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Coastal Landforms and General Geology

The northern Oregon coast, from the Columbia River to a point six miles north of the Siuslaw River, includes a wide variety of shoreline features. Short, narrow beaches lie at the base of low cliffs which form the seaward edge of uplifted marine terraces or benches. Numerous headlands, estuaries, and bays interrupt the continuity of the terraces and beaches. Where the coastline is low, near the bays, active sand dunes are present. Stabilized dunes are evident in some of the low areas and on some of the terraces.

Rocks exposed to erosion along the Oregon Coast are mainly sedimentary rocks of Tertiary age (2 to 60 million years old). The rocks are mostly sandstones, siltstones, mudstones, and shales.

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The headlands, which constitute the most resistant features along the coast, are with one exception (Cape Kiwanda) composed of igneous* rock, primarily basalts and other volcanic types of rock.

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Landslide Characteristics

Landslides take a variety of forms, but in almost all cases, a landslide can be defined as a rapid displacement of rock, soil, and sediments adjoining sloping ground in which the center of gravity of the mass of material advances downward and outward.

Each landslide has its own characteristics. The mechanisms, materials, and boundary restrictions may be quite different from slide to slide. However, slide nomenclature has been more or less standardized and is summarized in Figure 1.
In Newport, coastal retreat has been equally serious. Town plats of 1902 and 1912 were used to indicate former position of the sea cliff. Between 1902 and 1964, the coastline retreated from 35 to as much as 490 feet in the northern portion of the city. In the southern part of the city, between 1912 and 1964, the cliff edge retreated from 40 to 220 feet. In parts of Newport, the coast has retreated as much as eight feet annually.

**Landslide Prevention**

Total prevention of coastal landslides is an expensive undertaking. Such procedures as rock bolting, construction of complicated drainage systems, retaining walls and sea walls, and buttressing are well beyond the means of the average property owner. However, where limited steps have been taken to retard small but economically damaging slides, the results appear to be well worth the effort.

In the Oceanlake area of Lincoln City and near Seal Rock, north of Waldport, attempts are now being made to control the undercutting of the terrace material. Basalt boulders or riprap, piled at the base of the cliffs serve to weight the cliff base and prevent outward movement (Figure 14). Riprap also lessens the wave impact on the cliff base by providing a leading edge of resistant material to absorb much of the wave energy.

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“As the shearing forces approach the shear strength of a soil mass, certain sections fail by rearrangement of the soil grains and the formation of hairline cracks. Excess water in the disturbed soil is forced into other sections of the soil and failure of the soil mass continues as if by chain reaction. When the shear strength along a possible slide plane is reduced sufficiently, the entire mass becomes mobile and a slide occurs. At the moment a slide begins, the shearing forces are but slightly greater than the shear strength of the soil, but sliding causes a reduction in strength of 20 to 90 percent, depending on the sensitivity of the soil. Movement of the slide rapidly increases as the soil loses its strength. As the slide progresses, the driving force is reduced through reduction in slope and mixing of the slide material with more stable foreign soil. When the resisting force again is equal to the shearing force of the soil, the movement passes from sliding into slow creep. The surface of an old slide is particularly susceptible to the effects of excessive rainfall, since numerous deep fissures provide easy entrance for water and drainage is greatly disrupted.”

When a slide stops moving, equilibrium between gravity and the slide material’s shearing resistance is established. Removal of the toe may upset the equilibrium by unloading the base, thus permitting repeated movement of the slide.

One simple method of classifying landslides is by the nature of the slip surface on which the slide occurs, as shown in Table 1. Places where landslides in each of these classifications occur are shown on the fold-out map in the center of this booklet.

Utilities has occurred in numerous places along the northern coast—notably at Cape Meares near Tillamook and at Newport.

Coastline erosion in the vicinity of Cape Meares has been affected by jetty construction on the north side of the entrance to Tillamook Bay. This jetty apparently upset the equilibrium of sand transport by waves along the coast, causing a starvation of sand in the area south of the jetty. This has resulted in erosion of the entire sand and gravel spit, including the Cape Meares village area. Numerous estimates of erosion, based on town plat maps, aerial photographs, and direct observation have been made with regard to the rate of coastal retreat. From 1939 to 1961, the southern portion of Bay Ocean Beach was estimated to have retreated 500 feet. Closer to Cape Meares, materials are somewhat more resistant and the coast retreated 320 feet during the same period. During the winter of 1960 and 1961, 75 feet was eroded from the end of a street oriented at a right angle to the coastline in the village of Cape Meares. On the basis of several estimates, the average yearly coastal retreat has been about 30 feet in the vicinity of the village of Cape Meares.

