STUDIES RELATED TO WILDERNESS

WILDLIFE REFUGES

FLATTERY ROCKS, QUILLAYUTE NEEDLES, AND COPALIS, WASH. OREGON ISLANDS AND THREE ARCH ROCKS, OREG.

GEOLOGICAL SURVEY BULLETIN 1260-F-H

Summary Report on the Geology and Mineral Resources of the—

Flattery Rocks, Quillayute Needles, and Copalis National Wildlife Refuges Washington

Oregon Islands National Wildlife Refuge Oregon

Three Arch Rocks National Wildlife Refuges Oregon

By A. E. WEISSENBORN *and* PARKE D. SNAVELY, JR.

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A compilation of available geologic information

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STUDIES RELATED TO WILDERNESS

WILDLIFE REFUGES

The Wilderness Act (Public Law 88-577, Sept. 3, 1964) directs the Secretary of the Interior to review roadless areas of 5,000 contiguous acres or more, and every roadless island, within the national wildlife refuges and game ranges under his jurisdiction and to report on the suitability or nonsuitability of each such area or island for preservation as wilderness. As one aspect of the suitability studies, existing published and unpublished data on the geology and the occurrence of minerals subject to leasing under the mineral leasing laws are assembled in brief reports on each area. This bulletin is one such report and is one of a series by the U.S. Geological Survey and the U.S. Bureau of Mines on lands under the jurisdiction of the U.S. Department of the Interior.

Summary Report on the Geology and Mineral Resources of Flattery Rocks, Quillayute Needles, and Copalis National Wildlife Refuges Washington

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SUMMARY REPORT ON THE GEOLOGY AND MINERAL RESOURCES OF FLATTERY ROCKS, QUILLAYUTE NEEDLES, AND COPALIS NATIONAL WILDLIFE REFUGES, WASHINGTON

By A. E. WEISSENBORN and PARKE D. SNAVELY, JR.

SUMMARY

The Flattery Rocks, Quillayute Needles, and Copalis National Wildlife Refuges lie off the Pacific coast of the Olympic Peninsula between Cape Flattery and Grays Harbor. They have a total land area of 247 acres and consist of numerous small islands, sea stacks, and rocks that rise above a wave-cut platform. The refuges are in a belt of intensely folded and faulted marine sedimentary and volcanic rocks of early Eocene to Pliocene age. This belt borders the eastern margin of a depositional basin on the continental shelf that probably contains a thick sequence of upper Tertiary rocks. Pleistocene glaciofluvial deposits blanket the Tertiary strata along this coastal belt.

This part of coastal Washington has had no commercial production of oil and gas, but small production was obtained from a well a few miles south of the area under discussion. The approximately 35 test wells drilled in past years along the coastal strip and the number of offshore oil leases taken by various oil companies in the past few years, however, are indications of the interest in oil exploration in this area. It must be recognized that the deformed tectonic belt along, and adjacent to, the coast, which includes the refuges, may very well include structural or stratigraphic traps suitable for the accumulation of oil and gas.

A small amount of placer gold has been mined from some of the mainland beaches along the west side of the Olympic Peninsula, but the thin and limited deposits of beach sand that surround a few of the islands probably would not yield a significant amount of gold. The possibility of economic recovery of magnetite, ilmenite, or other minerals from the island beach sands likewise is remote. The few thin lenses of lignite that are interbedded with some of the upper Eocene sedimentary rocks appear to have no potential economic value. Sources of dimension stone and crushed stone occur in the refuges but could be more easily obtained elsewhere, as could sand and gravel.

Except for the untested possibilities for oil and gas, the refuges do not appear to contain significant mineral resources.

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INTRODUCTION

LOCATION AND GEOGRAPHY

This report discusses the geologic setting and mineral resources of numerous small islands, sea stacks, and rocks that rise above the wave-cut marine platform along coastal Washington between Cape Flattery and Grays Harbor. These islands and sea stacks are included in three national wildlife refuges, designated from north to south: Flattery Rocks National Wildlife Refuge, Quillayute Needles National Wildlife Refuge, and Copalis National Wildlife Refuge (pl. 1). The total land area of these three refuges is 247 acres. All the islands, sea stacks, and rocks that comprise the refuges are within about 2 miles of the shore.

Flattery Rocks Refuge, with a land area of 125 acres,[1] includes all the islands off the Washington coast between Cape Flattery and lat 48°02′ N., a distance of about 25 miles. The largest islands in the refuge are Ozette Island and the islands of the Bodelteh group off Cape Alava. The refuge also includes several hundred smaller islands and unnamed rocks. Tatoosh Island, which lies off Cape Flattery, is north of and outside the refuge.

Quillayute Needles Refuge, with a land area of 117 acres, includes all the islands between the southern limit of Flattery Rocks Refuge and a point 9 miles south of the Hoh River, a distance along the shore of a little more than 30 miles. The Quillayute Needles, from which the refuge gets its name, form a cluster of jagged rocks near the mouth of the Soleduck River. The refuge includes Destruction Island (fig. 1), the largest of the islands in the three refuges, James Island, Abbey Island, Rounded Island, Alexander Island, and numerous smaller islands and unnamed sea stacks and rocks.

