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ROCK UNITS AND COASTAL LANDFORMS BETWEEN NEWPORT AND LINCOLN CITY, OREGON

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The coast between Newport and Lincoln City is composed of sedimentary rock punctuated locally by volcanic rock. Where the shore is on sedimentary rock, it is characterized by a long, sandy beach in front of a sea cliff. Perched above the sea cliff is the sandy marine terrace that fringes most of this segment of the Oregon coast. Where volcanic rock interrupts the continuity of sedimentary rock, the regularity of the coastline is broken by jagged promontories, rocky shores, and sea stacks (Figure 1).



Figure 1. Yaquina Head composed of volcanic rock; Moloch Beach is on sedimentary rock. (State Highway Division photo by Kinney)



Figure 2. Landslide at Jumpoff Joe in Newport destroyed about 15 acres of coastal frontage and involved a number of houses.



Figure 3. Seaward dipping beds of Astoria Formation are exposed at Jumpoff Joe.

A number of different rock units (geologic formations) are exposed along this part of the Oregon Coast (see accompanying geologic map). Each unit is characterized by a kind of rock or suite of rocks that distinguishes it from other units. For this reason, each unit plays a different role in shaping the coastal landforms.

In the following text, the geologic formations are discussed from oldest to youngest beginning with those of Eocene age, dating back 40 or 50 million years ago, to those of Quaternary age, some of which are forming today. The distinctive landforms associated with each unit are described and also illustrated in the photographs.

Eocene formations

Siletz River Volcanics: This formation, consisting of basalt flows and pyroclastic rocks, is not exposed along the shore but crops out east of Devils Lake and is responsible for the rugged topography in the Coast Range to the east.

Nestucca Formation: These late Eocene siltstones and interbedded sandstones are the bedrock beneath the marine terrace north of Siletz Bay. They underlie the beach sand at Lincoln City and are often exposed during the winter and early spring after storm waves have swept away the sand. The Nestucca Formation is described in more detail by Snively and others (1969).

Oligocene formations

Siltstone of Alsea: This formation, named informally by Snively and others (1969), consists of massive to thick-bedded tuffaceous siltstone and very fine-grained sandstone. It is the bedrock along the east side of Siletz Bay and is exposed in a roadcut along U. S. Highway 101 just south of Schooner Creek at the north end of Siletz Bay.

Yaquina Formation: The Yaquina Formation is of diverse composition, consisting mainly of sandstone but also of conglomerate and siltstone (Snively and others, 1969). It is the bedrock beneath the marine terrace south of Siletz Bay and is exposed in a roadcut at the south end of the bay, but neither it nor the siltstone of Alsea is exposed along the shore in this segment of the coast.

Miocene formations

Nye Mudstone: The Nye Mudstone, of lower Miocene age, is described by Snively and others (1964) as a "...mixture of clay, silt, and very fine sand-size particles in varying proportions; the lithologic designation differs from place to place, but commonly is mudstone and siltstone, and less commonly silty, very fine-grained sandstone." The Nye crops out along



Figure 4. View south from Cape Foulweather toward terrace promontories on Astoria Formation; Yaquina Head in distance. (State Highway Division photo)



Figure 5. Devils Punchbowl in Astoria Formation is the collapsed roof of two sea caves. (State Highway Div. photo by Kinney)

the sea cliff at Newport beneath the Astoria Formation and is exposed in contact with the Astoria Formation at Jumpoff Joe, 1½ miles north of Yaquina Bay. It does not crop out along the shore north of Yaquina Head but underlies the terrace south of Gleneden Beach.

Beds of the Nye Mudstone have a high clay content and therefore have low shearing strength, especially when wet; areas underlain by this formation are subject to landslides along cliffs and in steep terrain. Along the shore between Yaquina Bay and Yaquina Head, the beds have a seaward inclination of as much as 30 degrees, which increases the threat of landslides in this formation. Much of the slumping along this part of the coast is attributed to yielding of weak beds along inclined bedding planes, and bedrock slumps are numerous. The largest slumped area is at the Jumpoff Joe locality in Newport; it involves about 15 acres along a quarter mile of the shore (Figure 2).

