The Ore Bin

Vol. 36, No. 11
November 1974

STATE OF OREGON
DEPARTMENT OF GEOLOGY AND MINERAL INDUSTRIES

The Ore Bin

Published Monthly By

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	521 N. E. "E" Street
Baker 97814	Grants Pass 97526

Subscription rate - $2.00 per calendar year
Available back issues $.25 each

Second class postage paid
at Portland, Oregon

State of Oregon
Department of Geology
and Mineral Industries
1069 State Office Bldg.
Portland Oregon 97201

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COASTAL LANDFORMS BETWEEN ROADS END AND TILLAMOOK BAY, OREGON

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Bold, rocky headlands alternating with long curved beaches, sandspits, and bays -- these are the dominant landforms that make up the more than 40 miles of scenic coastline between Roads End and Tillamook Bay. With the exception of Cape Kiwanda, which is composed of sandstone, the headlands are made of basalt, a rock that erodes slowly. The lowlands and bays between the headlands are in more easily eroded sedimentary rock. Thus the coastline is scalloped by a sequence of large protrusions and indentations. Viewed in detail, however, there are numerous small shoreline features such as points, knobs, coves, and sea stacks that are due to local variations in bedrock characteristics.

Geologic Background

Most of the bedrock of this part of the coastal region was laid down on the sea floor during the Tertiary Period when the Pacific Ocean extended inland over part of western Oregon. Some of the bedrock units (geologic formations) were erupted from local volcanoes, while others were carried into the sea by rivers. Their total thickness is now measured in miles. Their ages range from late Eocene (about 40 million years old) to late Miocene (about 12 million years old). See Figure 1.

In Miocene time, the land that is now the Coast and Coast Range began rising from the sea. According to McKee (1972, p. 157), "By the middle of the Miocene Epoch, about 15 million years ago, most of the Coast Range region had emerged from the Pacific." The major uplift and folding of the rock layers occurred during late Tertiary, within the past 10 million years, and culminated during the Pliocene Epoch. Volcanism continued along the edge of the sea until late Miocene or early Pliocene.

Resting on the eroded Tertiary bedrock are younger semi-consolidated sedimentary rocks and loose sedimentary material that has been deposited within the past 2 million years, the Quaternary Period. The oldest of these were deposited during the Pleistocene Epoch, which ended about 10 to 15

Period	Epoch	Beginning
Quaternary	Holocene Pleistocene	10-15 thousand years 2 million years
Tertiary	Pliocene Miocene Oligocene Eocene Paleocene	6 million years 22 million years 36 million years 58 million years 63 million years

Figure 1. Geologic calendar for the Cenozoic Era.
(From Flint and Skinner, 1974)

thousand years ago with the culmination of the ice age, and the youngest are of the Holocene (Recent) Epoch, the epoch in which we are living.

Since the characteristics of each rock unit (geologic formation) have important roles in landform development, a brief description of each is given below. The descriptions are in order of oldest to youngest. The accompanying map, pages 184-185, shows their distribution.

Tertiary bedrock

Nestucca Formation: The Nestucca Formation, of late Eocene age, "...consists primarily of interbedded, tuffaceous, and somewhat shaly siltstone and claystone, and feldspathic and basaltic sandstone," (Snavely and Vokes, 1949). Because of its high clay content, this formation is weak and very subject to landsliding. Weathering of the volcanic ash which makes up the tuffaceous component of the rock and also forms discrete ash layers produces a clay of soapy consistency and very little strength when wet.

The Nestucca Formation crops out along the beach at Roads End and in the cliffs of the small headland north of Roads End. It is exposed at numerous places along U.S. Highway 101 behind Cascade Head, along the road to Three Rocks, and along the seaward face of Cascade Head just north of Salmon River.

Basalt of Cascade Head: The basalt of Cascade Head is of late Eocene age and rests on the Nestucca Formation. It consists of a variety of volcanic rocks that includes dense flow lava, flow breccia, and tuffs. Some of the rock is vesicular, and in places the vesicles are filled with quartz. Interspaces between breccia fragments are filled mainly with quartz and zeolites. Numerous basalt dikes cutting the Nestucca Formation in roadcuts along the highway on the back side of Cascade Head probably solidified in fissures that channeled lava to the surface eruptions.

From the main occurrence of this basalt at Cascade Head, the unit extends to the northeast and forms hilly terrain south of the Little Nestucca

Figure 2. Roads End, north of Lincoln City, is built mostly on a Pleistocene marine terrace. Cascade Head is in the distance. (State Highway Division photo by Kinney)

Figure 3. Coves in the small headland south of Salmon River. Points of dark rock are basalt; lighter rock is Nestucca Formation. (State Highway Division photo by Kinney)

River. It forms a resistant facing along the sea cliffs in the small headland north of Roads End.

Oligocene to Miocene sedimentary rocks: Rocks of this age are widespread but are not assigned to specific formations by Schlicker and others (1972, p. 14) for this part of the Oregon Coast. The unit is composed of tuffaceous siltstone with lesser amounts of sandstone and claystone of considerable thickness. Erosion tends to produce a low, subdued topography. Exceptions are where more resistant beds occur, as at Porter Point south of Nestucca Bay. Here, a dense, hard, basaltic sandstone forms sea cliffs and rock knobs along the beach.

