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Mineralogical and Physical Composition of the Sands *of the* Oregon Coast from Coos Bay to the Mouth of the Columbia River

by
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University of Wisconsin

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Page

4, line 2, read "Heceta Beach", for Hecata Beach.

6, line 1, read "These minerals may also have been brought . . ."

7, end of next to bottom line, read "ellipsoids".

19, line 8, read "rich deposits".

line 17, read "1/8 to 1/4 mm - 55.75 %".

30, table of mineral analyses, under Zircon, 4th column, asterisks (*) mean "very common".

36, third line below (3) Beaches from Boiler Bay to Cascade Head, read "Siletz" for Siltez.

51, table of mineral analyses, No. 5, column 8, read "Muscovite" for Muscarite.

62, table 13, 2nd column heading, read "Cr_2O_3" for C_2O_3.

FOREWORD

In 1943 the Department published Bulletin No. 24 entitled "Origin of the Black Sands of the Coast of Southwest Oregon," by Dr. W. H. Twenhofel, head of the Department of Geology, University of Wisconsin. This publication represented field studies made during the summer of 1942 along the southern Oregon coast between the California line and Coos Bay. Studies of the coast sands were continued by Dr. Twenhofel during the summer of 1943, from Coos Bay north to the Columbia River. The present bulletin gives the results of both field and laboratory studies of the sands of this northern two-thirds of the Oregon coastal area, and is supplemental in substance to the bulletin previously published.

A large amount of painstaking work by Dr. Twenhofel has gone into this bulletin, particularly in laboratory mineral analyses, and the report should provide valuable reference data, as well as basic information, for future investigators.

Value of mineral products obtainable from present beaches in the section of the coast covered by the present report appears to be of relatively minor importance under present day conditions. Value of the scenic and recreational resources of the Oregon Coast is of course of major importance, even from a purely commercial standpoint.

The removal, transportation, and deposition of sands by ocean currents, large rivers, and winds are governed by simple natural laws, but because of the magnitude of the forces and quantities involved, results may not always be foreseen or guarded against. However, as Dr. Twenhofel emphasizes, careful studies of these forces are required in harbor, river, and highway construction; the land owners in beach areas must also be alive to migration of dune sand and its control in order to prevent destruction of property. This bulletin points the way to such studies.

F. W. Libbey
Director

December 1, 1945

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MINERALOGICAL AND PHYSICAL COMPOSITION OF THE SANDS OF THE OREGON COAST FROM COOS BAY TO THE MOUTH OF THE COLUMBIA RIVER

By

W. H. Twenhofel

Introduction

The field work on which this paper is based was done in June, July, and August, 1943. The work was essentially a continuation of that begun in 1942, results of a part of which were published in Bulletin 24 of the Oregon Department of Geology and Mineral Industries.

The field study of 1943 included the coastal area from the south end of the long spit which separates Coos Bay from the Pacific Ocean (where the work ended in 1942) to the beach at Fort Canby on the north side of the Columbia River (pl. 1). Nearly every foot of the accessible shore within the limits of the study was examined. The only exceptions are those parts which lack beaches, because of cliffs rising from the water, and many of the small bays within such cliffed shores. Most parts of the shore were generally traversed twice, once going from the place of starting, and once returning. Samples of the beach and bordering dune sands were collected wherever it seemed necessary. These were generally surface samples, but, where desirable, channel samples were taken to the greatest depth possible. In addition, samples were acquired at South Beach in Yaquina Bay to a depth of 5 feet.

In connection with the field work, assistance was received from many individuals. The writer is particularly indebted to Mr. Earl K. Nixon, formerly director of the Oregon Department of Geology and Mineral Industries, for the opportunity to make the study. The officers in command of the U.S. Coast Guard stations were very helpful and very courteously gave every possible assistance. The officers in command of the station in Charleston on Coos Bay and the station at the mouth of the Umpqua River provided boats and men to take the writer to the north sides of the bays. The officers in command of the Saunders Lake and Siltcoos Lake stations provided passes over the beaches under their jurisdiction. Particular indebtedness is due Lt. Col. L. L. Motz of the U.S. Army for permitting the study of the beach deposits within the limits of Forts Stevens and Canby. Col. Motz also provided transportation across the Columbia River and to Sand Island in the river. Also through the courtesy of Col. Motz, the writer was permitted to live in the officers' quarters and to take meals at the officers' mess while working about Fort Stevens. Dr. Wallace Lowry of the Department of Geology and Mineral Industries assisted in collecting surface and subsurface samples from South Beach in Yaquina Bay. The writer is indebted to his colleague, Dr. R. C. Emmons of the University of Wisconsin, for aid in photographing the sands.

Shore Physiography

The coast of Oregon from Coos Bay to the mouth of the Columbia River consists of several high headlands of rather limited coast extent separated by longer low coasts. The lands bordering the low coasts in most places are covered on the seaward margins by dunes. The headland areas contain cliffs of Tertiary sandstones and shales as well as intrusions and extrusions of black igneous rocks. These parts of the coast are, in general, noted for their scenic beauty. The sedimentary rocks are structurally weak and form high cliffs which in many places are precipitous. The coastal highway, U.S. 101, closely follows the shore over most of the cliffed parts of the coast, and the weakness of the rocks, together with the fact that in many localities bedding planes and joints are inclined toward the sea, constitutes a serious menace to those parts of the highway. Cliffed areas extend from Heceta Head to Yachats, from Yaquina Head north of Newport to Boiler Bay, from the north end of Wecoma Beach to Neskowin Creek, at Cape Kiwanda, Cape Lookout, Cape Falcon, and Tillamook Head. Some coasts have cliffs cut in Pleistocene and Recent dunes. These cliffs tend to be steep if the sands have become partially cemented.

The coast is generally low and dune-covered from Coos Bay to Heceta Head, from Cape Perpetua to Otter Rock, from Cape Kiwanda to a point north of Sand Lake, from Depoe Bay to Cape Lookout, from Cape Lookout to Cape Meares, from Cape Meares to Cape Falcon, from Cape Falcon to Tillamook Head, and from Seaside to the mouth of the Columbia River. The extent of low coast is at least five times that of the high sections. In general, the cliffed coast is moving inland because of erosion, whereas many areas of low coast are being extended into the sea. Low coasts usually have very straight shore lines.

These parts of the Oregon coast owe much of their detail to rather recent submergence, but that submergence has been only the latest movement is proved by the presence of remnants of elevated wave-cut terraces in many places. These are not conspicuous from Coos Bay to the mouth of the Columbia River. They are probably the most obvious surface features from Coos Bay southward. The late submergence is shown in the drowning of the mouths of the larger streams and the ascent of the tides in them for long distances, such for example as 34 miles up the Coquille River, 30 miles up the Coos River, and more than 100 miles up the Columbia River. Submergence also produced the many bays into which the larger streams now empty, and these in turn have been dammed from the sea by the building of spits across their seaward margins. Both wind and water participated in the building of the spits and some parts of them have been built to 50 feet or more above high-tide level. The spit on the north side of Winchester Bay - the bay at the mouth of the Umpqua River - and the one on the north side of Coos Bay are from 1 to 2 miles wide.

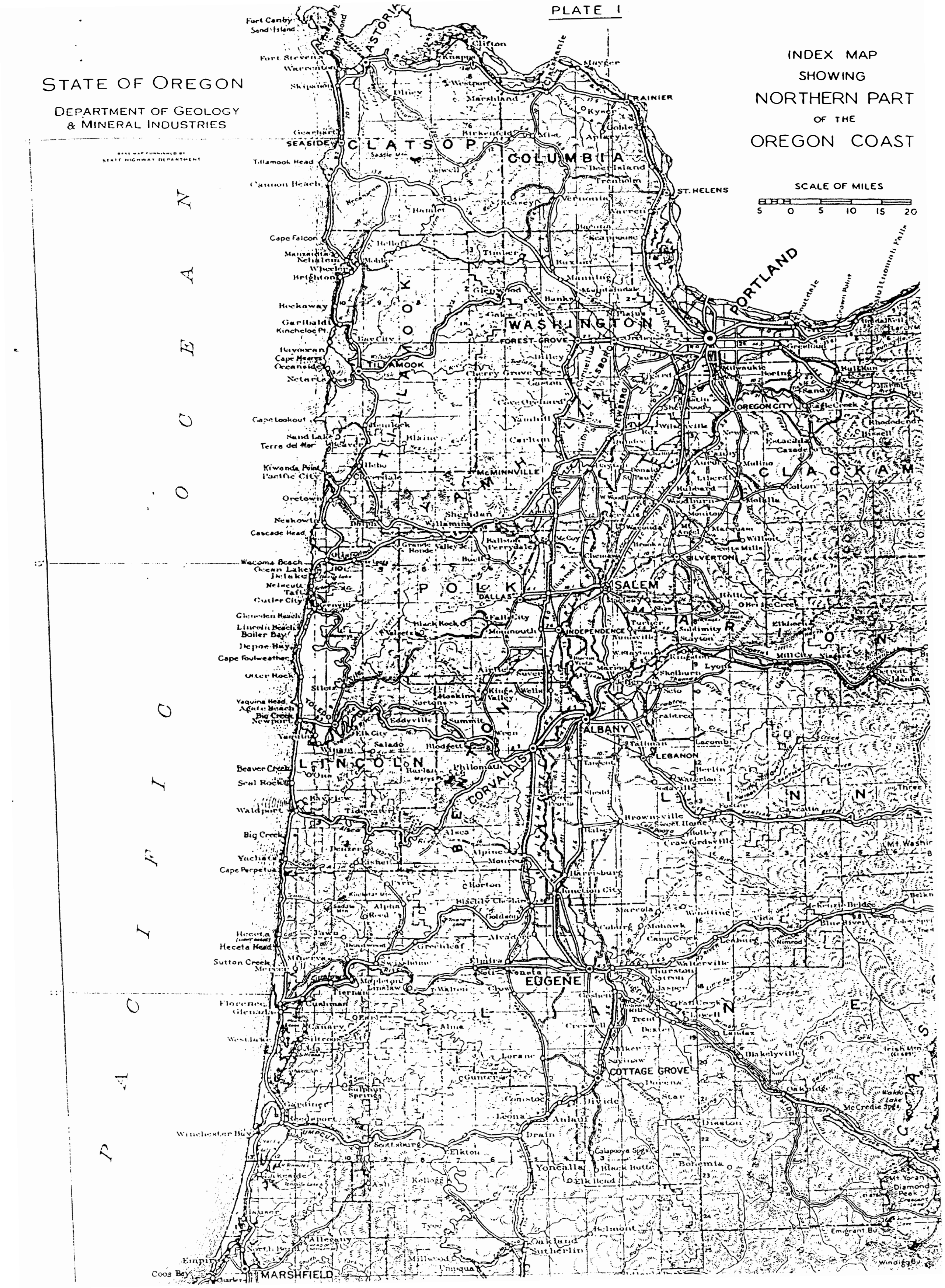
PLATE I
STATE OF OREGON
DEPARTMENT OF GEOLOGY
& MINERAL INDUSTRIES
INDEX MAP
SHOWING
NORTHERN PART
OF THE
OREGON COAST
SCALE OF MILES
5 0 5 10 15 20
PACIFIC OCEAN
CLATSOP
COLUMBIA
WASHINGTON
TILLAMOOK
YAMHILL
POLK
MARION
CLACKAMAS
LINCOLN
BENTON
LINN
LANE
ASTORIA
SEASIDE
ST. HELENS
RAINIER
PORTLAND
FOREST GROVE
OREGON CITY
McMINNVILLE
SALEM
SILVERTON
DALLAS
INDEPENDENCE
ALBANY
CORVALLIS
LEBANON
EUGENE
COTTAGE GROVE
MARSHFIELD
Coos Bay

The spits represent areas which have been taken from the sea. Other areas have been added to the land by the building of wide tidal beaches as well as by the construction ultimately of fore dunes over the landward margins of these beaches. This is perhaps best shown in the coastal area between the mouth of the Columbia River and Tillamook Head where in places the land has been built into the sea for a distance of 2 miles or more.

The coastal physiography has been influential in determining the physical composition of the beaches, and also the very existence of the beaches. High coasts are cliffed and beaches are narrow or lacking. Dunes are an almost invariable accompaniment of low coasts; they are rare on high coasts. Exceptions are on the top of the cliff between Netarts and Oceanside; south of the mouth of the Umpqua River; and in a few other places where dunes have been built on the tops of the cliffs. It is vain to seek for coarse materials on low coasts except where these are adjacent to headlands. The beaches of low coasts tend to be wide and nicely graded except where an adjacent high headland supplies an abundance of sediments. Beaches under such conditions tend to be narrow and steep. The coastal physiography also determines where erosion of the coastal rocks will take place and also where the coast will advance into the sea.

Character and Composition of the Beaches

Most beaches of the Oregon coast north of Coos Bay are composed of pale, yellowish-gray sands containing dark specks. The yellow is due to grains of yellow quartz or yellow rock. The dark specks are mainly particles of dark rocks, but some are black minerals such as magnetite, ilmenite, chromite, hornblende, and, rarely, pyroxene. Most sands are fine-grained, but medium- to coarse-grained sands are present adjacent to cliffed parts of the coast of which the composing rocks have the physical composition to produce coarse-grained fragments. The coarse-grained particles are generally found north of the cliffs from which they were derived. If the coastal rocks are fine-grained, slightly coherent sandstones, they cannot produce coarse-grained sands; if the cliffs contain igneous rocks, coarse-grained sands are possible. Medium and coarse-grained sands are present where waves and winds cooperate to remove most of the small particles.

Most sand beaches are gently graded from high to low tide level. This may be seen on Heceta Beach, Manzanita Beach, Wecoma Beach, the beach at Pacific City, and the long stretch of fine beach from Seaside to the mouth of the Columbia River. Parts of this last beach are known as Seaside, Gearhart, and Sunset. A few beaches are receiving such great quantities of sand that it is piled up in long windrows, or beach ridges, above high tide level. Such a condition exists between Boiler Bay and the south side of Siletz Bay where the beach is smothered with sands derived from the coast extending from Otter Rock to Boiler Bay. A great littoral barrier has been built which is steep on the seaward side, but which slopes gently inland.

There are a few other beaches where similar barriers are present. Automobiles readily travel on the gently graded beaches of fine-grained sand as may be seen on Hecata Beach, Cannon Beach, the long beach from Seaside to Fort Stevens, and others. The wet sands of some beaches are so firm that automobiles leave only very faint tracks.

The surface of the back parts of the sand beaches is usually irregular because of deposition by winds. Every low tide in non-rainy weather permits some sands, particularly those of the upper part of the beach, to become dry; these may then be moved to the back beach by the wind. If the coastal physiography permits and the winds are sufficiently strong, some sands are moved inland to form dunes, as has happened at the following places: Coos Bay spit and thence all the way to the mouth of the Umpqua River; from the spit on the north side of the Umpqua River to Heceta Head north of Florence; from Waldport to Otter Rock north of Newport; from Kernville on Siletz Bay to Cascade Head; from Neskowin to Cape Lookout; from Cape Lookout to Cape Falcon; and from Seaside to Fort Stevens. This represents most of the coast.

Some dunes are more than 100 feet high. There are at least six dune ridges at Sunset Beach. Each of these at one time formed a fore dune on the shore. The five inland ridges are covered with vegetation. Among many of the dunes and between the inner dune ridges and the original land, there are many lakes some of which rise and fall with the tide. Some dunes have dammed small streams, blocking their entrances to the sea. Others have deflected streams in the directions toward which the sands drift. As the dry season on the coast occurs during the time of the northwesterly winds, the result is that much of the stream deflection is to the south. In places, the dunes have added more than a mile to the land. Many dunes are advancing into plant-covered lands, thus extending the areas of barren lands. In some places dunes are filling the lakes for whose origin they may or may not be responsible.

Gravel and boulder beaches are not common on any part of the north Oregon coast except for short stretches north of headlands composed of resistant rock, and about the mouths of small streams. Gravel or boulder beaches are rarely present south of some headlands composed of resistant rocks. There is one such beach at "Roads End" north of Ocean Lake. An extensive gravel and boulder beach extends from Cape Meares to the middle of the seaward side of the spit separating Tillamook Bay from the sea. Another extends from Tillamook Head to the town of Seaside. The lower parts of these two beaches, in general, are composed of very large boulders which are rarely moved by the waves. The top parts of the beaches are composed of much smaller particles, but there is a range from pebbles less than half an inch in diameter to boulders more than a foot in diameter, the association of dimensions varying locally. The reason for the occurrence of the large boulders at low-tide level is that they cannot be moved from their present positions except by extremely strong waves, whereas smaller waves are present in the upper parts of the beaches.

These evidently have been selected from the lower parts of the beaches. Within the range of their competencies, the returning waters transport those particles down the beach to the sea. Such particles range in dimensions from clay and silt to sands and granules. They are either carried out to sea and deposited below the base level of deposition, or shifted along the coast to form beaches of these materials at places where the competencies of the shore currents become small. The large boulders over the lower parts of the two beaches may have complex histories, but it is probable that most of them were derived from the cliffs not far to the south of the places where the boulders are found. That there is movement of large particles northward along the coast is proved by the occurrence of large boulders at least half a mile north of cliffs from which they must have been derived. Some boulders may have come from the sea to be carried inland by the waves as the coast submerged. There are many sand beaches which contain small quantities of larger particles in the range from pebbles to small boulders.

Small beaches of coarse materials are not uncommon about the mouths of creeks which empty directly into the sea and not into an estuary. Such a beach may be seen about the mouth of China Creek which flows into the sea at the Muriel O. Ponsler Memorial Wayside Park, and also at the mouth of Rock Creek a short distance to the north. Beaches composed of mud were not found on the Oregon coast although sand beaches which contain small quantities of mud were found in some of the bays and estuaries. A beach composed of silt and very fine sand is present on the west side of Trestle Bay in the Columbia River.

The sands of the Oregon beaches have had complex histories. Any assemblage of sands on any of the beaches may be likened to the passengers on a transoceanic steamer. There may be passengers from every continent with ages ranging from infancy to more than the biblical three score years and ten, and the passengers may speak many different languages. Although it is unlikely that any sands on the Oregon beaches came from continents other than North America, it is probable that some sands were derived from areas as far east as the Rocky Mountains and also from coastal areas far to the north and south. That some of the sands originated directly from the coastal rocks is obvious from the small particles of these rocks in the sands adjacent to, and generally north of, the places on the coast where such rocks are being eroded by the waves. The Tertiary fine-grained sandstones which form many of the cliffs of the coast are an obvious source of quartz sand, and it is certain that the destruction of these fine-grained sandstones contributed to the sands of the beaches. The sands of these sandstones also had a complex history before they were finally deposited to become part of the Tertiary section.

In places, the sands of the beaches contain much chromite, magnetite, and ilmenite. Some of these minerals may have been derived from basic and ultrabasic igneous rocks exposed in the coastal cliffs of southern Oregon and northern California and in the mountains inland from the coast, as it is known that these rocks contain chromite, magnetite, and ilmenite.

These minerals may also have brought directly to the sea by streams such as the Rogue, Smith, and Klamath, flowing over these rocks. The Columbia River contributes much magnetite and ilmenite to the beaches about its mouth. The river acquired these minerals from the lavas of the Cascade Mountains and also from the basalts of the Columbia River Plateau. Some beach sands may have been derived from rocks of the coast now submerged so deep beneath the sea that they are immune to wave attack. Sands from these rocks would have moved inland as the beach migrated inland on the land. Most of the particles of chromite, magnetite, and ilmenite are of small dimension, between 1/16 and 1/8 mm. A few particles are between 1/8 and 1/4 mm. Some sands south of Tillamook Head contain very small particles of gold and platinum, all smaller than 1/16 mm. The platinum was originally derived from the same ultrabasic rocks that furnished the chromite. The gold is thought to have come originally from quartz veins in rocks which are older than the Tertiary. Some particles of the sands are young, by which it is meant that it has been but a short time since they were detached from a parent rock of igneous origin. These particles are angular; they have undergone little abrasion. Other particles in the sands are very round and some are spherical. These are believed to have been detached from parent rocks in the far distant past, perhaps in the early Paleozoic, or pre-Cambrian, to have traveled for a long time and a long distance, perhaps halting from time to time to become parts of sedimentary terranes. With the exception of the sands about the mouth of the Columbia River, it seems impossible to generalize on assemblages of sands of most of the Oregon beaches with respect to distances traveled, shapes, and roundness.

Most sands on the Oregon beaches are composed of light-colored minerals among which quartz predominates. Most quartz particles are transparent and have a fresh appearance, but some have a yellow color and many are slightly iron-stained. The yellow particles are believed to have had histories different from those of the clear grains. There are a few particles of milky quartz in some samples. Feldspar is always found in the beach sands and is rather common in some sands brought to the sea by the Columbia River. No sample has been studied or seen in which the quantity of feldspar exceeded that of quartz, although it is not unlikely that there are such sands. Small particles of olivine or epidote, or both olivine and epidote, are present in nearly every sample. Garnet occurs in most samples and generally the particles are small and little worn. Common components of all sands from Coos Bay to the mouth of the Columbia River are particles of black, brown, yellow, and other light-colored rocks. The black particles seem to be composed of scoria, basalt, or obsidian, which were probably derived from intrusive and extrusive lavas in the coastal rocks except about the mouth of the Columbia River where, in considerable, and probably large part, they were brought to the sea from the interior. Brown and yellow particles seem to be composed of flint (chert), but probably also of quartzite or of fine-grained igneous rocks. The rock particles range from well-rounded to angular. Well-rounded particles are not uncommon south of Cape Falcon;

they are either rare or completely absent in beaches extending from Seaside to the mouth of the Columbia River where the rock particles show little wear. Particles of dark rock are most abundant on the south ends of beaches limited on that end by cliffs containing intrusives or extrusives of basalt or scoria. The quantities in the sands seem to decrease northward from such cliffs. This is thought to indicate that the major transportation on the beaches has been northward, and the same generalization may be made for gravels and boulders. Sands with a high percentage of black minerals or black rock are concentrated at many places on the beaches. The former make the so-called black sands, the common minerals of which are quartz, magnetite, ilmenite, chromite, zircon, dark amphibole, pyroxene, olivine, epidote, and garnet. Garnet and olivine are so abundant in places as to give color to the sands, the former a red shade, the latter green. Most of these minerals have high specific gravities and are concentrated where the wind and water have competencies sufficient to bring in the minerals of high specific gravities - the so-called heavy minerals - but not sufficient to take them away. The places of concentration are mostly about the heads of bays, particularly on the north side of bays limited by headlands, and about the mouths and in the channels of small creeks where they cross the beach. Some minor concentration is produced by wind and this may be seen as a thin surface film over wind-drift surfaces on the back beach and occasionally on the dunes. Minerals of high specific gravities are rarely transported far inland by wind. Places of low concentration of heavy minerals are common; there are fewer of moderate concentration; and very few of rich concentration.