Astoria Formation: The middle Miocene Astoria Formation, which overlies the Nye Mudstone, is described by Snively and others (1969) as consisting "...principally of olive-gray, fine- to medium-grained micaceous, arkosic sandstone and dark carbonaceous siltstone. The sandstone beds range from massive to thin-bedded and generally are thicker in the upper part of the sequence." The Astoria Formation contains many fossils.

Between Yaquina Bay and Yaquina Head, the Astoria Formation is exposed above the Nye Mudstone in the sea cliff (Figure 3). From Yaquina Head to Cape Foulweather it is the bedrock below the terrace sediments, and it crops out extensively in the sea cliff and on the wave-cut platform between these points. It is exposed at inner Depoe Bay, in the sea cliffs at Boiler Bay, and at the mouth of Fogarty Creek. It underlies the terrace at Lincoln Beach but is not exposed along the beach.

From Yaquina Head to Otter Rock, a continuous, gently sloping beach lies in front of the sea cliff on the Astoria Formation and overlying terrace sandstone (Figure 4). The northern part is Beverly Beach and the southern part Moloch Beach.

Two promontories (Figure 4) south of Cape Foulweather are segments of a marine terrace developed on the Astoria Formation. The terrace is capped by a layer of sandstone, which gives the flat surface to these points of land. The Astoria Formation is exposed along the outer edges of the promontories where wave erosion has removed the terrace sandstone. It forms the present-day wave-cut platform, where marine gardens with many tidal pools support a luxuriant and varied assemblage of plants and animals.

The southernmost of the two promontories, at Otter Rock community, is the site of the famed Devils Punchbowl (Figure 5). This hole in the terrace was formed by collapse of the roof where two sea caves met, one from the north and the other from the west. Water enters the bowl at high tide, and during storms it churns and foams as in a boiling pot.

One of the most remarkable features in the Astoria Formation is the inner Depoe Bay (Figure 6). This very small and secure harbor lies behind



Figure 6. Basaltic wall shelters inner Depoe Bay from storm waves and erosion. (State Highway Division photo by Kinney)



Figure 7. Government point is a wave-cut platform on volcanic rock; Boiler Bay to north is eroded into sedimentary rock. (State Highway Division photo by Kinney)

a wall of basalt lava rock, and its access to the sea is a narrow chasm through the basalt wall. The basin is a low area in the topography formed principally by stream erosion along North and South Depoe Creeks. Much of the shaping of this small basin was done during the most recent glacial stage, the Wisconsin, when sea level stood several hundred feet lower than it does now. At that time the passage through the wall was a gorge through which the ancestral Depoe Creek flowed. With melting of the glacial ice, the sea rose to a level that caused flooding at the lower end of the drainage basin of Depoe Creek. In this respect, the origin of this small bay has something in common with large water bodies such as Yaquina Bay, where rise in sea level has "drowned" their lower parts and formed estuaries.

Boiler Bay (Figure 7), about $1\frac{1}{2}$ miles north of Depoe Bay, is eroded in the Astoria Formation, which is exposed beneath a thick terrace deposit along the inner cliffs of the bay. Boiler Bay was formed where wave erosion breached a layer of the same basalt as that at Depoe Bay. A fault and other fractures trending at nearly right angles to the shore helped direct the erosion.

A short distance north of Boiler Bay there is a cove in the Astoria Formation at the mouth of Fogarty Creek (Figure 8). This indentation is defended on both north and south sides by remnants of the basalt.

Depoe Bay Basalt: This middle Miocene basalt flow was described by Snively and others (1965) and named by the same writers (1973). The flow is exposed along the shore at Depoe Bay and forms the wall that separates the inner and outer bays (Figure 6). Here the rock is a pillow basalt breccia consisting of more or less dense ellipsoidal masses (pillows) of basalt enclosed in a matrix of angular basaltic glass fragments formed by the sudden chilling of hot lava coming in contact with sea water (Figure 9). Snively and co-workers state that the 75-foot thick breccia at Depoe Bay grades into a 50-foot subaerial (deposited on land) flow to the south. Numerous dikes and sills of this type of basalt cut the Astoria Formation just east of Depoe Bay, and it is believed that lava erupted from local fissures and flowed into the ancient sea (Snively and MacLeod, 1971).