Figure 13. Rock-terrace slump which has destroyed 20 acres of land on Cascade Head.
Landslides pictured on the foldout map (under pages 8 and 9) occur along the portion indicated by the pattern plotted in the offshore position. Slides are unlikely, although in some cases possible, along portions of the coast which show no pattern. Rock types exposed along the coast are shown along the landward side of the coast on the map. No attempt has been made to show the distribution of terrace deposits.* For more detailed reports concerning the landslides shown on this map, you may wish to read "Coastal Landslides of Northern Oregon" by William B. North and John V. Byrne. It was published in the Ore Bin, Vol. 27, No. 11, in November 1965, and is obtainable from the Oregon State Department of Geology and Mineral Industries, 1069 State Office Building, Portland, Oregon 97201.

* Unconsolidated sands and gravel overlying solid rock.

**Summary of Landslide and Rock Types** Landslides on the Oregon coast occur as the four basic kinds: slump, slide, fall, and shift. Each kind is usually associated with a definite coastal rock type. Igneous headlands and the headland material overlying igneous rocks are most susceptible to falls, either rock or debris. The resistant igneous rock is massive, providing few, if any, sloping zones of weakness such as bedding planes upon which slides can develop. Undercutting is slow and, when rocks break off, they fall in tabular masses leaving vertical cliffs. Joints and faults (two types of cracks), control the erosion of the igneous headlands. These cracks or fractures are zones of weakness that are eroded by waves. Evidence for weakening along nearly vertical fractures is seen in each headland. This weakening is particularly prominent on the western side of Tillamook Head and along Cape Perpetua.

Sedimentary rocks are involved in each type of landslide. Deep weathering of the sediments weakens the rock and makes the cliffs susceptible to undercutting. Cutting by waves, Unloading of the cliff base disrupts equilibrium of the relatively cohesive rock mass and slumping occurs. Block slides or "glides" are unusual in the sediments sequence, because beds are usually too thin for a separate block to detach and slide. Where sandstone has resisted deep weathering, some slides of tabular bodies on bedding planes have occurred, as on Cape Falcon.

Unconsolidated sands, silts, and gravels of uplifted marine terrace and dune deposits usually have no specific plane of movement and move as debris shifts. Mineral and rocky grains, acting as individual particles, provide no firm plane for movement of one mass over another. Slip-face sand movement, resulting in a cone or small fan, is common on dune and terrace faces. However, more often the oversteepened terrace cliffs move as debris shifts.

**Landslide Frequency and Rate of Coastal Retreat**

The occurrence of landslides can be correlated with high winter waves and increased rainfall. In all of Oregon, studies by the Department of Oceanography at Oregon State University have shown that during the period from 1916 to 1949 most landslides occurred from late fall to early spring. The highest frequency of slides is during December and January, the period, of major storms. Losses due to landslides have been extensive in some regions. Ecola Park, just north of Cannon Beach, and Cascade Head, north of Lincoln City, have undergone considerable alteration. Landsliding has destroyed or disrupted more than 200 acres of land in four separate slides. In 1961, the Ecola Park landslide moved about 125 acres during a two-week period. On Cascade Head, a slide in 1934 carried 20 acres of pasture down toward the sea (Figure 13). Two other landslides on Cascade Head have each destroyed more than 14 acres of grazing land. Severe damage to buildings, roads, and public facilities pictured on the foldout map.

**Table 1. Basic Landslide Types**

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<thead>
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* The type of material moved is used as a modifier. For example, movement of rock and terrace material along a cohesive slip surface would be termed "rock-terrace slump." If materials are considerably mixed, the word "debris" is applied to the landslide type.

Figures 2 and 3. Beachfront homes perch precariously above landslide areas. Retreat of cliffs becomes obvious from the air.
Figure 8. Road crews have dumped fill dirt and rock in an attempt to minimize slide activity near roadway.

Figure 9. A unique method of slide prevention. A homeowner has used old tires as riprap.

Figure 10. A coast resort motel has installed fencing and plantings to minimize slide activity in a slump area.

Figure 11. Dense foliage (left) and planking are two effective and inexpensive means of landslide prevention.

Figure 12. Tiered fencing has successfully deterred serious landsliding near this cliff-side beach house.

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Landslides of Oregon: North Coast

By John V. Byrne and William B. North
Department of Oceanography
Oregon State University
Published by the Oregon State University Sea Grant Marine Advisory Program