The quartz and feldspar sands south of Cape Falcon are commonly subangular to well-rounded, and nearly every 20-gram sample contains a few grains which are shiny spheres. A small percentage of very angular grains may likewise be expected in every sample. The grains of yellow quartz seem generally to be rounded to a higher degree than those of transparent quartz. It is assumed that these yellow grains and the well-rounded highly polished spherical grains have histories different from the others. The sands of the dunes are like those of the beaches with the exception that no sands of dunes are as coarse-grained as some of the beach sands, and the content of heavy minerals is either zero or very small. Olivine and epidote particles in beach sands are generally well-rounded, but garnet particles are angular to subangular except where the corners of crystals have been abraded. Particles of magnetite, ilmenite, and chromite in the sands of the beaches south of Cape Falcon are generally well-rounded in spite of the fact that most of these are less than 1/8 mm in diameter. This high degree of rounding may be explained as due to the high specific gravities of these minerals which favored traction rather than suspension transportation, thus making abrasion possible, but it is also probable that the high degree of rounding is due to the longer distance traveled and the longer time of traveling of these particles after release from the parent rock than many of their associates. Particles of zircon are usually well-rounded to elipsoids, but frequently little worn, nearly perfect crystals of zircon are found.

The sands north of Tillamook Head to and about the mouth of the Columbia River are highly angular and show essentially no wear. This applies to particles of all dimensions and of all mineral compositions, and leads to the view that the extent of travel was not long enough to produce abrasion, or the travel was of a kind which did not favor abrasion. Since the angularity is the same for all particles, it implies that extent or kind of travel was approximately the same for all. The sands north of Tillamook Head are so decidedly different in degree of rounding from those south of Cape Falcon that one cannot fail to note the difference; a sample may be identified readily as to general place of collection by this character alone.

The almost total absence of any rounding of the sands contributed by the Columbia River raises the question as to how much rounding of sand grains is really done by stream transportation. The Columbia River obtained the materials of these sands from rocks of the Cascade Mountains, the Columbia Lava Plateau, the plateau in Canada between the Rocky Mountains and the Coast Ranges, and, via the Snake River, from the mountains of Idaho and western Wyoming. Possible sources of the quartz are eastern Washington, eastern Oregon, the large Idaho batholith, and Canada. Many, and probably most, of the grains may be assumed to have been transported several hundred miles before they reached the sea. Moreover, after the particles were dumped into the sea by the Columbia River, they traveled north and south along the coast, the waves washing them at least as far south as Tillamook Head, a distance of about 20 miles. On the beach the sands were beaten around by the waves and currents and were swept about by the winds. All of this transportation produced little or no rounding. The studies by Russell and Taylor (1937), of the sands of the Mississippi River led them to the view that little rounding of sands is produced by stream transportation, and Pettijohn and Lundahl (1943), have recently expressed some agreement with this view. Thiel's (1940) experiments showed that quartz grains after being subjected to abrasion, comparable to that done by streams, over a period of 40 days and about 2,000 miles of travel, showed little wear. The rounding produced was barely or not at all visible. Other minerals, among which were garnet, tourmaline, hornblende, and apatite, showed much greater effects, with apatite the most affected. Krynine (1940), on the other hand, reports observations on the rounding of grains by stream transportation in New England, Pennsylvania, and the Himalaya Mountains. Until more is known of the sources of the sands observed by Krynine, one may hesitate to accept the soundness of his conclusions. Streams in the upper Mississippi Valley are transporting large quantities of well-rounded particles of sand dimension for whose rounding the streams are not responsible. These sands were derived from till, outwash, and Cambrian and Ordovician sandstones. The grains were well rounded before their acquirement by the streams. It may be possible that the sands seen by Krynine were acquired from sedimentary terranes over which the streams flowed and were rounded when acquired by the streams.

Many quartz particles in the sands of the beaches and in the dunes from Tillamook Head south to Coos Bay show some degree of rounding, but, in general, the sands as a whole are not well rounded. Some grains are highly rounded, but many more are little rounded and some show no rounding at all. Nevertheless, the quartz sands of the Oregon beaches and in the coastal dunes have been carried by streams, rolled around on the beaches by the waves of the sea, moved back and forth by the shore currents, and blown around by the winds for many thousands of years. Whence these quartz sands were originally derived is not known, but the buffetings they have received have resulted in only a little rounding of the grains. The immediate source of many of the sands is undoubtedly the Tertiary and Pleistocene sands of the coastal cliffs. However, the quartz grains which, in large part, form the sandstones of these cliffs must have had a long free existence before they were deposited as these formations. Only a slight degree of rounding had been acquired at the time deposition took place. Here are sands that have passed through at least two cycles of sedimentation, have been transported by streams, by winds, and by waves and currents of the sea, and show little effects of the travel.

The writer is convinced that too little is known of the rounding of sands and of the conditions which favor excellent rounding, and that a revision of ideas on this subject is long overdue. There has been too much bland acceptance that rounding takes place in several environments without much attempt being made to determine whether such acceptance has basis in fact. The writer is also convinced that such a high degree of rounding of the sand grains in both ancient and recent deposits indicates that the individual particles have traveled tremendous distances, and that the sands have had long histories prior to their final deposition to form the deposits in which they are now found. The nearly perfect rounding of sand grains as those in the Upper Cambrian and Lower Ordovician formations of the upper Mississippi Valley would seem to compel the conclusion that their history prior to entrance into these formations must be measured in millions of years.

The above considerations apply only to particles of the fine to coarse sand grade. They do not apply to particles in the range from granules to boulders. Rounding of particles of these dimensions has been well studied by Wentworth (1919), and others and the explanation of such rounding does not seem to be a difficult problem.

The quartz grains of the sands north of Tillamook Head also differ from those south of Cape Falcon in containing an abundance of included and attached magnetite and ilmenite. Grains of quartz with inclusions of these minerals may be found south of Cape Falcon, but are not as common as in the sands north of Tillamook Head.

The sands between Tillamook Head and Cape Falcon contain a considerable, and in some cases a dominant, percentage of angular particles mingled with rounded particles. Similarly, the quartz sands of this part of the beaches contain a considerable quantity of grains with inclusions of ilmenite and magnetite. The sands north of Tillamook Head are thought to have been brought to the sea mainly by the Columbia River, whereas those south of Cape Falcon are believed (1) to have been derived from erosion of the Tertiary sandstones of the shore; (2) to have been brought to the sea by the streams of that part of the coast; and (3) to have come from points farther south at some time before the recent submergence of the coast. The sands between Tillamook Head and Cape Falcon were partly derived from beaches north of Tillamook Head, partly from the rocks of the coast between Tillamook Head and Cape Falcon, and partly from beaches south of Cape Falcon.

Most sands of the dunes and beaches have shiny surfaces, and most well-rounded grains have surfaces of a high degree of brilliancy. Only an occasional particle has a "frosted" surface.

One of the most impressive features of the coastal sands is their fineness. Wentworth's (1922) classification of sands on the basis of dimension includes five classes, as follows:

Very coarse-grained	1 - 2 mm
Coarse-grained	1/2 - 1 mm
Medium-grained	1/4 - 1/2 mm
Fine-grained	1/8 - 1/4 mm
Very fine-grained	1/16 - 1/8 mm

Except for the rare deposits of boulders and gravels and thin veneers resulting from the blowing away of the finer materials, there are few coarse-grained sands (Wentworth classification) on the beaches. Many sands may be classified as medium-grained and perhaps more as fine-grained. Medium-grained sand with much coarse material is present from Boiler Bay to Siletz Bay and for a distance north of Siletz Bay. There are other patches of small extent. These sands are at the high and mid tide levels and have their maximum quantity in the range from 1/4 to 1/2 mm. The black sands are usually finer grained than the others.

Divisions of the Beaches

For purposes of description in this report the Oregon beaches from Coos Bay to the mouth of the Columbia River have been divided into parts separated by prominent headlands or stretches of cliffed coast. Seven divisions have been made which are as follows: (1) Coos Bay to Heceta Head; (2) Cape Perpetua to Otter Rock; (3) Boiler Bay to Cascade Head; (4) Cascade Head to Cape Lookout; (5) Cape Lookout to Cape Falcon; (6) Cape Falcon to Tillamook Head; and (7) Tillamook Head to and including the beaches on both sides of the mouth of the Columbia River.

(1) Beaches from Coos Bay to Heceta Head

These beaches can readily be divided into three parts which are: Coos Bay to Winchester Bay on the south side of the mouth of the Umpqua River, mouth of the Umpqua River to mouth of the Siuslaw River at Florence, and mouth of the Siuslaw River to Heceta Head.

The beach from the south end of the Coos Bay spit to the north side of the village of Winchester Bay is considerably isolated owing to the following conditions: distance from U.S. Highway 101; limited areas on this part of the coast suitable for settlement; the presence of an extensive and continuous dune area between the highway and the sea; and the presence of sloughs and dune lakes on the land side of the dune area. This beach is gently graded with a broad tidal zone, a back beach with wind drift deposits, and it has a wide dune area throughout its entire extent. The sands are generally fine-grained and are largely composed of quartz. Medium-grained sands are present over parts of the area of high tide level and in some places over mid and low tide levels. The sands are generally a pale, yellowish-gray color with dark specks (figs. 1, 2). From the south end of the Coos Bay spit to the dock of the Umpqua Coast Guard station on the south side of the mouth of the Umpqua River, this beach contains no concentration of heavy minerals. The beach at the village of Winchester Bay is composed largely of the same kinds of sands as make up the beaches of the south end of the Coos Bay spit, but there are a few places of spotty concentration of heavy minerals; none of these concentrations is important.

Descriptive analyses of the sands are given in table 1. The analyses show that the dimensional grade in largest quantity is between 1/4 and 1/2 mm and that most sands are from 3/5 to 4/5 quartz and feldspar; particles of rock are present in every sample. Zircon, magnetite, ilmenite, chromite, olivine, epidote, and garnet are represented by a mere trace or not at all. Three analyses are given below (nos. 4, 20, and 28):

Sand collected at high tide level 2 miles north of the Coast Guard trail on Coos Bay spit (no. 4 of table).

1/4 to 1/2 mm - 12.20%

Angular to round clear quartz	7.80 %
Rounded yellow quartz	2.10
Rounded rock	2.30

1/8 to 1/4 mm - 87.00%

Angular to subangular clear quartz	67.60 %
Subangular to round yellow quartz	10.10
Rounded rock	6.95
Round green mineral (epidote and olivine)	1.55
Round pink garnet	0.80

1/16 to 1/8 mm - 0.80%

Angular quartz	0.25 %
Round olivine	0.25
Round black minerals (magnetite, ilmenite, chromite, hornblende)	0.30
Garnet	trace

Totals

Clear quartz and feldspar	75.65 %
Yellow quartz	12.20
Rock	9.25
Green mineral	1.80
Garnet	0.80
Black mineral	0.30
Zircon	0.00
Total	100.00 %

Sand collected at low-tide level 1 mile south of Coast Guard trail at Saunders Lake (no. 20 of table).

1/2 to 1 mm - 9.40%

Subangular to round clear quartz	2.05 %
Round yellow quartz	0.50
Round rock	6.85

1/4 to 1/2 mm - 81.15%

Subangular clear quartz	36.60 %
Subround yellow quartz	21.95
Round rock	22.60

1/8 to 1/4 mm - 9.45%

Subangular clear quartz	4.25 %
Subangular yellow quartz	2.55
Rounded rock	2.65

Totals

Clear quartz and feldspar	42.90 %
Yellow quartz	25.00
Rock	32.10
Black mineral	0.00
Zircon	0.00
Total	100.00 %

Local concentration at high-tide level, Winchester Bay at village. The only concentration between Coos Bay and mouth of Umpqua River (no. 28 of table, weighted analysis).

1/4 to 1/2 mm - 9.80%

Subangular to round clear quartz	7.75 %
Round yellow quartz	1.10
Round rock	0.95

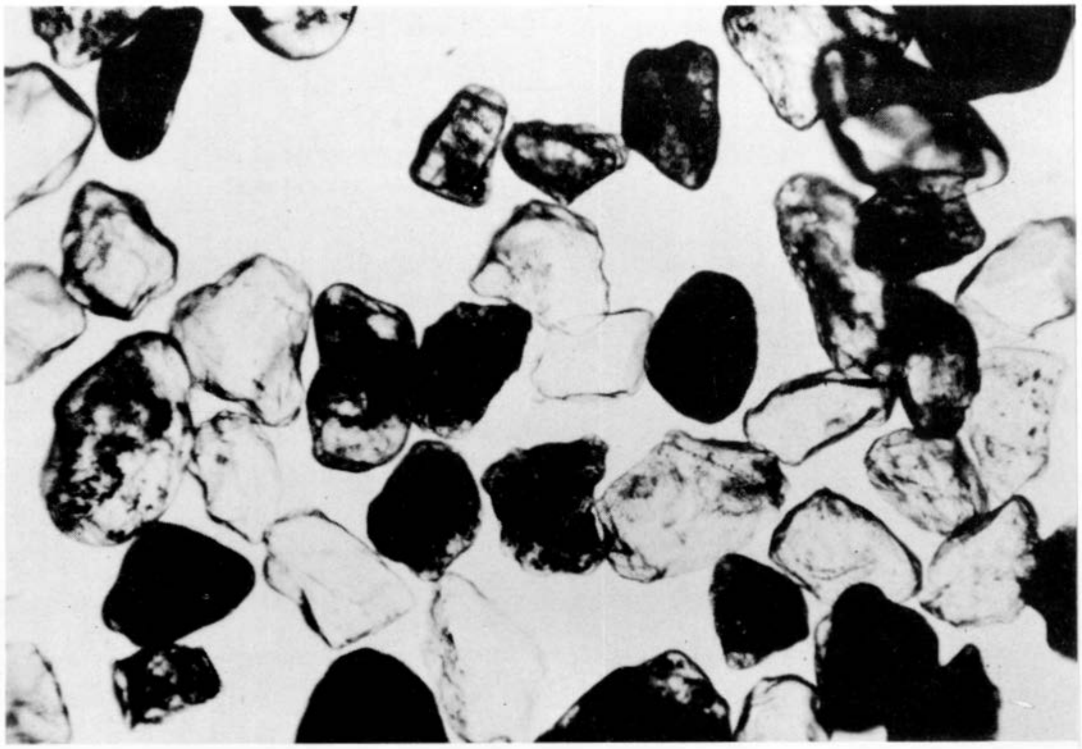

Fig. 1. Sands from high tide level, two miles north of beach end of U. S. Coast Guard trail across Coos Bay Spit. (X 80) The black grains are dark to black rock. The light-colored grains are quartz; some contain inclusions which are commonly magnetic. There is an occasional well-rounded grain, one of which is shown in the lower part of the figure. The slight degree of rounding of the quartz grains is noteworthy. Compare with sands of Figs. 4, 10, and 11. The sands were immersed in a chloronaphthalene (index of refraction 1.63) when photographed.

Fig. 2. Sands from high tide level about 3 miles south of the mouth of the Umpqua River. (X 80) The black grains are composed of dark rock. The light-colored grains are quartz, some of which contain inclusions. These are believed to be long-traveled sands. The limited degree of rounding is noteworthy. Compare with sands of Figs. 3, 10, and 11. Sands were photographed in chloronaphthalene.

1/8 to 1/4 mm - 81.30%

Angular to well-rounded clear quartz	47.30 %
Angular to well-rounded yellow quartz	7.35
Rounded rock	2.30
Rounded green minerals (epidote and olivine)	5.55
Angular (some very round) pink garnet	2.30
Rounded magnetite	5.40
Rounded ilmenite and chromite	11.10

1/16 to 1/8 mm - 8.90%

Mostly rounded quartz	1.15 %
Green mineral (epidote and olivine)	0.50
Pink garnet	0.20
Zircon	0.55
Magnetite	2.05
Ilmenite and chromite	4.45

Totals

Clear quartz and feldspar	56.20 %
Yellow quartz	8.45
Rock	3.25
Green mineral	6.05
Garnet	2.50
Zircon	0.55
Magnetite	7.45
Ilmenite and chromite	15.55
	100.00 %

Location and Analyses of Samples
of
Sands from Coos Bay to mouth of Umpqua River

Table 1.

1. End of Coos Bay Coast Guard trail to beach on Coos Bay Spit, high tide level.
2. Position same as no. 1, mid tide level.
3. Position same as no. 1, low tide level.
4. Two miles north of Coos Bay Coast Guard trail to beach on Coos Bay Spit, high tide level.
5. Same position as no. 4, mid tide level.
6. Same position as no. 4, low tide level.
7. Two to three miles north of Coast Guard trail to beach on Coos Bay Spit, high tide level.
8. Same position as no. 7, low tide level.
9. Three miles north of Coast Guard trail to beach on Coos Bay Spit, high tide level.
10. Four miles north of Coast Guard trail to beach on Coos Bay Spit, high tide level.
11. Five miles north of above starting point, high tide level.
12. Six " " " " " " " " "
13. Seven " " " " " " " " "
14. Eight " " " " " " " " "
15. Nine " " " " " " " " "
16. Ten " " " " " " " " "
17. Eleven " " " " " " " " "
18. One mile south of Saunders Lake Coast Guard trail to beach, high tide level.
19. Same position as no. 18, mid tide level.
20. Same position as no. 18, low tide level.
21. End of Saunders Lake Coast Guard trail to beach, high tide level.

Table 1 (Con't.)

22. Mouth of Ten-mile Creek, Saunders Lake, high tide level.
23. Four miles south of mouth of Umpqua River, high tide level.
24. Three " " " " " " " " " "
25. Two " " " " " " " " " "
26. One mile " " " " " " " " "
27. South side of mouth of Umpqua River, high tide level.
28. Winchester Bay at village, local concentration, high tide level.
29. " " " " , the common sand of the beach, high tide level.
30. " " " " , local concentration, high tide level.
31. " " " " , just south of old pier, high tide level.

Mechanical Analyses of Sands
Coos Bay to Umpqua River

No.	greater than 2 mm	1-2 mm	1/2-1 mm	1/4-1/2 mm	1/8-1/4 mm	1/16-1/8 mm	less than 1/16 mm	Remarks
1.			0.80	77.35	21.50	0.35		cement sand
2.			5.50	84.50	10.00			" "
3.			0.85	84.75	14.40			" "
4.				12.20	87.00	0.80		" "
5.			4.55	85.95	9.10	0.40		" "
6.			6.15	84.30	9.20	0.35		" "
7.				23.00	76.90	0.10		
8.				14.90	82.25	2.85		
9.				47.00	53.00			
10.			3.00	71.30	25.45	0.25		" "
11.				59.10	40.90			
12.			53.00	44.50	2.50			" "
13.			24.15	74.05	1.80			" "
14.			14.10	84.70	1.20			" "
15.			6.00	89.50	4.50			" "
16.			11.50	86.75	1.75			" "
17.				81.85	18.15			" "
18.				69.10	30.90			
19.		0.50	19.85	79.20	0.45			" "
20.			9.40	81.15	9.45			" "
21.			4.15	88.35	7.50			" "
22.				78.25	21.75			
23.				87.40	12.60			" "
24.			0.20	86.40	13.00	0.40		" "
25.			1.55	92.20	6.00	0.25		" "
26.				82.75	17.75			
27.			2.70	88.90	8.20	0.20		" "
28.				9.80	81.70	8.50		black sand
29.				23.20	74.45	2.35		bayhead
30.				15.40	77.85	6.75		black sand
31.				36.45	63.20	0.35		" "

Mineral Analyses of Sands
Coos Bay to Umpqua River

No.	Quartz Feldspar	Green Minerals	Garnet	Zircon	Magnetite	Ilmenite Chromite	Rock	Remarks
1.	88.30	trace	trace	rare grain	0.05	0.30	11.35	
2.	67.25	none	none	none	none	none	32.75	
3.	73.20	"	"	"	"	"	26.80	
4.	87.85	1.80	0.80	"	0.30		9.25	
5.	68.60	trace	trace	"	none		31.40	
6.	78.85	"	"	"	"		21.15	
7.				"	"			not analyzed
8.	56.10			rare grain	"		43.90	
9.	64.40			none	"		35.60	
10.	64.20	1.05		rare grain	0.15		34.60	
11.	88.20			none	none		11.80	
12.	69.05			"	"		30.95	
13.	76.40			"	"		23.60	
14.	65.80	trace		"	trace		34.20	
15.	77.05			"	none		22.95	
16.	65.95			"	"		34.05	
17.				rare grain				not analyzed
18.	81.55			none	"		18.45	
19.	76.35			"	0.10		23.55	
20.	67.90			"	trace		32.10	
21.	72.60			rare grain	"		27.40	
22.	88.25			none			11.75	
23.				"				not analyzed
24.				"				" "
25.	64.85			"			35.15	
26.				"				" "
27.	93.60	1.50		"	0.20		4.70	
28.*	64.05	6.55	2.45	0.55	8.55	14.60	3.25	black sand
29.		trace	trace	rare grain	0.40	0.95		not completely analyzed
30.	68.90	1.00	1.00	trace	10.65	12.35	6.10	black sand
31.	82.95			none	trace		17.05	

* Denotes percentage by weight, that is, specific gravity of grains has been considered.