Copalis Refuge extends from about 2 miles north of the Raft River to about 1½ miles north of Copalis River, a distance along the shore of about 25 miles. The islands in this reach of the coast are smaller and less numerous than those farther north. An 11-mile stretch between Grenville Arch and Copalis Rock contains no islands at all. The total land area of the refuge is only 5 acres. The principal named islands and sea stacks in the refuge are Arch Island, Tunnel Island, Willoughby Rock, Split Rock, Grenville Arch, and Copalis Rock.

In the absence of mineral production or known deposits, the U.S. Bureau of Mines has not examined the refuges, but the Bureau is informed of the findings and conclusions of the Geological Survey and concurs in them.

[1] The acreages of refuges in this report have been obtained from the U.S. Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife.

FIGURE 1.—Destruction Island, Quillayute Needles National Wildlife Refuge. This is the largest of the islands in the three wildlife refuges. Note the nearly level terrace from which the island was carved and the ribs of more resistant strata which extend out from the island onto the adjacent wave-cut platform. Also note the sand spit on the near end of the island.

PREVIOUS WORK

Ralph Arnold, of the U.S. Geological Survey, made a reconnaissance survey of the coast of the Olympic Peninsula in 1904 and discussed the general geology of the area (Arnold, 1906; Arnold and Hannibal, 1913). In separate publications he briefly described beach placers along the coast that were being worked for gold at the time of his visit (Arnold, 1905a) and mentioned an occurrence of lignite on the beach below Portage Head, adjacent to what is now the Flattery Rocks Refuge (Arnold, 1905b). Reagan (1909), in a treatise on the Olympic Peninsula, gave further information on the geology of part of the area and on occurrences of gold, oil, coal, and construction material along the Olympic coast. Lupton (1913) discussed the potential of the Washington coastal region for the production of oil and gas. Weaver (1916) gave a more detailed description of the stratigraphy along the Olympic coast and commented on petroleum occurrences in this area. He presented additional information and revised some of his original conclusions regarding the stratigraphy in a later publication (Weaver, 1937).

SOURCES OF GEOLOGIC DATA

This report is based in large part on information derived from published reports (see "References cited"). The report also includes unpublished geologic information obtained by Snavely and Norman MacLeod in the course of other investigations by the U.S. Geological Survey. Unpublished maps of the Olympic coast by Sheldon L. Glover provided pertinent information as to the distribution of major rock units. These maps were made available through the courtesy of Marshall T. Huntting, Supervisor, Division of Mines and Geology, Department of Conservation, State of Washington. Weldon W. Rau, of the same organization, supplied foraminiferal age determinations for some of the sedimentary units referred to in this report. An unpublished geologic report dated September 1941 on a part of the Pacific coastal region, Olympic Peninsula, Wash., by H. R. Johnson and J. R. Pemberton, also was consulted. This report is the result of work done for the State and other property owners in connection with the condemnation of lands by the Federal Government to enlarge the Olympic National Park.

GEOLOGY

The western side of the Olympic Peninsula consists of an uplifted broad coastal plain that extends from Cape Flattery southward to Grays Harbor. The undulating surface of this plain rises eastward and merges with the foothills of the Olympic Mountains. The surface of this plain from Portage Head to south of Point Grenville is mantled with a thick blanket of Pleistocene sediments. With rare exceptions the underlying Tertiary rocks are exposed only in some of the river valleys that cross the plain or in the sea cliffs that border the shore. The encroaching waters of the Pacific have eroded this uplifted plain and have formed steep cliffs along the coast. For most of the distance between Cape Flattery and Point Grenville these cliffs rise abruptly 50–300 feet above a wave-cut platform cut on Tertiary rocks. The surface of this platform is nearly level, and much of it is exposed at low tide (fig. 2). The platform reaches its greatest extent west of Ozette Lake where it is nearly 2 miles wide. More commonly, it extends about half a mile from the shore. The surface of the platform is studded with small islands, sea stacks, and rocks, many of which are exposed at low tide and are covered or partially covered at high tide. Wave action is intense, and only the more resistant rocks withstand the battering. Islands can be found in all stages of development from partially isolated promontories to true islands several acres in extent.

FIGURE 2.—Broad wave-cut marine platform, Flattery Rocks Refuge, between Ozette Island and Cape Alava. At low tide the average width of this rock-studded platform is about 1,500 feet.

STRATIGRAPHY

The stratigraphic succession along the west coast of the Olympic Peninsula has not been established because of the structural complexities in the area, general paucity of fossils, and the lack of continuous exposures and distinctive stratigraphic horizon markers. For the purposes of this report the rocks in this area can be divided into three groups: (1) a lower Eocene to middle(?) Miocene sequence of intensely deformed strata consisting of thin- to thick-bedded sandstone and siltstone with interbedded conglomerate, pebbly mudstone and pebbly standstone, and basalt flows and breccias; (2) a less deformed sequence consisting of massive to well-bedded sandstone and siltstone of late Miocene to Pliocene age; and (3) sands and gravels of early and late Pleistocene age that mantle virtually all the older rocks.