Astoria Formation: The Astoria Formation is a thick-bedded, medium-grained gray sandstone; it is generally weathered to a buff color. The main body of the formation on this part of the Coast begins south of Cape Lookout, where it is exposed in roadcuts along the highway and extends northward around Cape Meares to Tillamook Bay. It is the bedrock beneath the the terrace along the east side of Netarts Bay. The headland of Cape Kiwanda is composed of this rock.

Tertiary intrusive rocks: These are dikes, sills, and other intrusive bodies of middle to late Miocene age and are mostly of basaltic composition. The only outstanding example along this part of the shore is Haystack Rock off Cape Kiwanda. A large dike is exposed in a roadcut about a mile south of Tierra Del Mar, and a small one cuts the sandstone on the south side of Cape Kiwanda at its landward end.

Miocene volcanic rocks: These are late Miocene basalt flows and associated intrusions that were feeders to the flows. The flows are partly pillow lavas and breccias, which either erupted under the ocean or flowed into it, and partly dense, columnar-jointed basalt that erupted onto land. Both pillow basalt and thin flows with columnar structure are exposed in roadcuts and in a quarry at the summit of the road over the Cape. In some places, lavas and sandstone are intermixed.

This basalt is a time equivalent of the Columbia River Basalt in the Columbia River Gorge and of the basalt at Depoe Bay, Cape Foulweather, and Yaquina Head on the Oregon Coast to the south. From Cape Lookout, it extends northeastward along the southern end of Netarts Bay. It is the bedrock at Oceanside and extends north to form Cape Meares headland.

Quaternary deposits

Marine terrace sediments: Terrace deposits were laid down over wave-cut benches during interglacial stages of the Pleistocene Epoch when there was little ice on the land at northern latitudes and sea level stood higher than it does now. The most recent interglacial stage, the Sangamon, preceded the Wisconsin glacial stage; remnants of a terrace formed during that stage are present at several places along this stretch of the Coast.

Marine terrace deposits are composed mostly of loosely cemented sandstone, but locally there may be conglomerate at the base, or siltstone or conglomerate interbedded with the sandstone. In some places wood is abundant. Where the terrace deposits are adjacent to basaltic headlands, layers of angular basalt fragments (talus) are interbedded with the terrace sediments.

Roads End (Figure 2) is at the north end of the long terrace segment that begins at Siletz Bay and upon which nearly all of Lincoln City is built. Part of Tierra Del Mar is on a terrace that extends northward for about 2 miles along the southeastern side of Sand Lake. A small segment extends south from Cape Lookout to about Camp Meriwether, where it is mostly covered with dune sand. The camping and picnic areas at Cape Lookout State Park are on a terrace that extends northward along the east edge of Netarts Bay about a mile beyond Netarts community, where it disappears beneath a sand dune.

River alluvium: The rivers all have alluvial plains, most of which extend many miles upstream. At the lower ends of the valleys, the alluvial sand, silt, and clay merge with the silt and clay of the tidal flats along the estuaries to form meadows that support the dairy industry. The most extensive alluvial plain is in the Tillamook embayment, where bay filling and the alluvial sedimentation by the five rivers that empty into the bay have created an extensive lowland that forms the heart of the Tillamook dairyland.

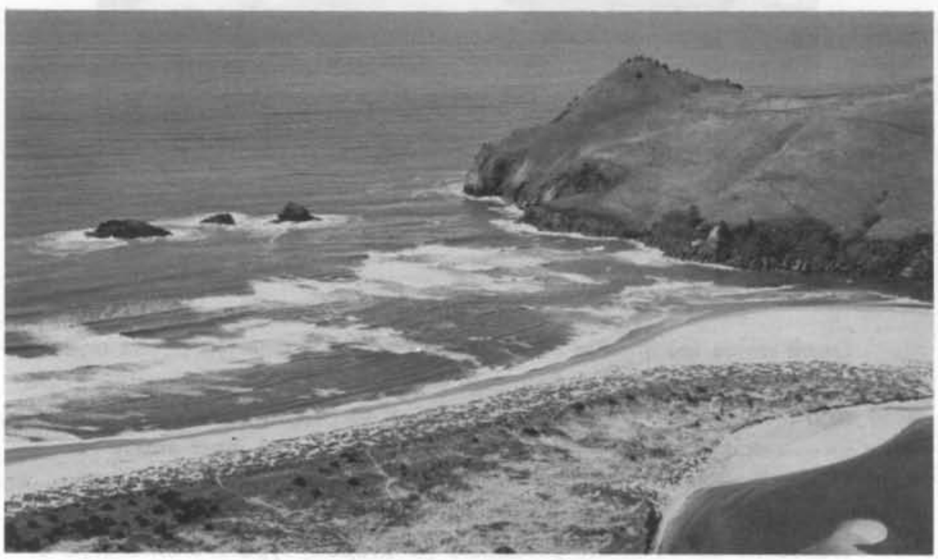


Figure 4. Three Rocks at the mouth of Salmon River are composed of Cascade Head basalt and are remnants of the basalt promontory at the southern part of Cascade Head. (State Highway Division photo by Kinney)

Figure 5. Irregular shore along the face of Cascade Head. (State Highway Division photo by Kinney)

Dune sand: Dune sand is of both Pleistocene and Holocene age. In places, stratified terrace sandstones are overlain by ancient rusty-yellow dune sand that in turn is mantled by a thick soil layer beneath a forest of large spruce and fir trees. Pleistocene dune sands are most easily recognized where they are penetrated by roadcuts that reveal their complex cross bedding.