The beach from the mouth of the Umpqua River to the mouth of the Suislaw River is gently graded with a broad tidal zone. Back of the beach there is an area of dunes which in many places, particularly just north of the Umpqua River, is more than a mile wide. The sands are mainly composed of quartz and feldspar and no concentration of black mineral particles was found either on the beach or in the dune areas, except for a small quantity near high tide level on the north bank of the Umpqua River near its mouth, and also on the back beach on the north side of the mouth of the Siltcoos River. Neither of these concentrations is important. Analyses are given in table 2 (nos. 1-11).

Location and Analyses of Samples of Sands from Umpqua River to Heceta Head

Table 2.

1. North Beach, Umpqua Bay, spit at mouth of Umpqua River at end of Coast Guard trail to beach, high tide level.
2. North bank of the Umpqua River on inside of the Umpqua Spit, low tide level.
3. One mile north of end of Coast Guard trail to beach, high tide level.
4. Same place as number 3, low tide level.
5. Creek about six miles north of Coast Guard trail to beach, high tide level.
6. North side of mouth of Siltcoos River, small concentration of black mineral, high tide level.
7. Two and a half miles north of mouth of Siltcoos River, about 2 feet from number 8, high tide level.
8. Two and a half miles north of the mouth of the Siltcoos River, sands blown by wind from the tidal zone and deposited at high tide level.
9. Lag granules, three miles north of the mouth of the Siltcoos River, sands drifted into ripples by wind with the fine sands blown away, high tide level.
10. Wind lag granules, four miles north of mouth of Siltcoos River, high tide level.
11. Two miles south of mouth of Suislaw River, near low tide level.
12. North of jetty on the north side of the Suislaw River, low tide level.
13. Same place as number 18, high tide level.
14. About two miles north of mouth of Suislaw River, Heceta Beach, low tide level.
15. Same place as number 14, high tide level.
16. 4500 feet south of the mouth of Sutton Creek at north end of the Suislaw Coast Guard patrol, beginning of concentration of black sands, high tide level.
17. 3000 feet south of the creek of number 12, channel through 8", high tide level.
18. 2000 feet south of creek of number 12, channel sample through 8", high tide level.
19. 1800 feet south of mouth of creek of number 12, north end of the concentration of black sands, values become less with depth. Sample from surface, high tide level.
20. Composite, not average, of 16 to 18.

Mechanical Analyses of Sands Umpqua River to Heceta Head

No.	greater than 2 mm	1-2 mm	1/2-1 mm	1/4-1/2 mm	1/8-1/4 mm	1/16-1/8 mm	less than 1/16 mm	Remarks
1.				62.90	37.10	trace		
2.			1.30	73.80	24.90	"		
3.				26.70	73.00	0.30		
4.			0.70	50.70	48.60			
5.			trace	18.35	81.30	0.35		
6.				22.60	75.05	2.35		
7.				68.95	31.05	trace		
8.				83.15	16.85			
9.		15.16	48.14	35.14	1.56	trace		
10.	0.40	11.80	59.25	25.50	2.40	0.65		
11.			0.45	47.90	51.65	trace		
12.			0.50	57.20	41.60	0.70		L.T., N. side Suislaw River.
13.			3.65	88.50	7.85			H.T., N. side Suislaw River.
14.			0.15	43.50	55.35	1.00		L.T., 2 miles N. Suislaw Riv.

Mechanical Analyses of Sands
Umpqua River to Heceta Head
(Con't.)

No.	greater than 2 mm	1-2 mm	1/2-1 mm	1/4-1/2 mm	1/8-1/4 mm	1/16-1/8 mm	less than 1/16mm	Remarks
15.				4.20	69.70	26.10		H.T.,N. si Suislaw Ri
16.				16.67	62.67	20.66		Black sand
17.				10.25	77.15	12.60		" "
18.				10.85	76.10	13.05		" "
19.				0.70	47.50	49.70	2.10	" "

Mineral Analyses of Sands
Umpqua River to Heceta Head

No.	Quartz Feldspar	Olivine Epidote	Garnet	Zircon	Magnetite	Ilmenite Chromite	Rock	Remarks
1.	91.80						8.20	
2.	86.95						13.05	
3.								Not analyz
4.	86.35						13.65	
5.								Not analyz
6.	98.75	0.50	0.25		0.30	0.20		
7.								Not analyz
8.	78.70						21.30	
9.	52.14	2.26			0.30		42.10	3.5% shell
10.	57.75						38.55	3.7% "
11.								Not analy:
12.	84.60	0.05			0.15		15.20	Low tide
13.	84.85						15.15	High tide
14.	84.85	trace	trace		trace	0.20	13.95	Low tide
15.	45.80	20.05	6.95	2.65	4.25	14.35	5.95	H. T., lean black san
16.*	62.00	12.13	6.97	0.73	1.80	6.80	9.57	Lean blac
17.	65.95	13.15	5.25	P.	0.35	12.10	3.20	" "
18.*	59.23	9.60	4.57	0.37	0.50	5.60	20.13	" "
19.	26.75	24.10	6.40	trace	2.80	39.95		Rich "
20.*	56.55	13.23	4.49	0.63	1.27	9.02	14.81	Composite

* Denotes percentage by weight, that is, specific gravity of grains has been considered.

Heceta Beach extends from the north side of the Suislaw River to Sea Lion Point just south of Heceta Head. The beach is gently graded and is composed of clean, yellowish-gray sand. It is backed throughout its entire extent by a wide dune area, but the dunes are stabilized by vegetation.

Heceta Beach is separated into two parts by Sutton Creek which flows over a sand-fill bay. The sands of both beach and dunes are composed mainly of quartz and feldspar. A sma concentration of black minerals is present at high tide level to about 1700 feet south fro Sutton Creek and there is a moderate concentration from about 1700 feet to about 5000 feet south. Epidote, olivine, and garnet are associated with the black minerals. The width of the black sand belt ranges from 25 to 30 feet and the thickness may average 2 to 3 feet. It is estimated that 7000 to 8000 cubic yards of concentrate is available, from which it is estimated that 3500 tons of ilmenite and chromite, 650 tons of magnetite, and 70 tons of zircon could be extracted. Analyses of the sands from this locality are given in table 2 (nos. 12-20), and a detailed analysis of no. 18 is given below.

Sample no. 18 of table, 8-inch channel, high tide level, 2000 feet south of Sutton Creek at the north end of the Siuslaw Coast Guard patrol, weighted analysis.

1/4 to 1/2 mm - 10.00 %	
Angular to rounded clear quartz, 1 grain in 20 with frosted surface	7.93 %
Rounded olivine and epidote	0.27
Rounded rock	1.80
1/8 to 1/4 mm - 76.80 %	
Angular to rounded clear quartz, 1 grain in 33 with frosted surface	49.07 %
Rounded olivine	5.97
Angular pink garnet	3.43
Rounded rock	18.33
1/16 to 1/8 mm - 13.20 %	
Strongly magnetic	
Rounded magnetite	0.50 %
Moderately magnetic - 1.73 %	
Angular clear quartz	0.03
Rounded olivine and epidote	0.07
Angular pink and red garnet	0.10
Rounded ilmenite and chromite	1.53
Mildly magnetic - 9.47 %	
Angular clear quartz	1.07
Rounded olivine and epidote	3.30
Angular pink and red garnet	1.03
Rounded ilmenite and chromite	4.07
Nonmagnetic - 1.50 %	
Angular clear quartz	1.13
Rounded zircon	0.37
Totals	
Quartz and feldspar	59.23 %
Green minerals	9.61
Garnet	4.56
Zircon	0.37
Magnetite	0.50
Ilmenite and chromite	5.60
Rock	20.13
Total	100.00 %

The generally precipitous coast from Heceta Head to Cape Perpetua south of Yachats has few beaches. All beaches are small and the composing materials are probably very migratory. Most rocks of the coast are slightly resistant and produce few coarse fragments. Small creeks enter most of the bays, and coarse materials are present about the mouths of most, if not all, of them. China Creek, so named because Chinese miners worked the sand for gold, enters the sea at the Muriel O. Ponsler Memorial Wayside Park, and olivine, epidote, garnet, and black metallic minerals are concentrated in small but locally very rick deposits about its mouth. Large particles ranging from pebbles to boulders are mingled with the sands. The varying competencies of the waves and currents of the sea and the currents of the creek have resulted in great variations in the deposits. Patches, largely composed of black metallic minerals, of green minerals and garnet, and of coarse materials are intermingled. Analyses of the sands about the mouth of China Creek are given in table 3. Detailed analyses of two of the sands (nos. 2, 3) are given below.

Muriel O. Ponsler Memorial Wayside Park, garnet - black sand, high tide level, weighted analysis (no. 2 of table).

1/8 to 1/4 mm - 45.75 %	
Strongly magnetic	
Rounded, nearly pure magnetite, some with quartz attached	1.70 %
Mildiy magnetic - 44.70 %	
Angular to rounded clear quartz	1.80
Rounded olivine and epidote	7.30
Angular garnet	15.95
Rounded rock	0.85
Rounded ilmenite and chromite	18.80
Nonmagnetic	
Angular to rounded clear quartz	10.35
1/16 to 1/8 mm - 43.25 %	
Strongly magnetic	
Rounded magnetite	4.45 %
Moderately magnetic	
Rounded ilmenite and chromite	3.80
Mildly magnetic - 30.90 %	
Angular clear quartz	0.60
Rounded olivine and epidote	2.35
Angular pink and red garnet	3.65
Rounded ilmenite and chromite	24.30
Nonmagnetic	
Ellipsoidally rounded zircon	4.10

Totals

Quartz and feldspar	12.75 %
Olivine and epidote	9.65
Garnet	19.60
Zircon	4.10
Magnetite	6.15
Ilmenite and chromite	46.90
Rock	1.08
Total	100.00 %

Black sand, Muriel O. Ponsler Memorial Wayside Park, high tide level, weighted analysis (no. 3 of table 2).

1/4 to 1/2 mm - 1.44 %

Subangular to rounded clear and yellow quartz	1.24 %
Rounded rock	0.20

1/8 to 1/4 mm - 51.48 %

Strongly magnetic	
Rounded magnetite, some grains with attached quartz	1.12 %
Mildly magnetic - 40.88 %	
Subangular to subround quartz	5.36
Rounded olivine and epidote	11.76
Angular and rounded pink and red garnet	14.16
Rounded rock	0.36
Rounded ilmenite and chromite	9.24
Nonmagnetic - 9.48 %	
Subangular to subround quartz	5.32
Rounded olivine and epidote	2.24
Angular and rounded pink and red garnet	1.40
Rounded rock and black mineral	0.52

1/16 to 1/8 mm - 47.08 %

Strongly magnetic	
Rounded magnetite	9.36 %
Mildly magnetic - 35.12 %	
Rounded and angular quartz	0.50
Rounded olivine and epidote	1.44
Angular pink and red garnet	3.76
Ellipsoidally rounded zircon	1.42
Rounded ilmenite and chromite	28.00
Nonmagnetic - 2.60 %	
Ellipsoidally rounded zircon	2.30
Angular quartz	0.30

Totals

Quartz and feldspar	12.72 %
Olivine and epidote	15.44
Garnet	15.32
Zircon	3.72
Magnetite	14.48
Ilmenite and chromite	37.24
Rock	1.08
Total	100.00 %

(2) Beaches from Cape Perpetua to Otter Rock

These beaches may be divided into four parts as follows: Yachats to Waldport; Waldport to Seal Rocks; Seal Rocks to Yaquina Head; and Yaquina Head to Otter Rock. The parts are considered in the order given.

The beach extending from Yachats to Waldport is easily accessible, gently graded, and cliffed over most of its extent, but the cliffs are not high except in the immediate vicinity of Waldport. There are no dunes of significance, and deposits due to wind are few. The dominant mineral composing the sands of the beach is quartz. The color of the sands as an aggregate is a pale, yellowish-gray with dark specks. There are small concentrations of sands composed of black minerals about the mouths of most of the small creeks where these cross high tide level, but none about the mouths of the large Yachats and Big creeks. It may seem strange that the small creeks show concentration and the large ones none. This is due to the different competencies of the currents of the creeks. The shore currents and waves move sands into the creeks at high tide. The small creeks move the light-weight minerals outward at low tide, but cannot move heavy minerals unless the particles are very small; hence, the heavy minerals remain in the channels and, as these channels shift after each high tide, the concentrations ultimately show in the banks. Large creeks, like Yachats, have competencies great enough to move both the light and heavy minerals out to sea. Here they may be deposited or may be returned to the beach and moved along the coast until a small creek or some barrier lowers the competencies of the currents.

A small creek about halfway between the San Marine Autocourt (this is the third small creek south of Big Creek) has quite rich concentration of black mineral particles in its channel and banks In places the sands are solidly black. Most of the black mineral particles are ilmenite and chromite. A lean deposit extends about 16 feet south of the creek to about 200 feet north. The occurrence is at the high tide level, has a width of 20 to 30 feet, and has an average thickness of not more than 2 feet. The volume is estimated at 400 cubic yards containing 43.1 percent of black minerals and 3.50 percent zircon (see detailed analysis below). Except in and immediately adjacent to the creek, the deposits are too low-grade to be of commercial importance; the creek deposits are too small in volume.

Third creek south of Big Creek south of Waldport and north of Yachats, bank of creek at high tide level, 6-inch channel. Weighted analysis (no. 4 of table).

1/4 to 1/2 mm - 2.10 %

Subangular to rounded quartz	1.40 %
Rounded rock	0.70

1/8 to 1/4 mm - 42.45 %	
Subangular to rounded quartz	25.30 %
Rounded rock	7.45
Rounded olivine and epidote	5.85
Angular pink and red garnet	3.85
1/16 to 1/8 mm - 55.45 %	
Strongly magnetic	
Rounded magnetite	6.85 %
Moderately magnetic	
Rounded ilmenite and chromite	13.90
Mildly magnetic - 30.40 %	
Angular to subangular quartz	1.15
Rounded olivine and epidote	3.40
Angular pink and red garnet	1.80
Ellipsoidally rounded zircon	0.30
Rounded ilmenite and chromite	23.75
Nonmagnetic - 4.30 %	
Angular to subangular quartz	1.10
Ellipsoidally rounded zircon	3.20
Totals	
Quartz and feldspar	28.95 %
Olivine and epidote	9.25
Garnet	5.65
Zircon	3.50
Magnetite	6.85
Ilmenite and chromite	37.65
Rock	8.15
Total	100.00 %

Two small creeks unite on the beach just north of Big Creek and are responsible for a considerable concentration of black mineral particles extending, at the high tide level, about 200 feet on each side of their junction. The width of the concentration ranges between 50 and 100 feet and the average thickness probably does not exceed 2 feet. Concentration is greatest in the creek and decreases to the north and south. It is estimated that about 1000 cubic yards is present of which about 14 percent is composed of black minerals, mainly ilmenite and chromite. Thin films of black mineral particles are found all the way from the "Big Stump" to the entrance of Alsea Bay at Waldport, but none of these is important. A 1-foot bed of black sand is exposed in the bank of the creek just south of the U.S. Coast Guard lookout on the south side of the entrance to Alsea Bay. This bed contains 11.90 percent magnetite, 54.93 percent ilmenite and chromite, and 4.47 percent zircon. A detailed analysis of this deposit is given below. The deposit is of small extent. The sands of the beaches within Alsea Bay are composed largely of quartz, are fine-grained, and show no concentration of economic minerals.

Small creek at Coast Guard lookout, south of entrance to Alsea Bay, bed a foot thick in bank of a small creek, high tide level, weighted analysis (no. 15 of table 3).

1/4 to 1/2 mm - 3.83 %	
Subangular to rounded quartz	3.17 %
Rounded olivine and epidote	0.20
Angular pink and red garnet	0.03
Rounded rock	0.43
1/8 to 1/4 mm - 27.77 %	
Strongly magnetic	
Rounded magnetite, many grains with crystal faces, some with attached quartz	0.37 %
Moderately magnetic	
Rounded ilmenite and chromite	0.80
Mildly magnetic - 15.80 %	
Angular to rounded quartz	1.03
Rounded olivine and epidote	3.53
Angular pink and red garnet	4.40
Rounded rock	0.17
Rounded ilmenite and chromite	6.67
Nonmagnetic, contains a little zircon - 10.80 %	
Angular to rounded quartz	9.00
Rounded olivine and epidote	0.47
Angular pink and red garnet	0.17
Rounded rock	1.16
1/16 to 1/8 mm - 68.40 %	
Strongly magnetic	
Rounded magnetite	11.53 %
Moderately magnetic	
Rounded ilmenite and chromite	33.60
Mildly magnetic - 19.00 %	
Angular to subangular quartz	0.67
Rounded olivine and epidote	1.70
Angular pink and red garnet	4.10
Ellipsoidally rounded zircon	0.17
Nonmagnetic	
Ellipsoidally rounded zircon	4.27
Totals	
Quartz and feldspar	13.87 %
Olivine and epidote	4.90
Garnet	8.63
Zircon	4.47
Magnetite	11.90
Ilmenite and chromite	54.93
Rock	1.30
Total	100.00 %

The sands at several places on the beach from Yachats to Waldport are reported to have been worked by Chinese for gold. Concentrations of zircon, magnetite, ilmenite, and chromite, although very rich over small areas, are too small in quantity for economic development under current conditions.

The beach from Waldport to Seal Rocks has a wide dune area between U.S. Highway 101 and the sea. The beach is gently graded and it is largely composed of pale yellowish-gray sands of which quartz is the chief mineral. There is small to moderate concentration of black mineral particles at high tide level over an area extending from 1500 to 2000 feet south of Buckley Creek. The particles of black minerals are small, concentration is in the form of thin laminae which originally seem to have been thin films on the surface of the sands. The concentration has a width of 100 to 150 feet and an extent along the beach of 500 feet. The average thickness does not exceed 2 feet. It is estimated that about 1000 cubic yards of about 25 percent concentration of black metallic minerals is available. There is little magnetite. The deposit is probably migratory. Analyses of these sands are given in table 3 (nos. 17, 18).

The beach from Seal Rocks to the south jetty of Yaquina Bay is gently graded and is largely composed of fine-grained pale yellowish-gray quartz sands. There are no gravels. Dunes margin a considerable part of the coast, most of which is cliffed to some degree. There is a lean concentration of black mineral particles about 1.5 miles north of Seal Rocks and south of the beach end of a road from Highway 101. About a quarter of a mile north of this road, a rich but interrupted concentration at high tide level extends about 850 feet along the base of the cliff. The width of the concentration ranges from 20 to 30 feet, and the thickness from a thin film at the cliff to perhaps 2 feet at a distance of 20 to 30 feet from its foot; about 700 cubic yards is available. The deposits are migratory and do not have economic importance under current conditions. Analyses of these sands are given in table 3 (nos. 19 and 20). It will be noticed that half the weight of sample 20 consists of black metallic minerals. Except for small shows of black mineral particles, there are no additional concentrations in the area extending to the mouth of Beaver Creek. There is a small to moderate concentration of black mineral particles at high tide level for 1500 to 2000 feet north of Beaver Creek. The concentrations begin at the foot of the bedrock cliffs north of Beaver Creek and extend outward from the cliffs for as much as 100 feet. The average width is much less. Thence to the south entrance of Yaquina Bay there is essentially no concentration of black mineral particles. Analyses of sands from north of Beaver Creek show an average content of a little over 2 percent magnetite, and an average content of a little over 15 percent ilmenite and chromite. There is about 7000 cubic yards of sand that has a content of metallic black minerals of approximately these percentages (nos. 21 - 23 of table 3).

The shore is cliffed from the north jetty of Yaquina Bay to the point where the town of Newport begins. The tidal zone is gently graded, narrow, and either without or with only limited deposits at the high tide level. The beach deposits consist mainly of pale yellowish-gray quartz sands with which are mingled larger particles ranging from granules to boulders. Places where water seeps from the cliffs in considerable quantity show small concentrations of garnet and black mineral particles. All sands on this beach are migratory.

The Newport beach adjacent to the municipal pavilion has a rich concentration of black sand at the high tide level. This extends along the foot of the concrete seawall for about 500 feet north of the end of the driveway to the beach, and for about 100 feet south of the south end of the seawall, a total distance of 750 to 800 feet. The average width is estimated as 50 feet. The sands contain large particles ranging from pebbles to boulders. They rest on a wave-cut rock surface and range in thickness from a thin film at the seawall to about 3 feet on the seaward margin. It is estimated that about 2000 cubic yards is present with a weighted composition of 3.20 percent zircon, 14.73 percent magnetite, and 55 percent ilmenite and chromite.

A detailed analysis of the sands of this deposit is given below:

Black sands from Newport Beach, weighted analysis

1/4 to 1/2 mm 2.43 %	
Angular to rounded quartz	2.43 %
1/8 to 1/4 mm - 73.77 %	
Strongly magnetic	
Rounded magnetite	9.27 %
Mildly magnetic - 59.80 %	
Angular to rounded quartz	2.44
Rounded olivine and epidote	4.03
Angular pink and red garnet	13.23
Rounded ilmenite and chromite	40.10
Nonmagnetic - 4.70 %	
Angular to rounded quartz	3.53
Ellipsoidally rounded zircon	1.17
1/16 to 1/8 mm - 23.80 %	
Strongly magnetic	
Rounded magnetite	5.47 %
Moderately magnetic	
Rounded ilmenite and chromite	7.20
Mildly magnetic - 9.27 %	
Angular quartz	0.40
Rounded olivine and epidote	0.37
Angular pink and red garnet	0.63
Ellipsoidally rounded zircon	0.17
Rounded ilmenite and chromite	7.70
Nonmagnetic	
Ellipsoidally rounded zircon	1.86 (fig. 4)
Totals	
Quartz and feldspar	8.80 %
Olivine and epidote	4.40
Garnet	13.86
Zircon	3.20
Magnetite	14.74
Ilmenite and chromite	55.00
Total	100.00 %

Estimating the specific gravity of the sands at about 3.5 gives a total of about 5000 tons (dry weight) which would yield 158 tons of zircon, 736 tons of magnetite, and 2,750 tons of ilmenite and chromite.