ROCKS OF EARLY EOCENE TO MIDDLE(?) MIOCENE AGE

These rocks consist of marine sedimentary rocks and volcanics. The volcanic rocks occur mainly as headlands, such as Hogback, Little Hogback, and Point Grenville in the Copalis Refuge; in the Flattery Rocks Refuge, volcanic rocks compose Portage Head, the headland near Point of Arches, and a narrow band near Cape Flattery. They are composed of basalt breccia and pillow lava and have been intensely sheared and, in most places, have been altered to greenstone. Zeolites and calcite are present in amygdules and as cement in tuff-breccias. It is probable that most of these volcanic rocks are of submarine origin; however, in many places shearing has virtually destroyed pillow structures in the basalt and produced tectonic breccias. At Cape Flattery these volcanic rocks are the westernmost exposures of the Crescent Formation of early to middle Eocene age. They form a broad horseshoe-shaped rim around the entire Olympic Mountains and attain thicknesses of more than 30,000 feet. The volcanic rocks that crop out south of Cape Flattery are correlative with the Crescent Formation.

The sedimentary rocks in this sequence consist of marine sandstone (lithic wacke), conglomerate, siltstone, interbedded siltstone and fine-grained sandstone, and pebbly mudstone and pebbly sandstone. The sandstone is massive and thick to thin bedded (fig. 3). Individual beds are as much as 40 feet thick. Commonly, beds show grading; the coarser

FIGURE 3.—Outcrop of overturned well-laminated rhythmically bedded sandstone near B.M. 120, sec. 21, T. 25 N., R. 13 W., Destruction Island quadrangle, just east of Quillayute Needles Refuge.

grained sandstone at the base of some beds contains intraformational siltstone chips. The upper part of many of the sandstone beds is thinly laminated and in places contains macerated plant material and large fragments of carbonized wood. Several very thick massive graded sandstone beds contain large (as much as 20 ft across) loose infolds of well-bedded sandstone and siltstone. Thin shale beds are present above some graded sandstone beds. Sole markings have been observed at the base of some beds, and channels occur locally. Sedimentary features, such as described above, suggest that many of these sandstone sequences have been deposited by turbidity currents. A wide variety of conglomeratic units occur in the sequence and range in thickness from more than 50 feet to less than 6 inches. In lithology, they range from poorly sorted boulder or cobble conglomerates to pebbly sandstone and pebbly mudstone (fig. 4). Some conglomerates are composed of silt-

FIGURE 4.—Pebble to cobble conglomerate and pebbly sandstone. Sec. 33, T. 22 N., R. 13 W., Taholah quadrangle, east of Copalis Refuge.

stone clasts (fig. 5); however, the thicker bedded units in some areas contain metamorphic and igneous clasts in addition to clasts of sedimentary rocks. A thick section of conglomerate and pebbly sandstone is exposed near the mouth of the Hoh River. There the beds are 1–10 feet thick and have a sandy matrix. The maximum clast size is about 6 inches, with an average of ½–¾ inch. The clasts are composed of granitic, hornfeldsic, and basaltic material and are rounded to subangular. Lenses of very fine grained sandstone and siltstone (fig. 6) are intimately associated with this conglomeratic sequence. Although only a few fossils are found in the sandstone, siltstone, and conglomerate sequence, these strata probably range in age from middle Eocene to middle(?) Miocene.

Most interesting and perplexing are a number of exposures of a chaotic mixture of lower Tertiary rocks which can best be described as a tectonic melange. Although most of the exposures of this melange are involved in recent landslides and details of its character are masked, is consists of a heterogeneous mixture of large blocks and infolds of graywacke (as much as 100 ft in length) and blocks of bedded siltstone set in a clay matrix. The so-called "smell-muds," which have a strong petroliferous odor, occur in the clay that forms the melange. Thin-bedded siltstone blocks occurring in this melange have yielded a late Oligocene to early Miocene foraminiferal fauna. In places, large blocks

FIGURE 5.—Sandstone with angular siltstone fragments. Sec. 13, T. 26 N., R 14 W., Forks quadrangle, Washington coast east of Quillayute Needles Refuge.

FIGURE 6.—Thin-bedded fine-grained sandstone and siltstone and boulder conglomerate. Sec. 13, T. 26 N., R. 14 W., Forks quadrangle, on Washington coast east of Quillayute Needles Refuge.

of basalt are associated with the melange where it is in fault contact with basalt breccias, as at Little Hogback. The melange has some similarities to the so-called "argille scagliose" of the foothills of the northern Apennines in Italy (Sitter, 1956). As postulated for the "argille scagliose," the origin of the melange on the Olympic coast also may be due to a combination of gravity thrusts and large-scale intraformational gravity sliding.

The abundance of marine conglomerates, pebbly mudstones, and turbidite units, as well as common intraformational slumping of beds (fig. 7) and the occurrence of chaotic masses of loose blocks of sandstone and other rocks in clay, all suggest that these rocks were deposited

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FIGURE 7.—Intraformation chaotic slump structures in a sequence of interbedded sandstone and siltstone on Ozette Island, Flattery Rock Refuge.

on a relatively steep unstable slope predominantly by different types of mass downslope movement (turbidity currents, submarine landsliding, and slumping).