Holocene dunes of the parabolic (U-shaped) type are extensive at Cape Kiwanda and Sand Lake, and remnants of three large parabolic dunes lie north of Netarts Bay. Smaller dunes occupy the crests of beach ridges and sandspits. Most of the dune surface is stabilized with grass or pine forest, but in the Cape Kiwanda and Sand Lake localities there is still considerable dune-forming activity (see Figure 13).

North of Roads End is a small headland consisting mainly of sedimentary rock of the Nestucca Formation partly protected from erosion by basalt along its seaward side (Figures 2, 3). The basalt was once continuous along the shore in the form of a wall in front of the sedimentary rock, but wave erosion has breached the wall in several places. Where the basalt wall has been removed, erosion is cutting rapidly into the soft sedimentary rock, and small coves have formed (Figure 3). Landsliding in the Nestucca Formation combined with wave erosion continues to enlarge the coves. In time the sedimentary rock will be removed from behind the basalt, and the basalt masses will become separated from the mainland, forming offshore sea stacks. Three Rocks, just to the north off the mouth of Salmon River (Figure 4), are of similar origin.

Cascade Head (Figures 4,5), with sea cliffs rising more than 500 feet above the sea and a shore front of more than 5 miles, is one of Oregon's largest headlands, rivaling Tillamook Head in size. The basalt mass that makes up the headland lies between Salmon River and Neskowin Creek and covers an area of about 7 square miles. The highest point has an altitude of 760 feet.

The shore front of the southern half of Cascade Head is undergoing the same kind of erosion as the small headland to the south. With breaching of the basalt wall, extensive landsliding has been activated along six embayments (North and Byrne, 1965, p. 228). The largest landslide, a tenth of a mile north of Salmon River, is reported to have occurred in 1934 and destroyed 20 acres of pastureland.

Proposal Rock (Figure 6), a small tree-covered island or sea stack at Neskowin, is a basalt remnant of a once larger Cascade Head. Tree stumps (Figure 7) on the beach just north of the sea cliffs have a radiocarbon date of nearly 2,000 years. Their presence at sea level indicates that either the land has subsided since the trees were growing or the sea has risen (or both).

North of Cascade Head to Nestucca Bay is a continuous beach along a shore that, from the headland almost to Porter Point north of Camp Winema, has been built outward from the edge of the upland. Such a built-up shore is referred to as prograded. A beach ridge with sand dunes along the crest has impounded Daley Lake (Figure 8). The lake was once more than twice its present size, but the southern part is now a bog.

Nestucca Bay is the main body of an estuary at the confluence of Nestucca and Little Nestucca Rivers. A south-projecting sandspit (Figure 9) has deflected the mouth of the Nestucca River southward about $3\frac{1}{2}$ miles. Both rivers have wide alluvial plains, and the main Nestucca plain extends far inland.

Cape Kiwanda (Figures 10,11), at the north edge of the Nestucca embayment, is an unusual promontory in that it is composed almost entirely

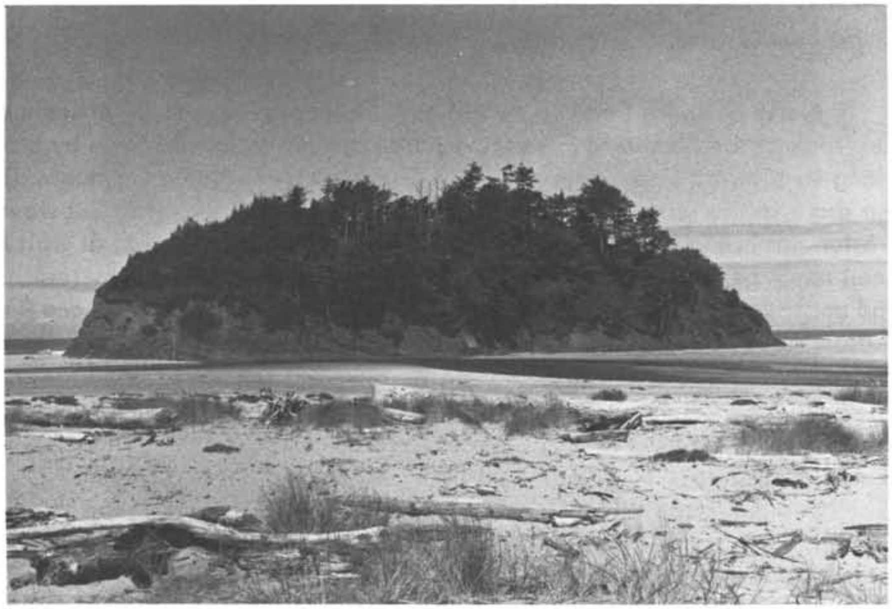


Figure 6. Proposal Rock, on the beach at Neskowin, is a remnant of Cascade Head basalt.

