologists who have worked in Oregon. In this investigation three divisions were helpful in the work in the Eocene, the lowest called the Umpqua; over this the Tyee; and the highest part of the Eocene, the Coaledo.

The Umpqua: The surface exposures of the Umpqua are found in Douglas and Coos counties overlying the Cretaceous, the type locality being along the Umpqua river east of Roseburg where this formation was named by Joseph S. Diller of the United States Geological Survey.

The lowest part of the Umpqua consists of a great thickness of conglomerate, made up largely of pebbles of Cretaceous or Pre-Cretaceous material. In the section measured from Roseburg to the coast (see plate II) the conglomerate was in places 2000 feet thick. There were beds of coarse sandstone in the upper parts of the conglomerate. Overlying these were dark muddy sandstone and brown shale beds having a thickness of from 1000 to 3000 feet, the total thickness of the Umpqua being in some places as much as 5000 feet. As a whole the Umpqua is rather barren of fossil life. A foot or two of sandstone or shale will at times be found very rich in fossil remains and then there will be hundreds of feet of thickness seemingly devoid of fossils.

Tyee: This formation was given its name by Joseph S. Diller in the Roseburg folio (No. 49) of the United States Geological Survey, the type locality being Tyee mountain in Douglas county. The Tyee is exposed over a larger area in western Oregon than any of the rocks of the other geologic divisions. It makes up the greater part of the surface exposures of the Eocene shown in Section A-A, Plate 2, Section B-B, Plate 3, and Section C-C, Plate 4.

The Tyee is predominantly a sandstone member and the character of deposition would seem to indicate that it was laid down in a slowly receding shallow sea throughout the entire region west of the Willamette and north of the Umpqua river. The sandstone is, when fresh, blue-gray to green-gray in color and very micaceous, the small flakes of white muscovite mica being very characteristic of the Tyee. The sandstone is usually quite massive with thin separations of micaceous muddy-gray shale carrying tiny fragments of carbonized wood. Much of the sandstone also carries small fragments of carbon. In the lower and also upper part of the Tyee, the sandstone is more thinly bedded with numerous thin interbedded shale layers.

In the measured Section A-A, Plate 2, the Tyee is about 2000 feet thick. In section B-B, Plate 3, more than 5000 feet of Tyee was measured and neither the top nor bottom of it was found in that section. In section C-C, Plate 4, over 4000 feet of Tyee was measured and this did not include the entire thickness. The Tyee has been classed largely on lithologic characteristics and in Sections B-B and C-C, it is possible that the measured thickness includes some sandy phases of the underlying Umpqua and the overlying Coaledo.

The Tyee is almost devoid of fossil life except for the small showing of wood fragments. The *Venericardia planicosta* has been found in the Tyee near the town of Monroe.

Coaledo: The top member of the Eocene has been named by J. S. Diller in the Coos Bay Folio (No. 73), United States Geological Survey, the Coaledo, after the town of Coaledo, Coos county. During this period of the Eocene, the larger part of western Oregon was above sea-level with the coast region one of extensive swampy areas where peat bogs were formed. The Coaledo consists of a series of fresh, brackish and marine beds of sandstone and muddy shale. In the Coos Bay region are a number of coal seams and some of these are thick enough to pay to mine although the coal is not of high grade.

The greatest thickness of the Coaledo is approximately 4000 feet in the Coos Bay region. The Coaledo has undoubtedly been included as Tyee in the measured sections north of Coos Bay, as it is much like the Tyee except for the coal measures, and these coal beds are rather local in extent as they were formed in relatively small basins. Throughout the whole of the Coaledo, there is a scarcity of fossil life, but in some of the brackish and marine beds there are quite abundant remains of oysters, Mytiluses, etc.

Oligocene

Following the Eocene period, the deposits of Oligocene sandstones and shales were laid down covering western Oregon as far south as Eugene. Possibly the shoreline was still farther south, and subsequent erosion has removed the evidence of the extreme southern limit of the Oligocene deposits. As the south half of Western Oregon was doubtless a land surface during most of Oligocene time, it is from Lane county north that the Oligocene is of importance and in the north coastal counties where the greatest thickness now exists.

For convenience, the Oligocene has been divided into three periods—Toledo, Yaquina and Acila shales.

Toledo: This is the lowest member of the Oligocene and its name was taken from the type locality three miles south of Toledo in Lincoln county. This division is made up of tuffaceous sandstone and shales. They are green-gray on the unweathered surfaces, but in the weathered portions vary in color from white to yellow to red. The sandstone is rather thinly bedded and sandy shale makes up the greater part of this series.

From three miles south of Toledo to Oysterville, there is a total thickness of 2800 feet of the Toledo sandstone and shales. These may not all be of Oligocene age but possibly transitional between the Eocene and Oligocene. There is a lack of fossil life in the Toledo and the tuffaceous character of the deposition may account for the scarcity of life during that period.

Yaquina: Overlying the Toledo is the Yaquina sandstone. The lower half of this division is coarse-grained, buff-colored sandstone interbedded with carbonaceous shale. Some of the lowest shale members occasionally carry thin seams of soft coal and one of these about six inches thick has been prospected near Toledo.

Above the coarse sandstone is a micaceous blue-gray sandstone, heavy-bedded, very fine-grained and quite fossiliferous. Here are found many Oligocene fossils, *Aturia angustata, Acila thracia* Phaecoides, Spisula, etc.

The Yaquina division measures 2300 feet thick, of which the lower part of coarse-grained sandstone is 1000 feet.

Acila Shales: This name has been given to the upper member of the Oligocene as found in the section from Yaquina to Newport, *Acila shumardi* being found quite generally throughout this section. It is a very dark blackish-gray shale and even where weathered is dull gray in color. It is fine-grained and when freshly fractured gives a pronounced petroleum odor. In the section measured from Yaquina to Newport, this Acila shale is 2100 feet thick. A part of this same member is found along the coast north of Newport in the vicinity of Jump-off Joe Rock and here 800 feet of thickness is exposed.

This shale was named from the fossil Acila shells that are found in it, the *Acila shumardi* being used as the type fossil. In the Newport region the shale contains innumerable shall shiny brown fish scales and throughout its entire thickness gives evidence of having been deposited during a period rich in marine life.

In the Oligocene in many of the northwestern counties of Oregon, in the vicinity of Tillamook, Astoria, Clatskanie, Buxton and Willamina, the upper member or Acila shale has been found, but in only the Newport region was this shale petroliferous in odor and in no other places was it of the favorable nature found at Newport.

Astoria Shales: The shales in the town of Astoria have been studied by a number of geologists and this occurrence has been given as a type locality for upper Oligocene of Oregon. The division of Acila shales used in this report possibly could be properly called Astoria shales.

There is a total thickness of more than 7000 feet of Oligocene in the Newport Section C-C, Plate 4, and nearly this much Oligocene was found in the Section D-D, Plate 5.

Miocene

Following the Oligocene, and with slight unconformity, we find in the coastal region of Tillamook, Lincoln and Clatsop counties, the sandstones and shales of the Miocene period. A good section can be seen just west of Newport along the coast. The Miocene found in Coos county west of Marshfield shows a marked unconformity with the underlying Eocene, for here the entire Oligocene series is missing.

The Miocene found in the Newport region is a dense sandy shale, tuffaceous in character. In the weathered surfaces it is yellow to gray-brown, and in the unweathered olive-gray to bluish-gray in color. Marine vertebrates have been found in these beds and large fossil pectens, the *Pecten propetulus* being a marker for these beds.

About the middle of the Miocene period of the Tertiary world-wide deformation of the earth's crust occurred. The Alps, Himalayas and Andes were largely formed during this time interval and in Oregon, uplift of the Cascade Range possibly began. This was also a period of basaltic intrusions and flows in Oregon. The present deposits of Miocene in Oregon doubtless represent only remnants since during the Pliocene much of the Miocene was eroded. The total thickness of Miocene now found in western Oregon would measure less than 1000 feet and a thickness of from 500 to 800 feet would mark its importance on the total of the Tertiary.

Pliocene

The period of the Pliocene is one in which most of western Oregon was well above sea-level and most of the Pliocene deposits are fresh-water sandstones, clays, shales and gravel beds. Along the coast there are some Pliocene beds of marine origin. There is no great thickness of either the Pliocene or Pleistocene deposits in Oregon west of the Cascade Range of mountains, and in this investigation they are of very little importance. The greatest thickness of the combined Pleistocene and Pliocene would not exceed 800 feet and where found, the thickness is rarely over 400 feet. These formations are interesting in their marked unconformity with the older formations.