ROCKS OF LATE MIOCENE TO PLIOCENE AGE

Well-bedded marine sandstones and concretionary siltstones (fig. 8) occur in the Cape Elizabeth area where they have been faulted against, but probably also unconformably overlie, the Eocene to Miocene rocks of the lower unit. The most common rock type is an organically churned fossiliferous silty sandstone and sandy siltstone. Some beds contain abundant siltstone clast, and thin-shelled clams are common. Conglomerate is interbedded in silty sandstone north of the mouth of the Quinault River. Fauna collected from this unit indicate a late Miocene to Pliocene age.

PLEISTOCENE SAND AND GRAVEL

As much as 100 feet of poorly consolidated sand and gravel (fig. 9) unconformably overlies the Tertiary rocks. In coastal areas the unconformity probably represents an early Pleistocene marine-cut platform. Although in some areas the deposits are composed predominantly of sand, most of them are intimate mixtures of crossbedded and channeled sand, gravelly sand, and gravel. Older deposits are iron stained, and their cobbles have weathered rinds. These terrace deposits represent glaciofluvial outwash sand and gravel that were deposited during Pleistocene alpine and continental glaciation.

FIGURE 8.—Channel sandstone cutting thin-bedded concretionary sandstone and siltstone beds. Both units are of Pliocene age and are exposed in sea cliffs just south of the Quinault River, on the mainland adjacent to the Copalis Refuge.

STRUCTURE

Early workers recognized that the rocks exposed along the coast had been folded and faulted, but they seem not to have appreciated the extent and intensity of the deformation. Generally speaking, the wildlife refuges lie within a structually complex belt that parallels the western coast of the Olympic Peninsula. Only a small part of the width of this belt is exposed for study, as it is covered on the west by water and on the east by Pleistocene deposits. The strata have been highly deformed and complexly faulted. In areas underlain by volcanic rocks, sandstones, conglomerates, and siltstones of Eocene to middle(?) Miocene age, the bedding is generally very steeply dipping, and vertical to overturned beds are common. Isoclinal folds, some with nearly vertical axes, can be seen on the wave-cut platforms (fig. 10) and in sea cliff exposures. Amplitudes of the folds range from 10 to 100 feet. Complex faulting is also common. These older rocks are in places separated from upper Miocene and Pliocene sequences by through-going faults that may have major strike-slip separation. The upper Miocene and Pliocene rocks themselves tend to be much less deformed than the older rocks and generally have low dips. This suggests that the major tectonism was pre-late Miocene, although tectonism continued beyond the Pliocene.

FIGURE 9.—Sea cliff exposure of about 100 feet of poorly consolidated interbedded sand and gravel of early Pleistocene age just south of Ruby Beach, east of Quillayute Needles Refuge.

MINERAL RESOURCES

OIL AND GAS

The presence of oil seeps and "smell-muds" has long been known along the Washington coast. To the present (1966), the only well in the State with subcommercial production (about 12,000 bbl) is located just south of the area of this report. However, the approximately 35 wells that have been drilled along the Washington coast within the area encompassed by this report provide an indication of the oil and gas potential that oil companies believe to be present in the coastal area of Washington. This interest is further emphasized by the number

FIGURE 10.—Tightly folded Eocene(?) sandstone strata exposed on wave-cut platform. Sec. 32, T. 29 N., R. 15 W., about 1 mile north of Cape Johnson, La Push quadrangle, Quillayute Needles Refuge.

of offshore leases recently taken up by various oil companies on the continental shelf just west of the area covered by this report.

The coast line of Washington lies at the eastern fringe of a depositional basin in which a thick sequence of upper Tertiary sedimentary deposits accumulated. The tectonically deformed belt, which lies near the eastern margin of this basin and includes the coastal area and the adjacent islands, may very well contain both structural and stratigraphic traps suitable for the accumulation of oil or gas. However, the fact that the nearshore area is so complexly deformed suggests that future exploration may be more fruitful farther offshore where deformation is less severe and the thick sequence of post-middle(?) Miocene sediments is less disturbed. A few of the larger islands might be used for test drilling sites.

GOLD

The discovery of gold in 1904 in the beach sands of the Washington coast brought on a minor gold rush. Reagan (1909) states that most of the beaches from Cape Flattery to the mouth of the Columbia were soon staked. The beach placers were described by Arnold (1905a) shortly after their discovery. The only deposits from which there is a recorded production of gold are confined to a strip of beach 13 miles long extending from 10 miles south of Cape Flattery to 6 miles south of the mouth of the Ozette River. Within this strip, beach placer deposits were worked at Shishi Beach between Portage Head and

Point of Arches, at Ozette Beach north and south of the mouth of the Ozette River, at Yellow Banks about 5 miles south of Ozette Indian village, and probably at a few other places north of the Quillayute River. Arnold states that to the time of his visit in 1904 the Shishi Beach placers had produced $15,000 in gold. Reagan estimates the total production of the Washington beach placers between 1904 and 1906 as $30,000. The placers obviously were not especially rich, and there is no record of production after 1908.