At Depoe Bay, the lava flow forms a jagged, steeply sloping surface along the water's edge, and in places trenches and small caves have been eroded along fractures. One of the caves has an opening at its landward end through which the force of waves causes water to erupt, at times in columns several tens of feet high. These features, called spouting horns, are common along parts of the Oregon coast, and the one at Depoe Bay is one of the most spectacular (Figure 10).

The Depoe Bay Basalt extends northward from Depoe Bay but lies inland from the shore until it appears again at Boiler Bay, where small isolated masses, through their superior resistance to erosion, impart an irregularity to the inner edge of the bay. It lies along the shore north of Boiler Bay as far as Lincoln Beach. The rock knob at the mouth of Fogarty Creek (Figure 8) and the sea cliff northward to Fishing Rock (Figure 11) are of this basalt, and an isolated remnant of the flow forms a reef opposite Lincoln



Figure 8. Fogarty Creek enters a small cove protected by basalt shoulders. (State Highway Div. photo by Kinney)

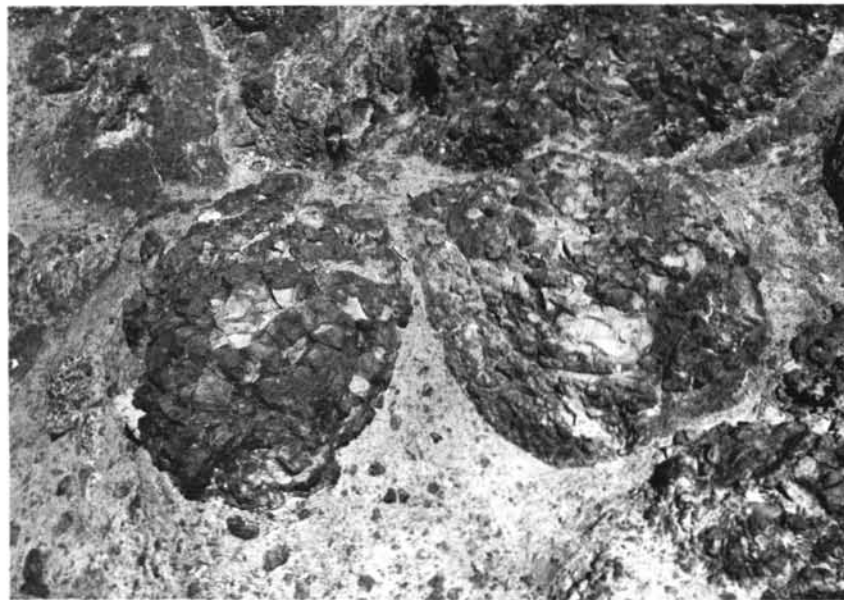


Figure 9. Pillow structure formed when hot lava of Depoe Bay Basalt poured into seawater.



Figure 10. Spouting Horn at Depoe Bay shoots up through a hole in the roof of a sea cave. (State Highway Division photo)

Beach Wayside, just north of Fishing Rock. Off Neptune Beach, a reef and two small islands, Otter Rock and Whaleback, are remnants of subaerial flows of this formation.

Sandstone of Whale Cove: An unnamed middle Miocene unit of sandstone 200 to 300 feet thick lies between the Depoe Bay Basalt and the slightly younger Cape Foulweather Basalt in the Whale Cove-Depoe Bay locality. This unit, informally referred to as the sandstone of Whale Cove, is described by Snavely and others (1969), who state, "Massive to thick-bedded medium- to fine-grained arkosic sandstone and thin-bedded micaceous carbonaceous siltstone to fine-grained sandstone constitute the bulk of the unit."

Whale Cove (Figure 12) was eroded in this sandstone, which forms the sea cliffs along the east and north edges of the cove. The erosion was probably directed initially along an east-west fault that cuts across the sandstone and the basalt that lies between it and the ocean. Once erosion breached



Figure 11. Fishing Rock at south end of Lincoln Beach is a remnant of Depoe Bay Basalt. (State Highway Div. photo by Kinney)