SUMMARY OF GEOLOGIC HISTORY

The rocks that existed before Cretaceous time in western Oregon are so completely metamorphosed that they mark a limit below which it would be useless to expect to find any petroleum products. These metamorphic rocks make the bedrock upon which the younger rocks have been laid down.

The metamorphic bedrock is exposed without covering in the extreme southern counties of western Oregon. As we go north, the Cretaceous conglomerates, sandstones and shales are found covering the metamorphics. Still farther north, there is a layer of Eocene sandstones, conglomerates and shales. On top of the Eocene still farther north, is a covering of thousands of feet of sandstone and shales of the Oligocene, and in the northernmost and north-coastal counties are a few hundred feet of Miocene sandstones and shales lying on top of the Oligocene.

On top of this is a relatively thin covering of Pliocene and Pleistocene sandstones, clays and gravels over part of the central valley section and over much of the coastal region.

Attention should be called to the fact that great igneous or volcanic activity occurred during the Cretaceous, Eocene, Oligocene, Miocene and Pliocene periods. This is very important because thereby the entire western part of Oregon has been broken and cut by innumerable dikes and igneous intrusions.

RELIEF MAP AND SECTIONS OF WESTERN OREGON

Four east and west sections were surveyed to show the major geologic structures and to measure the thickness of the different geologic divisions. As can readily be understood each of these sections includes geologic data obtained over a rather wide strip of country north and south of the section lines and surveyed from the Cascade mountain range to the Pacific Ocean.

These data were compiled for each of the main surveys and from these was prepared a general section along an east and west line. These generalized sections have attempted to give only the main geologic structure and must be understood to show only these main features. In order to make the sections more readable to those to whom geologic sections may not be readily understood, a relief map of western Oregon was cut and the sections fitted to the topography along such lines. The relief map of Oregon has the vertical scale about five times the horizontal scale in order to make the relief more apparent. In fitting the geologic sections to these two different scales it was found necessary to take into account the exaggeration in the vertical scale in preparing the sections. This has made the sections rather hypothetical and they should be considered as giving only the big important features of the geology.

In the surveying of these sections the field data for section A-A, Plate 2, and Section C-C, Plate 4, are the work of Ewart G. Sinclair and Dr. Warren D. Smith; Herbert Schench assisted in the survey of Section A-A. Section B-B, Plate 3, and Section D-D, Plate 5, were surveyed by Clarence B. Osborne, assisted by Frank Kelsey.

ECONOMIC GEOLOGY

In any geologic investigation to locate areas in which oil or gas can be developed in commercial quantities, there should be an understanding of the geologic data that are generally accepted as having proven of vital importance in the study of oil fields throughout the world. For this reason, a brief statement will be given on the known sources of oil and gas, the types of geologic structures that have been found to be necessary for the concentration of commercial quantities of these products, the types of porous rocks that have been found to be satisfactory reservoirs for the oil or gas, and the other conditions that are of importance in retaining the oil in such reservoirs.

SOURCES OF OIL

Petroleum geologists, after a study of the oil fields of the world, are generally agreed that the great bulk of petroleum commercially produced had as its origin organic matter from animal or plant or a combination of animal and plant remains. This organic material has been deposited in and with some dense fine-grained material such as silt or lime that today we find as shale or limestone. Geologic evidence seems to indicate that for petroleum products such deposition has always taken place under marine or saline water conditions. The deposits of shales of fresh water origin do not seem to have been satisfactory as a source of oil.

In this discussion petroleum products will be used as a term including not only crude oil but also petroleum gas. This does not include marsh gas.

Sandstones or conglomerates or other coarse-grained deposits, although often rich in fossil shell remains have not been found to be a satisfactory source of oil. It may be that at the time of deposition the coarse porous nature of the material allowed the organic remains to be removed mechanically or into solution in the overlying water, and thus most of the decomposed organic material necessary to the formation of petroleum would be taken away; whereas the fine-grained shales or lime or other dense material may in a purely mechanical way have sealed in place each particle of organic material, so that later when the whole mass of shale or limestone was subjected to certain geologic action, these organic materials would be changed into petroleum products.

In order that commercial quantities of petroleum be formed it is necessary that there be a satisfactory source. Since living matter is the original source of petroleum the geologic conditions at the time of deposition must have been such that an abundance of live matter existed. The greatest variety and quantity of life exists on the earth during tropical, moist conditions.

Regions that are either cold or arid are not productive of abundant life. Regions subjected to frequent depositions of volcanic dust, even though tropical, are regions in which there is frequent destruction of life. Long periods of uniform conditions are important in producing abundant life over any large area.

The study of geologic history shows that the different regions of the earth have been subjected to very extreme changes of climate and this too is destructive to the building up of abundant life. An area that has marine or saline sedimentary beds of shale, limestone or similar fine-

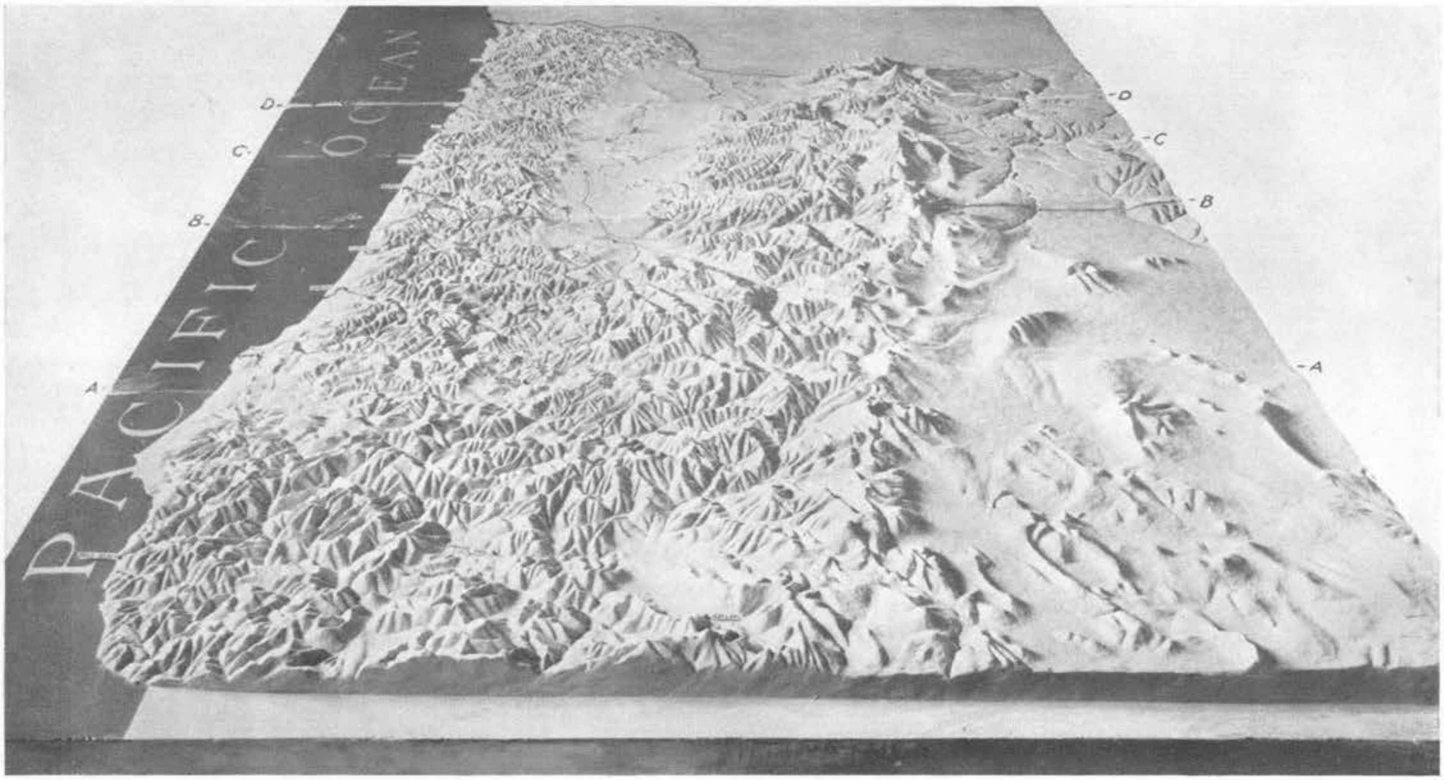

Plate 1. Relief map of Western Oregon showing location of geologic cross-sections which follow.