Figure 7. Tree stumps in surf south of Neskowin indicate rising sea level or sinking land. (Photo by Bill Holser)

Figure 8. Daley Lake is impounded by a beach ridge on a prograded shore north of Neskowin. Rocky shore north (left) of the lake is Porter Point. (State Highway Division photo by Kinney)

of sandstone of the Astoria Formation. This point of sandstone owes its survival in small part to the basalt dike on its south side but more importantly to Haystack Rock (Figure 10), a basalt sea stack four-tenths of a mile to the southwest. At one time, the promontory extended to Haystack Rock, which defended the sandstone from severe winter wave attacks from the southwest. Erosion on the flanks of the promontory finally separated the the basalt from the sandstone, isolating it as a sea stack. With the loss of the protection provided by the basalt, the tip of the Cape receded to its present position. Haystack Rock still gives some protection to the Cape by receiving part of the assault of the storms from the southwest, but the Cape is being visibly eroded, principally by undercutting along the sea cliffs and by rock fall. Cape Kiwanda, with its caves and arches and deep chasms, is a marvelous example of natural sandstone sculpture on a large scale (Figures 11, 12) and has been referred to as one of the most photogenic landforms in America. Remnants of huge parabolic dunes that mantle the highest parts of Cape Kiwanda add to the scenic interest of the locality. East of the Cape, dunes, now partly forested, have blocked drainage to the ocean and have formed small lakes behind tongues of sand (Figure 13).

North of Cape Kiwanda, Sears Lake (Figure 14) occupies a shallow indentation in the Tertiary bedrock and is dammed by beach sand that forms a barrier similar to that at Daley Lake.

Figure 9. Nestucca Spit, projecting from Cape Kiwanda, deflects the Nestucca River southward to Nestucca Bay, where it joins the Little Nestucca River. (State Highway Division photo by Kinney)

Sand Lake (Figure 15) is in a small embayment occupied by a shallow body of water and about an equal amount of tidal marshland. Only small streams flow into the embayment, but an opening between north- and south-projecting sandspits allows the tidal movement of water in and out; consequently Sand Lake is actually a small estuary. From Sand Lake, the beach continues to Cape Lookout; along the northern part it is in front of a sea cliff of terrace sediment.

Cape Lookout (Figure 16) is a narrow promontory of Miocene basalt about 1 3/4 miles long. The layers of basalt in the Cape are tilted toward the north and the ground surface slopes in the same general direction; hence, the cliffs along the nearly straight south side are considerably higher --

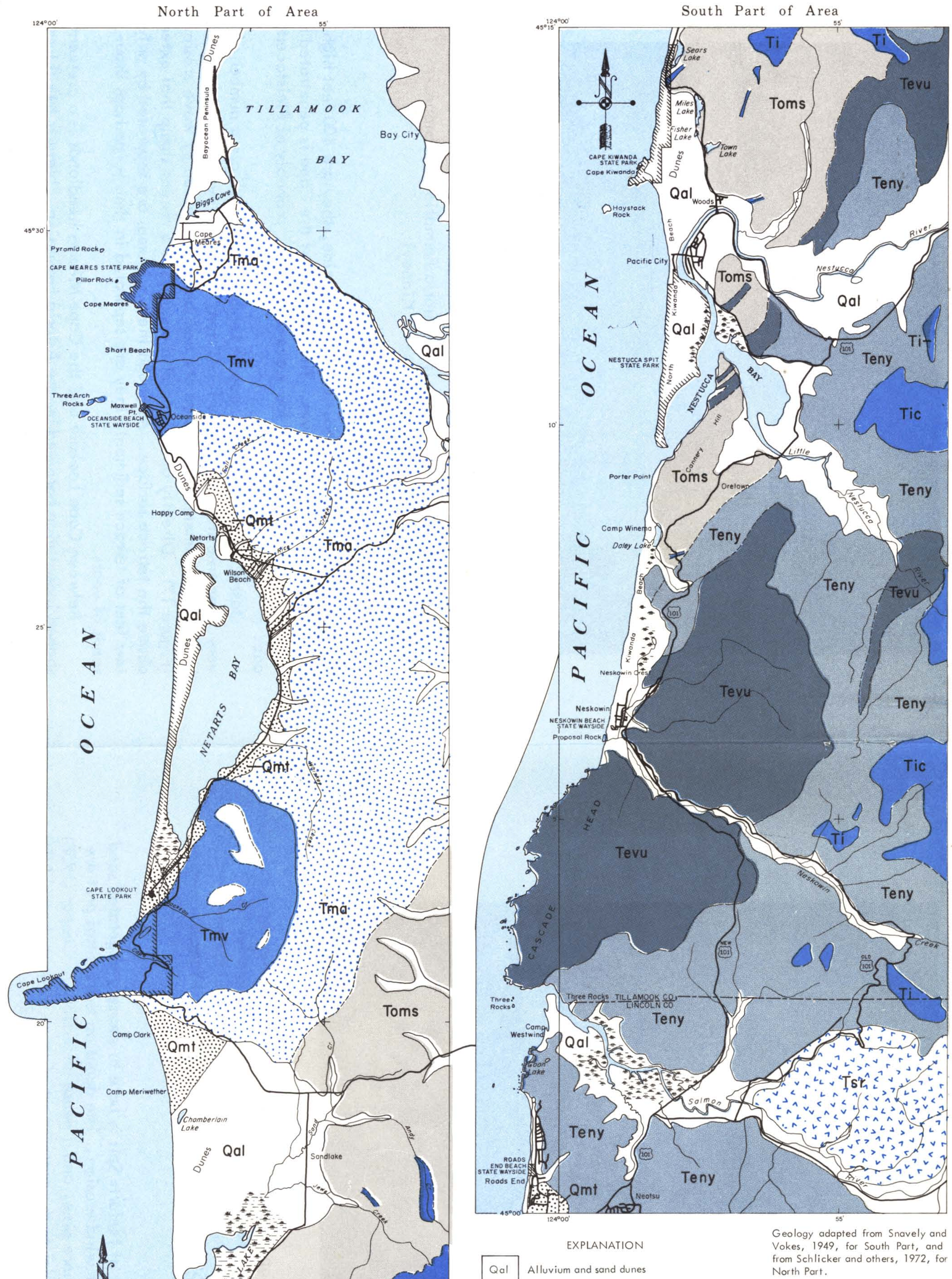
Figure 10. Haystack Rock off Cape Kiwanda is a remnant of a basalt intrusion. Cape Kiwanda is of Astoria Formation sandstone. (State Highway Division photo by Kinney)

