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

FIELD OFFICES

2033 First Street
Baker 97814

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

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

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

Introduction

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

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

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

Geologic sketch

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

* Publication authorized by the Director, U. S. Geological Survey
** Geologists, U. S. Geological Survey, Menlo Park, California

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

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

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

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

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

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

THE MAGNIFICENT OREGON COAST

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

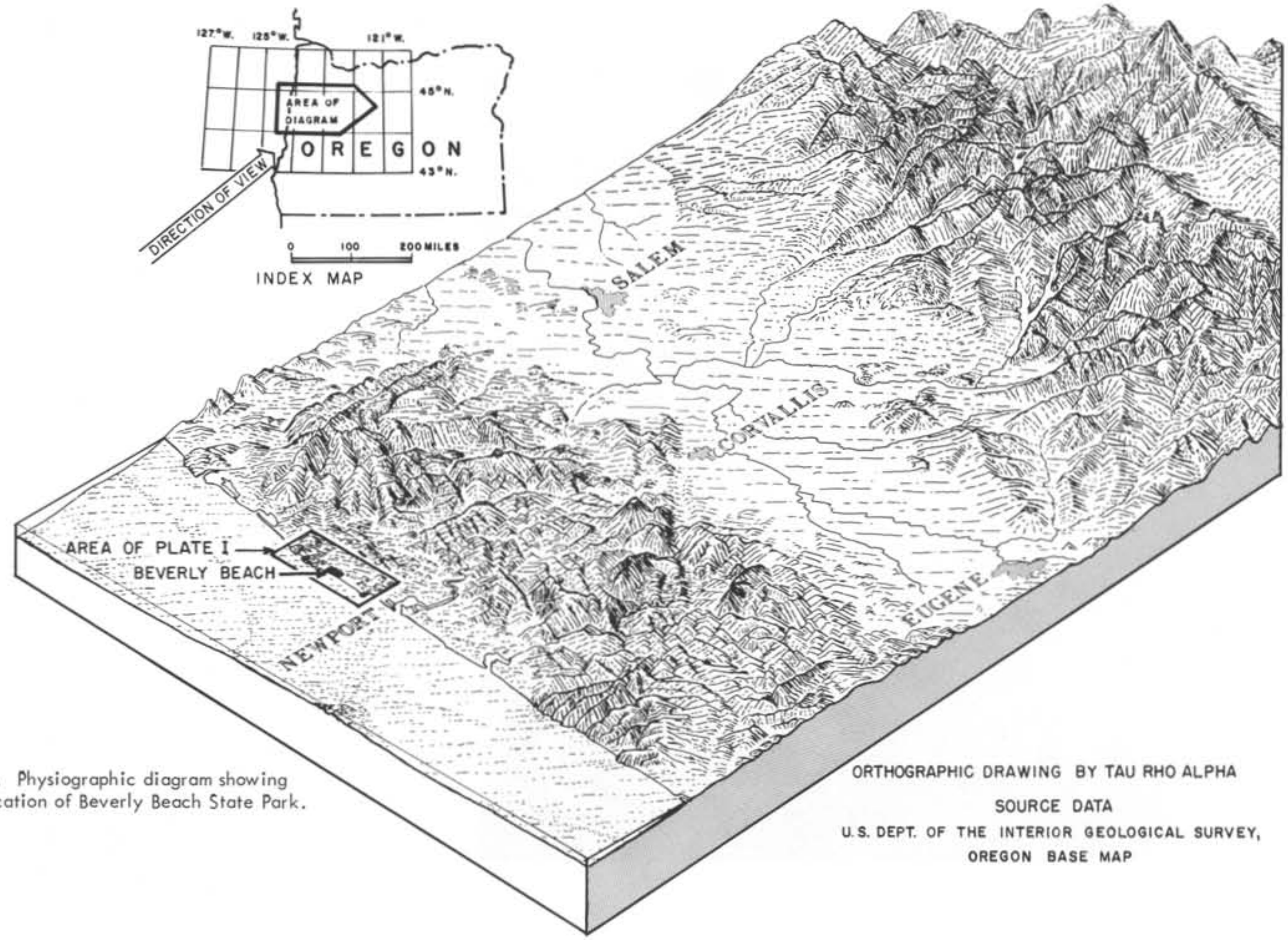

Figure 2. Physiographic diagram showing the location of Beverly Beach State Park.