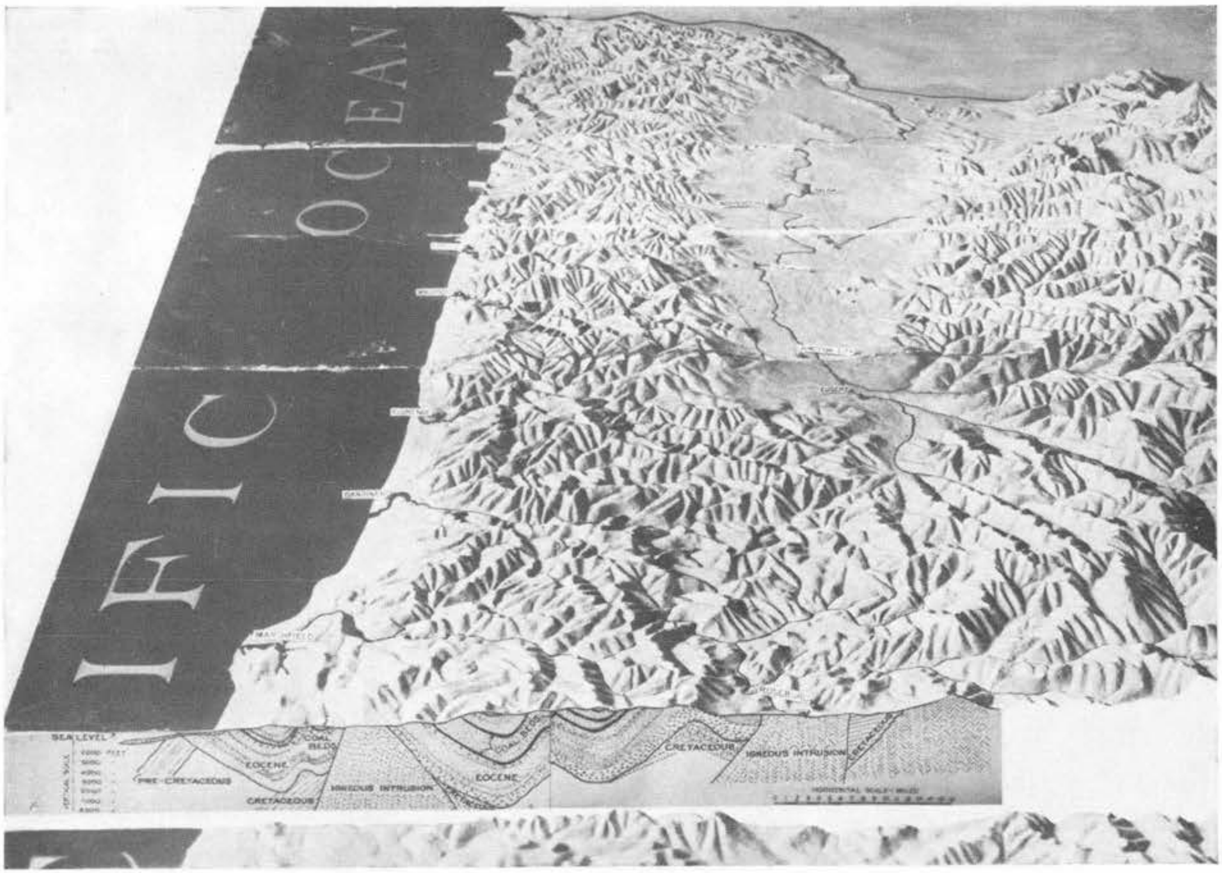

Plate 2. General Geologic Section A-A (Coos Bay-Roseburg

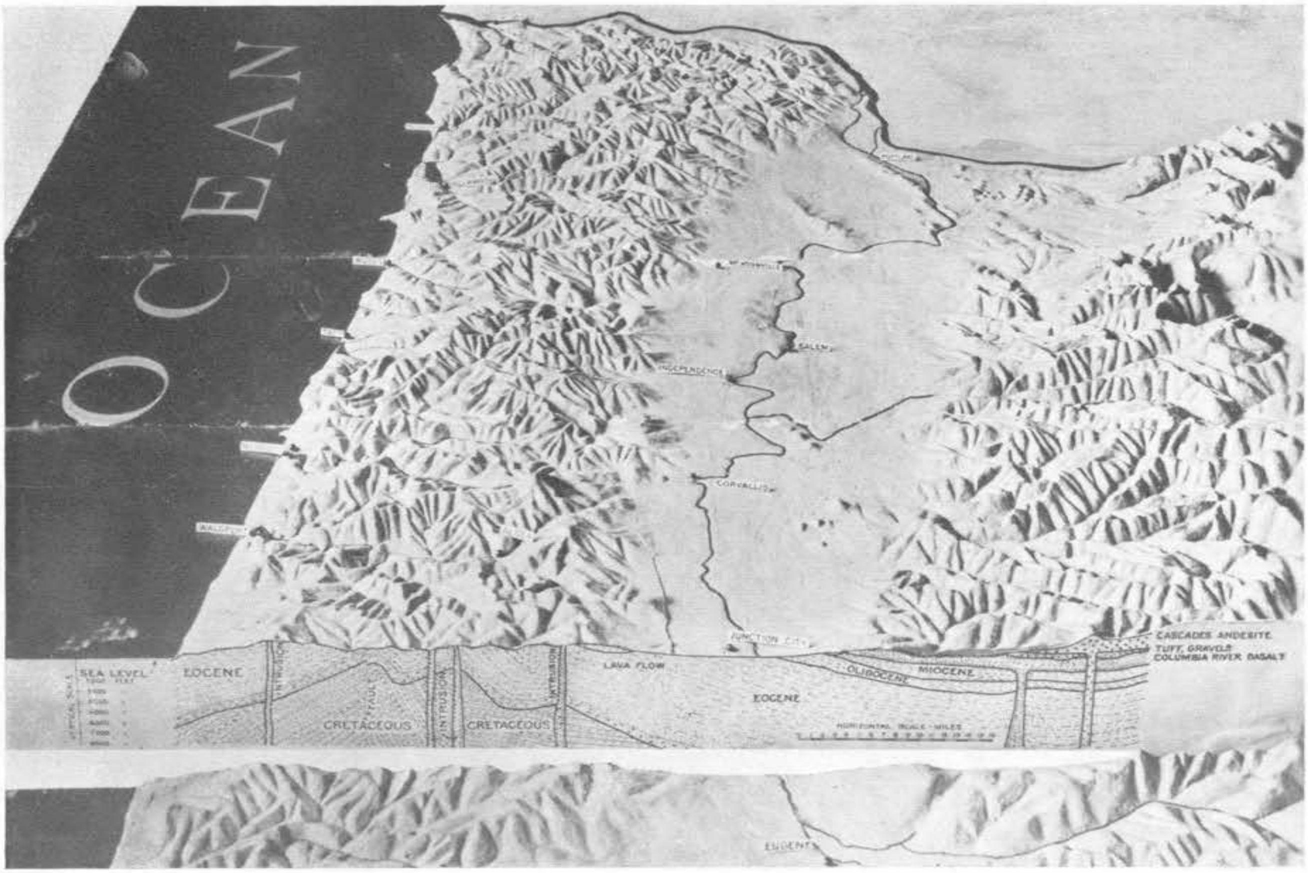

Plate 3. General Geologic Section B-B (Siuslaw Valley-Eugene)