North of Jump-Off-Joe, the cliff on the north end of the town of Newport, there is a small bay which is limited on the north by Yaquina Head and is a part of what is known as Agate Beach. Big Creek flows into this bay. The beach is gently graded, is composed mainly of pale yellowish-gray quartz sands, and has no dunes on the adjacent land. The sands contain large particles ranging from pebbles to boulders. The beach of this bay contains one of the richest concentrations of metallic black minerals seen on the northern half of the coast of Oregon. In places, light-colored sands deposited by wind cover the black sands. The deposit is at high tide level and extends about 2000 feet north of Big Creek and about 700 feet south. The average width north of the creek is estimated as 30 feet and south of the creek as 75 feet. The deposits rest on a wave-cut bedrock surface. Those north of the creek are estimated to have an average thickness of 2 feet and those south, 2.5 feet. The deposits may be migratory, but this is not considered likely. It is estimated that the deposits contain about 8000 cubic yards with an average content of 4.15 percent zircon, 14.61 percent magnetite, and 53.45 percent ilmenite and chromite.

It is estimated that the deposits should average about 3 tons per cubic yard which with the percentages would yield about 1000 tons of zircon, 3500 tons of magnetite, and 12,800 tons of ilmenite and chromite. Analyses of the sands of this deposit are given in table 3 (figs. 4 - 7).

Location and Analyses of Samples
of
Sands from Heceta Head to Otter Rock

Table 3.

1. Muriel O. Ponsler Memorial State Park, 6-in. channel, high tide level, black sand.
2. Muriel O. Ponsler Memorial State Park, high tide level, garnet-black sand.
3. Muriel O. Ponsler Memorial State Park, high tide level, black sand.
4. Third creek south of Big Creek, south of Waldport, bank of creek at high tide level. 6-in. channel.
5. About 2 miles north of Yachats and 325 feet south of third creek south of Big Creek, high tide level.
6. About 2 miles north of Yachats and 200 feet south of third creek south of Big Creek, High tide level.
7. Wind drift at high tide level, about a mile north of Big Stump.
8. High tide level at Big Stump.
9. First creek north of Big Creek, top inch at high tide level.
10. First creek north of Big Creek, for 6 inches below sample 9, both at high tide level and 100 feet south of creek.
11. One hundred yards south of first creek north of Big Creek, 8-in. channel at high tide level.
12. First creek north of Big Creek, high tide level.
13. Between first and second creeks north of Big Creek, wind drift at high tide level.
14. Waldport, just south of Coast Guard Lookout on the south side of the Alsea estuary at Waldport, high tide level and wind laid from the beach.

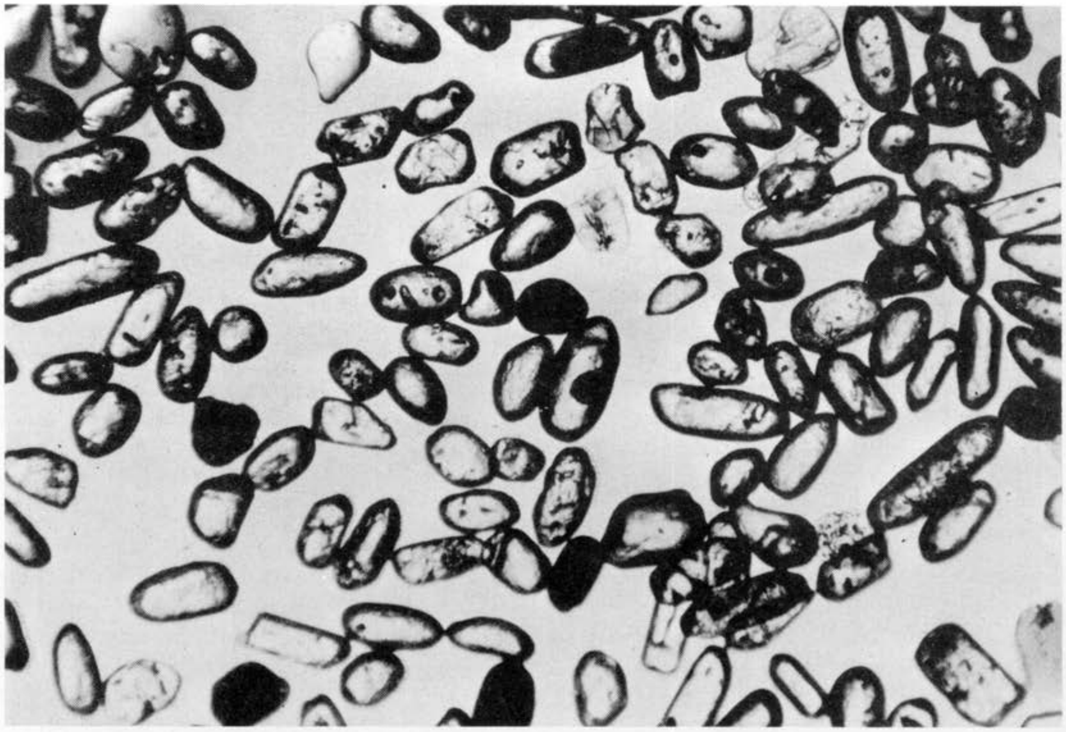

Fig. 3. Zircon concentrate from the nonmagnetic part of the 1/16–1/8 mm fraction from Newport Beach at the beach pavilion (X 80). The well-rounded grains of high relief are zircon of which many contain inclusions. As some zircon grains were extracted from the 1/16–1/8 mm fraction and included with the mildly magnetic grains, it seems obvious that the inclusions in some cases are magnetic. The dark well-rounded grains are olivine or epidote. The little rounded to angular light-colored grains are quartz. The high degree of rounding of the zircon grains is noteworthy and also noteworthy is the presence of a few grains which are little rounded. Photographed in liquid of index 1.68.

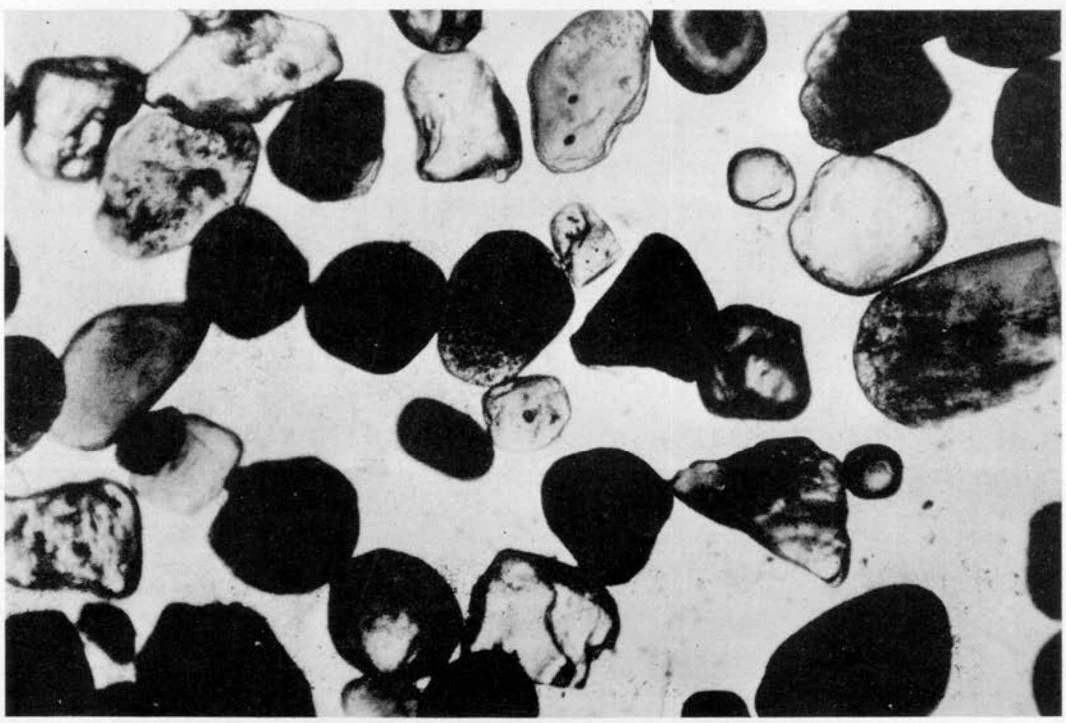

Fig. 4. The 1/4–1/2 mm fraction of sand collected 1000 feet north of Big Creek, Agate Beach. The light-colored grains are quartz of which many contain inclusions, some of which are magnetic. The well-rounded dark grains are mostly olivine and epidote; a few are pieces of rock. An occasional grain of magnetite is present. This sample is one of rich concentration of magnetic minerals and the rounding of the grains has reached a higher degree than in sands of the same beach with little to no concentration. Photographed in liquid of index 1.63.

Table 3 (Con't)

15. Bank of small creek at the Coast Guard Lookout on the south side of the Alsea estuary at Waldport. Bed a foot thick and at the high tide level.
16. Waldport, south side of estuary and seaward from the village, high tide level.
17. South of Seal Rock, about Buckley Creek, 8-in. channel at high tide level.
18. South of Seal Rock, about Buckley Creek, rich concentrate at high tide level.
19. About a mile north of Seal Rock, mid tide level.
20. About a mile north of Seal Rock, bed at foot of cliff at high tide level and bed 3 - 6-in. thick.
21. North side of Beaver Creek, high tide level.
22. Wind drifted sand at the high tide level, 250 to 300 feet south of the third creek north of Beaver Creek.
23. One-half mile north of Beaver Creek, 8-in. channel at the high tide level.
24. Newport Beach at the pavilion, high tide level, composite sample from four places.
25. On the south end of a black sand deposit on the south end of Agate Beach, about 2 miles north of Newport and south of Big Creek, high tide level.
26. Bank of Big Creek on the south end of Agate Beach and about 2 miles north of Newport, high tide level.
27. 1000 feet south of Big Creek on the south end of Agate Beach, high tide level.
28. 600 feet north of Big Creek on the south end of Agate Beach, high tide level.
29. High tide level at a creek about a mile north of the lighthouse.

Mechanical Analyses of Sands
Heceta Head to Otter Rock

No.	greater than 2 mm	1-2 mm	1/2-1 mm	1/4-1/2 mm	1/8-1/4 mm	1/16-1/8 mm	less than 1/16 mm	Remarks
1.				1.80	60.75	37.45		Black sand
2.					56.75	43.25		" "
3.				1.44	51.48	47.08		" "
4.				2.10	42.45	55.45		
5.				11.55	73.35	15.10		
6.				4.90	66.30	28.80		
7.				5.45	92.40	2.15		
8.				7.85	87.05	5.10		
9.				1.05	37.50	61.45		" "
10.				1.60	87.40	11.00		
11.				3.45	70.15	26.40		" "
12.				3.15	58.85	38.00		" "
13.				33.40	66.60	trace		
14.				4.15	93.95	1.90		
15.				3.83	27.77	68.40		" "
16.				11.35	87.50	1.15		
17.				1.05	76.60	22.35		
18.				0.93	48.67	50.40		" "
19.				8.30	90.85	0.85		Mid tide
20.				6.83	41.20	51.97		Black sand
21.				4.20	81.75	14.05		" "
22.				6.00	80.00	14.00		" "
23.				5.08	74.36	20.56		" "
24.				2.43	73.77	23.80		" "
25.				0.85	50.35	48.80		" "
26.				trace	32.24	67.76		" "
27.				"	36.80	63.20		" "
28.					15.80	84.20		" "
29.				37.60	61.90	0.50		" "

Mineral Analyses of Sands
Heceta Head to Otter Rock
(Percent)

No.	Quartz Feldspar	Olivine Epidote	Garnet	Zircon	Magnetite	Ilmenite Chromite	Rock	Remarks
1.*	38.50	21.00	11.75	2.15	1.95	12.45	11.75	Hb. 0.45 black san
2.*	12.75	9.65	19.60	4.10	6.15	46.90	0.85	Black sand
3.*	12.72	15.44	15.32	3.72	14.48	37.24	1.08	" "
4.*	28.95	9.25	5.65	3.50	6.85	37.65	8.15	" "
5.	66.30	13.95	1.50	common	1.25	13.65	3.35	" "
6.	53.30	10.15	3.10	0.00	trace	32.40	1.05	" "
7.	76.80	4.90	trace	0.00	0.00	9.20	9.10	
8.	92.30	2.70	0.00	0.00	0.00	1.35	3.65	
9.*	25.35	10.10	8.95	2.15	6.80	42.80	3.85	" "
10.	73.05	8.40	2.20	0.00	trace	10.65	5.70	
11.*	58.35	15.70	2.50	1.00	1.95	14.60	3.05	Hb. 2.85*
12.*	52.25	15.65	4.10	1.25	4.65	16.60	5.50	
13.	93.55	trace	trace	0.00	0.00	0.00	6.45	
14.	90.50	trace	trace	0.00	trace	trace	9.50	
15.*	13.87	4.90	8.63	4.47	11.90	54.93	1.30	Black sand
16.	81.80	1.95	0.15	0.00	trace	0.50	15.50	
17.	72.35	5.10	1.95	0.35	1.00	11.50	7.75	
18.*	39.60	8.13	5.13	1.50	3.40	34.24	8.00	" "
19.		Nearly 100 percent quartz						Mid tide
20.*	21.47	9.30	5.37	3.16	7.27	50.53	3.00	Black sand
21.	62.75	12.05	1.25	rare	2.05	21.90	0.00	" "
22.	58.05	11.45	2.30	0.00	1.70	8.40	18.05	" " Shell 0.05
23.	66.96	5.44	0.92	common	2.44	14.88	9.36	Black sand
24.*	8.80	4.43	13.87	3.17	14.73	55.00	0.00	" "
25.*	14.20	12.70	19.45	3.70	10.20	39.15	0.60	" "
26.*	8.76	13.28	14.40	3.76	15.08	44.72	0.00	" "
27.*	4.52	5.72	6.16	3.76	16.72	62.84	0.28	" "
28.*	1.60	4.04	4.52	5.40	16.44	67.12	0.88	" "
29.	90.15	0.65	trace	rare	trace	trace	9.20	

* Denotes percentage by weight, that is, adjusted to specific gravities.

Yaquina Bay has an extensive beach, tidal flat, and dune area on its south side which is known as South Beach. The beach and tidal flat have been reported to have a concentration of zircon and metallic black minerals consisting of magnetite, ilmenite, and chromite. Samples collected from the beach and tidal flat do not check such a report. A plant-covered flat area above ordinary high tide level has a considerable concentration of the metallic black minerals in the 3 to 4 inches just below the soil layer, but the quantities are not sufficiently large for commercial extraction. These deposits may have been made by high waves which brought a mineral aggregate but which returned the light minerals to the sea and left behind the heavy minerals. The deposits may also have been brought by winds which left the heavy minerals where they now lie and carried the light minerals into the dunes beyond. Analyses of the sands of the grass-covered area are given in nos. 31 and 32 of table 5.

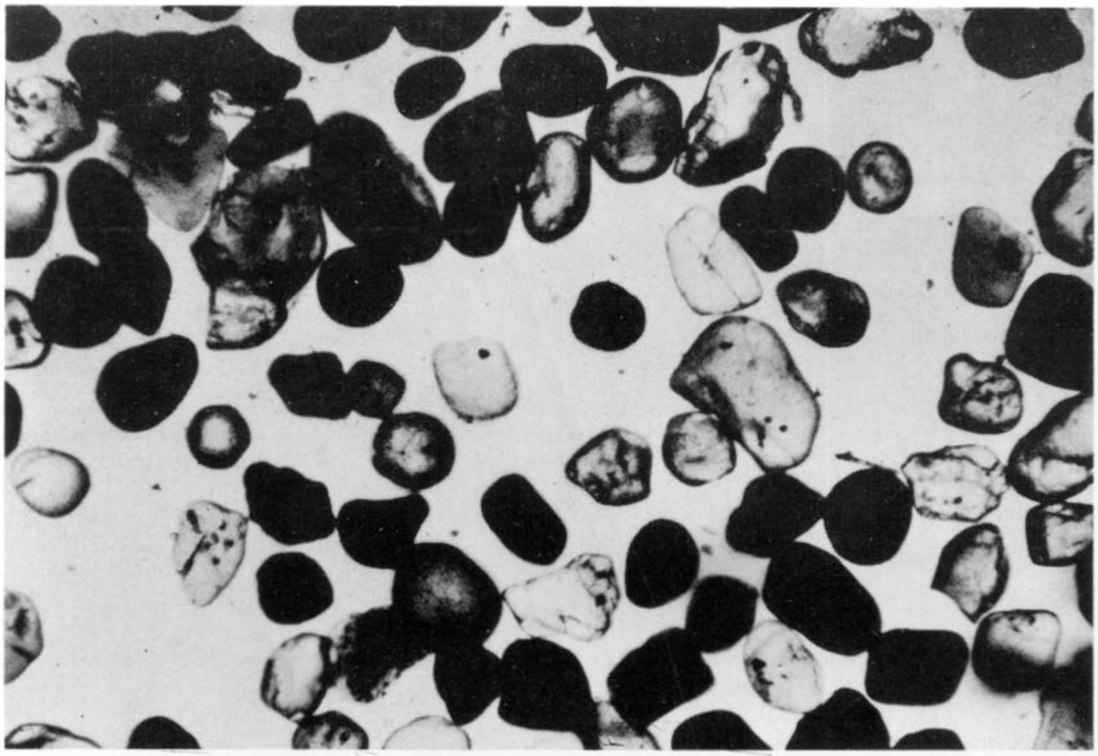

Fig. 5. The 1/8–1/4 mm fraction of the same sands as Figs. 4 and 6 (X 80). The well-rounded dark grains are mostly olivine and epidote. A few well-rounded grains of high relief are zircon and some well-rounded black grains are magnetite, ilmenite, or chromite. The light-colored grains are quartz of which many contain inclusions. Some of the quartz grains are not well rounded. Highly angular grains are either quartz or garnet. Sands immersed in liquid of index 1.63 when photographed.

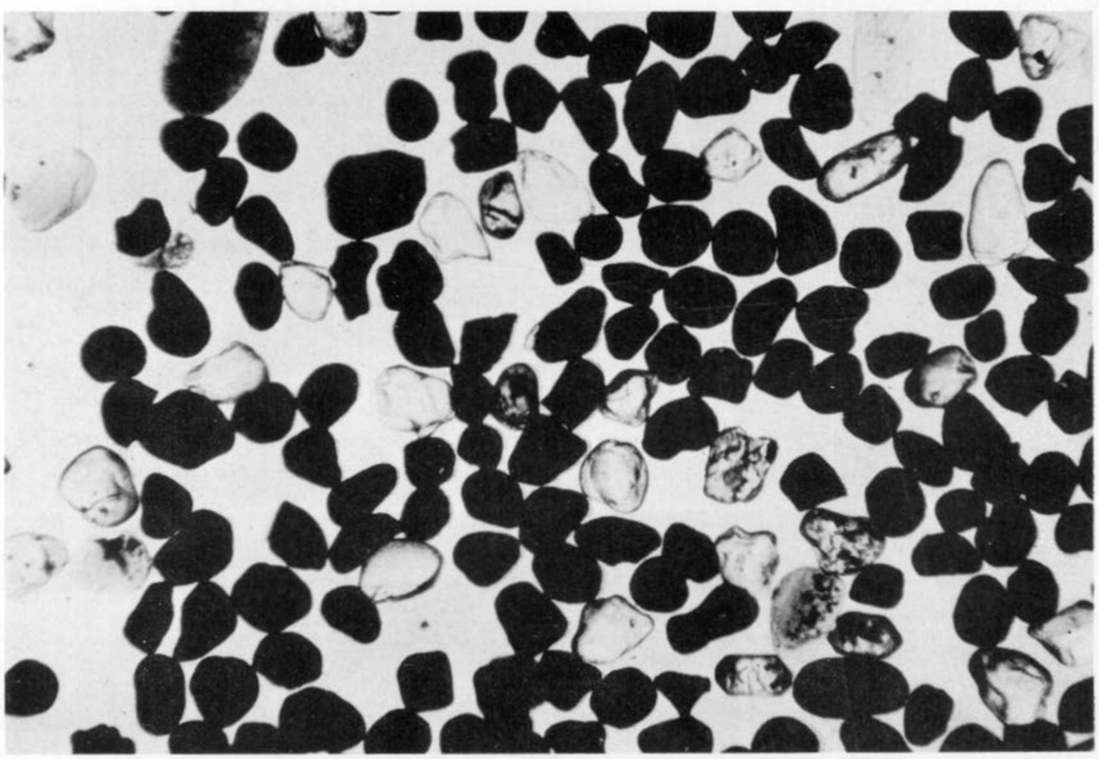

Fig. 6. The 1/16–1/8 mm fraction of the same sands as Figs. 4 and 5 (X 80). The fairly well-rounded black grains are mainly magnetite, ilmenite, or chromite. These have shiny, polished surfaces. The angular light-colored grains are quartz or garnet, the former containing inclusions. The ellipsoidally rounded grains of high relief are zircon. Sands were immersed in liquid of index 1.68 when photographed.