800 feet on the landward end. On the north side, they are 400 feet high and indented with scenic coves. The blunt tip of the Cape is penetrated by a sea cave and notched by a low wave-cut bench, probably of Pleistocene age.

Just south of the picnic area at Lookout State Park are a number of very large tree stumps, in growth position, at beach level. Once buried by terrace sediments, the stumps are now being uncovered by wave erosion (Figure 17). Directly above one of the stumps is a recent stump that extends above the terrace surface. Although the two stumps are separated by only a few feet of terrace sediment, they are separated in time by perhaps thousands of years.

Between Cape Lookout and the Cape Meares headlands is a crescent-shaped indentation bordered by the Astoria Formation. Netarts Bay (Figure 18) occupies the indentation behind the long, narrow Netarts Spit projecting 6 miles northward from Cape Lookout. Netarts Bay is a very shallow body receiving water from a few small streams. The bay empties and fills through a well-established channel at the north end, and at low tide it becomes a broad mudflat with small drainage channels.

GEOLOGIC MAP OF THE OREGON COAST FROM ROADS END TO TILLAMOOK BAY



EXPLANATION

- Qal — Alluvium and sand dunes
- Qmt — Marine terrace deposits
- Tmv — Miocene volcanics
- Ti — Intrusive rocks
- Tma — Astoria Formation
- Toms — Oligocene, Miocene sedimentary rocks
- Tevu — Eocene volcanic rocks undifferentiated
- Teny — Eocene Nestucca and Yamhill Formations
- Tsr — Siletz River Volcanics

Geology adapted from Snavely and Vokes, 1949, for South Part, and from Schlicker and others, 1972, for North Part.

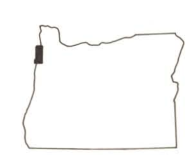

LOCATION MAP

Figure 11. Cape Kiwanda. The roundish wooded area above the center of the photograph and a smaller one at the southern edge of the Cape are dune remnants. (State Highway Division photo by Kinney)

The northern part of Netarts Spit is bare to sparsely vegetated sand and is an area of active wind erosion. The dunes on the central part are forested with spruce, shore pine, and a dense understory. Cooper (1958) relates part of these dunes to the easternmost of three truncated parabolic dunes north of the bay.

North of Netarts Bay is a large area of Miocene basalt with two seaward-projecting lobes. From the southern lobe a small headland, Maxwell Point, shelters the beach at Oceanside (Figure 19). Between the two basalt lobes is Short Beach (Figure 20). The northern basalt lobe, Cape Meares (Figure 21), consists of elongate rock points separated by deep coves. There

Figure 12. Waves beating against the cliff at Cape Kiwanda. A tunnel penetrates a wall of sandstone to form an arch. (State Highway Div. photo)

Figure 13. Parabolic (U-shaped) sand dunes east of Cape Kiwanda. Town Lake, Fisher Lake, and Miles Lake are impounded by the dunes. (State Highway Division photo by Kinney)

Figure 14. Sears Lake is impounded by a beach ridge on a prograded shore. Sand Lake and a large parabolic dune are in the distance. (State Highway Division photo by Kinney)