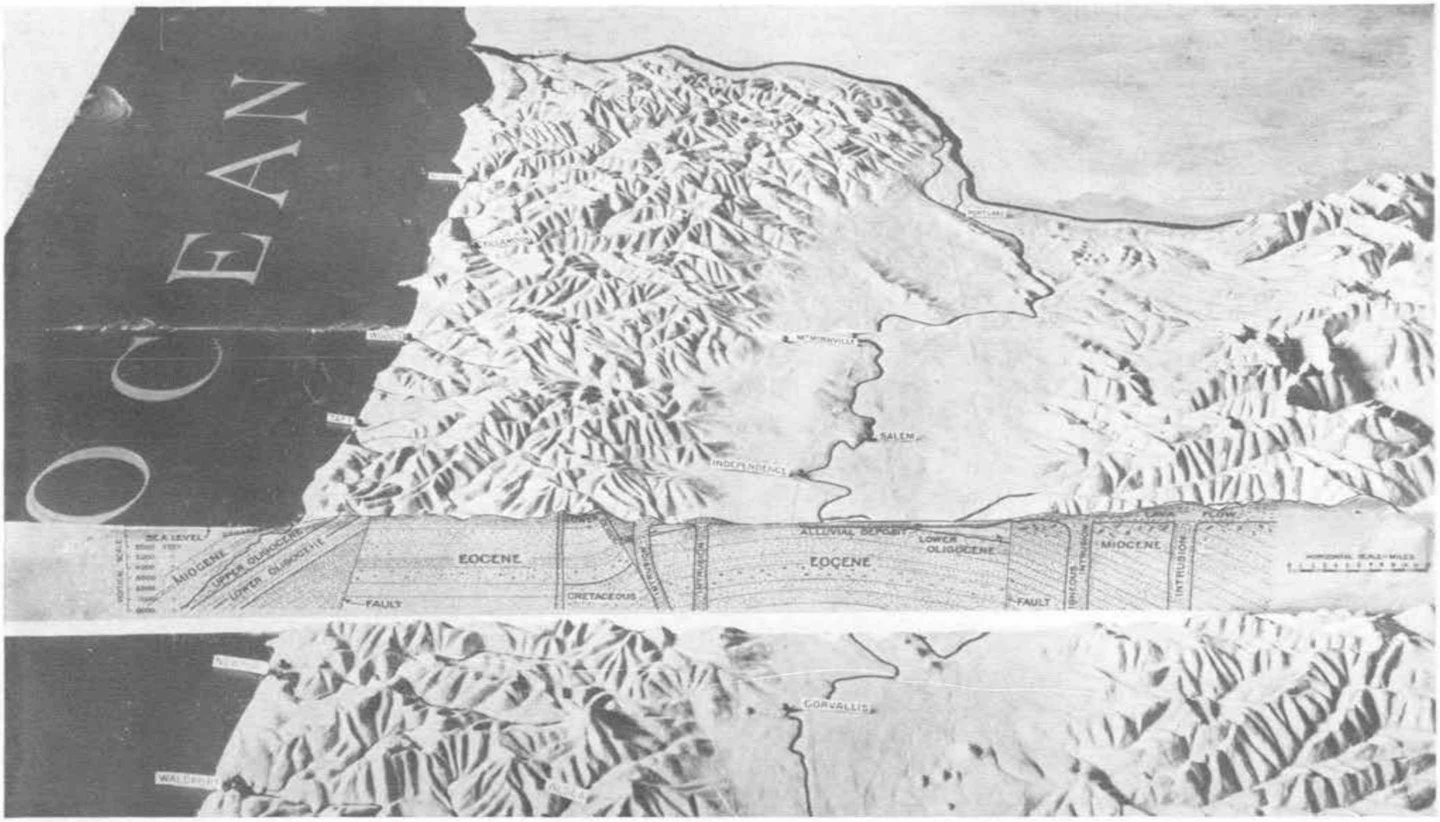

Plate 4. General Geologic section C-C (Yaquina Bay-Santiam River)

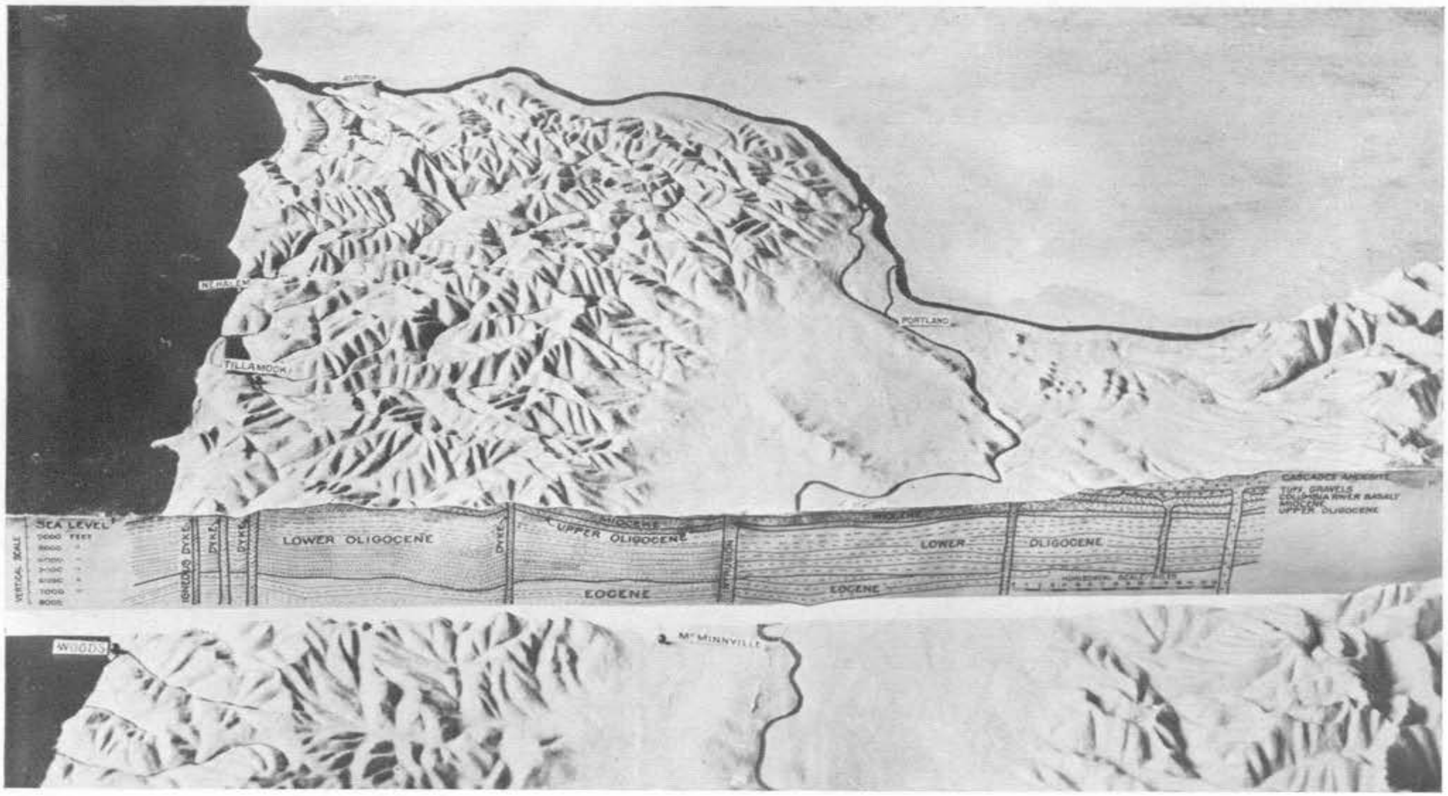

Plate 5. General Geologic Section D-D (Tillamook-Clackamas Counties)

grained sediments rich in organic remains from which petroleum products can be obtained, will be a possible productive petroleum area if other necessary conditions are also satisfactory.

Fine-grained sandstone might be, if very rich in life, a source of petroleum products, but coarse sandstones or conglomerates or breccias cannot be regarded as being at all favorable as a source of such products. Metamorphic rocks even though they were originally sedimentary and rich in organic life, must be eliminated as being a possible source of oil since the geologic action sufficient to produce the metamorphism would have driven off all petroleum products if any had ever been present. A region of entirely igneous rocks cannot be regarded as a possible source of petroleum (except in some theory of inorganic chemical reaction to produce the petroleum hydrocarbons). There is no satisfactory evidence that nature has ever produced oil in commercial quantities by chemical combinations of inorganic material.

PETROLEUM RESERVOIRS

If organic matter in shale or limestone were to ever remain in the condition in which it was deposited there would be no deposits of crude oil or gas, but stresses and strains in the crust of the earth seem to produce a change in the organic remains, making of them hydrocarbons of petroleum. There are great bodies of shale in Colorado, Utah and Montana that carry a high amount of organic remains and yet they show no trace of oil until subjected to either great straining movements or high temperature by which the organic remains become petroleum hydrocarbons. If a region has material that can be a source of petroleum it must also have adjacent to this source a porous member, either sandstone, conglomerate, shattered shale, a highly-creviced limestone or rock carrying openings or caverns in which the oil can be held and from which it can be removed when such porous material is tapped by a well or other opening.