The deposits of the dunes were, of course, made by winds which brought the sands from the beach, left those composed of heavy minerals in the seaward dunes, and carried the light minerals inland. The deposits in the dunes were sampled by channelling. It is estimated that there is present 10,000 to 15,000 cubic yards of wind concentrates in the fore dune with compositions as shown by the analyses given in table 4. A composite analysis by weight of all the samples shows 1.50 percent zircon, 2.53 percent magnetite, and 31.50 percent ilmenite and chromite. If the sands are estimated at 2 tons per cubic yard, they would yield 300 tons of zircon, 500 tons of magnetite, and 6300 tons of ilmenite and chromite. A weighted analysis of no. 2 of table 4 is shown below:

Fore dune of South Beach, Yaquina Bay, 3-foot channel from middle of dune, weighted analysis.

1/8 to 1/4 mm = 52.90 %	
Angular to rounded clear quartz	12.50 %
Rounded yellow quartz	5.00
Rounded olivine and epidote	17.60
Angular pink and red garnet	4.85
Rounded magnetite	0.40
Rounded ilmenite and chromite	10.15
Rounded rock	2.40
1/16 to 1/8 mm = 47.10 %	
Angular to round clear quartz with common ellipsoidally rounded zircon	2.50 %
Rounded olivine and epidote	5.25
Angular pink and red garnet	4.70
Rounded magnetite	2.85
Rounded ilmenite and chromite	31.80
Totals	
Clear quartz and feldspar	15.00 %
Yellow quartz	5.00
Olivine and epidote	22.85
Garnet	9.55
Magnetite	3.25
Ilmenite and chromite	41.95
Rock	2.40
Total	100.00 %

Mechanical Analyses of Sands
South Beach, Yaquina Bay

Table 4.

No.	greater than 2 mm	1-2 mm	1/2-1 mm	1/4-1/2 mm	1/8-1/4 mm	1/16-1/8 mm	less than 1/16 mm	Remarks
1.				2.30	73.40	24.30		2.5-ft. channel, west side of dune.
2.				trace	52.90	47.10		3-ft. channel, middle of dune.
3.				5.84	73.44	20.72		2-ft. channel, middle of dune.
4.				0.90	93.65	5.45		3-ft. channel, east side of dune.
5.				0.15	57.05	42.60	0.20	Wind drift, 150 feet from high tide.
6.				2.00	67.37	30.63		Composite, 1-5.
7.				0.90	93.65	5.45		Wind deposit on Ferry road.

Mineral Analyses of Sands
South Beach, Yaquina Bay
(Percent)

No.	Quartz	Olivine Epidote	Garnet	Zircon	Magnetite	Ilmenite Chromite	Rock	Remarks
1.	47.90	13.50	3.40	0.00	1.90	26.20	7.10	
2.	25.10	23.55	8.60	common*	3.25	36.55	2.95	
3.	46.52	13.28	8.24	common	1.48	26.12	4.36	
4.	40.00	14.95	6.10	0.00	5.35	33.60		
5.	21.50	21.05	10.85	common*	7.75	38.15	0.70	Silt
6.*	29.53	14.00	15.60	1.50	2.53	31.50	5.34	Composite, 1-5
7.		Mostly quartz		rare	trace	trace		

* Denotes percentage by weight, that is, adjusted for specific gravities.

The tidal flat of Yaquina Bay is exposed at low tide for 300 to 400 feet, and the composing sediments are mainly fine sands as shown by the analyses. They also contain a little clay and silt, together with a little organic matter and some iron sulphide. The proportion of clay and silt is small and is composed largely of finely divided quartz and hydrous silicates. Occasionally a small quantity of magnetic minerals is present, but they are not common. The sands beneath the surface are dark brown to black, largely from the iron sulphide. The deposits are the dwelling place of many sand- and mud-eating animals among which there are at least one crustacean, two or more pelecypods (clams), and some wormlike organisms. The pelecypods maintain openings to the surface and periodically eject water filled with sand. The sand forms small mounds around the openings. These mounds contain more heavy minerals than other parts of the tidal flat deposits. An analysis of the materials of the clam mounds is given in no. 30 of table 5.

The sands are literally kneaded by the burrowing of the animals which dwell in them and it is not unlikely that most, if not all, of the constituents of the deposits have made one or more passages through the intestinal tracts of these organisms. They eject large quantities of materials on the surface around openings which they maintain, and it is likely that mixing is complete to the depths to which the activities of the organisms now extend or have extended in the past. Ejection of materials on the surface seems to be done mostly by clams, and the little mounds with openings in the center cover the surface by the thousands. Some animals produce cylindrical excrements. These are small and approximate 1 mm or less in diameter and are about twice as long. The composing materials are fine sands which seem to be bound together with some organic substance. As Yaquina Bay is the drowned lower end of a river valley submerged during the late Pleistocene and Recent, the mixing probably began before and proceeded during the entire time of submergence. Because of the mixing, the deposits are considered to be homogeneous from top to bottom; thus, samples of the top part are representative of the whole. The mixing seems quite generally to have destroyed stratification which has been seen only in overlying wind deposits and in those very recent or other deposits which have not been subjected to the activities of the organisms.

The small quantity of silt and clay in the tidal flat deposits makes it possible to push or drive a pipe into them, and sampling below the surface was first attempted by means of an open pipe. The pipe was easily driven to the depths desired, but it was always empty when pulled. A peat sampling device was borrowed from Professor H. P. Hansen of the Botany Department of Oregon State College at Corvallis, but it failed to work because the fine sands entered and "froze" the closing mechanism. A soil sampling device borrowed from Professor C. V. Rusek of the Soils Department of the same institution failed to work for the same reason. Core samples were finally obtained by means of a device made for the purpose by Chief C. C. Ralph of the Portland Fire Department with subsequent modifications by Dr. W. D. Lowry of the Oregon Department of Geology and Mineral Industries, and by the writer.

Sampling of the surface materials was done at low tide level. The stations are indicated in the diagram of figure 8 by letters A to G. Channel sampling was not possible in these positions, but was possible at high and mid tide levels on the sides of pits dug in the sands to depths ranging to about 2 feet (fig.8). The deposits were core sampled at high and low tide levels to a depth of about 5 feet by means of the core sampler devised by Chief Ralph. Figure 9 shows stations of the surface and channel sampling, and figure 3 shows the stations of core sampling. At most stations where core sampling was done, two samples were collected of which one extends from the surface to the depth penetrated (about 5 feet), and the other is from the bottom of the hole. The former is designated "composite," the latter, "single."

Results of the analyses of the surface and channel samples collected are shown in tables 5 and 6. Composites of samples 1 to 7; 8 to 12, 15, 16, and 19 to 21; and 14, 17, and 22 to 24 are given in nos. 27, 28, and 29 of table, and composites of core samples in nos. 42, 43, and 44 of table 7. These analyses show that about 80 percent of the sands is in the 1/8 to 1/4 mm range; that in only six cases is the quantity in the 1/4 to 1/2 mm range greater than 15 percent; that the composition is largely quartz and rock; and that zircon is rare, magnetite about 0.35 percent, and ilmenite and chromite about 4 percent. These values are small and do not justify any attempt at development. The analyses also show that the samples collected at all places have about the same dimensional composition.

Mechanical Analyses of Channel Samples[1]
South Beach, Yaquina Bay
Table 5.

No.	greater than 2 mm	1-2 mm	1/2-1 mm	1/4-1/2 mm	1/8-1/4 mm	1/16-1/8 mm	less than 1/16 mm	Remarks
1.			0.35	9.15	84.10	6.40		
2.				10.10	80.15	8.85	0.90	
3.				12.95	80.35	5.90	0.80	
4.				11.55	79.30	8.90	0.25	
5.				12.85	78.85	8.15	0.15	
6.				11.35	78.90	9.60	0.15	
7.				12.10	80.10	7.50	0.30	
8.				14.40	79.55	5.70	0.35	
9.				4.45	85.80	7.75	2.00	
10.			0.25	15.10	75.15	9.35	0.15	
11.				7.90	81.10	8.35	2.65	
12.				8.50	77.40	10.25	3.85	
13.				8.10	78.90	6.45	6.55	
14.			trace	6.30	81.15	10.15	2.40	
15.				7.05	79.45	10.00	3.50	
16.				9.80	79.20	8.45	2.55	
17.				5.30	81.40	12.55	0.75	
18.				6.50	76.00	16.00	1.50	
19.				7.30	77.70	14.05	0.95	
20.			trace	2.50	74.10	22.00	1.40	
21.				4.35	82.35	12.40	1.00	
22.				5.75	80.50	12.65	1.10	
23.				2.10	78.00	19.45	0.45	
24.				6.05	79.75	12.70	1.60	
25.				4.50	61.40	33.60	0.50	Bay end of Ferry Road.
26.			trace	11.50	79.75	8.75	trace	Extreme west side.
27.			trace	13.10	80.80	5.90	0.20	Composite, 1-7.
28.*			trace	6.35	80.25	11.40	2.00	Composite, 8-12 15, 16, 19-21.
29.*				5.60	80.50	12.50	1.40	Composite, 14, 17, 22-24.
30.				3.35	73.00	22.25	1.40	Clam mounds.
31.				5.70	76.65	17.25	0.40	Channel in grassland.
32.				8.30	70.20	9.95	11.55	Channel in grassland.

[1]Note position on fig. 1 for tide level.

*Denotes percentage by weight.

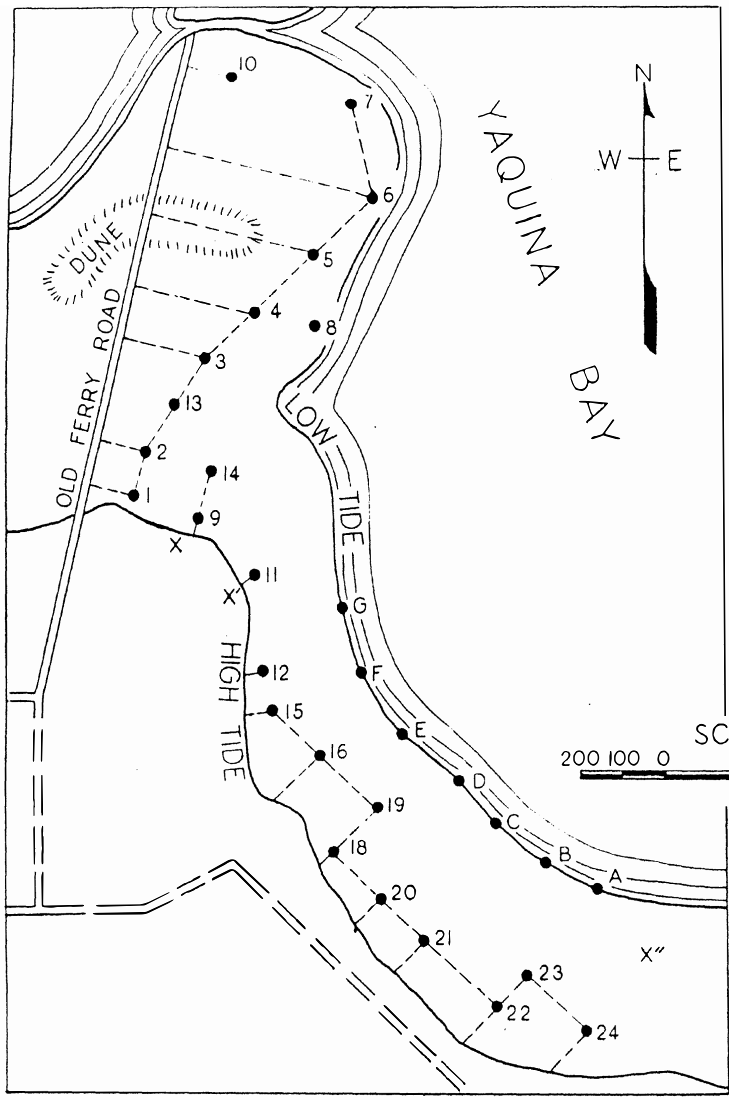

Fig. 8. Location of channel and surface samples on South Beach, Yaquina Bay. Letters A to G show the location of surface samples. Numbers 1 to 25, 31, and 32 show where channel samples were collected from the sides of pits. The pits ranged in depth from 2.5 to 3 feet. X indicates position of a cabin; X', a barge; and X", a wrecked boat. Stations shown by figures are at the high tide and mid-tide levels. The line of stations

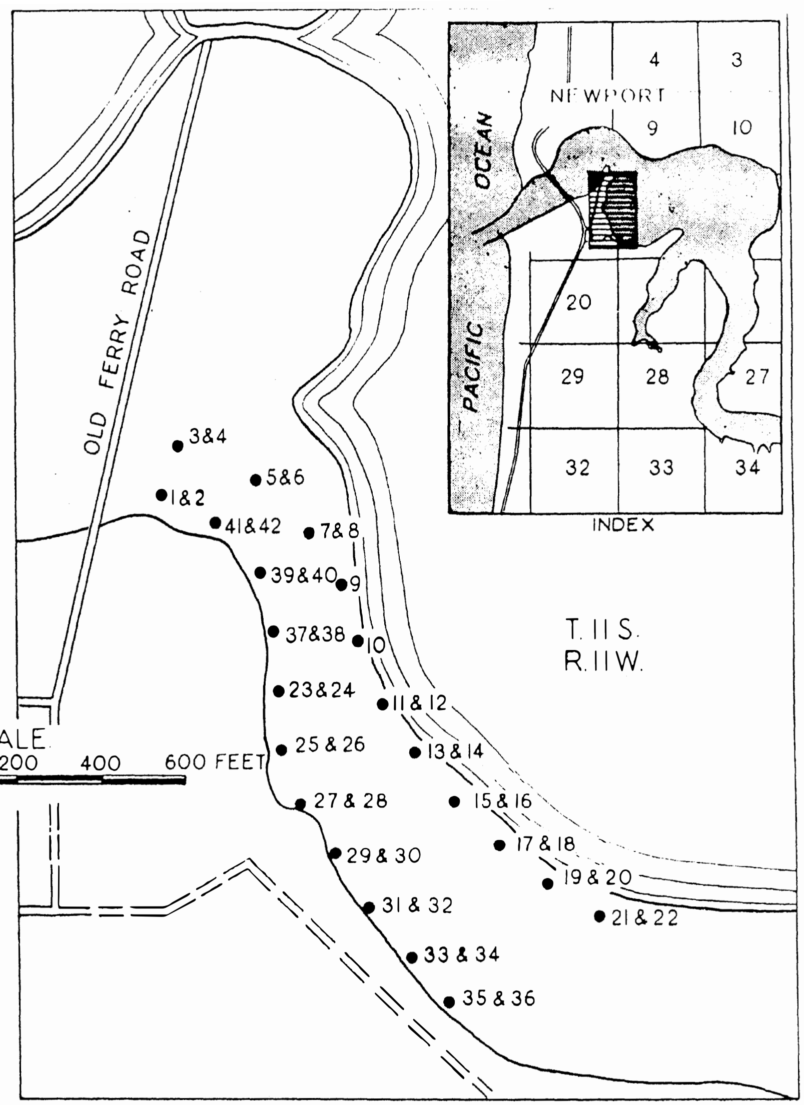

Fig. 9. Diagram showing position of core samples and samples collected at the approximate depth of 5 feet, on South Beach, Yaquina Bay. Two samples were generally collected, one designated composite, which is a core through 5 feet, and another designated single, which was acquired from the depth of 5 feet. Positions on the two tide levels are approximately 150 feet apart.

Mineral Analyses of Channel Samples
South Beach, Yaquina Bay
(Percent)

No.	Rock Quartz	Olivine Epidote	Garnet	Zircon	Magnetite	Ilmenite Chromite	Clay Silt
1.				rare	1.40		0.00
2.				"	0.45		0.90
3.				"	0.30		0.80
4.				"	0.45	2.95	0.25
5.				none	trace	trace	0.15
6.				rare	0.70	"	0.15
7.				"	0.30		0.30
8.				"	0.35		0.35
9.				"	0.45		2.00
10.				"	0.95		0.15
11.	92.70	trace	trace	none	0.50	4.15	2.65
12.				rare	0.25		3.85
13.				"	0.25		6.55
14.	90.20	1.50	0.45	"	0.55	4.90	2.40
15.	86.85	1.90	0.50	none	0.50	5.35	rock 1.40 clay 3.50
16.		present	present	"	0.55	1.25	2.50
17.				rare	0.50		0.75
18.				occasional	1.10	5.00	1.50
19.	52.80	7.90	4.10	rare	0.60	6.75	rock 26.90 clay 0.95
20.	0.25	2.10	1.35	common	2.45	12.55	1.30
21.	91.00	6.05	1.25	rare	0.80		0.90
22.				"	0.90		1.10
23.	82.50	4.05	1.85	occasional	1.10	10.05	0.45
24.				rare	0.40		1.10
25.	48.75	14.05	7.90	occasional	3.20	25.50	0.50
26.	83.20	1.00	1.20	rare	0.50	4.10	trace
27.	71.55	2.80	2.45	"	0.25	2.15	rock 20.60 clay 0.20
28.*	60.95	6.35	2.05	"	0.50	7.65	rock 20.50 clay 2.00
29.*	63.00	10.20	2.05	"	0.30	3.70	rock 19.35 clay 1.40
30.*	42.95	6.65	7.90	0.45	1.60	12.85	rock 26.20 clay 1.40
31.	86.15	2.30	0.80	rare	1.65	8.70	0.40
32.				"	0.45		11.55

*Denotes percentage by weight.

Mechanical Analyses of Sands
Low Tide Level, South Beach, Yaquina Bay
Table 6.

No.	greater than 2 mm	1-2 mm	1/2-1mm	1/4-1/2 mm	1/8-1/4 mm	1/16-1/8 mm	less than 1/16 mm	Remarks
A				10.40	80.30	7.45	1.85	
B			trace	8.60	80.40	9.70	1.30	
C				7.50	79.85	11.00	1.65	
D			"	7.00	80.85	11.15	1.00	
E				6.30	77.25	15.25	1.20	
F				7.30	82.40	9.05	1.25	
G				0.90	53.20	45.90		Surface inch
H			"	6.05	82.35	10.25	1.35	Composite A - F

Mineral Analyses of Sands
Low Tide Level, South Beach, Yaquina Bay
(Percent)

No.	Quartz Feldspar	Olivine Epidote	Garnet	Zircon	Magnetite	Ilmenite Chromite	Rock	Clay Silt
A				0.00	0.50			1.85
B				0.00	0.35			1.30
C				rare	0.55			1.30
D				"	0.55			2.00
E	87.15	5.30	2.05	"	0.80	3.50		1.20
F	60.45	10.30	2.30	"	1.50	2.00	22.20	1.25
G	22.10	11.90	6.10	common	9.20	50.50	0.20	
H	63.40	8.85	3.25	rare	0.10			

Mechanical Analyses of Core Samples
South Beach, Yaquina Bay
Table 7.

No.	greater than 2 mm	1-2 mm	1/2-1 mm	1/4-1/2 mm	1/8-1/4 mm	1/16-1/8 mm	less than 1/16 mm	Remarks
1.			trace	11.20	79.80	7.50	1.50	Single, high tide
2.			"	9.35	86.20	4.05	0.40	Composite, " "
3.			"	6.65	83.85	9.00	0.50	" " "
4.			"	11.80	79.65	6.10	2.45	Single, low "
5.			"	9.50	79.45	9.00	2.05	Composite, " "
6.			"	16.55	71.25	9.80	2.40	Single, " "
7.								Lost, " "
8.			0.65	20.55	66.40	10.35	2.05	Single, " "
9.		0.60	0.45	9.20	77.00	7.75	5.00	Composite, " "
10.			0.30	13.35	63.90	11.45	11.00	" " "
11.			trace	12.35	76.25	7.95	3.45	" " "
12.			0.65	19.10	72.40	5.60	2.25	Single, " "
13.			0.20	12.60	80.45	6.00	0.75	Composite, " "
14.			0.25	14.15	77.30	6.40	1.90	Single, " "
15.			trace	9.55	82.30	7.30	0.85	Composite, " "
16.			"	15.10	76.55	7.20	1.15	Single, " "
17.			"	9.05	80.45	10.00	0.50	Composite, " "
18.			"	12.60	77.10	9.20	1.10	Single, " "
19.			"	9.85	78.15	10.85	1.15	Composite, " "
20.			"	14.75	75.90	7.25	2.10	Single, " "
21.			"	7.80	80.15	11.15	0.90	Composite, " "
22.			"	14.60	71.95	8.05	5.40	Single, " "
23.				11.00	79.40	8.20	1.40	Composite, high "
24.			"	11.00	79.40	8.20	1.40	" " "
25.			"	7.40	82.65	8.25	1.70	" " "
26.								Lost, " "
27.				8.25	82.15	9.20	0.40	Composite, " "
28.			"	14.30	79.00	6.00	0.70	Single, " "
29.				7.80	81.50	10.30	0.40	Composite, " "
30.			"	11.55	81.20	6.65	0.60	Single, " "
31.								Lost, " "
32.				11.50	81.70	6.50	0.30	Single, " "
33.				9.45	78.80	11.45	0.30	Composite, " "
34.			0.10	13.20	80.05	5.40	1.25	Single, " "
35.				6.05	83.85	9.60	0.50	Composite, " "
36.		0.15	0.20	13.55	77.90	7.10	1.10	Single, " "
37.			trace	11.90	80.00	7.20	0.90	Composite, " "
38.			0.40	15.15	76.45	6.40	1.60	Single, " "
39.				8.15	78.60	12.00	1.25	Composite, " "
40.			0.15	13.15	79.25	6.70	0.75	Single, " "

Mechanical Analyses of Table 7 (Cont.)

No.	greater than 2 mm	1-2 mm	1/2-1 mm	1/4-1/2 mm	1/8-1/4 mm	1/16-1/8 mm	less than 1/16 mm	Remarks
41.			trace	8.40	83.85	7.15	0.60	Composite, high tide
42.*		0.05	0.05	13.15	78.00	6.00	1.85	Composite or composites from 5 ft.
43.*			0.05	12.55	77.60	8.30	1.50	Composite or composites from 5 ft., low tide.
44.*				9.70	80.05	9.15	1.10	Composite or composites from 5 ft., high tide.