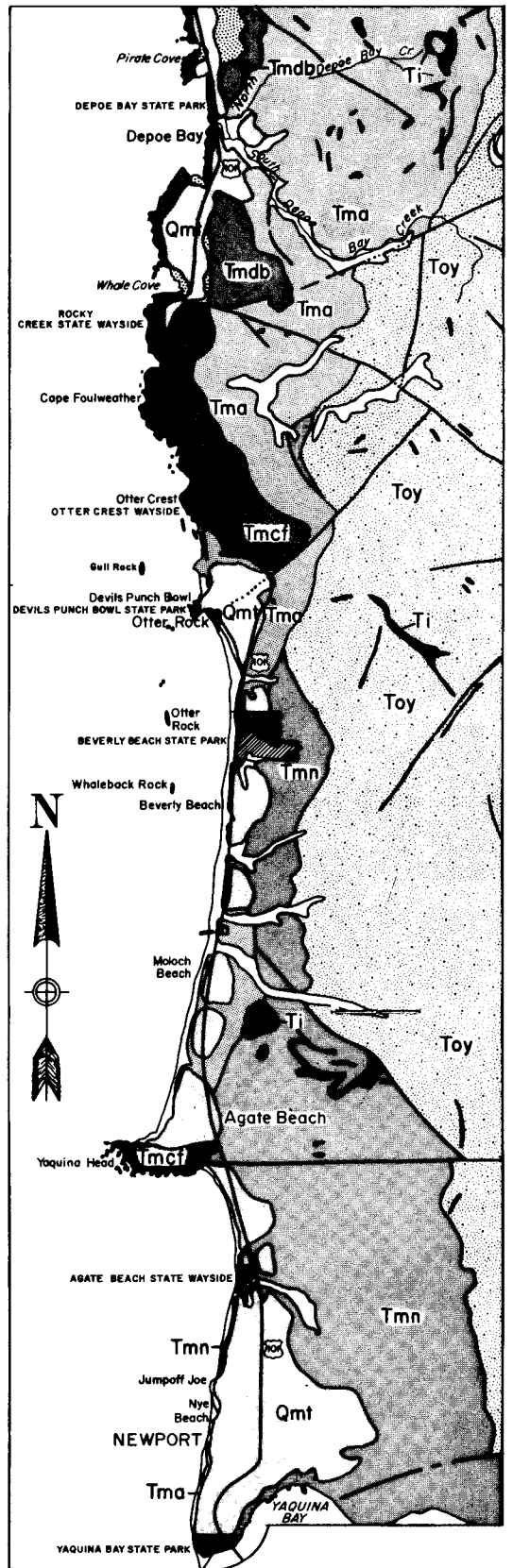
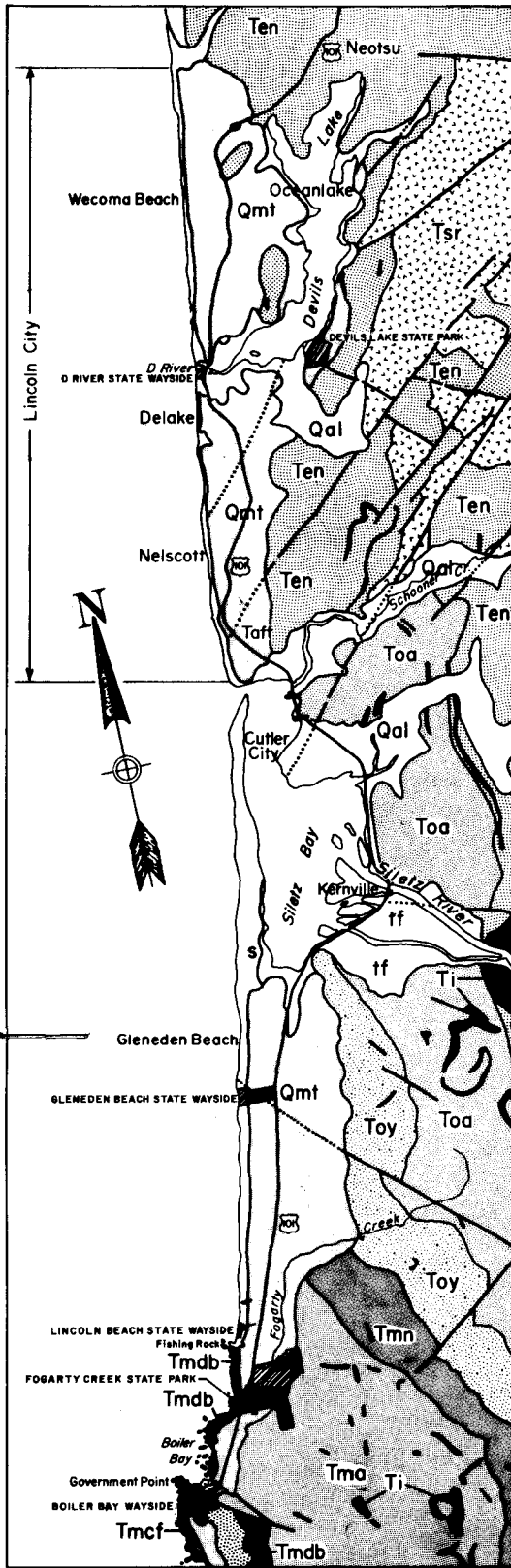
Figure 12. Whale Cove in the foreground and outer Depoe Bay in the distance. (State Highway Div. photo by Kinney)