The beach placer deposits are thin and lie on a wave-cut platform of eroded Tertiary sedimentary rocks at the base of steep bluffs facing the sea. The gold presumably is derived from upper Pleistocene outwash sand, gravel, and till derived from continental glaciation. Arnold states that colors can be panned from all the streams flowing across the areas underlain by Pleistocene deposits. The "pay sands," however, occur only at the base of the sea cliffs where concentration by wave action has taken place. The gold is in worn flakes, indicating that it has traveled a considerable distance and that it may have been reworked more than once. It is commonly associated with magnetite (black sand) or with garnet (ruby sand) and in places with pyrite. Arnold reports that small amounts of platinum minerals are found with the gold.

Aerial photographs show that small beaches occur around some of the larger islands within the wildlife refuges as, for example, Destruction Island (fig. 1). There is no record of gold production from any of these island beaches, although it is conceivable that in favorable places gold placers could be associated with some of them. These beach sands lie on the wave-cut rock platform and are likely to be too limited in extent or to be too thin to be of much commercial interest. The best potential for gold production would appear to be from the present beaches along the coast, or perhaps from deeper water sediments west of the wave-cut platform from which the islands of the wildlife refuges rise.

In places, the Tertiary rocks are cut by small quartz veins. At Point of Arches these veins are reported to carry small amounts of gold and silver (Arnold, 1906). So far as is known, there has never been any production of gold from these quartz veins nor has the presence of gold or silver ever been substantiated.

BLACK SAND

Black sand deposits that contain magnetite, ilmenite, and other heavy minerals occur at various places along the Washington coast. Similar black sands could be associated with some of the island beaches. The largest and richest of the deposits are south of the area of this report near the mouth of the Columbia River. To date (1966) it has not been feasible to exploit even these deposits. It is extremely unlikely that any of the island beach deposits would be of commercial interest.

COAL

Thin irregular lenses of lignite, which may represent single coalified logs, occur in sandstone units of probable late(?) Eocene age at several localities along the Washington coast between Cape Flattery and Grays Harbor. Specific examples are below Portage Head (Reagan, 1909; Arnold, 1905b) and at Jefferson Cove, just south of Hoh Head (N. S. MacLeod, written commun., 1966). These coal lenses give no indication that they would ever be of commercial interest. It is unlikely that any coal on the island refuges would be of great value.

STONE

Stone suitable for dimension stone probably could be obtained from some of the islands in the refuges, particularly sandstone from islands in the vicinity of Cape Flattery. However, sources of supply on the mainland are of equally good quality and better situated to meet whatever demand should develop. Large quantities of stone suitable for riprap, crushed rock, and other construction stone, could be obtained from some of the island refuges, but as is true of dimension stone, other equally good and more convenient sources of supply are available on the mainland.

SAND AND GRAVEL

Beaches that might yield sand and gravel fringe a few of the larger islands. However, much larger and more accessible sources of sand and gravel are abundant at many places along the shore of the mainland. It is unlikely that it would ever be desirable or economically feasible to exploit the much smaller and less accessible island beaches.

CONCLUSIONS

According to available information, the Flattery Rocks, Quillayute Needles, and the Copalis National Wildlife Refuges do not contain significant mineral resources, but the potential for oil and gas at depth in the area is not yet fully tested.

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Summary Report on the Geology and Mineral Resources of the Oregon Islands National Wildlife Refuge, Oregon

By A. E. WEISSENBORN *and* PARKE D. SNAVELY, Jr.

STUDIES RELATED TO WILDERNESS—WILDLIFE REFUGES

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SUMMARY REPORT ON THE GEOLOGY AND MINERAL RESOURCES OF THE OREGON ISLANDS NATIONAL WILDLIFE REFUGE, OREGON

By A. E. WEISSENBORN and PARKE D. SNAVELY, JR.

SUMMARY

The Oregon Islands National Wildlife Refuge consists principally of Goat Island, a small island off the coast of Oregon south of Cape Ferrelo and northwest of Brookings. Sandstone beds of the Dothan Formation, which crop out on the adjacent mainland, probably make up most of the island and nearby islets. Except for possible use of the sandstone as a source of crushed stone or other types of construction stone, the island has no known mineral resources of economic value.

INTRODUCTION

Oregon Islands National Wildlife Refuge lies off the coast of Oregon about 3 miles southeast of Cape Ferrelo. It is directly west of Harris Beach State Park and 1–1½ miles northwest of the town of Brookings (fig. 1). Goat Island, which rises 184 feet above sea level, composes most of the refuge. Numerous surrounding islets and rocks that project just above sea level form the remainder of the refuge (figs. 1, 2). The total land are of the refuge is 21 acres.

The following discussion of the geology and mineral resources of the Oregon Islands Refuge is based entirely on a review of previous studies. Diller (1914) reported on the mineral resources of the area, as did Butler and Mitchell (1916), but in both of these reports the geologic work in the Brookings area was of a cursory nature. Pardee (1934) studied the beach placers of the Oregon coast, in the course of which he mapped the beach and terrace deposits along the coast including those between Cape Ferrelo and the Oregon-California boundary. The most detailed information on the geology of this area is portrayed on a preliminary geologic map of southwestern Oregon by Wells (1955). A publication by Koch (1966) gives additional information on the stratigraphy and structure of the area around Brookings.