*Denotes percentages by weight.

Mineral Analyses of Core Samples
South Beach, Yaquina Bay
(Percent)

No.	Quartz Feldspar	Olivine Epidote	Garnet	Zircon	Magnetite	Ilmenite Chromite	Rock	Clay Silt	Remarks
1.				occasional	trace			1.50	
2.	66.60	4.40	1.10	rare	0.45	1.45	25.60	0.40	
3.	61.50	8.65	4.45	"	0.75	2.90	21.25	0.50	
4.	61.08	0.30	0.30	"	1.00	1.45	23.42	2.45	
5.				"	0.30			2.05	
6.	59.85	5.50	1.55	"	0.45	3.70	26.70	2.40	0.25 shell
7.									
8.				"	0.35			2.05	
9.				"	0.30			5.00	
10.	56.70	6.05	2.60	"	0.30	4.60	18.65	11.00	0.10 shell
11.				"	0.50			3.45	
12.				"	0.40			2.25	
13.	58.00	3.20	3.80	"	0.40	2.20	31.65	0.75	
14.	71.15	4.35	1.95	"	0.50	3.00	17.15	1.90	
15.	70.45	4.90	1.35	"	0.15	3.85	18.60	0.70	
16.				"	0.30			1.15	
17.				occasional	0.95			0.50	
18.				rare	0.65			1.10	
19.				"	0.70			1.05	
20.				"	0.20			2.10	
21.				"	0.50			0.90	
22.				"	0.25			5.40	
23.				"	0.35			1.40	
24.				"	0.40			2.00	
25.	67.60	9.10	0.95	"	0.35	3.15	17.15	1.70	
26.									
27.				"	0.45			0.40	
28.				"	0.35			0.70	
29.	60.10	13.50	3.25	"	0.40	4.75	17.60	0.40	
30.				"	0.25			0.60	
31.									
32.	69.00	5.35	1.80	"	0.60	2.45	20.50	0.30	
33.				common	0.65			0.30	
34.	63.65	6.85	1.10	rare	0.35	1.50	25.30	1.25	
35.				"	0.50			0.50	
36.				"	0.20			1.10	
37.				"	0.35	0.35		0.90	
38.				"	0.45			1.60	
39.				"	0.55			1.25	

Mineral Analyses of Table 7 (Cont.)

No.	Quartz Feldspar	Olivine Epidote	Garnet	Zircon	Magnetite	Ilmenite Chromite	Rock	Clay Silt	Remarks
40.	63.85	4.45	3.05	rare	0.55	3.10	24.30	0.70	
41.				"	0.40			0.60	
42.	63.50	3.85	1.90	"	0.60	1.85	26.45	1.85	0.10 mica
43.	58.90	8.55	2.50	"	0.40	2.80	25.35	1.50	
44.	59.10	7.95	5.35	"	0.45	10.90	15.20	1.05	

The several deposits of black mineral concentrates in the Newport region can be summarized as follows:

		Zircon	Magnetite	Ilmenite and Chromite
South Beach	10,000 cubic yards	300 tons	500 tons	6,300 tons
Newport Beach	2,000 " "	150 "	730 "	2,750 "
Beach at Big Creek	8,000 " "	1,000 "	3,500 "	12,800 "
Total	20,000 cubic yards	1,450 tons	4,730 tons	21,850 tons

This is a respectable quantity of useful minerals. It is believed that the estimates are conservative.

Between Yaquina Head and Otter Rock, there is a fine gently graded beach composed mainly of pale yellowish-gray quartz sands with black specks. Five creeks flow across this beach, each having a small concentration of black mineral particles in its channel at the high tide level. None is important. There is some concentration of particles of black rocks to form black sands in a small bay between Otter Rock and Otter Crest.

The beach from Cape Perpetua to Otter Rock is one of the richest in zircon and metallic black minerals on the northern part of the coast of Oregon, and ultimately the black sands in the vicinity of Newport may be developed. The other sands of the beaches in this vicinity have little economic importance.

(3) Beaches from Boiler Bay to Cascade Head

These beaches may be divided into three sections, as follows: Boiler Bay to and including Siletz Bay; Siletz Bay to Surf Tides; and Wecoma Beach from Surf Tides to Roads End.

The beach between Boiler Bay and the north end of the spit separating Siltez Bay from the sea is covered with medium-grained sands which contain an abundance of particles of black rock believed to have been derived from the coastal rocks south of Boiler Bay. The sands are among the coarsest on the northern part of the coast of Oregon and are piled in a great beach ridge which slopes steeply to the sea and gently or not at all inland. The ridge is several hundred feet outward from the cliff which follows the coast to the beginning of the dune-crowned Siletz Bay spit. So much sand is brought from the cliffs to the south that the shore currents are unable to carry it away. The cliffs are high and contain much black lava. They are undergoing active erosion and their height increases the quantity of shore materials for distribution in the beach materials. Many small particles of black rock are thus present in the sands which are thus somewhat darker in color than the sands of most Oregon beaches. There are no concentrations of black mineral particles, but there are concentrations of black rock. Analyses are given in table 8.

Location and Analyses of Samples
of
Sands from Boiler Bay to Cascade Head

Table 8.

1. Gleneden Beach, high tide level.
2. North side of entrance to Siletz Bay, high tide level.
3. One mile north of north side of entrance to Siletz Bay, high tide level.
4. Same place as number 3, high tide level.
5. Two and a half miles north of north side of entrance to Siletz Bay, high tide level.
6. Delake, bank of stream at high tide level.
7. Foot of cliff, 1800 feet north of Delake, high tide level.
8. Foot of cliff about a half mile north of Surf Tides Hotel, rich deposit at high tide level, about 20 by 100 feet.
9. About two miles north of Surf Tides Hotel, high tide level.
10. South end of houses, Cascade Head, high tide level.
11. Foot of cliff south of Cascade Head, high tide level.

Mechanical Analyses of Sands
Boiler Bay to Cascade Head

No.	greater than 2 mm	1-2 mm	1/2-1 mm	1/4-1/2 mm	1/8-1/4 mm	1/16-1/8 mm	less than 1/16 mm	Remarks
1.	0.50	4.85	38.70	54.70	1.20			H.T. level, cement sand
2.	1.70	10.67	69.13	18.00	0.50			" " " " "
3.			3.25	89.65	7.10			" " " " "
4.			22.50	75.97	1.53			" " " " "
5.			30.00	66.60	3.40	trace		" " " " "
6.				36.40	47.20	16.40		" " " " "
7.			4.88	54.36	38.72	2.04		" " " black sand
8.				3.00	54.50	42.50		" " " rich black sand
9.				0.36	50.00	49.64		" " " black sand
10.				97.20	0.15	2.65		" " " cement sand
11.				19.12	51.04	29.84		" " " rich black sand

Mineral Analyses of Sands
Boiler Bay to Cascade Head
(Percent)

No.	Quartz Feldspar	Olivine Epidote	Garnet	Zircon	Magnetite	Ilmenite Chromite	Rock	Others	Remarks
1.	64.10			0.00			35.85	shell 0.05	
2.	55.93	1.40	0.17	0.00	trace	trace	41.37	1.13	
3.	75.60	1.60		0.00			22.80		
4.	67.67	5.00		0.00			26.93	0.40	
5.	72.70	3.20		0.00			24.10		
6.	41.00	17.75	1.20	rare	7.40	25.65	7.00		
7.*	21.28	12.16	5.24	0.00	12.40	46.80	5.12		
8.*	1.90	3.05	3.35	1.90	9.75	79.35	0.70		
9.	41.08	12.92	4.28	rare	6.28	33.52	1.92		
10.	79.80	9.00	0.85	0.00	trace	2.25	8.10		
11.*	28.64	11.40	3.28	1.00	6.92	44.64	4.12		

* Denotes percentage by weight.

The beaches and tidal flats of Siletz Bay, large areas of the bottom of which are exposed at low tide, are composed of fine-grained pale yellowish-gray quartz sands mixed with small percentages of particles of clay and silt, together with some organic matter and small particles of dark-colored rock.

The abundance of particles of black rock in the sands from Boiler Bay to the end of the spit of Siletz Bay compared to the relatively small proportion of such particles between Yaquina Head and Otter Rock should prove conclusively that the main movement of sands over this part of the beach is northward. Otherwise the sands from Otter Rock to Yaquina Head should be as abundantly filled with particles of black rock as are those north of Boiler Bay.

The beach north of the entrance to Siletz Bay is covered with medium-grained sands for about one-third of the distance to Delake. The sands form a beach ridge which slopes steeply to the sea, but is either gently or not at all inclined inland. The beach ridge disappears about a third of the distance from Siletz Bay to Delake and the beach becomes gently graded. The sands have a pale yellowish-gray color with dark specks. They are composed mainly of quartz but contain many particles of black rock which probably were derived from the cliffs south of Boiler Bay. In places, these black particles of rock are concentrated to make deposits of black sands. A detailed analysis of sands from high tide level on the north side of the entrance to Siletz Bay is as follows:

North side of entrance to Siletz Bay (no. 2 of table 8). High tide level. Not weighted.

<u>2 mm - 1.70 %</u>	
Rock	1.50 %
Shell	0.20
<u>1 to 2 mm - 10.67 %</u>	
Subangular quartz and feldspar	0.90 %
Rounded rock	9.24
Shell	0.53
<u>1/2 to 1 mm - 69.13 %</u>	
Subangular to rounded quartz	41.30 %
Subround olivine and epidote	1.23
Subround to round rock	25.20
Shell	0.40
<u>1/4 to 1/2 mm - 18.00 %</u>	
Rounded quartz	13.23 %
Rounded olivine and epidote	0.17
Rounded garnet	0.17
Rounded rock	4.43
<u>1/8 to 1/4 mm - 0.50 %</u>	
Subangular to round quartz	0.50 %
Magnetite	trace
<u>1/16 to 1/8 mm - trace</u>	

Totals

Quartz and feldspar	55.93 %
Olivine and epidote	1.40
Garnet	0.17
Magnetite	trace
Rock	41.37
Shell	1.13
Total	100.00 %

Small concentrations of black mineral particles as thin films on the surface were found in the channel of one creek south of Delake and at several places at high tide level. There are also some concentrations of black mineral particles in the channel and banks of the creek crossing the beach at Delake. These are neither rich nor large. Pale yellowish-gray sands make up the beach for about 1400 feet north of this creek where there begins a moderate concentration of black mineral particles at the high tide level with an extent northward of 250 feet. The black mineral particles take the form of thin laminae interbedded with a much greater thickness of the quartz sands. The deposits also contain large particles ranging from pebbles to cobbles. Thence northward to the hotel known as Surf Tides there is an excess of supply of beach materials and a beach ridge is formed. The sands of this part of the beach contain either few or no black mineral particles.

A splendid beach, known as Wecoma, begins at Surf Tides and extends north to the headland just south of Salmon River at the settlement known as "Roads End." This beach is in places bordered by a dune area. The materials of the beach are mainly quartz sands, the aggregate having a pale yellowish-gray color. Small particles of dark rock are common in the beach materials. Black mineral particles are concentrated in small patches at the foot of the shore cliffs where seepages from the dune sands produce small streams, and also in the channels of small streams which flow across the beach. The areas of concentration are not more than 20 feet wide, and most deposits contain large particles in the size range from pebbles to small boulders. The beach is gently graded from the south end of the "Roads End" settlement to the cliffs to the north, and is composed of light-colored sands in which particles of black minerals or rock are not common. Analyses are given in table 8. Between Delake and "Roads End", small exposures of peat are present in the lower part of the shore cliffs, or in the upper part of the beach. None are important. There are no concentrations of metallic black mineral of economic importance on this section of the beach.

(4) Beaches from Cascade Head to Cape Lookout

These beaches may be divided into three sections, as follows: Cascade Head to Nestucca Bay, Nestucca Bay to Cape Kiwanda, and Cape Kiwanda to Cape Lookout.

The beach from Cascade Head to Neskowin Creek is largely composed of quartz sands with a considerable content of particles of black rock thought to have been derived from Cascade Head.

Thin streaks of metallic black minerals were seen just back of Neskowin Inn in a recently eroded bank of Neskowin Creek. Otherwise there are no concentrations of black metallic minerals on this part of the beach. The beach from Neskowin Creek to Nestucca Bay is wide at low tide, is gently graded, and has wind-deposited sands over a considerable extent of the back beach; dunes are local inland. The wind has concentrated thin streaks of black mineral particles and particles of black rock on the upper part of the back beach adjacent to the old tourist cottages south of the mouth of Nestucca River. Analyses are given in Table 9.

Location and Analyses of Samples
of
Sands from Cascade Head to Cape Lookout

Table 9.

1. Mouth of Neskowin Creek, high tide level.
2. About 3 miles north of Neskowin Creek, high tide level.
3. About 4 miles north of Neskowin Creek at foot of cliffs, high tide level.
4. Pacific City, high tide level.
5. Beach at foot of hill south of Terra del Mar, 6-inch channel near southern edge of deposit, high tide level.
6. Terra del Mar, little creek at north end of rich deposit, high tide level, 6-inch channel.
7. Top part of beach at Terra del Mar, wind sorted.
8. Back of beach at foot of cliff south of Cape Lookout, high tide level, wind and water sorted, considerable black sand.

Mechanical Analyses of Sands
Cascade Head to Cape Lookout

No.	greater than 2 mm	1-2 mm	1/2-1 mm	1/4-1/2 mm	1/8-1/4 mm	1/16-1/8 mm	less than 1/16 mm	Remarks
1.			3.65	89.70	6.65			cement sand
2.			0.50	84.35	15.15			" "
3.			0.45	51.45	40.75	7.35		
4.				77.10	22.90	trace		
5.					64.56	35.44		black sand
6.				18.15	60.50	21.35		" "
7.				16.55	69.80	13.65		
8.				12.48	61.44	26.08		" "

Mineral Analyses of Sands
Cascade Head to Cape Lookout
(Percent)

No.	Quartz Feldspar	Olivine Epidote	Garnet	Zircon	Magnetite	Ilmenite Chromite	Rock	Remarks
1.	70.85	0.65	0.00	0.00			27.85	shell 0.65
2.	83.25		"	"			16.75	
3.	57.40	2.95	2.20	rare	1.15	25.85	5.60	hb. 4.85
4.	85.20			0.00			14.80	
5.*	28.16	10.04	2.04	1.84	3.12	52.04	2.76	black sand
6.*	42.70	17.65	1.50	common	1.85	30.10	6.20	" "
7.	60.70	13.25	0.95	rare	1.10	10.30	13.70	
8.*	39.88	19.56	1.64	1.24	5.60	29.92	2.16	" "

*Denotes percentage by weight, that is, specific gravities of the minerals are considered.

The beach from the south end of the spit on the north side of Nestucca River to Cape Kiwanda is gently graded and composed of light-colored sands which are mainly quartz with many particles of black rock. Black mineral particles were observed only about the mouth of Nestucca River. Cape Kiwanda is composed of poorly cemented fine-grained sandstones which supply sands much like those of the present beaches.

The beach from Cape Kiwanda to Cape Lookout is gently graded and is mainly composed of pale yellowish-gray quartz sands. South of the village of Terra del Mar and beginning at the foot of the road from Pacific City and extending for about about a quarter of a mile toward the village of Terra del Mar, there is a considerable concentration of metallic black minerals at high tide level. The deposit is from 30 to 40 feet wide, and some spots are very rich, but most of them show only moderate concentration. The deposit is not very thick, as this part of the beach is cut on bedrock. Large particles ranging in size from pebbles to boulders are present. A detailed analysis of a sample from this locality is as follows:

Terra del Mar, high tide level at little creek on north end of rich deposit, 6-inch channel, weighted (no. 6 of table 9).

1/4 to 1/2 mm - 18.15 %	
Subround to rounded quartz and feldspar	15.10 %
Rounded rock	2.90
Rounded olivine and epidote	0.15
1/8 to 1/4 mm - 60.50 %	
Rounded quartz	26.75 %
Rounded olivine and epidote	15.70
Angular pink and red garnet	0.65
Rounded magnetite	trace
Rounded ilmenite and chromite	14.10
Rounded rock	3.30
1/16 to 1/8 mm - 21.35 %	
Strongly magnetic	
Rounded magnetite	1.85 %
Mildly magnetic - 18.50 %	
Angular quartz, a little zircon	0.25
Rounded olivine and epidote	1.70
Angular pink and red garnet	0.80
Rounded ilmenite and chromite	15.80
Nonmagnetic - 0.95 %	
Angular to rounded quartz, a little zircon	0.60
Rounded olivine and epidote	0.10
Angular pink and red garnet	0.05
Rounded ilmenite and chromite	0.20
Totals	
Quartz and feldspar	42.70 %
Olivine and epidote	17.65
Garnet	1.50
Magnetite	1.85
Ilmenite and chromite	30.10
Rock	6.20
Total	100.00 %

Some black sands are exposed in the recently deposited sands of the shore and some may be present east of the road, here just above the beach, in low areas overgrown with vegetation. This seems to be suggested by the fact that waters which seep from beneath the road are highly stained with iron oxide. The north end of the area of concentration is about half a mile south from the center of the village of Terra del Mar. Southward from this concentration to Cape Kiwanda and northward from Terra del Mar to the outlet of Sand Lake the beach materials are composed of quartz and feldspar sands in which there are a few particles of black rock. Much of the coast is margined by dunes. Thin veneers of black mineral particles are present in places on the beach sands and nearly every seep from the dunes shows a small concentration. None of these is important. Analyses are given in Table 9.

The beach from Sand Lake to Cape Lookout is gently graded, and the beach materials consist of pale yellowish-gray sands which are mostly quartz. Particles of black rock are common. A small quantity of black mineral particles was seen in thin laminae on the north side of the entrance to Sand Lake, and small concentrations are present at seeps from the dune cliffs which border most of the shore, and in the channels of small streams which flow across the beach. None of these are important. There is a small deposit of black mineral particles and particles of black rock on the north end of this beach in the back of the small bay south of Cape Lookout. The deposit is at the high tide level, is about 1000 feet long, and passes into yellowish-gray sands on the south end and into large particles, from pebbles to boulders in size, on the north. The deposit has no economic importance as both the concentration and yardage are small. Analyses are given in Table 9 on page 40.

(5) Beaches from Cape Lookout to Cape Falcon

The beaches are divided into five sections, as follows: Cape Lookout to the north end of the spit separating Netarts Bay from the sea; Netarts Bay to Cape Meares; Cape Meares to the north end of the spit separating Tillamook Bay from the sea; Tillamook Bay to the south side of the entrance into Nehalem Bay, and from the south end of the spit which separates Nehalem Bay from the sea to Cape Falcon.

The beach from the north side of Cape Lookout to the north end of the Netarts Bay spit is gently graded and is composed of fine-grained quartz sands with a considerable content of dark rock derived from the coastal cliffs. The color of the aggregate is a pale yellowish-gray with dark specks. Except on the extreme south end, a prominent fore dune borders the beach, inland from which there is either a wide dune area or a marsh. A small quantity of metallic black minerals was seen in the channel of the little creek that flows across the beach just north of Cape Lookout. The rocks of Cape Lookout do not seem to be contributing much coarse material to the beach.

The bottom of Netarts Bay is extensively exposed at low tide, and is covered with fine sand and silt which is black from the presence of organic matter and iron sulphide. No concentration of black mineral particles was seen.

There is a considerable concentration of black mineral particles on the beach on the north side of the entrance to Netarts Bay. The concentration begins at the east end of the village and extends nearly to the entrance to the bay. The deposits are at high tide level and range in width from about 10 to 60 feet with an extent along the beach of about 1000 feet. The black sands are interbedded with light-colored sands, and concentration is locally rich. The thickness is estimated to range from 2 to 4 feet. Large particles ranging from pebbles to boulders 2 inches or more in diameter are present. A weighted analysis of one of the samples from this deposit is as follows:

East end of black sand deposit of Netarts Bay, high tide level, weighted analysis (no. 2 of table).

1/4 to 1/2 mm = 1.20 %	
Mostly quartz, no magnetite or other metallic black mineral, a little olivine or epidote.	
1/8 to 1/4 mm = 56.20 %	
Strongly magnetic	
Rounded magnetite, some with attached quartz	3.92 %
Mildly magnetic = 35.50 %	
Angular to subround quartz	1.61
Rounded olivine and epidote	15.56
Angular pink and red garnet	6.35
Rounded ilmenite and chromite	11.88
Rounded rock	0.10
Nonmagnetic = 16.78 %	
Subangular quartz	13.94
Rounded olivine and epidote	2.60
Garnet	0.14
1/16 to 1/8 mm = 42.60 %	
Strongly magnetic	
Rounded magnetite	4.48 %
Mildly magnetic = 36.95 %	
Rounded olivine and epidote	2.30
Angular pink and red garnet	1.54
Ellipsoidally rounded zircon	1.04
Rounded ilmenite and chromite	32.07
Nonmagnetic = 1.17 %	
Rounded olivine and epidote	0.04
Angular garnet	0.07
Ellipsoidally rounded zircon	1.06
Totals	
Quartz and feldspar	16.75 %
Olivine and epidote	20.60
Garnet	8.10
Zircon	2.10
Magnetite	8.40
Ilmenite and chromite	43.95
Rock	0.10
Total	100.00 %

Thin films of black sand are present on wind-drifted surfaces of the back beach to the end of the point which limits the north side of the entrance into Netarts Bay. Northward from this point the beach is gently graded to the village of Oceanside and is composed of light-colored sands with some particles of dark rock.

The source of the black mineral particles present on Netarts Beach is not known. Possibly they came from the south, but there are some indications that they may have been washed from the Pleistocene to Recent sands on which the village of Netarts is in part built. Black sands appear in the cliffs where landslides have exposed the section, and they may be seen on the Sunset Trail up the cliff from the beach.