Figure 13. North end of outer Depoe Bay (lower left of photo) and Pirate Cove (center left of photo) carved into sandstone and basalt. (State Highway Div. photo by Kinney)



Figure 14. Otter Crest on Cape Foulweather rises abruptly out of sea and provides spectacular views from its top. (State Highway Div. photo)



EXPLANATION

Qal tf	Alluvium and estuary deposits
s	Beach, sandspits, and dunes
Qmt	Marine terrace deposits
Tmcf	Cape Foulweather Basalt
Tmwc	Sandstone of Whale Cove
Tmdb	Depoe Bay Basalt

Tma	Astoria Formation
Tmn	Nye Mudstone
Toy	Yaquina Formation
Toa	Siltstone of Alsea
Ten	Nestucca Formation
Tsr	Siletz River Volcanic Series

Ti— Intrusive rocks

Geologic map of coastal Lincoln County between Newport and Lincoln City. Adapted from maps by Snaveley and MacLeod, published in Schlicker and others (1973).

the wall of basalt, the cove was enlarged in the softer sandstone. North-trending faults and fractures in the rock helped promote the cove's enlargement, and sea caves and small re-entrants formed along some of the fractures.

From Whale Cove, the sandstone formation extends northward beneath the terrace sandstone and is the rock in which the wide outer Depoe Bay was formed (Figures 12 and 13). It forms the sea cliffs at the north and south ends of this bay, and, as at Whale Cove, the sea cliffs are irregular and penetrated by small coves and sea caves.

Pirate Cove (Figure 13), a short distance north of Depoe Bay, is partly in the sandstone of Whale Cove, and the sea cliffs along the inner edges of the cove have caves, chasms, and other features characteristic of this sandstone. The sandstone ends just south of Boiler Bay.

Cape Foulweather Basalt: The Cape Foulweather Basalt, named by Snively and others (1973), is the younger of the two middle Miocene basalt units along this part of the Oregon Coast. It is more extensive than Depoe Bay Basalt and is the major contributor to the shore's irregularity. The unit includes several textural varieties of volcanic basalt but consists predominantly of breccia and water-laid fragmental debris (Snively and others, 1969). It also contains massive subaerial flows and submarine pillow lavas. Volcanic necks and feeder dikes that cut through the layers of erupted rock indicate that the eruptions were from local centers. Particles that went into the ocean were reworked into poorly sorted and crudely stratified deposits that fringe the main body of erupted rock.

The main center of eruption of this basalt was at Cape Foulweather, where layers of basalt breccia and dense lava accumulated to a great thickness. The Cape, with cliffs and precipitous seaward slopes that rise to a height of 500 feet at Otter Crest (Figure 14) is one of the most ruggedly beautiful headlands on the Oregon Coast. From the viewpoint at Otter Crest, one can see miles of coastline to the south (Figure 4). North of Otter Crest the shoreline around the Cape is very irregular, with numerous small coves and smaller promontories (Figure 15).

The Cape Foulweather Basalt extends along the shore as far as Boiler Bay, and north of the Cape the rock consists mostly of fragmental types. It is the bedrock beneath the terrace along the shore between the Cape and Government Point (Figure 7). The basalt helps to enclose and protect Whale Cove, outer Depoe Bay, and Pirate Cove.