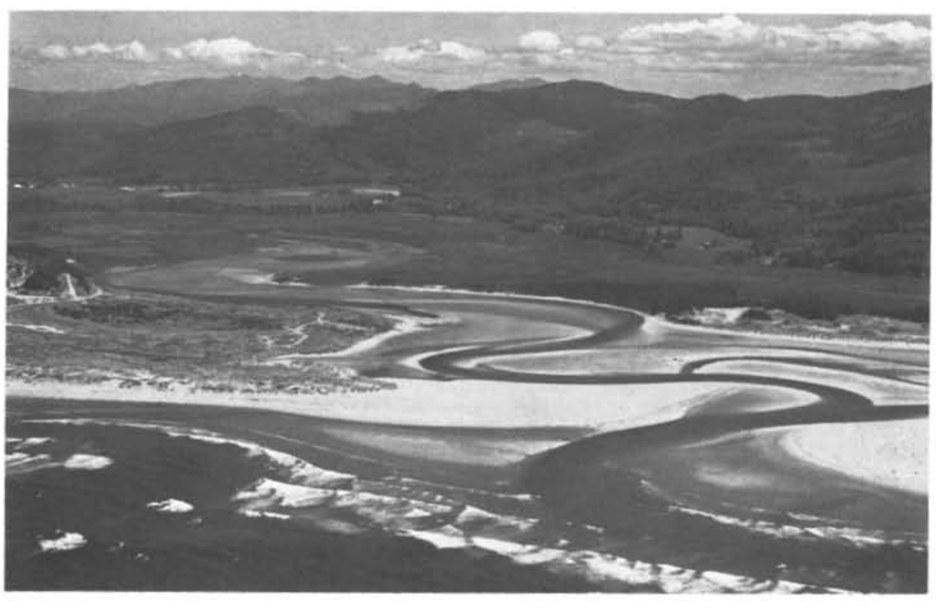


Figure 15. Stream channels wind through the tidal flats at Sand Lake. The wooded island east of the bare flats is a dune remnant. (State Highway Division photo by Kinney)

Figure 16. Cape Lookout is a narrow basalt headland 1 3/4 miles long with a sea cave and a wave-cut bench at its tip. (State Highway Division photo by Kinney)

Figure 17. Tree roots of two ages in terrace sediments at Cape Lookout State Park. Upper stump is of modern age; lower may be as old as Pleistocene.

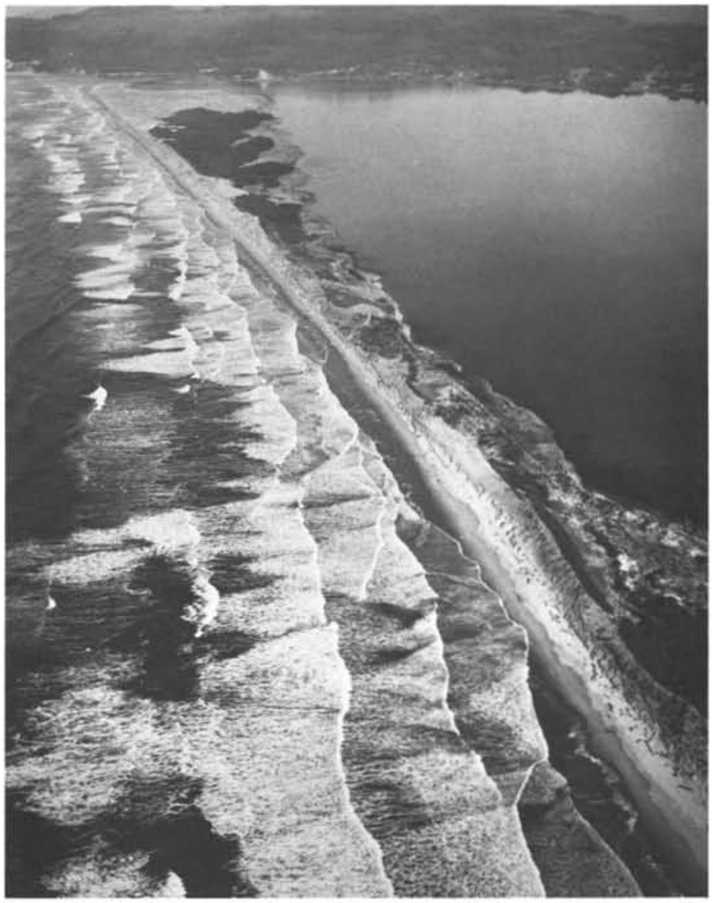


Figure 18. Netarts Bay and sandspit. The forested area near the middle of the sandspit is on dune remnants. (State Highway Division photo by Kinney)

sea cliffs rise in vertical or nearly vertical walls to elevations of 400 feet. A lighthouse is situated at the tip of the longest projection.

Extending offshore from Maxwell Point for nearly a mile are rock knobs, stacks, and arches, all remnants of a former promontory. The largest are Three Arch Rocks (Figure 22) whose arches were most likely sea caves or tunnels when these rocks were connected to the mainland. The middle arch is visible from the southern end of Netarts Bay, and the inner and outer ones can be seen from the tip of Cape Meares. Ofshore from Cape Meares are Pillar Rock and Pyramid Rock (Figure 23). Both of these sea stacks are nesting places for sea birds and, like a number of other offshore rocks, have been declared wildlife sanctuaries.