It is generally believed that petroleum products if found commercially will be in porous material generally overlying the organic shale or other sedimentary source of the petroleum. Evidence would indicate that petroleum products, being lighter than water, are forced up through porous rocks on top of the water and would, if not interrupted, finally be forced out on the surface of the earth or up to the top of the underground water. If there is, however, an impervious bed of shale or limestone or dense sandstone or other dense material, then the oil will be trapped when such layer is reached and it will rise no higher.

If the beds or rocks that are the source of this oil, the porous reservoir bed, and the impervious capping all lie in a horizontal position, then any well sunk through the cap layer would find no great accumulation of petroleum products. But if these beds had all been folded and there was sufficient water, rock or gas pressure to force the oil into the highest parts of the folds, then along the crests of these folds, called anticlines, there would be a concentration of the oil from both slopes or sides of each anticline. If instead of a simple fold, there had been a dome, then the petroleum products would accumulate from all sides of this dome and be found concentrated in the reservoir space at the top of the dome and under the impervious cap. Anticlinal folds or domes with slopes extending over large areas are most favorable for a great accumulation of petroleum. Sharp folds with limited drainage area are at best only small producers unless the beds in which the oil originates are extremely thick.

It can be easily understood that if the crest of the anticline is tilted there is a chance that the oil will be forced by pressure to higher points along the crest of the anticline to where the impervious cap-rock may be exposed and cut away at the surface of the earth so that it would no longer hold back the petroleum. In a region of light oils this would result in the area draining itself of its petroleum and the oil would be lost. In the oil fields of California and in other regions where asphaltic oil is produced the cutting of the caprock has resulted in the escape of large quantities of oil, but the evaporation of the lighter oil products eventually leaves the opening from the porous reservoir clogged with asphalt, and other heavier parts of the oil, so that the outlet is finally cut off. Such an anticline may still be productive of oil on being drilled down the plunge of the anticline below the outcropping beds and where they are still under sufficient cover.

If the caprock at the crest of an anticline or dome is broken by faults, then the oil will probably migrate to higher beds and unless it is again trapped by a higher impervious layer, will be lost.

If igneous material is intruded into a series of folded sediments where an accumulation of oil has already occurred, it will probably either disturb the beds so that the oil can escape or the heat action may be sufficient to burn out the oil. In certain fields, however, it has been found that where the intrusions took place prior to the oil accumulation, the intruded material in the form of dikes or sills sealed the beds so that avenues for the escape of the oil were cut off and pools of oil have accumulated in the formations adjacent to these igneous masses.

SUMMARY OF GEOLOGIC CONDITIONS FAVORABLE FOR COMMERCIAL DEPOSITS OF PETROLEUM

First. If any region is to be productive of petroleum it must have beds that could be a source of petroleum.

Second. The petroleum products must be found in beds porous enough to hold the oil and yet when tapped by a well there must be chance for the oil to flow to the well.

Third. The porous reservoir beds must be overlain by beds of dense impervious material so as to prevent the further upward movement of the petroleum.

Fourth. There must be a folding of the beds containing the oil, and of the impervious caprock bed, so that the petroleum of a considerable area can be concentrated in the top of domes or anticlinal folds.

Fifth. For lighter oils a geologic structure of the general shape of a dome is necessary in order that the impervious caprock will retain the oil at the top of the dome and prevent any further movment of it. Asphaltic oils can work up the crest of a plunging anticline which has been cut by erosion and by evaporation seal the porous reservoir bed so that part of the oil is still retained in the crest of the anticline in that portion where the productive horizons have not been eroded.

Sixth. One other requirement might be added, namely, that the porous reservoir containing the petroleum products must be within possible drilling distance from the earth's surface.

DISCUSSION OF PETROLEUM POSSIBILITIES

Having in mind the points that are of importance in deciding the possibilities of developing petroleum products in any area, we will now review the information obtained in this investigation of the geology of western Oregon.

PRE-CRETACEOUS

As has already been stated, there is a bedrock floor of Pre-Cretaceous metamorphic rocks underlying all of the rocks deposited since the beginning of Cretaceous time. This bedrock floor is exposed in the extreme southwestern counties of Oregon and from there north is covered in general by an ever-increasing thickness of younger deposits. Because of its highly metamorphosed condition it cannot be regarded as being a possible source or producer of petroleum products.

CRETACEOUS AS A POSSIBLE PRODUCER

The only Cretaceous found in western Oregon is in Jackson, Josephine, Curry and southern Coos and Douglas counties. This Cretaceous has been subjected to such extreme folding and faulting that even if it carried good sources of petroleum originally it would be of doubtful productive value. Upon careful examination of the better looking shale of the Cretaceous, and after tests of these shales, they were discarded as offering nothing favorable as a productive petroleum horizon. As has been stated, the Cretaceous beds are sharply folded and faulted, and if they carried shales that could produce even small quantities of petroleum products, there would be oil indications in the form of either live seeps or petroleum residues. There is no evidence that the Cretaceous of western Oregon has ever been productive of petroleum products.

In southwestern Humboldt county in California, there are a number of seeps of light oil that are believed to be of Cretaceous or Pre-Cretaceous origin. These seeps were examined but the occurrence offered no hope of Cretaceous or Pre-Cretaceous petroleum products in western Oregon. This region of seeps in Humboldt county is faulted and badly folded in much the same way as are the Cretaceous beds in western Oregon. If oil exists in the Cretaceous of western Oregon there should be many oil seeps but none are found.

These light oil seeps in Humboldt county have caused the drilling of a number of wells in that region but to date it has been found that the rocks are too badly faulted and folded to allow the accumulation of oil in commercial quantities.

Chester W. Washburne, in his "Reconnaissance of the Geology and Oil Prospects of Northwestern Oregon," United States Geological Survey Bull. 590, page 53, in discussing Clatsop County says,—"As the surface rocks of this region are generally saturated with circulating ground water that reaches the surface in the rainy season, it is not unreasonable to think that the water has washed out all of the free oil of the rock that can be removed by water displacement." This statement has produced in the minds of the people interested in oil development in Oregon an idea that the heavy rainfall of Oregon is ample reason for there being no live light oil seeps throughout the entire western part of the state. The live light oil seeps in Humboldt county are in a region having an annual rainfall of over one hundred inches and with all of this water the seeps continue very active throughout the entire year.

At the end of the Cretaceous period in western Oregon the entire region was raised above sea-level and in addition to the extreme earth movements that folded and faulted the beds, there was a long period of erosion that removed all but the lower part of the Cretaceous in southwestern Oregon. It is possible that farther north more of the Cretaceous beds were left uneroded, but all of the Cretaceous in the northern and central counties is covered so deeply by later deposits that even if there were a possible favorable horizon in such upper-Cretaceous it would still be beyond the reach of the drill. There is no evidence that the Cretaceous which is within reach of the drill in northern Coos and Douglas counties is any more favorable than that exposed on the surface in the southern part of these counties.

EOCENE

Overlying the Cretaceous are the Eocene deposits which have been divided into three divisions, the Umpqua, the Tyee, and the Coaledo. The lowest member, the Umpqua, is made up of from 1000 to 2000 feet of conglomerate beds in Coos and Douglas counties where the lower Eocene is exposed. Over this is from 200 to 1000 feet of sandy shale containing wood fragments. Nothing was found in the Umpqua that could be regarded as favorable for a source of petroleum products. Tests made of the best of this shale did not show a trace of oil and none of it was found to be at all favorable in carrying any great amount of organic remains.

The Tyee overlies the Umpqua and is essentially a sandstone member with occasional thin muddy shale beds between the heavier sandstone layers. The Tyee generally is a thick, rather lifeless, sandstone that makes up much of the central part of the Coast Range from Coos to Tillamook county. In Coos county it measured 2000 feet thick between the top of the Umpqua and the bottom of the overlying Coaledo. North of Coos county, in Lane county, over 5000 feet of Tyee was found, and in Lincoln county over 4000 feet, and neither of these measurements gave the complete thickness of this member. The shale beds in the Tyee are lacking in evidence of organic remains that could be regarded as being a source of petroleum.

Traces of Oil Near Town of Florence

In one locality traces of oil have been found in the Tyee in Lane county near Florence, Oregon, on the Johnson ranch, which is located on the east side of the North Fork of the Siuslaw river about six miles from the town of Florence. The oil was found filling some of the cavities of a vesicular volcanic sill or dike which is exposed on the hillside about a quarter of a mile back of the ranch house. At two places this intrusive rock has been exposed by short open cuts. Traces of clear yellow thick oil are found filling tiny spaces and cracks in this volcanic rock.