The cliff between Netarts Bay and Oceanside is undergoing vigorous erosion but, as it is composed of weak sandstones and shales overlain by dune sands, it cannot contribute coarse sediments.

The beach from Cape Meares, the bold headland south of the mouth of Tillamook Bay, to about the mid length of the long spit separating Tillamook Bay from the sea, is almost entirely composed of coarse materials ranging from granules to boulders 10 inches or more in diameter. Patches of coarse-grained sands are present in places in the midst of cobbles and boulders. The beach on the north end of the spit is composed of pale yellowish-gray sands which are mainly quartz. Dune sands cover the spit from high tide level to a maximum height of 50 feet or more. The spit is wide but not high on the north end, high and much narrower (also wooded) in the middle part, and low and very narrow on the south end. The height is due to a large fore dune. The bay side of the spit is composed entirely of pale yellowish-gray sands which are mainly composed of quartz. The village of Bayocean is built on the middle part of the spit on the bay side and at one time a large hotel and several fine residences were erected on top of the fore dune. A great storm in 1939 caused the waves to cut into the dune and led to the destruction of the houses on its summit.

The south end of the seaward side of the Bayocean Beach has one of the most extensive deposits of gravels and boulders seen in this entire survey. The materials are largely composed of black rock and they form a beach which is very steep toward the sea. The coarse materials seem to have been derived from the headland of Cape Meares on the south.

Garibaldi Beach, on the north side of Tillamook Bay, is a large sand bar composed of pale-yellowish, light-gray sands. The bar is bordered on both sides by finer grained sands containing some silt and clay. Considerable fragmentary shell material is present. A small beach just west of Garibaldi Beach is composed of yellowish-gray quartz sands with boulders on the back beach.

A broad beach extends from the north jetty of Tillamook Bay to the mouth of the Nehalem River. This beach is gently graded, is composed of fine-grained, pale yellowish-gray sands which are mainly quartz. There is a considerable wind-swept area above high tide, and a fore dune extends from the north jetty of Tillamook Bay at Barview to a point north of Manhattan

Beach. There are no coarse materials among the beach sands other than a few pebbles. No concentration of black minerals was seen, but in places there are concentrations of particles of black rock.

Gently graded Manzanita beach lies north of the mouth of Nehalem River. The sands composing this beach are fine-grained and mainly composed of quartz. There are no large particles over most of the beach, but coarse particles are present for a short distance south of Cape Faloon whose cliffs limit Manzanita beach on the north. The beach is backed by a dune ridge. Analyses are given in Table 10.

Location and Analyses of Samples
of
Sands from Cape Lookout to Tillamook Head

Table 10.

1. North side of Cape Lookout, high tide level.
2. East end of black sands of Netarts Bay, high tide level.
3. West end of black sands, Netarts Bay, high tide level.
4. Just west of sentry station, Netarts Bay, high tide level.
5. Point at north entrance to Netarts Bay, high tide level.
6. North of north jetty of Tillamook Bay, high tide level.
7. Same place as no. 6, low tide level.
8. Rockaway beach, high tide level.
9. Manzanita beach, about a mile south of the village, high tide level.
10. Creek concentration in creek entering Arch Cape beach, high tide level.
11. Arch Cape beach, high tide level.
12. Arcadia cabins beach, high tide level.
13. Arcadia cabins beach, north of Hug Point, high tide level, wind and creek concentration. Concentration of upper half inch.
14. Cannon Beach, north of creek, high tide level.
15. South bank of Nehalem River, concentrated by wind, very high tide level.

Mechanical Analyses of Sands
Cape Lookout to Tillamook Head

No.	greater than 2 mm.	1-2 mm	1/2-1 mm	1/4-1/2 mm	1/8-1/4 mm	1/16-1/8 mm	less than 1/16 mm	Remarks
1.				7.85	90.55	1.60		
2.				1.20	56.20	42.60		Black sand
3.				3.30	71.60	25.10		" "
4.				1.75	90.50	7.75		
5.			0.20	9.90	89.40	0.50		
6.				60.50	39.50	trace		
7.			1.55	86.20	12.25			Cement sand
8.				32.50	67.50			
9.				15.05	84.95	trace		
10.				5.16	79.20	15.64		
11.				3.25	96.25	0.50		
12.				4.40	94.90	0.70		
13.				2.00	89.80	8.20		
14.				2.60	96.95	0.45		
15.			0.70	70.55	28.75			

Mineral Analyses of Sands
Cape Lookout to Tillamook Head
(Percent)

No.	Quartz Feldspar	Olivine Epidote	Garnet	Zircon	Magnetite	Ilmenite Chromite	Rock	Remarks
1.				0.00	trace	trace		
2.	16.75	20.60	8.10	2.10	8.40	43.95	0.10	Black sand
3.	56.20	0.95	0.40	common	28.15	14.30		" "
4.	57.50	22.00	0.35	rare	3.20	16.95		
5.	89.95	2.45	trace	"	trace	trace	7.50	Shell 0.10
6.				0.00				
7.	69.50	0.20		0.00			30.30	
8.	88.20	0.60	0.20	0.00	trace	trace	11.00	
9.				0.00	"	"		
10.*	60.40	9.16	0.88	rare	6.76	19.52	3.28	
11.				0.00	trace	trace		
12.				0.00	"	"		
13.				0.00	"	"		
14.*	61.05	11.25	0.35	0.00	1.25	21.35	4.75	
15.*	47.25	15.05		0.00			37.70	

*Denotes percentage by weight.

(6) Beach between Cape Falcon and Tillamook Head

Arch Cape limits this beach on the south, and Cannon Beach, adjacent to the village of the same name, is on the north. The beach is interrupted by short but steep salients, some of which rise from the water, even at low tide. The southernmost part of this beach extends from Cape Falcon to Hug Point, several miles to the north. This section is gently graded and is composed of pale yellowish-gray, fine-grained sands which are mostly quartz. A small quantity of coarse materials is present at the high tide level at the foot of the rock cliff just south of Hug Point. The shore is cliffed in bedrock for most of the extent and there are no dunes. The only concentrations of black mineral particles seen were in the channels of some of the creeks which flow over the beach. None is important.

The beach north of Hug Point to Silver Point is backed by a cliff of bedrock and there are no dunes. The sands of the beach have a pale yellowish-gray color, are fine-grained, and are composed mostly of clear quartz with some particles of black rock. No concentrations of metallic black minerals were seen.

Cannon Beach extends from Silver Point to the creek north of Cannon Beach village. The beach is gently graded, and is composed of pale-yellowish-gray sands which are mainly quartz. The beach materials contain no gravel except just inland from the conspicuous stack of Haystack Rock where there is a considerable extent of coarse, more or less angular cobbles and boulders which are largely derived from the basic igneous rocks of which the stack is composed. Small particles of this black rock are locally concentrated to form black sands. The adjacent beach contains particles of black rock which probably came from the stack or from similar rocks in the shore cliffs. The shore cliffs are generally low, and there are dunes of significance.

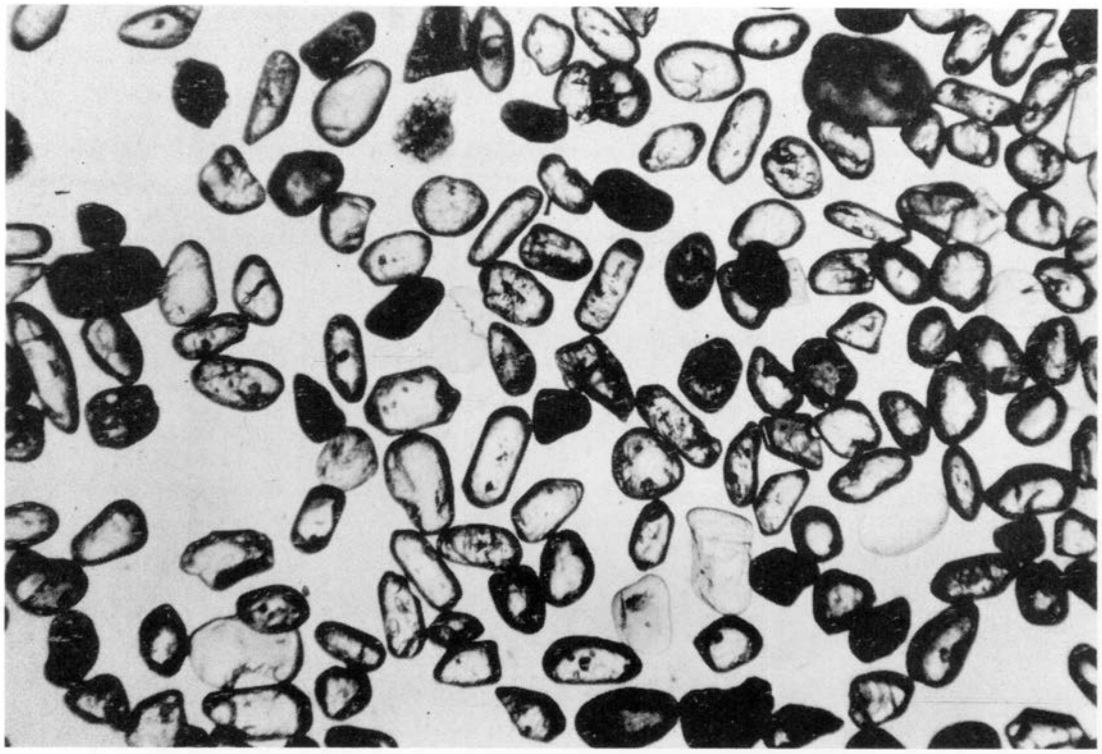

Fig. 7. Nonmagnetic part of 1/16–1/8 mm fraction of sample of Fig. 6 (X 80). The ellipsoidally rounded grains of high relief are zircon. The light-colored grains of low relief are quartz. The well-rounded black grains are nonmagnetic and are dark garnet. Inclusions are present in some grains of zircon. Sands were immersed in liquid of index 1.68 when photographed.

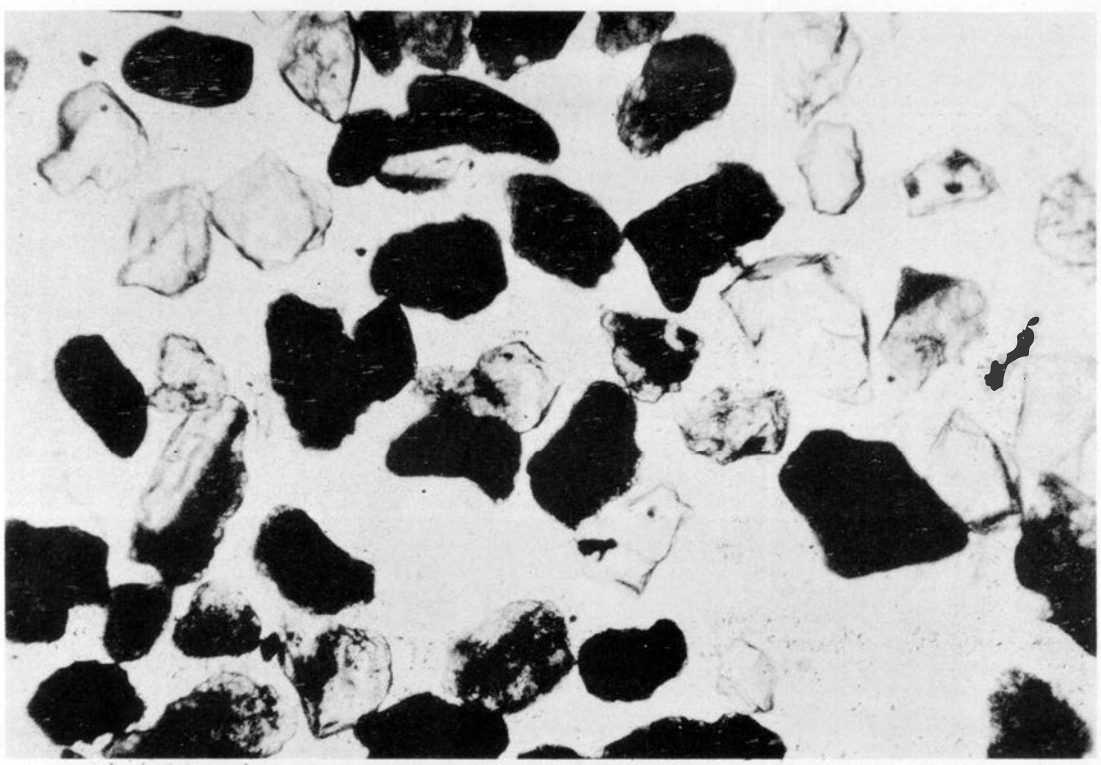

Fig. 10. Sand from high tide level. Seaside Beach, south of Necanicum River, part of whole sample (X 80). The high angularity of the grains is very apparent. Compare with sands of Figs. 3, 4, and 11. Sands were immersed in liquid of index 1.63 when photographed.

No concentrates of black mineral particles were seen, but analyses show that these minerals are present in minute quantities. The beach north of Elk Creek is like that south of the Creek. A small concentration of black minerals was seen in the north bank of the creek. The cliffs to the north contain black lava, but no gravel of any kind was seen south of these cliffs. Evidently coarse sediments derived from the breaking down of these cliffs is not being carried southward.

(7) Beaches from Tillamook Head to the mouth of the Columbia River

A sequence of truly magnificant beaches extends from Seaside, just north of Tillamook Head, to the south jetty of the Columbia River. The beaches of Seaside, Gearhart, and Sunset are parts of the sequence. The only coarse materials on these beaches are found southward from Broadway in the town of Seaside to Tillamook Head. Much of this part of the beach is steep toward the sea and contains coarse materials ranging from pebbles to very large boulders. The deposits north of Tillamook Head have advanced the land seaward and have deflected the Necanicum River to the north. Gravel beaches formerly extended farther north as gravel-beach ridges are visible in the town of Seaside in places that are north of the present limits of gravel on the shore. The south end of the town of Seaside is built on these gravel-beach deposits. The sand beaches which extend from Seaside to the mouth of the Columbia River are gently graded and are without beach ridges. The sands are fine-grained, have a pale yellowish-gray color, and are composed largely of light-colored minerals, mainly quartz and feldspar. Small particles of black rocks and black minerals are almost universally present. In contrast to the sands south of Tillamook Head, those that form the beaches from Seaside to the mouth of the Columbia River are decidedly angular, contain far more feldspar, and the quartz particles contain abundant inclusions of magnetite and ilmenite (fig. 10). These sands were brought to the sea mainly by the Columbia River, and it is obvious that little to no rounding of particles was effected in the transportation by the river, or by the wave and current transportation along the beach from the mouth of the Columbia River to Seaside. Dune ridges border the coast from Broadway in Seaside to the south jetty of the Columbia River. This part of the coast has the most extensive dune area of any part of the coast of Oregon. In general, the dune ridges are covered with vegetation, but this is not true of the area on the north end of Seaside extending to the south side of the Necanicum River. Six dune ridges, each successively at one time a fore dune as the shore was built westward into the sea, are present at Sunset Beach village. U.S. Highway 101 is built on top of dune ridge no. 6, counting from the beach. The topography suggests that other dune ridges may lie inland from the highway. There is no important concentration of black mineral particles on any part of this long series of beaches. A few thin veneers of black mineral particles were seen just south of the south jetty of the Columbia River.

The construction of the south jetty of the Columbia River led to enlargement of the extent of dune deposits which was largely done through prograding of the shore. This has been studied and described by W. T. McLaughlin and R. L. Brown (1942) of the U.S. Department of Agriculture whose circular, Controlling coastal sand dunes in the Pacific Northwest, should be read by all who live on the coast of Oregon and Washington.

(8) Beaches about the mouth of the Columbia River.

A broad beach extends up the Columbia River from the south jetty to the places on the shore where man-made constructions have made beaches impossible. This beach is bordered by low dunes which to some extent have been stabilized by plantings, and the dune area has been widened since the building of the south jetty. The sands of the low and mid tide zones of this beach are largely composed of quartz and feldspar, and the aggregate has a pale yellowish-gray color. The grains of quartz are angular and contain inclusions of magnetite and ilmenite. There are no concentrations of black mineral particles in these zones. Wind and water have produced concentration above the mid tide zone, but the volumes are small. Concentration begins just east of the south jetty of the Columbia River and it is spotty in richness. The beach on the west side of Trestle Bay, the bay that once extended inland to include the waters now crossed by the railroad extending from Fort Stevens to the lighthouse and here so designated for purposes of convenience, is composed of very fine, light-colored sand and silt. Beginning about the middle of the back part of Trestle Bay and extending eastward for more than 2000 feet, there is a rich concentration of black metallic minerals at very high tide level and above. Two channel samples showed percentages of approximately 60 percent magnetite and 15 percent ilmenite. Some quartz adheres to or surrounds some of the black minerals, and some of those black minerals are not magnetic. There is no concentration of black minerals at this place in the low and mid tide zones. The sands filled with black minerals are also filled with driftwood. It is estimated that 5000 to 10,000 cubic yards of black sands are present over this part of the beach, or between 15,000 and 30,000 cubic yards of which 50 percent or more is magnetite and 15 percent is ilmenite. Chromite and zircon are rare in these black sands (figs. 11, 12).

Rich deposits of black sands are reported to have been encountered in the construction of the dock at Fort Stevens. The sands removed were spread over adjacent lowlands and any concentration was destroyed. The exposed sands and those removed do not show anything of importance.

As concentrations of black magnetic mineral particles were encountered inland from the mouth of the Columbia River and as rich sands are present from the south jetty to the entrance of Trestle Bay and in Trestle Bay, it may be assumed that rich concentration is present under a considerable area. Analyses of these sands are given in Table 11.

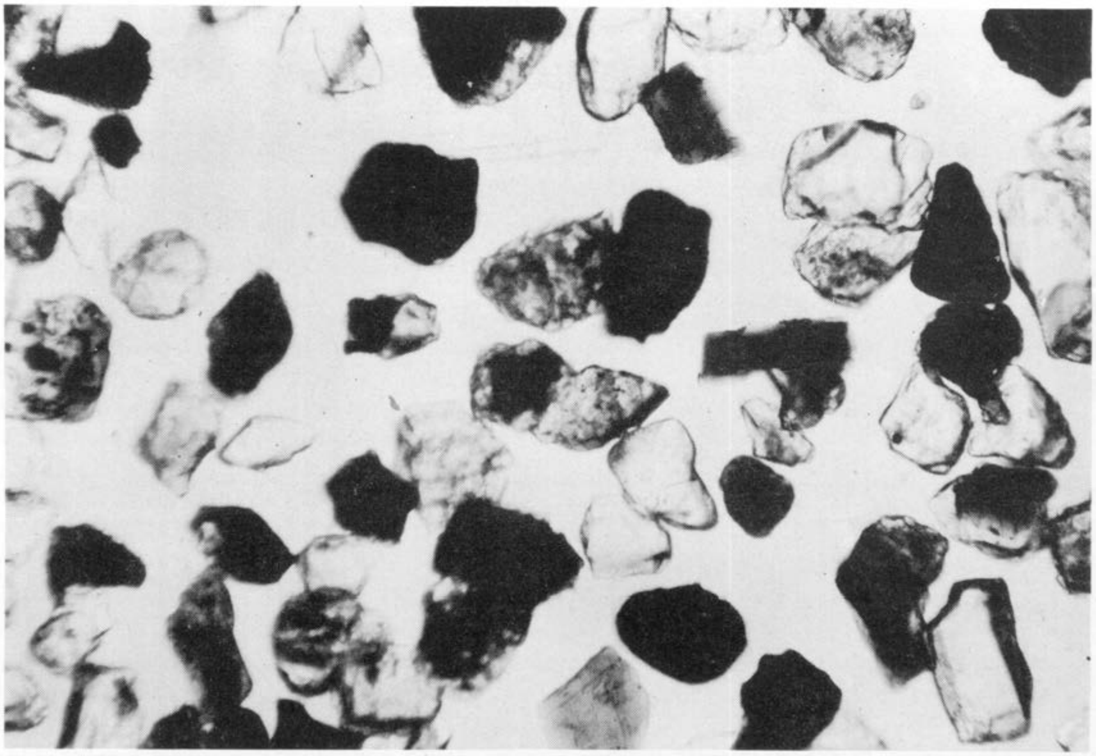

Fig. 11. Beach sand from high tide level, about a mile south of south jetty at mouth of Columbia River (X 80). The light-colored grains are quartz. These show high angularity. The black grains are ferro-magnesian minerals and just right of the center is a prismatic grain which has green color and is euhedral. This sand is like that on the beach at Seaside. Compare with sands of Figs. 3, 4, and 10. Sands were immersed in liquid of index 1.63 when photographed.