Figure 19. Maxwell Point at Oceanside is a small basalt promontory on the southern lobe of the basalt mass. (State Highway Div. photo by Kinney)

Figure 20. Short Beach, south of Cape Meares, lies along an indentation in the basalt mass. (State Highway Division photo by Kinney)

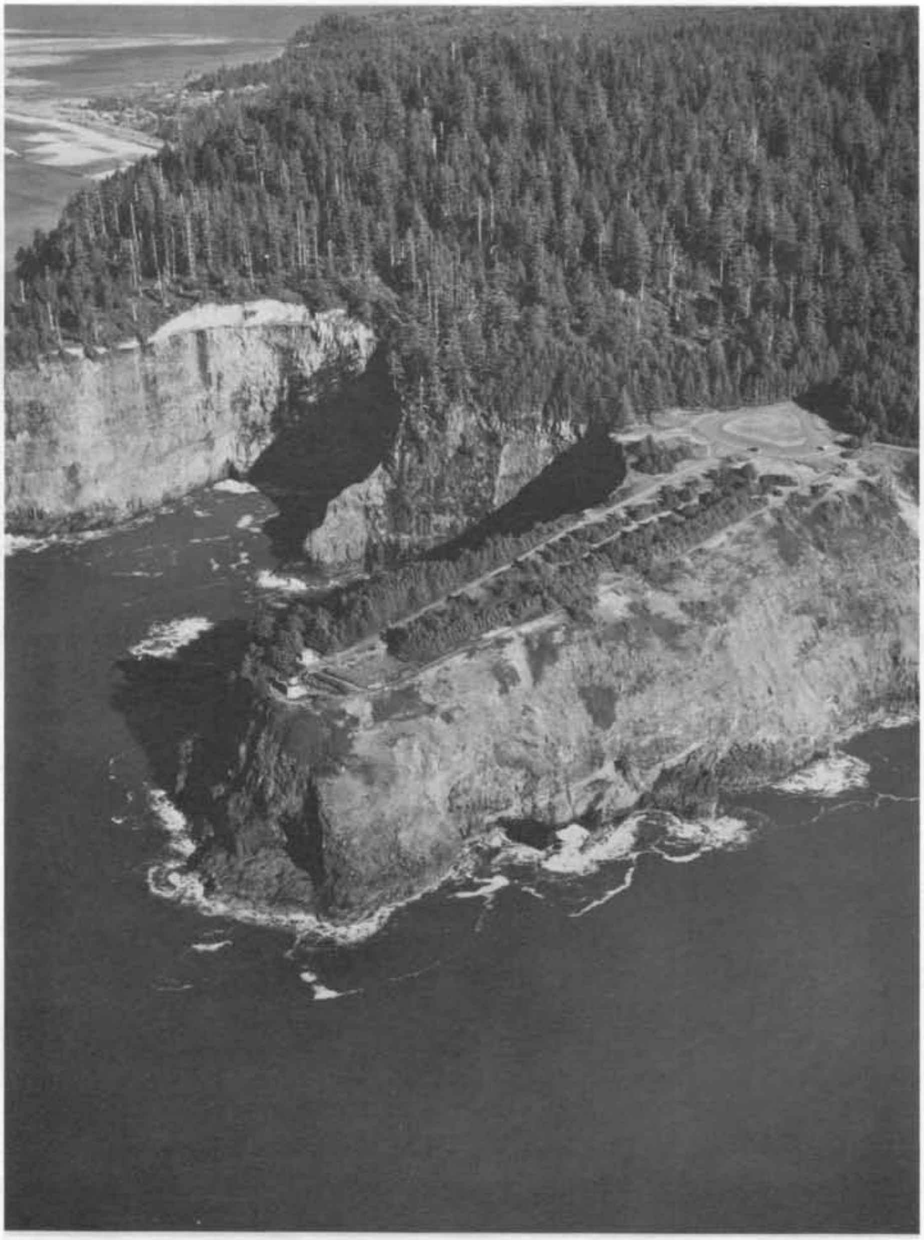


Figure 21. Cape Meares consists of basalt flows that are overlain in places by Miocene sedimentary rock, some of which is exposed at the top of the sea cliff in the upper left part of the photograph. (State Highway Division photo by Kinney)

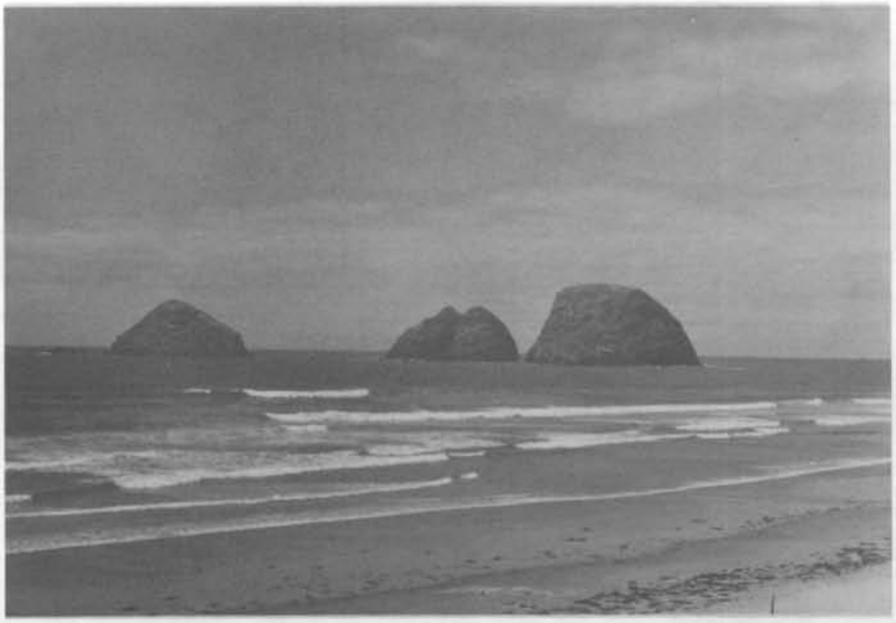


Figure 22. Three Arch Rocks off Oceanside are basalt remnants, each with a tunnel through it.