At Rocky Creek Wayside the Cape Foulweather Basalt is an unsorted and crudely stratified breccia (Figure 16) overlying dense flow basalt. The strata are fairly steeply inclined and are the accumulations of volcanic fragments and flows on the flank of a volcanic cone. North-trending fractures in the rock at this locality have directed the wave erosion that has shaped a picturesque setting of a chasm, sea caves, trenches, and isolated wave-washed rocks (Figure 17).

At Government Point the fragmental rock is roughly size-sorted and



Figure 15. Rugged shore of Cape Foulweather north of Otter Crest.



Figure 16. Basalt breccia of Cape Foulweather Basalt at Rocky Creek Wayside was erupted from a volcanic cone in Miocene time.



Figure 17. Rocky Creek Wayside is situated on a small marine terrace composed of basalt. (State Highway Div. photo by Kinney)



Figure 18. Waves and turbulent water at Government Point, a marine terrace eroded on fragmental volcanic rock. (State Highway Div. photo)

stratified, which suggests a submarine site of deposition. Much of the material is about the size of pebbles. Volcanic fragments of this size are called lapilli, and the rock is designated a lapilli tuff; the coarser textured rock is classed as breccia. These rocks are part of the apron of water-deposited fragmental volcanic debris that formed a fringe around the seaward edge of the main center of eruption at Cape Foulweather.

Government Point is a favorite viewpoint for wave-watchers. During storms, waves strike the rocks with eruptive violence (Figure 18) or rush plunging into adjacent Boiler Bay (Figure 7), at times causing the surface of the bay to turn white with foam and seething water. Though the turbulence of the water in Boiler Bay during storms is not the basis for the name, the condition does lend appropriateness to it. The bay gets its name from the boiler of a wrecked ship which was visible for many years, until it finally rusted away.

Yaquina Head (Figure 1) is composed of the same kind of basalt as that at Cape Foulweather, and the breccias and dense flows are similar to those at the Cape. Dikes and sills cutting the extrusive layers indicate a local center of eruption. The flows at Yaquina Head overlie the Astoria Formation, and in places the lava became intermixed with the sandstone. The contact is clearly exposed in the cliffs at the ends of the beaches on both sides of Yaquina Head (Figure 19).

This point of land was once much more extensive and is slowly but steadily being worn away by the waves. Because of more rapid erosion in areas of weakest rock, owing to either hardness difference or fracturing, the outline of Yaquina Head is very irregular. As erosion has progressed, more resistant parts have become separated from the mainland and are now small stacks and rock knobs.

The steep-sided island (Figure 20) lying offshore about half a mile southwest of Otter Crest is an isolated remnant of the Cape Foulweather Basalt. This island is referred to as both Gull Rock and Otter Rock.

Dikes cropping out on the wave-cut platform between Otter Crest and Otter Rock headland are related to the Cape Foulweather Basalt and were probably part of the feeder system for the flows. Dikes and sills in the hills and on the beach north of Cape Foulweather are of middle Miocene age but have not been correlated with either the Depoe Bay Basalt or the Cape Foulweather Basalt.

A row of rock knobs at the north end of Siletz Bay near the mouth of Schooner Creek is along a dike that is also exposed in the nearby roadcut. Another dike about a quarter of a mile to the south forms a rock knob on a point of land. The Inn at Spanish Head is built on a basalt sill which has two seaward projections that form natural breakwaters. Remnants of the sill are awash in the surf zone a few hundred yards to the north. A dike complex about half a mile north of Nelscott community forms a reef that projects seaward nearly at right angles to the beach.



Figure 19. Intermixed sedimentary rock and basalt on south side of Yaquina Head.



Figure 20. Gull Rock south of Otter Crest is a remnant of the former headland.

Quaternary deposits

Terrace sediments: At times of higher sea level during the Pleistocene Ice Age, wave erosion cut platforms and benches on the bedrock along the shore the same way it does today, but at a higher elevation. After the platform was cut, sediments were deposited over it as the water level rose. When the sea level again lowered, a terrace was left behind.

The terrace sediments are mostly weakly consolidated sand, but in many places there is a gravel layer directly above the bedrock. Less commonly, gravel is interlayered with the sand. These gravel beds are a source of agates and other interesting rocks on the beaches. Agate hunting is best during the winter, when much of the sand has been removed by storm waves that leave exposed gravel. The source of the agates at Agate Beach is cavity fillings in the basalt at Yaquina Head and gravel layers in the terrace sediments. As the sea cliff is eroded, a new supply of agates is added to the beach.