This volcanic rock has been intruded so as to lie immediately above a dark bed of shale about four feet in thickness. Where exposed it is in contact with the shale. At the ranch we were told of one oil-filled cavity the size of a walnut being found, but at the time of the visit of the writer only a few pieces of the igneous rock could be located that contained any oil and this was in cavities not larger than grains of wheat.

While no fossils could be discovered in the underlying shale bed it is possible that it is the source of the small amount of oil, and that the oil has been forced from the shale through cracks in the igneous rock to fill such cavities as could be reached. No trace of oil could be found in the sandstone that is above the igneous intrusion nor other evidence of oil in any of the other formations in this vicinity. These traces of petroleum are of interest in showing that material has existed in the Tyee here that could under favorable conditions produce a trace of real oil but there are no indications that oil has ever been produced by the rocks in this region in quantities sufficient to make it of commercial value.

As has been stated, the Tyee is very largely made up of porous sandstone throughout and even if the occasional thin shale beds were all possible sources of oil, it is doubtful if enough oil would be produced in any part of the Tyee to be of commercial importance. But a careful study of the Tyee in many exposed sections throughout western Oregon has shown that the shales are not of a satisfactory character to produce any oil and the small traces found on the Johnson ranch cannot be regarded as being an indication that commercial quantities of petroleum will be found in this formation.

Overlying the Tyee in western Coos County, is the Coaledo and this marks the upper part of the Eocene period. In this region, there is 4000 feet of Coaledo made up of fresh water sandstones and shales with occasional brackish water shale beds. In the upper part of the Coaledo are a number of coal beds. A study of the beds of shale and sandstone, and tests of the more favorable looking shales failed to show any part of the Coaledo that could be regarded as a source of petroleum in commercial amounts, as none of the samples gave even a trace of oil. The sandstone members of the Coaledo, even when the structure is favorable for oil concentration, contained no evidence of ever having been the container of oil. The subject of oil seeps will be taken up later but it should be noted that in Coos county there are a number of folds which are so cut that there should be live seeps if any part of the Coaledo is productive of oil. But nowhere in the Coaledo was it possible to find petroleum seeps or signs of petroleum residue. As the pitch coal of Coos county has been the cause of attempts to develop oil in this region, an investigation was made of the occurrence of this material.

The "Pitch Coal" of Coos County

In the coal beds of the Coos Bay region the miners have occasionally found small seams and narrow veins of what they call "pitch coal." These usually occur at or near broken or faulted areas in the coal beds. This "pitch coal" is a dull resinous brown to brownish-black in color; when powdered it has a very resinous feeling, and when lighted with a match burns like a tar or pitch product.

It was described by J. S. Diller when he made the examination of the Coos Bay coal field and samples were at that time thoroughly analyzed by W. C. Day.* Mr. Day in his report says:

"Briefly stated, my conclusions are that the pitch coal is a variety of asphaltum, and that it has not been formed from the coal alone with which it is associated, although vegetable material similar to that which yields coal may have formed some of the original material which, by a process of distillation, was converted into the pitch coal."

Because this "pitch coal" does contain some material which seems to be a variety of asphaltum, it has been given considerable attention as

* Day, W. C., 19th Annual Report, U. S. Geol. Survey, Part III, pp. 270-376, 1899. Results of tests given.

furnishing a slight indication of asphaltic oil for this region. In the present examination, the Libby mine was visited but at the time of examination, July, 1919, the miners were unable to find any "pitch coal." The miners all seemed quite familiar with "pitch coal" although they stated that it was not of common occurrence and when found it was usually at or near faulted places in the coal beds. The "pitch coal" at times had been found making up a small part of the main coal bed and at other times in the well-defined seams cutting through the coal bed. These seams of pitch coal had been known to extend into the caprock above the coal bed but none of the miners ever found the seams going below the coal into the underlying sedimentary beds.

If the "pitch coal" should be seriously regarded as indicating a possible supply of asphaltic oil underlying this coal region, then the seams in which it is found should cut through the beds underlying the coal and show a connection with such an underlying source. Nowhere could the writer find evidence that this pitch coal came from any source but the coal beds proper or by combination with the coal and the beds lying immediately under the coal.

In the examination of this region it was found that the coal beds at times lie just above beds containing marine or brackish water fossils, and it seems possible that with faulting these fossil beds might have been the source of small amounts of asphaltic material that could have united with distillation tar products from the coal and thus have produced the small veins of "pitch coal." During this examination only one vein of pitch coal was seen and this was in the Knight coal vein at Riverton. Samples of this and samples from the Libby mine are, in all physical tests, tar distillation products rather than asphaltic.

An examination of a thickness of more than 10,000 feet of sediments underlying the coal through to the metamorphic beds certainly shows no shales of a satisfactory character to be a source of oil in commercial quantities, and there is no indication that any of these underlying beds have ever produced or contained oil in commercial amounts.

From all of the evidence obtained and from tests made in this investigation it can be stated that the "pitch coal" is in part, if not almost entirely, a product of the coal veins themselves and if it does contain some variety of asphaltum this asphaltum has been derived from organic remains in beds very closely associated with the coal beds. The sedimentary beds below the coal give no indication of having contained asphaltic oil or of ever having been the source of oil in commercial quantities.

The Eocene sedimentaries of conglomerate, sandstone and shales with a total thickness of more than 9000 feet are exposed as the surface rock in most of Coos, Douglas, Benton, Lane, Lincoln and part of Polk counties. In the exposures in southern Coos and Douglas counties, most of the Eocene has been removed by erosion and the thickness overlying the Cretaceous varies from nothing to the total of more than 9000 feet. In Yamhill, Tillamook, Washington, Columbia and Clatsop counties, the 9000 feet of Eocene is generally covered by from nothing to more than 10,000 feet of the younger beds of shales, sandstone and conglomerates.

The entire Eocene offers no evidence that is favorable for the production of petroleum in commercial quantities. Wells sunk in it in Coos county have found traces of inflammable gas but there is enough vegetable organic matter throughout the shales and sandstones of the Eocene to produce the small amounts of gas encountered in these wells.

OLIGOCENE

As already stated, the south half of western Oregon was above sea-level during the Oligocene period, and it is only north of an east and west line through Eugene that the deposits of Oligocene are of importance. The Oligocene is exposed on the surface along the west slope of the Coast Range in Lincoln, Tillamook and Clatsop counties and on the east slope in Columbia, Tillamook, Washington, Yamhill, Polk and Benton counties.

In Section C-C, Plate 4, there is a thickness of about 7500 feet of Oligocene from the top of the Eocene to the bottom of the Miocene. The Oligocene was divided into three periods, the Toledo, the Yaquina, and the Acila shales.

The oldest and lowest division, the Toledo, consists of nearly 3000 feet of tuffaceous shales and sandstones. This entire thickness is made up of beds carrying almost no evidence of organic remains and there is a lack of indications of marine life. The great deposits of tuffaceous material were doubtless very unfavorable for the growth of much animal or vegetable life and the entire Toledo presents no material that would be encouraging as a source of petroleum products.

The middle division of the Oligocene called in this investigation the Yaquina, measures 2300 feet in the Section C-C, Plate 4. The lower 1300 feet is made up of coarse-grained sandstone, the upper 1000 feet is fine-grained bluish-colored sandstone fairly rich in fossil shells of the Oligocene period. In no part of northwestern Oregon where the middle Oligocene could be studied was it of a good character to be a source of oil.

The top member of the Oligocene was given the name of Acila shales because in the first section measured near Newport, it was found to be a dark-colored shale rich in fossil *Acila shumardi* shells. In this section, from Yaquina to Newport in Lincoln county, a thickness of 2100 feet of Acila shales was measured. This shale has great numbers of fossil fish scales and is quite generally rich in organic remains. The shale is fine-grained, and when fresh, a dark gray in color. Fresh fractured pieces smell of petroleum for a few seconds after the shale has been broken. This shale in the vicinity of Newport is a possible source of petroleum products if it can be found to have overlying it a porous reservoir bed, and, furthermore, properly folded and capped with an impervious layer to retain any accumulation of oil.

Miocene deposits overlie the Acila shales in the vicinity of Newport. These are dense sandy shale deposits largely composed of fine-grained tuffaceous material. This would be a good impervious capping but is not of satisfactory character as a reservoir material. The structure north and south of Newport as far as the Acila shales are exposed is a monocline dipping gently toward the west. For this reason, the overlying Miocene beds generally cover the Acila shales along the Pacific Coast line. At no place were there favorable folds in the Miocene where it covered the Acila shales and it is doubtful if such structure exists in this region as it is all part of the major structure of that part of the coast, namely, monoclinal.