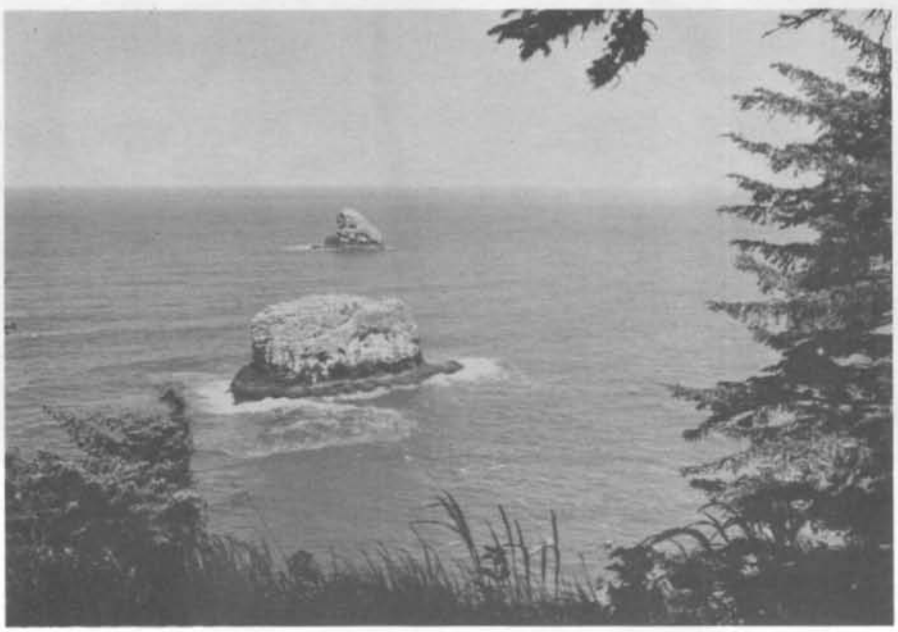


Figure 23. Pillar Rock, shaped like a brimmed hat, and Pyramid Rock in the distance are basalt sea stacks off Cape Meares.

Figure 24. Bayocean Peninsula, the sandspit at Tillamook Bay, projects 4 miles northward from Cape Meares. A dike along the Bay was built to close a mile-long gap eroded during a storm in 1952. A beach ridge makes a natural connection along the ocean shore. (State Highway Division photo by Kinney)

Projecting 4 miles northward from Cape Meares is Tillamook Spit, known also as Bayocean Peninsula (Figure 24). Toward its northern end, the spit has dune remnants that reach heights of 140 feet. Most of the dunes are forested, but some are still active. According to Cooper (1958, p. 84), a reconstruction of the dune system indicates that the outlet for Tillamook Bay was formerly at the south end of the spit.

Tillamook Spit has had a history of damaging erosion that began during the construction of the jetty on the north side of the Tillamook Bay outlet. Jetty construction began in 1914, and the structure was completed in 1933. According to Dicken (1961), erosion probably began between 1920 and 1925. The rate of erosion was slow at first but became noticable in the early 1930's. From 1926 to 1932 erosion was about 1 foot per year at Bayocean, a resort developed on the spit in 1906. Waves broke through the spit in 1932, and property at Bayocean was severely damaged. In 1939, winter storms caused heavy damage to the peninsula. The road at the south end of the spit was cut in two, and a hotel and natatorium at Bayocean were destroyed. Dicken estimates that erosion between 1939 and 1960 was about 50 feet per year.

By 1952, there was a mile-long break in the sandspit. In 1955-56 a dike was constructed to seal it. A beach ridge has subsequently formed a natural connection between the mainland and the detached part of the spit, and a shallow lake lies between the dike and the beach.

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HULL NEW GEOLOGIST AT BAKER OFFICE

Donald A. Hull has joined the Department staff as Economic Geologist at the Baker field office. During the coming months he will be working with Dick Bowen in the Department's on-going geothermal exploration program funded by the U.S. Bureau of Mines.

Don has had considerable experience in geologic and mineral exploration and management and has been working in these capacities for Homestake Mining Co. for most of the years since 1964. Prior to joining the Department staff, he was manager of Homestake's regional exploration programs in northwestern United States and Canada.

Don graduated from Wallace High School, Wallace, Idaho in 1955; he obtained his B.S. degree from the University of Idaho, Moscow, Idaho in 1960, his M.S. degree from McGill University, Quebec in 1963, and his Ph.D. degree from the University of Nevada, Reno, Nevada in 1970. He is married and has three children.

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Page 1

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3. FREQUENCY OF ISSUE: Monthly
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5. LOCATION OF THE HEADQUARTERS OR GENERAL BUSINESS OFFICES OF THE PUBLISHERS *(Not printers)*: 1069 State Office Building, Portland, Oregon 97201
6. NAMES AND ADDRESSES OF PUBLISHER, EDITOR, AND MANAGING EDITOR

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