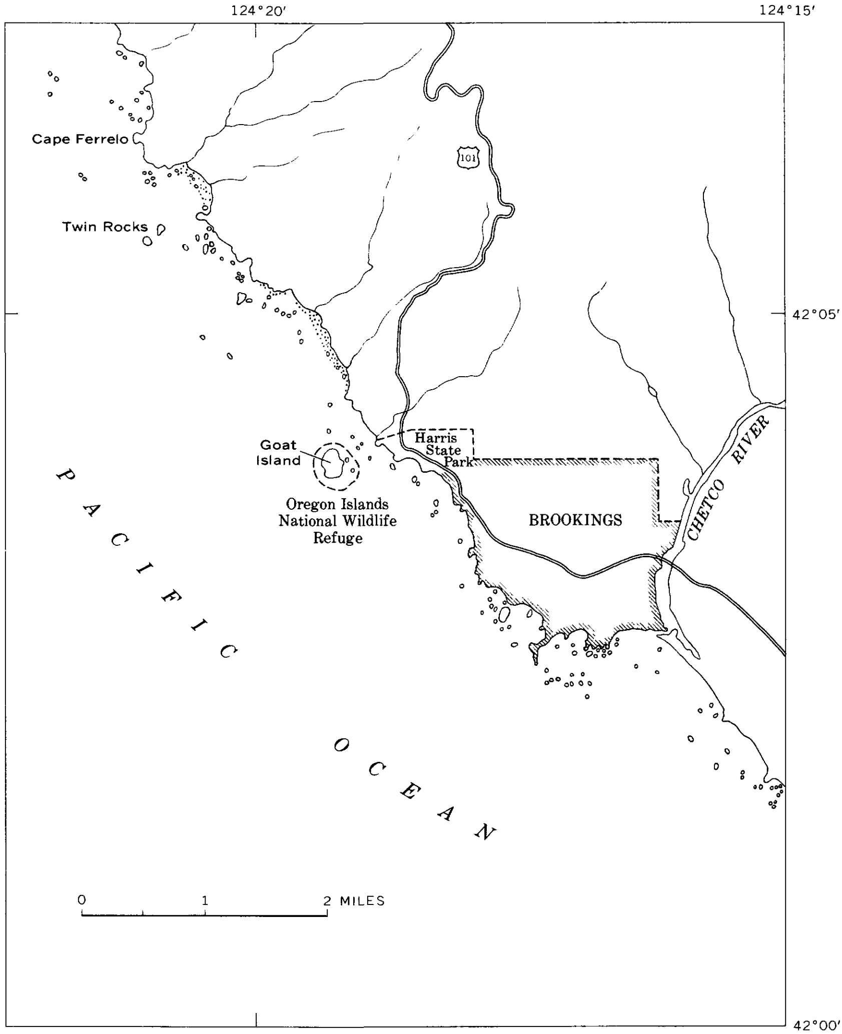

FIGURE 1.—Map showing location of Oregon Islands National Wildlife Refuge.

In the absence of mineral production or deposits, the U.S. Bureau of Mines has not had occasion to examine the refuge, but the Bureau is informed of the findings and conclusions of the Geological Survey and concurs in them.

GEOLOGY

The coastal area contiguous to the Oregon Islands National Wildlife Refuge is underlain by the Dothan Formation, described by Diller (1907) as an extensive succession of conformable sandstones and shales

FIGURE 2.—Vertical aerial photograph of Oregon Islands National Wildlife Refuge. The large island in lower center of photograph is Goat Island. Harris Beach State Park is on the mainland three-fourths of a mile east of Goat Island. The town of Brookings is a short distance beyond the lower right-hand corner of the photograph.

of Jurassic age, characterized by beds from 10 to more than 100 feet thick. Sandstones predominate, and locally, there are thin beds of pebble conglomerate and small lenses of radiolarian chert.

The shales are gray black, weathering gray, and locally have a slaty cleavage. The sandstones are gray, weathering yellowish brown, and most beds are firmly cemented by silica. In places, a schistose structure results from the presence of numerous veinlets of quartz. The thin beds of conglomerate are made up mainly of siliceous pebbles. The radiolarian chert is gray to red, and in most outcrops is banded with thin interfilms of brown shale.

Goat Island and the other islets that make up the Oregon Islands National Wildlife Refuge are presumed to be composed of rocks of the Dothan Formation, just as the nearby mainland shore, but we have been unable to find specific identification of the rock in any geologic map or report. Less likely, intrusive igneous rocks such as crop out at Mount Emily, about 9 miles northeast of Goat Island, may underlie the refuge.

MINERAL RESOURCES

There are no published records of any mineral deposits on the mainland in the vicinity of the Oregon Islands National Wildlife Refuge. Review of all available information indicates that the refuge contains no known economically valuable mineral deposits, and it is unlikely that any potentially valuable deposits are present. Rocks of the Dothan Formation, of which the refuge is likely formed, can have no more than nominal value as sources of crushed rock or other forms of construction stone, because identical material should be more readily accessible in far greater quantity nearby on the mainland.