There have been such frequent rumors of oil being found along the beach near Waldport that it may be possible that at some distance out to sea these Acila shales have been covered by a more favorable phase of the Miocene sediments and that a fold does exist under the Pacific which is seeping some oil. In this investigation difficulty was experienced in actually finding any evidence of real crude oil along the shore near Waldport, but the local inhabitants state that these oil showings are usually found after a strong coast storm in the winter.

The Acila shales forming the upper part of the Oligocene are found on the west slope of the Coast Range in Tillamook and Clatsop counties, and on the east slope in Yamhill, Tillamook and Columbia counties. In all of the other exposures of Acila shales found the shale was of a more sandy character and did not have the favorable petroleum odor observed near Newport. Volcanic intrusions so frequent in Tillamook, Clatsop, Columbia and Yamhill counties have broken through many of the anticlinal folds in the sedimentary rock. If in all of these counties there is one fold in which the Acila shale could be a source of oil under favorable conditions for accumulation and concentration, there are without doubt many folds that have been broken by volcanic intrusion or by erosion. There should be, under these conditions, innumerable oil indications in the form of seeps or sand showing oil residues. This is not the case, inasmuch as no real oil indications were seen in these counties and none of the inhabitants who have been interested in oil prospecting could be found who could show a real indication of oil.

MIOCENE

The Miocene is a marine deposit along the shoreline of the Coast counties where it is rarely over 500 to 800 feet thick. It is tuffaceous in character, being largely a series of sandy shale layers. As a source of petroleum, it offers no possibilities and is of interest only because it lies immediately above the Acila shales. Its qualifications as a reservoir for oil produced by the Acila shales has already been discussed, and with the exception of this one possibility, the Miocene deposits of western Oregon are of little importance in the question of petroleum development. The Pliocene and Pleistocene also are of no importance in this investigation, except that they are generally unconformable to the older sedimentaries that they overlie, and for this reason prevent the working out of good structural maps of geology in such regions where they cover the older formations.

JACKSON COUNTY

North of Medford, and as far south as Ashland, attempts have been made from time to time to find petroleum in Jackson county. As the more recent sedimentaries of this region are somewhat cut off from the balance of western Oregon by the basaltic flows and outcrops of older Pre-Cretaceous metamorphic rocks, Jackson county has been treated as a separate problem. It should be stated, however, that the range of sedimentary rocks in Jackson county extends from the Pre-Cretaceous metamorphics to the Upper Eocene and possibly Post-Eocene tuffaceous beds. These different horizons are so much like those already described in this report that there is really little reason to justify a repetition of the discussion of the Pre-Cretaceous, Cretaceous and Eocene as found in Jackson county.

The Pre-Cretaceous in Jackson county makes up the larger part of the Siskiyou mountains. It consists of metamorphic rocks, namely, schists, slaty shales, quartzites and serpentine. These have been cut by innumerable quartz veins, large and small, which, in some localities, are of so frequent occurrence that they give at a distance a whitish appearance to the entire exposure.

There is marked evidence that during Cretaceous time the Siskiyou mountains existed as a land mass and that in Jackson county numerous high points in the pre-Cretaceous metamorphics stood as islands above the sea-level. The Cretaceous sediments now exposed are found in a narrow area along the west side of Bear creek from Ashland at the south to the Rogue river. The width of the strip is quite variable as the deposits extend back into all of the small valleys. The lowest Cretaceous found is made up of hard fine-grained sandstone in thin layers from two to five inches thick. Slabs of this sandstone are used for sidewalks and doorsteps in this county. It is gray-brown to buff-colored and is composed very largely of Pre-Cretaceous material. Over this is about 1000 feet of sandy blue-colored shale carrying marine fossils. The Cretaceous beds all dip gently to the east with a maximum of about 10 degrees, and where there is some slight folding indicated, the folds are low plunging anticlines with their axes dipping toward the east.

Eocene sediments cover the district to the west and north of Bear creek and can be traced as far east as the lava flows. Beyond the lava which caps the hills to the east is a great thickness of tuffaceous deposits lacking in evidence of fossil life which seem to be terrestrial deposits in age older than the lava flows. The entire Eocene identified includes about 9000 feet of conglomerates, sandstones, shale and sandstone with the upper part carrying small seams of coal. On top of this are tuffaceous deposits. The sequence of beds and the character of deposition agrees very well with the measurements of the Eocene in Coos county.

The conglomerate is composed of boulders of quartzite, chert, igneous rock and eroded Cretaceous material. The sandstone overlying the conglomerate is largely made up of reworked Cretaceous sandstone. Above the conglomerate-sandstone member there is about 800 to 1000 feet of shale like the Umpqua shale already described. It also is lacking in evidence of marine life and, as elsewhere, offers nothing favorable as a producer of petroleum. Above this is about 2500 feet of sandstone with some interbedded shale. This sandstone is light-colored and carries occasional wood fragments. It is quite micaceous, carrying much of white muscovite mica. At the top of the sandstone are conglomerate beds in places 12 feet thick. These are much like the basal conglomerate beds of the Eocene. Above the thin conglomeratic beds are tuffaceous sandstones which show thin coal seams. Over this is about 5000 feet of tuffaceous sandstone, the lower part being dark brown in color and containing many angular igneous fragments that do not show waterworn edges. These tuffaceous sandstones are capped by lava flows which are separated from them by about 100 feet of white volcanic ash.

The lava flows cut off further investigation of these beds. In structure, they all dip gently to the east and while minor folds are found the axes of all likewise plunge gently to the east. In Antelope creek east of the outcrops of Eocene, the lava cap has been cut through and the white volcanic ash is exposed. In Section 4, T. 38 S., R. 2 E., on Antelope creek, a few small seams of dried, hard asphalt have been found. This asphalt is so dry that the tuffaceous material alongside of the seams rarely shows any discoloration due to the asphaltic oils. The seams are very thin and to date only a small amount of asphalt has ever been found. Antelope valley shows many intrusive dikes and it is possible that some of these have by distillation of the underlying shale beds produced a small amount of asphaltic material that has by pressure worked its way up to the seams in the rock to where it is now found.

Conclusion

The Cretaceous and Eocene deposits of Jackson county are well exposed for study and throughout their entire thickness offer no horizons favorable as a source of commercial quantities of petroleum. This region with its gentle monoclinal structure and its open plunging anticlines should show innumerable indications of petroleum if such material exists or ever had existed in any quantity in Jackson county. The region is such an "open" one and is so easily studied that a careful examination is very conclusive that it offers no favorable territory for the production of petroleum products in commercial amounts.

NEHALEM WAX

Since about 1810 somewhat more than 12 tons of material known as Nehalem Wax has been collected in the vicinity of Nehalem in Tillamook county. This has very generally been put to the same use as ordinary commercial beeswax. Much of this material has been taken from a recent sand bed lying just above high-tide level near the beach town of Manzanita and it is still possible to find small amounts of the wax at this place. Occasional fragments of the wax have been picked up along the shore as far as 40 miles north and south of Nehalem.

In the Public Library of Portland, Oregon, may be found nearly all of the reports and articles that have been published in regard to this interesting subject. Probably the most complete and scientific investigation of this wax has been made by Professor O. F. Stafford, formerly professor of Chemistry, Oregon University.* In his report Professor Stafford presents very conclusive chemical evidence that Nehalem wax is a real beeswax of possible Philippine Island source, and that it should not be confused with ozocerite or other mineral wax.

Nehalem wax has played so interesting a part in the early coastal history of Oregon and enters into so many of the legends of the coast tribes of Indians that one is tempted in writing of it to spend considerable time discussing these legends, in which the story of Nehalem wax is so interwoven with early-day pirates, wrecked ships, fugitive sailors, Chinese junks, Indian tribes with red hair, the early fur traders, etc. But after investigating the actual occurrence of this wax in the undisturbed sand beds at Manzanita together with a study of the geology of the region, and after a careful review of most of the reports, tests, legends and articles that have been published on the subject, the writer is satisfied that Nehalem wax offers nothing that is of any importance in the discussion of oil possibilities of western Oregon.

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*Stafford, O. F., Nehalem Wax—Portland Oregonian Sunday Supplement, Sunday, January 26, 1907.