Terraces are widest and longest where the bedrock is sedimentary, but they are well formed on the fragmental basalts north of Cape Foulweather and on the outer end of Yaquina Head. Pleistocene sediments along the shore range in thickness from a few feet to more than a hundred feet. Sea cliffs at Lincoln City reach heights of more than 100 feet and are mostly of terrace sandstone with a capping of dune sand.

River and estuary deposits: There are two estuaries in this stretch of the coast, Yaquina Bay (Figure 21) and Siletz Bay. Estuaries are formed where the sea has encroached on the lower ends of rivers because of a rise in sea level. In some of the larger rivers, they are affected by tides and the inflow of salt water for many miles upstream.

The flat plains along the estuaries are of sediments, mostly silt, sand, and clay, that were carried by the rivers and deposited in the quieter water of the bays. Most of the deposition took place at times when the sea level was higher and the bays were enlarged, but alluvium continues to be added to the plains whenever the rivers spill over their banks during floods.

Beaches and sandspits: The sand and gravel on the beach form a thin veneer over a wave-eroded surface on bedrock (the wave-cut platform). The beach is sometimes referred to as a river of sand because the sand moves along the shore with the longshore currents. Along the Oregon Coast, winter winds from the south and southwest give the currents a predominantly northward motion; summer winds from northerly directions drive the currents southward. Sand accumulates on the beach during summer, but most of it is swept away during the winter storms when the wave energy is high. In some places, the bedrock is swept clear, and in others the beach deposit becomes mostly gravel.

Sandspits are extensions of the beach that project into and terminate in open water (Figure 22). They are located at the mouths of bays, some projecting from the north and others from the south. Some bays may have



Figure 21. Entrance to Yaquina Bay, an estuary that formed by drowning of the river mouth with rising sea level. (State Highway Div. photo by Kinney)



Figure 22. Sandspits at entrance to Siletz Bay. Sandspit at right is more than 2 miles long. (State Highway Div. photo by Kinney)

both a north and a south projecting spit, as at Siletz Bay, but one will usually be longer than the other. A sandspit is in delicate balance with the waves, currents, tides, and sand supply; fluctuations in any one or a combination of these factors have an immediate and sometimes devastating effect, such as breaching during storms. A given sandspit may survive as a landform, but its position, size, outline, and contours will change.



Figure 23. Low dunes on Siletz Spit stabilized by grass. Basalt riprap provides temporary protection for houses until next assault by high tides and storm waves. (State Highway Div. photo by Kinney)

Sand dunes: Because most of the shore between Newport and Lincoln City has a sea cliff along it, preventing sand from blowing inland from the beach, there are few recent dunes. Old Pleistocene-age dunes composed of brownish-yellow sand are situated on the marine terrace at a number of places between Newport and northern Lincoln City. The old dunes are stabilized by soil and vegetation, but where exposed they are subject to erosion. They are visible in the higher sea cliffs, in highway cuts, and in excavations.

Dunes along the Siletz sandspit are the most recently active, but over most of the sandspit they have been stabilized with European Beach grass (Figure 23). On the seaward side at the end of the spit, sand is still being moved by the wind. Erosion by waves during storms and high tides of winter are constantly wearing away the outer margin of this spit, endangering houses built too near the edge and requiring the placement of rock (rip-rap) to retard the erosive undermining of the structures.

Devils Lake, the only large lake on this part of the Oregon coast, owes its origin to drowning of the lower part of a stream valley and blocking of the stream's mouth by dunes and beach deposits. Since the volume of water flowing in D River is not sufficient to keep the bottom of the river channel below sea level, a fresh-water lake results rather than a salt-water estuary.