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Summary Report on the Geology and Mineral Resources of the Three Arch Rocks National Wildlife Refuge, Oregon

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STUDIES RELATED TO WILDERNESS—WILDLIFE REFUGES

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SUMMARY REPORT OF THE GEOLOGY AND MINERAL RESOURCES OF THE THREE ARCH ROCKS, NATIONAL WILDLIFE REFUGE, OREGON

By A. E. Weissenborn and Parke D. Snavely, Jr.

SUMMARY

Three Arch Rocks National Wildlife Refuge consists of three volcanic-rock islands south of Cape Meares and offshore from Oceanside, Oreg. The total land area of the refuge is 17 acres. The islands are composed of basalt, part of an extensive body that forms cliffs on the nearby mainland shore. The basalt rests on a thick sequence of Tertiary marine sedimentary rocks. These rocks have a theoretical potential for oil or gas, but no surface structures favorable for the accumulation of oil or gas are known in the immediate vicinity of the refuge. The basalt of the islands has only nominal value as a source of crushed stone for construction purposes, because equally suitable and more conveniently located sources of basalt are widely distributed along the Oregon coast.

Aside from the basalt flows of which the islands are formed, the refuge contains no known mineral resources.

INTRODUCTION

Three Arch Rocks National Wildlife Refuge consists of three small islands and a few rocks, all composed of basalt flows (figs. 1, 2). They lie about half a mile off the Oregon Coast nearly due west of the town of Oceanside and about 1½ miles south of Cape Meares (fig. 3). The total land area of the refuge is 17 acres, according to figures provided by the U.S. Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife.

The Oregon coast adjacent to the Three Arch National Wildlife Refuge was mapped in reconnaissance by Warren and his coworkers (Warren and others, 1945). This mapping did not include the small islands off the coast, but the rocks that form the Three Arch National Wildlife Refuge are the seaward extension of the Miocene basalt that forms Cape Meares. Rocks in the vicinity of Cape Meares have been

FIGURE 1.—Three Arch Rocks National Wildlife Refuge looking toward the northeast. Islands consist of pillow lavas and subaerial basalt flows with low dip to northwest. Photograph courtesy of U.S. Bureau of Sport Fisheries and Wildlife.

examined by Snavely as part of a study of the volcanic rocks of the Oregon Coast Range.

In the absence of mineral production or known mineral deposits, the U.S. Bureau of Mines has not had occasion to examine the refuge, but the Bureau is informed of the findings and conclusions of the Geological Survey and concurs in them.

GEOLOGY

Cape Meares and the islands adjacent to it are formed of a relatively thin layer of middle Miocene basalt flows, breccia, and associated feeder dikes (fig. 4). Similar basalts form headlands along northern coastal Oregon at Yaquina Head, Cape Foulweather, Cape Lookout, and Tillamook Head. These volcanic rocks were extruded from a local center near a middle Miocene strand and are of both subareal and submarine origin (Snavely and others, 1965). These middle Miocene basalts are the youngest Tertiary rocks exposed along the northern coast of Oregon.

The basaltic rocks of the Cape Meares area extend seaward to form Three Arch Rocks and other rocks and sea stacks. They consist of low-dipping pillow lava, subaerial flows, and breccias, together with associated feeder dikes and sills and small pluglike bodies. The basalt is medium to dark gray, fine grained, and nonporphyritic. Calcic andesine to sodic labradorite (An_{40}–An_{60}) form 5–50 percent of the rocks. Augite to subcalcic augite and pigeonite make up 5–40 percent. Opaque minerals, largely magnetite, average about 2 percent of the rock but may range from less than 1 to more than 10 percent (Snavely and others, 1965).

Chemically, the middle Miocene basalts are similar to the Yakima Basalt of the Columbia River Group (Waters, 1961). The following analyses illustrate this similarity.

	A[1]	*B*[2]
SiO_2	54.8	54.60
Al_2O_3	13.5	13.52
Fe_2O_3	3.9	1.96
FeO	8.7	10.46
MgO	3.0	3.52
CaO	6.3	7.45
Na_2O	3.2	3.09
K_2O	1.5	1.74
H_2O+	.91	.87
H_2O-	1.6	.10
TiO_2	2.0	2.54
P_2O_5	.37	.09
MnO	.18	.13
CO_2	$<.05$	None
Total	100.1	100.07

[1] Basalt feeder dike, Cape Meares State Park. Rapid rock analysis by methods described by Shapiro and Braunoch (1962). Analysts: Paul Elmore, Sam Botts, Gillson Chloe, Lowell Artis, and H. Smith, U.S. Geological Survey.

[2] Yakima Basalt from basal flow 5 miles west of Waterville, Douglas County, Wash. From Waters (1961).