VOLCANIC ACTIVITY

In the foregoing pages only occasional reference has been made to volcanic activity. The great areas that are covered by lava flows and the occasional remnant of some crater or volcanic vent are not of so much importance in this investigation as are the intrusive volcanic rocks that are found so frequently as dikes or sills in all of the counties of western Oregon. If there could be carried out in western Oregon a careful mapping of the igneous dikes and sills such map would present some very impressive reasons for doubting if commercial production of petroleum could be expected even if there were favorable sedimentary deposits to produce and hold the oil.

Igneous dikes and sills are generally regarded as a menace in petroleum territory for there is evidence in many areas where such intrusions occur that by their heat they have either burned out or volatilized and destroyed the accumulated oil. In other regions, igneous dikes have upon cooling left open seams and passageways through which the gas and oil could escape. In nearly all petroleum territory where there are igneous dikes that have not entirely destroyed the oil, there are oil seeps of great extent through cracks opened up by the intrusives.

A study of the igneous intrusions in western Oregon gives evidence that these have very rarely altered the surrounding sedimentary rock for a distance of more than a few inches; and it is doubted if they would, as a rule, have been destructive of petroleum products for more than a short distance beyond the limits of the intrusive material. But there is good evidence that most of these intrusions have made ideal passageways for the escape of petroleum products and western Oregon should, therefore, have an almost unlimited number of oil indications in the form of live seeps, or of the heavier petroleum residues. This, however, is not the case, and throughout the most careful search for such seeps or other indications no evidence of petroleum products has been found. So many springs of water and very often sulphur springs of deep-seated origin exist at or near the igneous intrusions that one is certainly justified in expecting to find oil seeps or traces of petroleum in these springs if such petroleum existed in any of the sedimentary beds cut by the intrusive material.

It should be noted that these intrusions have cut through all of the sedimentaries from the oldest metamorphic rocks up to the surface of the earth and have actually prospected the oil possibilities to a far greater depth than can ever be opened up by any oil well. The statement has often been made that no one can say whether Oregon can produce petroleum until the state has been thoroughly drilled by a great many properly-located deep wells. The truth is that nature has already opened up passages for oil by these intrusive dikes and many of them are found breaking through the very crest of anticlines and, therefore, ideally located for prospecting the petroleum possibilities of all the sedimentary beds cut by such intrusives.

OIL SEEPS

Oil seeps in any of the petroleum regions of the world have been known of and talked about by the local inhabitants long before the development of petroleum. The seeps in California were known to the Indians long before the arrival of the first white explorers and the earliest records of the first Spanish to explore California tell of the "strange springs of black pitch." These are the asphaltic oil seeps found in the coast counties of southern California. A description of some of these seeps is given by Professor Peckham* in telling of a region on the east slope of the Coast Range mountains about one hundred miles north of the town of Ventura, California. He says:

"I have examined some of the most extensive veins of asphaltum yet discovered. They have been traced across the country continuously for miles and have been mined to a depth of more than 300 feet. In chemical composition the asphaltum bears a specific relation to the petroleum of Ventura county. They both contain the esters of the pyridine bases. These asphaltum veins lie on one side of, and irregularly parallel with a stratum of sandstone, which, like all of the strata of that region, stands nearly vertical. Along this sandstone stratum bitumen exudes for a long distance. Against it, and on the other side of it, rests a bed of infusorial earth at least 1000 feet in thickness, in some places saturated with bitumen, but for the most part clean and white. These formations extend across the country parallel for miles with the general trend of the Coast Ranges. Enormous springs of maltha, issuing therefrom at intervals, have produced at several points flood plains of asphaltum that fill the small valleys like a glacier, many feet in depth and square miles in extent. The maltha is invariably accompanied with water, and at several points there are evidences that at some period in the past history of those outflows the springs that are now cold have been gigantic hot springs of silicated water similar to those that I believe produced the famous Pitch Lake of Trinidad."

The description of Professor Peckham has been given to show the kind of evidence of petroleum to be found in a region that is badly broken so as to allow the free escape of the crude oil. It is true that there are many very productive oil territories in the United States where no oil seeps are to be found but such oil regions are in gently-folded sedimentary beds that are free from breaks or leaks of all kinds and their geologic structure cannot be likened to that found in western Oregon.

In general the geologic structure of western Oregon is much like that found in California and it should reasonably be expected that if oil does exist in Oregon there would be innumerable seeps, as there are in the oil regions of California. It should be noted that the California oil regions are not broken by volcanic intrusions as are found in Oregon,

* Peckham, Professor, Proc. Am. Philosophical Soc. Vol XXXVI, No. 154, pp. 110-111.

and really, with these intrusions, if oil were to exist in Oregon there ought to be even a greater showing of seeps than found in California.

The igneous rocks of Oregon are generally rich in iron salts and this is also true of many of the sedimentary beds. These dissolved iron salts often give rise to a thin scum or film on the surface of quiet pools of water and throughout the state have frequently been regarded as oil seeps. Decayed vegetation will at times form a jelly-like mass in the bottom of springs and pools of water and this has frequently been reported as being "something like vaseline" and regarded as an indication of oil.

The Oregon Bureau of Mines and Geology, through the press, announced that an investigation would be made for petroleum in western Oregon and requested any who knew of oil indications to write to the Bureau. Answers came from every county in western Oregon and as far as possible the field forces visited and examined reported indications. In addition, as the field parties worked over the different parts of the area, the people were questioned as to their knowledge of oil indications and these were visited. Of all the reported oil indications examined during the investigation about 95 per cent were iron scums and the balance largely showings of decayed vegetation or odorous mud, which bear no relation to the occurrence of petroleum.

In no place in western Oregon was there found to be a live oil seep or any favorable indications of petroleum residues, except the oil trace described near Florence in Lane county, the Acila shales near Newport, and the asphalt found in the tuffaceous beds in Jackson county. These have already been discussed under other headings.

An oil seep, on the North Fork of the Yamhill river, above the McMinnville bridge about a quarter of a mile, was reported to the Bureau of Mines by J. W. Tilden. This spring had floating on its surface a layer of clear oil having the odor of kerosene. A sample of this oil was taken from the surface of the spring by Clarence B. Osborne on August 27, 1919, and sent to the Bureau of Tests and Inspection in Los Angeles, California. The sample was found to contain two per cent foreign matter in the form of water, leaves, dead insects and inorganic material. The remaining 98 per cent was kerosene of the commercial grade of "lantern oil." It had the same specific gravity, the same initial and final boiling points, the same flash and burning points, and the same odor and color as kerosene.

Kerosene is a highly specialized manufactured product and a pure kerosene seep would by the action of nature be extremely improbable. The nature of this seep and the character of the oil were such that the necessary time was not spent to determine how this lantern oil was reaching the spring.

FINAL CONCLUSIONS

A study of the rocks which make up western Oregon from the Pre-Cretaceous metamorphics through the layers of Cretaceous, Eocene, Oligocene, Miocene and Pliocene has shown only one horizon, namely, the Acila shales of the upper Oligocene, that could be a possible source of petroleum products in commercial quantities. Only in the region near Newport in Lincoln county were the Acila shales found to be of a favorable character, and here there was a lack of a good overlying porous sandstone to act as a reservoir. There was in this locality a lack of proper folding also to make possible the accumulation of petroleum products to be of commercial importance, even if these shales had been overlain by a good reservoir sand and a satisfactory capping layer.

In this investigation the Acila shales offer the only favorable source of oil and, without the other necessary conditions being fulfilled, there is little to hope for from them. While only the Newport region was found to have the Upper Oligocene of a favorable nature, it is possible that in the coastal region north of here the other necessary requirements may be fulfilled. It was not possible in this investigation to find indications that such an area does exist along the west slope of the Coast Range. East of the Coast Range in Columbia, Washington, Tillamook, Polk and Yamhill counties, the upper Oligocene where seen is not of a favorable character as a possible source of petroleum products.

In this investigation a careful study of the geologic formations and tests of the better looking shales failed to give any encouragement that western Oregon would have areas in which petroleum products exist in commercial quantities. The lack of satisfactory indications, in the form of oil seeps or the heavier residues, when considered with the fact that because of the generally broken condition of the formations there should be innumerable indications, leads to but one conclusion:—that hopes of productive oil fields in western Oregon are not founded on any satisfactory evidence that can be found by a careful study of the geology.

(Signed) HARRISON AND EATON,
By ARTHUR EATON.

Denver, Colorado, February 6, 1920.

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