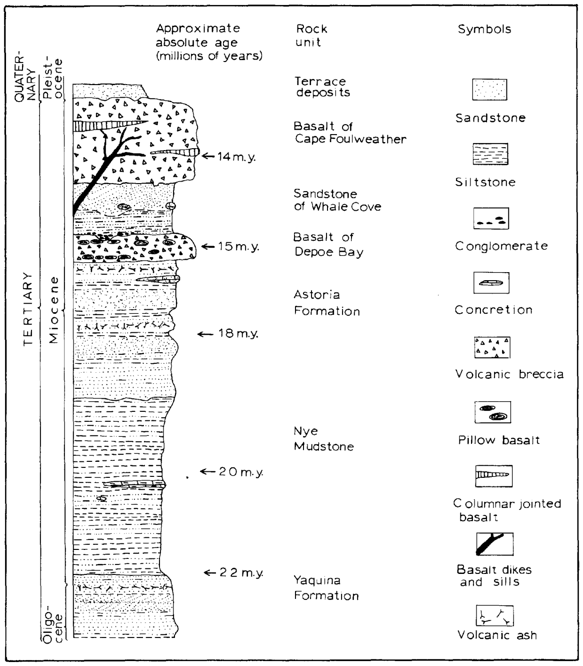

Figure 3

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

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

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

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

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

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

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

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

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

Pictorial Guide

We have selected 12 photographs (figures 4-15) of exposures that are readily accessible to the visitor and that illustrate significant geologic features along this section of the Oregon coast. These photographs and brief descriptions appear on the following pages. The photography localities are indicated by circled numbers on the geologic map (plate 1). We suggest that visitors first stop at Otter Crest on Cape Foulweather, (see figure 1) which provides a spectacular overview of the coastal area in the vicinity of Beverly Beach State Park.

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ON THE BEACH

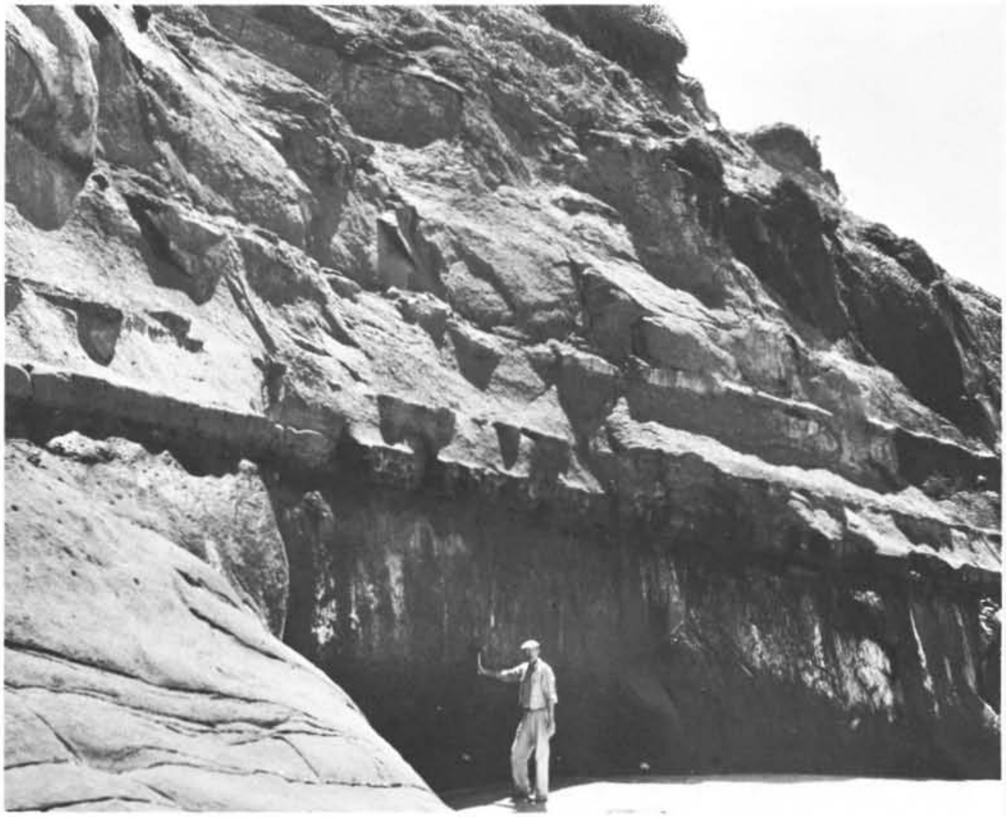
Figure 4. Beverly Beach State Park includes this broad sandy beach, which is exposed here at low tide. Cape Foulweather, a Miocene volcano, forms the high headland north of Beverly Beach. The light-colored strata south of this headland are sandstone and siltstone beds of the Miocene Astoria Formation.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