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OTHER COASTAL LANDFORMS ARTICLES AVAILABLE

Among the many articles previously published in The ORE BIN on landforms and geology of the coastal areas of Oregon are the following, copies of which are available at Department offices for 25¢ each:

- Lund, Ernest H., Coastal landforms between Florence and Yachats, Oregon: Ore Bin, v. 33, no. 2, p. 21-44, Feb. 1971.
- _____, Coastal landforms between Yachats and Newport, Oregon: Ore Bin, v. 34, no. 5, p. 73-92, May 1972.
- _____, Coastal landforms between Tillamook Bay and the Columbia River, Oregon: Ore Bin, v. 34, no. 11, p. 173-194, Nov. 1972.
- _____, Oregon coastal dunes between Coos Bay and Sea Lion Point: Ore Bin, v. 35, no. 5, p. 73-92, May 1973.
- _____, Landforms along the coast of southern Coos County, Oregon: Ore Bin, v. 35, no. 12, p. 189-210, Dec. 1973.
- Hunter, R. E., Clifton, H. E., and Phillips, R. L., Geology of the stacks and reefs off the southern Oregon coast: Ore Bin, v. 32, no. 10, p. 185-201, October 1970.
- Snively, P. D., Jr., and MacLeod, N. S., Visitor's guide to the geology of the coastal area near Beverly Beach State Park, Oregon: Ore Bin, v. 33, no. 5, p. 85-105, May 1971.

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BULL RUN WATERSHED GEOLOGY PUBLISHED

"Geologic Hazards of the Bull Run Watershed, Multnomah and Clackamas Counties, Oregon" is the latest of the Department's bulletins dealing with environmental geology. The author is John D. Beaulieu, Department stratigrapher.

The Bull Run watershed, situated at the foot of Mount Hood in the Western Cascades, is Portland's sole source of water and is an excellent timber-producing area. As part of a comprehensive land management program, the geologic hazards study was initiated to provide basic data regarding the capabilities of the land and the types of natural hazards threatening water quality. The bulletin discusses geologic units, geologic hazards, runoff, and historic landslides.

Bulletin 82 has 86 pages, 71 photographs, 14 drafted figures, 6 tables, and two maps on a scale of 2 inches to a mile. The bulletin can be obtained from the Oregon Department of Geology and Mineral Industries at its offices in Portland, Baker, and Grants Pass. Price is \$5.00.

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GEOTHERMAL DEVELOPMENTS

Auction date set for Vale KGRA

The first competitive Federal auction for geothermal resources in Oregon has been scheduled for 10:00 a.m. June 21. The auction will be for a 1,347.17 acre leasing unit near Vale. Sealed bids will be accepted for the unit until sale time at the Bureau of Land Management office, 729 N. E. Oregon Street, P.O. Box 2965, Portland, Oregon 97208.

Information on specific details and terms of the offering can be obtained at the BLM office.

Addition to Vale KGRA

An additional area of 11,535.27 acres has been added to the Vale Hot Springs Known Geothermal Resource Area. Location is as follows:

- T. 18 S., R. 45 E., Sec. 34: all
- T. 19 S., R. 45 E., Sec. 2-4, 9-15, 23-26, 36 inclusive
- T. 19 S., R. 36 E., Sec. 19, 30: all

New KGRA defined at Belknap-Foley Hot Springs

An area of 5,066.21 acres adjacent to Belknap and Foley Hot Springs has been identified as a Known Geothermal Resource Area by the Conservation Division of the U.S. Geological Survey. Location is as follows:

- T. 16 S., R. 6 E., Secs. 14, 20-23, 26, 28, 29: all

New KGRA defined at McCredie Hot Springs

An area of 3,658.60 acres adjacent to McCredie Hot Springs has been identified as a KGRA by the Conservation Division of the U.S. Geological Survey. Location is as follows:

- T. 21 S., R. 4 E., Secs. 25, 26, 35, 36: all
- T. 22 S., R. 4 E., Sec. 1: all
- T. 21 S., R. 5 E., Sec. 31: all

Geothermal leases are for 10 years, with provisions for renewal to a maximum of 40 years. "Diligent exploration" is required and a rental fee of not less than \$2 an acre per year will be charged prior to production. After five years, rentals will go up \$1 an acre per year through the tenth year.

The Geological Survey identified 84,000 acres of Oregon land in seven areas as Known Geothermal Resource Areas (KGRA). Since January 1, there have been 693 applications filed for leases in Oregon for approximately 1.5 million acres of Federal land not previously identified for its geothermal potential.

AVAILABLE PUBLICATIONS

(Please include remittance with order; postage free. All sales are final - no returns. Upon request, a complete list of Department publications, including out-of-print, will be mailed)

BULLETINS

8. Feasibility of steel plant in lower Columbia River area, rev. 1940: Miller . . .	\$0.40
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