The middle Miocene basalts that form the surface rocks at Cape Meares and Three Arch Rocks overlie a thick sequence of Tertiary marine sedimentary rocks that were deposited in a structural feature known as the Tillamook embayment, which extends along the coast from Tillamook Bay to Sand Lake. These sedimentary rocks are more than 8,000 feet thick and range in age from middle Eocene to middle Miocene (Warren and others, 1945).

The Tertiary sedimentary sequence rests on more than 10,000 feet of lower to middle Eocene basaltic pillow lavas and breccias that contain interbeds of marine tuffaceous siltstone and basaltic sandstone (Snavely and Wagner, 1964). These basalts and interlayered sediments are known as the Tillamook Volcanic Series (Warren and others, 1945) and are the oldest rocks exposed in the northern part of the Oregon Coast Range.

MINERAL RESOURCES

Construction material.—The Miocene basalts of western Oregon have been extensively quarried for road metal; some have been used for dimension stone. Generally, the basalt is too highly jointed to provide large enough blocks for jetty rock. The basalt that forms Three Arch Rocks would be suitable for use as road metal, but numerous more conveniently located sources on the immediately adjacent mainland can supply any conceivable need for this type of material.

Oil and gas.—The thick sequence of marine Tertiary strata that underlies the thin surface cover of basalt contains potential source beds and reservoir rocks for petroleum or natural gas. Although the petroleum potential of this coastal area cannot be discounted, no structure suitable for the entrapment of oil or gas is known in the immediate vicinity of Three Arch Rocks, as the strata generally dip homoclinally seaward. These small rocky islands appear to be too limited in extent and too precipitous to provide desirable drilling sites for offshore drilling.

FIGURE 2.—View looking north to Three Arch Rocks National Wildlife Refuge. Photograph courtesy of U.S. Bureau of Sport Fisheries and Wildlife.

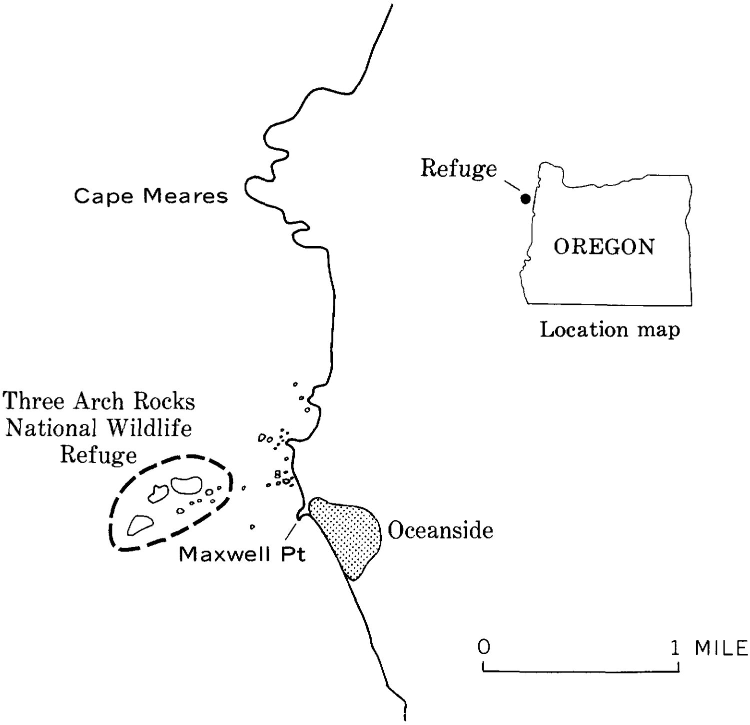

FIGURE 3.—Location of Three Arch Rocks National Wildlife Refuge, Oreg.

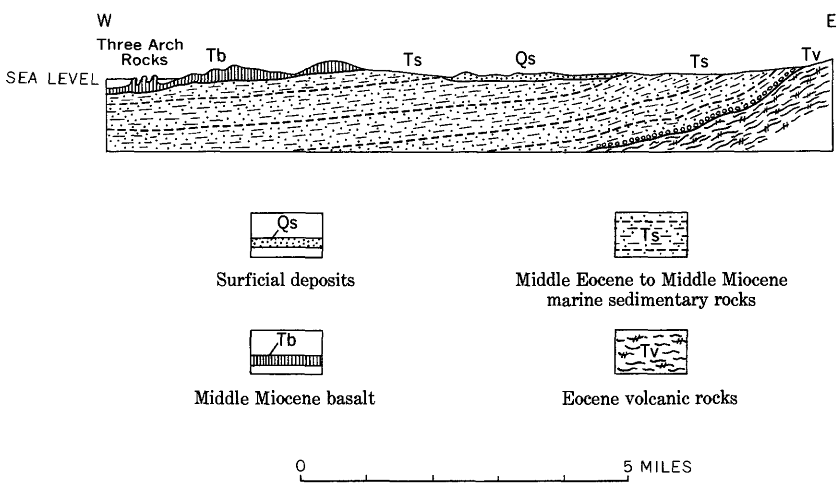

FIGURE 4.—Geologic section through Three Arch Rocks. Modified from cross section by Warren, Grivetti, and Norbisrath (1945).

Analysis of available information indicates that Three Arch Rocks National Wildlife Refuge does not contain significant mineral resources.

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