AN ANCIENT VOLCANO ASTRIDE THE BEACH

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

THE FLOOR OF THE BEACH

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



FOSSIL LAYERS, A FEW PAGES OF EARTH'S HISTORY

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

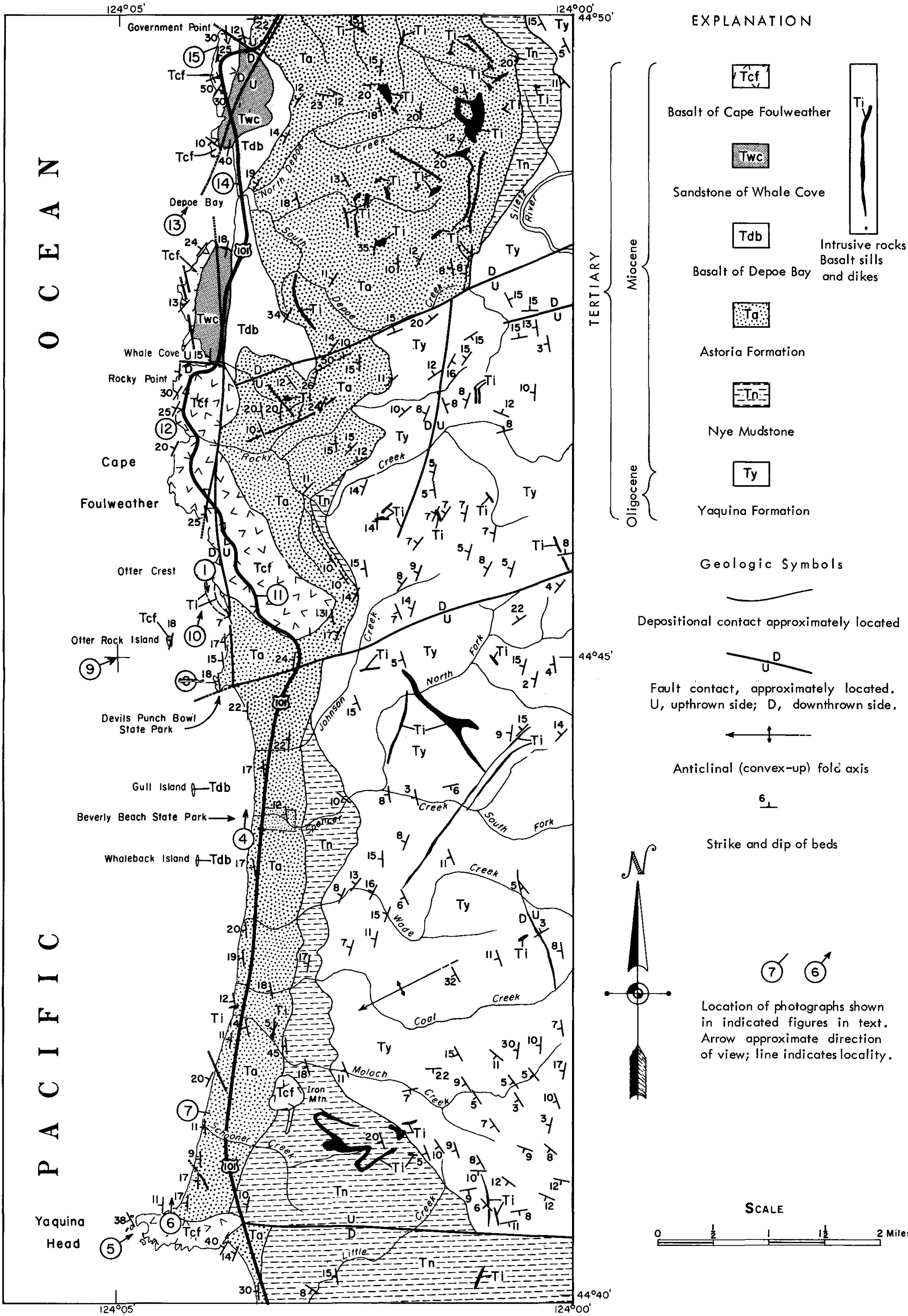


Plate 1. Generalized geologic map of coastal Oregon between Yaquina Head and Government Point. Pleistocene marine terrace deposits and Holocene beach sands and stream alluvium are not shown.

SATAN'S CAULDRON

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

A VIEW FROM THE PACIFIC

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

A RING OF BASALT

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

A FAN OF BASALT

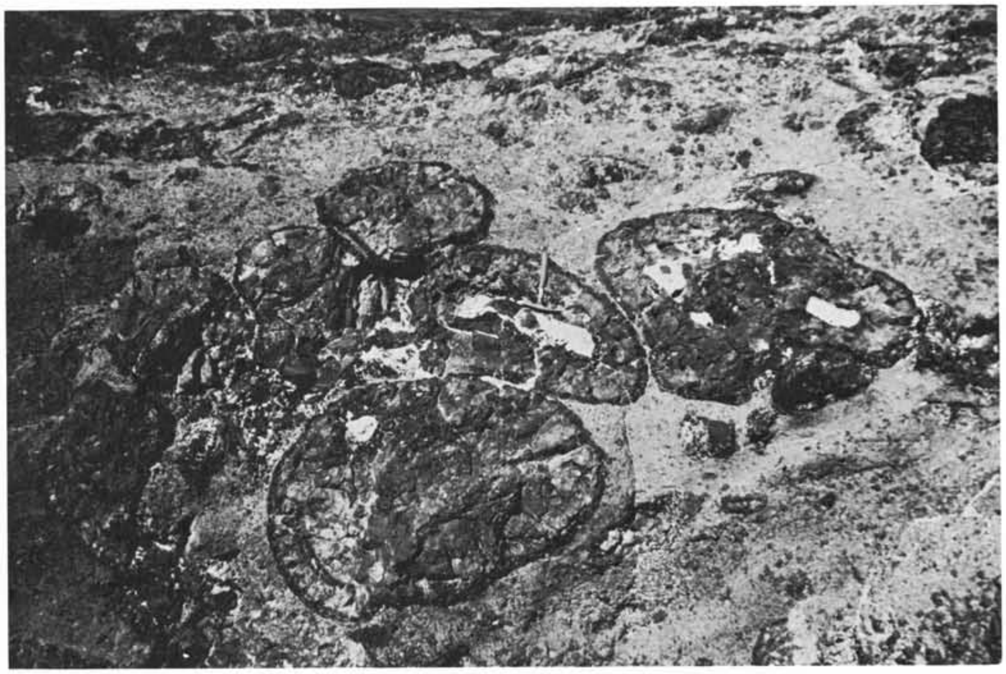
Figure 11. This small volcanic neck is exposed in a quarry along U. S. 101 on Cape Foulweather southeast of Otter Crest. Molten lava from deep within the earth was disgorged to the surface through this volcanic neck. After the last eruption, the lava that remained in the neck cooled and solidified to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

BROKEN BASALT

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

A SEA WALL OF LAVA

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



A BED OF PILLOWS

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

A TUFF AND BRECCIA OUTCROP

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

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HIGH METAL COSTS PREDICTED

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

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

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MEGADIAMONDS PRODUCED

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

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

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BIBLIOGRAPHY OF NORTH AMERICAN GEOLOGY

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

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STRUCTURES IN COLUMBIA RIVER BASALT MAPPED

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

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JAMES P. JACKSON DIES

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

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

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

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GROUNDWATER IN CLATSOP DUNES

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

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

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