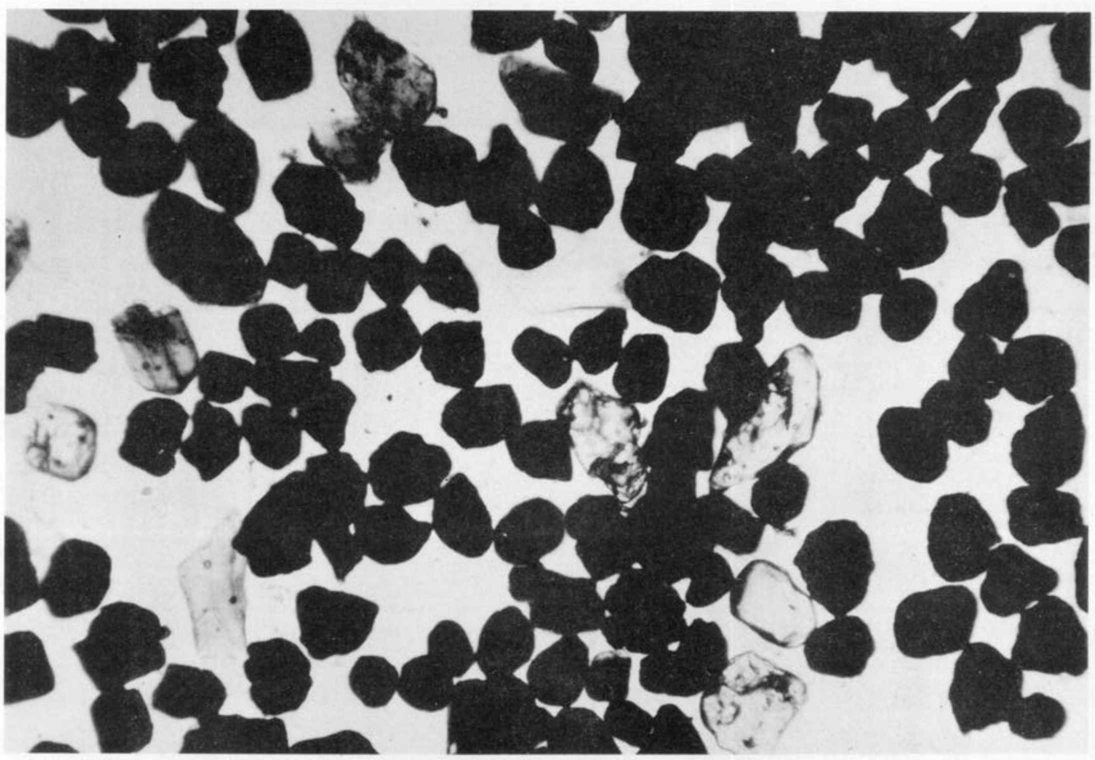

Fig. 12. Sand from 2-foot channel from the east side of Trestle Bay (X 80). The black grains are magnetite or ilmenite, light-colored grains are quartz filled with inclusions and there are some grains of feldspar. Many quartz grains are attracted by a magnet so that inclusions are magnetic. The grains are little or not at all rounded and the black grains should be compared with those in the sands at Newport Beach or about Big Creek on Agate Beach. The difference in rounding is conspicuous. Sands were immersed in liquid of index 1.63 when photographed.

Location and Analyses of Samples
of
Sands from Seaside to Fort Canby

Table 11.

1. Seaside Beach at end of Broadway, high tide level.
2. Seaside Beach, south side of Necanicum River, high tide level.
3. North side of Necanicum River, high tide level.
4. Two to three miles north of Necanicum River, high tide level.
5. Sunset Beach road, high tide level.
6. About four miles north of Sunset Beach road, high tide level.
7. Peter Iredale wreck, high tide level.
8. About a mile north of Peter Iredale wreck, high tide level.
9. About 2 miles north of Peter Iredale wreck, high tide level.
10. About a mile south of the south jetty of the Columbia River, Fort Stevens, high tide level.
11. Just south of the south jetty of the Columbia River, low tide level.
12. Just south of the south jetty of the Columbia River, high tide level.
13. North side of south jetty of the Columbia River, Fort Stevens, high tide level.
14. North side of south jetty of the Columbia River, high wave and wind deposit.
15. Rich concentrate inland from point northeast of the south jetty of the Columbia River, high wave and wind deposit.
16. One mile inland along the Columbia River on the north side of the south jetty of the Columbia River, high tide level.
17. West entrance to Trestle Bay, high tide level.
18. Back of Trestle Bay, high tide level.
19. Back of Trestle Bay, very high wave and wind deposit, 2-foot channel sample.
20. East side of Trestle Bay, high tide level, 2-foot channel sample.
21. East point of Trestle Bay, high tide level.
22. Fort Stevens dock, high tide level.
23. Left bank of the Columbia River at Hammond, just outside Fort Stevens, high tide level.
24. Sand Island in the Columbia River, southwest of dock on the upstream side of the island high tide level.
25. Dock on Sand Island on the upstream side of the island, high tide level.
26. East side of little jetty on the north side of the Columbia River, Fort Canby, high tide level.
27. Ocean side of little jetty at Fort Canby, high tide level.
28. Fort Canby road to beach on the ocean, high tide level.
29. Fort Canby road to beach on the ocean, very high beach.
30. North of large jetty on the north side of Columbia River, high tide level.

Mechanical Analyses of Sands
Seaside to Fort Canby

No.	greater than 2 mm	1-2 mm	1/2-1 mm	1/4-1/2 mm	1/8-1/4 mm	1/16-1/8 mm	less than 1/16 mm	Remarks
1.				3.65	93.25	3.10		High tide level
2.				15.35	82.55	2.10		" " "
3.				13.40	83.20	3.40		" " "
4.				5.70	90.75	3.55		" " "
5.				8.50	88.75	2.75		" " "
6.				33.00	65.70	1.30		" " "
7.				12.05	85.30	2.65		" " "
8.				4.85	90.30	4.85		" " "
9.				11.50	88.50	trace		" " "
10.				6.70	87.15	6.15		" " "
11.				30.50	68.50	1.00		Low tide level
12.				2.35	79.90	17.75		High " "
13.				13.65	83.40	2.95		" " "
14.				2.77	75.60	21.63		High wave and wind deposit
15.				2.95	70.85	26.20		High tide level black sand
16.			trace	16.65	69.30	14.05		High wave and wind deposit
17.			"	47.30	52.20	0.50		High tide level
18.				10.00	68.28	21.72		" " " black sand
19.				7.35	58.10	34.55		High tide level black sand
20.				1.10	59.75	36.00	3.15	High tide level
21.				29.45	66.80	3.75		" " "
22.				11.35	74.20	14.45		" " "
23.				5 55	91.65	2.80		" " "
24.				trace	57.88	42.12		" " " black sand
25.				16.40	67.35	15.80	0.45	High tide level black sand
26.				45.25	53.60	1.15		High tide level
27.				50.10	49.40	0.50		" " "
28.				34.05	65.50	0.45		" " "
29.				2.25	90.65	7.10		High beach
30.				32.80	66.70	0.50		High tide level

Mineral Analyses of Sands
Seaside to Port Canby
(Percent)

No.	Quartz Feldspar	Olivine Epidote	Garnet	Zircon	Magnetite	Ilmenite Chromite	Rock	Others	Remarks
1.	78.90	1.60		0.00			19.50		
2.	80.30	0.10	trace	0.00	trace	trace	19.60		
3.	68.90			0.00	"	"	31.10		
4.	79.20			0.00			20.80		
5.	75.15	trace		0.00		20.40	5.35	Muscarite 0.10	
6.									Not analyzed
7.	74.20	1.00		0.00		24.80			
8.	68.75	5.80		0.00	0.50	0.60	24.35		
9.	70.20	trace		0.00	trace	trace	29.80		
10.				0.00					Not analyzed
11.	66.00	trace		0.00	0.35		33.00		0.65 unclassified
12.	63.20	7.30	0.20	0.00	4.10	9.80	13.65	Hornblende 1.75	
13.	66.15	1.25	1.10	rare	0.75	1.10	29.65		
14.*	14.73	7.90	2.43	"	51.50	22.57	0.87		Rich black sand
15.*	13.44	14.36	1.88	"	45.32	25.00	0.00		Rich black sand
16.*	47.40	4.40	0.50	0.00	17.60	11.30	18.80		Black sand
17.				0.00					Not analyze
18.	42.20	2.60	0.15	0.00	30.25	19.70	5.10		Rich black sand
19.*	20.20	0.85	0.55	0.00	54.60	11.50	6.90	Hornblende 5.40	
20.*	4.57	3.27	1.50	0.00	65.20	25.46			Rich black sand
21.*	64.15	1.70	0.60	occasional	1.15	1.20	31.20		
22.				0.00					Not analyze
23.*	63.80	3.20	0.40	rare	0.45	0.35	26.80		
24.*	1.36	3.00	1.00	"	78.28	15.80	0.56		Rich black sand
25.*	31.67	5.77	2.33	"	20.33	27.53	12.37		Black sand
26.	59.95	3.45		0.00	0.35	0.80	35.45		
27.	72.60			0.00	0.15	0.35	26.90		
28.				0.00				Not analyzed, (like 26)	
29.								" " " "	
30.								" " " "	

*Denotes percentage by weight, that is, the specific gravities of the minerals are considered.

There are two jetties on the north side of the mouth of the Columbia River, each extending outward from Cape Disappointment. The southern jetty is the shorter. Wind and waves have built up a large deposit of sand and driftwood on both sides of the jetties, and the whole terminates against the precipitous cliff of Cape Disappointment. Lean to moderate concentration of black magnetic minerals is present in some sands above the high tide level; most of the concentration here has been effected by the winds in blowing light-weight sands away. The deposits contain few boulders but much driftwood. Analyses are given in table 11.

An extensive gently graded beach lies north of the long north jetty. The sands have a pale yellowish gray color, are fine-grained, and are composed largely of quartz and particles of light and dark rock. No concentration of magnetic minerals was seen in the tidal zone, but thin veneers produced by wind were seen on wind-drift surfaces of the back beach. The deposits contain an abundance of driftwood.

Sand Island in the Columbia River is composed entirely of sand and driftwood. The island has been made by river deposition, and it is said to have increased in area since the building of the jetties. There are very rich concentrations of black mineral particles on Sand Island, particularly on the south side. The concentrations were seen in the high and upper mid tidal zones and there may be much beneath the vegetation which covers most of the island. There is a very rich concentration of black sand on the upstream side of the island on both sides of the old docks and on the south side to the trestle connecting the main or west part of the island. Concentration is very rich on the south side of the dock; less on the north side. The main part of the island has excellent concentration on the south side, very poor on the north side - the side toward the mainland of Washington. The sands of the island are everywhere filled with driftwood and this wood seems to be more abundant in places where the black sand concentration is greatest. Thus, where the sands are almost solidly black, there is as much or more driftwood than sand. One analysis showed 94 percent of magnetic minerals of which 78.28 percent was magnetite. There must be thousands of tons of magnetic black sands n Sand Island. It is thought that wave wash from the ocean is responsible for the richer oncentration on the south side.

The black minerals near the mouth of the Columbia River were evidently brought by the iver largely from the Columbia River Plateau and the Cascade Mountains, and were derived rom the basic igneous rocks of those regions. The river certainly brought to the sea the ngular quartz sands with their included and attached magnetic minerals. With some exceptions ie sands about the mouth of the Columbia River are in the first cycle of sedimentation and re derived from igneous rocks. Analyses of these sands are given in table 11.

Factors Controlling Deposition of Sediments on the Oregon Beaches and in the Dunes

Factors which control the deposition of sediments on the Oregon beaches are the shore physiography, the sources of the sediments, the kinds of sediments supplied, the recent submergence of the coast, the two important transporting agencies of wind and water, and the directions of impingement of waves, currents, and winds on the coast. The physiography of the coast has already been considered.

One source of supply of sediments is affected by the coastal physiography. Many sediments are eroded from the headlands, few from the indentations of the coast. Coarse sediments are derived from those cliffs which are composed of strong rocks. Cliffs composed of weak sandstones and shales of the Tertiary and Pleistocene sections supply fine sands, silts, and clays, and many of the fine sands of the beaches were evidently derived from this source. Silts and clays do not remain long on the Oregon beaches. They are either blown inland by the winds and thus generally lose their identity, or they are carried out to sea and deposited where they are not likely to be further affected by the agents of transportation. Headlands containing intrusive and extrusive igneous rocks supply materials ranging from the size of clay particles to large boulders.

Some sediments are supplied by streams which flow into the ocean on parts of the Oregon coast, but as every large stream from the Coquille to the Columbia is drowned in its lower reaches, few of the sediments derived from the headwaters of these streams reach the sea except in the case of the Columbia River which generally has sufficient current velocity to carry sand, silt, and clay to the sea. The Columbia River brings no gravel to the sea. Fine sediments may continue to be transported from the bays to the sea by the tides. The quantities thus brought to the sea are not known, but for most of the streams they are not thought to be large. It is believed that all coarse sediments transported from the headwaters of the large streams are, and for a long time have been, deposited in the bays created about the mouths of these streams by the recent depression of the coast. Small streams which flow from high parts of the coast transport all sediments to the sea. As these streams do not originate far inland, the sediments supplied by them are similar to those produced by wave attack on adjacent headland. Some sediments are brought to the northern coast of Oregon from other coastal areas to the south, perhaps also from the north, but sediments coming from the north would have difficulty crossing the Columbia River. The quantities derived from the coastal areas beyond the limits of this study do not seem to be determinable, but it is believed that most of the metallic black minerals in the sands south of Tillamook Head had their origin south of the mouth of the Coquille River.

The recent submergence created the bays about the original mouths of the large streams, and indirectly this submergence led to the formation of the large spits which now separate these bays from the sea, although the direct work of building was done by the waves and currents of the sea and by the winds. Alsea and Netarts Bays have been largely filled with sediments and every bay has been filled to some degree. The sediments are largely fine-grained sands, silts, and clays except about the places of entrance of the streams into the bays where coarse sediments may be expected. The beaches of the bays are composed mostly of fine-grained sands except where vegetation is invading the water or where the coasts are being eroded and coarse materials may be acquired.

Waves and currents sweep sediments to and from the beaches, bringing in all that availabilities and competencies permit, and returning all to the sea within the competencies of the returning waters. As competencies of incoming waters are generally greater than outgoing, any very coarse sediments that are brought to a beach may be expected to remain there until worn to fineness; only the finer materials brought to a beach may be expected to be returned to the sea by the waves.

Shore currents carry sediments within the range of their competencies and deposit coarse and heavy sediments as competencies decrease. The maximum quantity of sediments will be found where the greatest decrease in competency takes place. The directions of shore currents are largely determined by the directions of wave impingement on a shore (Twenhofel, 1943). The waves reach the Oregon coast from a general southwesterly direction from about late September to about late May, and from a general northwesterly direction for the rest of the year. The former period is the more stormy one and the time of the strongest waves and winds; the latter is a period of weak waves and mild winds. Thus, the strongest shore currents, in general, move northward along the shore from late September to late May. During the period from late May to late September, the general movement of the shore currents is southward, but, as these are generally not strong currents, only fine-grained materials are moved. All materials acquired by the currents remain in transportation until some obstacle, such as a stream or prominent headland, lowers velocity. This leads to decrease in competency and compels some deposition. The coastal physiography may direct a current out to sea and lower velocity and competency in this way (Twenhofel, 1943). Ordinarily, only the north-moving shore currents carry coarse materials which may therefore be expected to be found immediately north of sources, and not at all, or only to a small extent, south of sources. That this is actually true is shown by the distribution of coarse sediments on the northern coast of Oregon where they are mostly north of the source rocks in the headlands; on the south sides of the same headlands, the beaches generally have sands extending over their entire width.

It should not be understood, however, that there are no strong southward-moving shore currents during the period from late September to late May, or northward-moving currents from late May to late September. Parts of the coast may have currents in the opposite direction from normal because of coastal physiography. A wave striking a coast from a southwesterly direction may produce a current to the south on the south side of a headland, and cause some sediments to move south during the period of southwesterly winds. Similarly a wave striking a coast from a northwesterly direction may produce a north-moving shore current on the north side of a headland.

Prevailing winds blow from a northwesterly direction during the summer season from late May to late September at an average velocity of 15 miles per hour with maximum velocities seldom exceeding 40 miles per hour. They blow from a southwesterly direction from late September to late May with an average velocity of 16 miles per hour with occasional gales of 55 miles per hour or more and a few storms of 85 to 90 miles per hour (McLaughlin and Brown, 1942:5). Under most circumstances the winds blow with an inland-directed component.

Sands are ordinarily moved by winds when they are dry. The dry season is from late May to late September, and on sunny days and the succeeding nights of this period the sands are generally dry at and above high tide level, and also part way down to low tide level some of the time. The period from late November to late March is the rainy season during which there are many times when the sands are too wet for the wind to move them. However, this is the period of stronger winds, and large quantities of sands may be moved if they are dry. Owing to the greater prevalence of dryness during the summer period, it may be expected that much sand is then moved and that the movement is in a southeasterly rather than northeasterly direction. Transportation by wind and water is selective; materials of increasing dimensions and weights are acquired as competencies rise, and are deposited as competencies fall. Particles of small dimension and low specific gravity are more readily transported than particles of large dimension and high specific gravity. Thus, the particles moved from the beaches by winds consist largely of the smaller particles and particles of low specific gravity. Particles of high specific gravity, such as chromite, ilmenite, magnetite, zircon, and other heavy minerals, unless the particles are very small, are rarely transported by winds and therefore they are left on the beach. This is shown in the analyses of dune sands (table 12, page 56). Thus, the minerals of the wind-deposited sands of the dunes are generally composed of quartz, feldspar, calcite, and other light-weight minerals; each time a dune is built on the coast of Oregon, the sands remaining on the beaches from which the dune sands were derived increase in percentage of particles of high specific gravity. Theoretically, the sand beaches might ultimately become composed entirely of particles of high specific gravity owing to extraction by the winds of all particles of quartz and other light-weight minerals. That this does not frequently happen is due to the continued introduction of new mineral supplies by the shore currents and the incoming waves, and also because of the protection afforded the sands underneath by the heavy and large particles left on the surface as the smaller and light-weight particles are removed. This effect may often be seen on wind-drift surfaces where the so-called lag of the large and heavy particles makes a veneer that protects the underlying small and light-weight particles.

Location and Analyses of Samples
of
Dune Sands from Coos Bay to Columbia River

Table 12.

1. Coos Bay. Coos Bay Spit, bay side of Coos Bay Coast Guard trail to beach.
2. Dune sand on Coos Bay Spit, two miles north of Coast Guard trail.
3. Dune sand, nine miles north of Coast Guard trail on the Coos Bay spit.
4. Dune above the beach, one mile south of the Saunders Lake Coast Guard trail.
5. Sand from top of dune at Saunders Lake, one mile from sea on Coast Guard trail.
6. Dune south of the mouth of Tahkenitch Creek, dune about a mile from the sea.
7. Dune on the Umpqua Bay Spit about a mile north of the mouth of the river.
8. About the middle of the Umpqua Spit, about a mile north of the mouth of the river.
9. Top of dune from one-fourth to one-half a mile from the sea on Sand Lake.
10. Dune sand from a dune about three miles north of Neskowin Creek.
11. Wind drift sand above high tide level, Pacific City.
12. Dune above back beach about four miles south of the Sunset Beach road.
13. Dune on Sunset Beach road, the present fore dune.
14. Wind drift sands above back beach on Fort Stevens road to beach at Peter Iredale wreck.
15. Local surface wind concentration of back minerals above back beach about a mile north of the Peter Iredale wreck.
16. Dune sand just south of the south jetty of the Columbia River, Fort Stevens.
17. Wind drift sands on the north side of the south jetty of the Columbia River, Fort Stevens.
18. Wind concentrate on the north side of the south jetty of the Columbia River, Fort Stevens.
19. Top of little jetty on the north side of the Columbia River, Fort Canby.

Mechanical Analyses of Dune Sands
Coos Bay to Columbia River

No.	greater than 2 mm	1-2 mm	1/2-1 mm	1/4-1/2 mm	1/8-1/4 mm	1/16-1/8 mm	less than 1/16 mm	Remarks
1.				56.30	43.40	0.30		
2.				11.20	88.10	0.70		
3.				33.10	66.40	0.50		
4.				77.50	22.50	trace		
5.				48.70	50.50	0.80		
6.			0.60	50.90	47.00	1.50		
7.				18.50	79.90	1.60		
8.			0.40	39.60	59.55	0.45		
9.				50.00	48.90	1.10		
10.				66.50	33.00	0.50		
11.				60.50	39.20	0.30		
12.				7.60	87.00	5.40		
13.				7.90	86.40	5.70		
14.				1.35	87.05	11.60		
15.				8.12	85.88	6.00		
16.				1.60	81.90	16.50		
17.				7.85	79.40	12.75		
18.				6.20	84.45	9.35		
19.				2.53	75.30	22.17		

Mineral Analyses of Dune Sands
Coos Bay to Columbia River
(Percent)

No.	Quartz Feldspar	Olivine Epidote	Garnet	Zircon	Magnetite	Ilmenite Chromite	Rock	Remarks
1.	85.25			0.00	trace	trace	14.75	
2.				0.00				Not analyzed
3.	83.95			0.00	"	"	16.05	
4.	79.40			0.00	"	"	20.60	
5.	93.40	0.30		0.00	0.40		5.90	
6.	94.60		trace	0.00	trace	trace	5.40	
7.	90.85	1.35		rare	0.20	0.70	7.00	
8.	97.30	0.05		0.00	0.20		2.45	
9.	90.55	0.25	0.05	0.00	0.60		8.55	
10.	81.00	2.15	0.05	0.00	0.35		16.45	
11.				0.00	trace			Not analyzed
12.	72.30	0.80		0.00	0.80		26.10	
13.	70.80		trace	0.00	1.10		28.10	
14.	71.10			0.00	trace		28.90	
15.	36.72	2.20	0.12	0.00	13.80	40.24	6.92	Black sand
16.	52.50	3.30		0.00	6.65	34.50		3.05 Hb. Black sand
17.	51.60	2.95	1.75	rare	13.75	22.50	7.45	
18.				0.00	2.00			
19.	14.13	8.20	1.77	0.00	48.23	23.30	3.17	1.20 Hb. Black sand

The sands carried inland are ultimately deposited, and some of them form or add to the dunes. Some come to rest in the midst of vegetation and merely build the surface higher. Some fall in streams, lakes, and bays. Much sand is deposited along the windward margins of streams, both on the land and in the water. This may lead to deflection of the streams in the directions toward which the winds are blowing. The currents of the streams and the outgoing tidal currents of the bays may return some sands to the sea where they again are subject to the action of the waves and currents, and again in the course of time some of them may be deposited on the beaches. Wind may again seize these sands and send them back to the dunes or the streams. It is probable that many sands of the coast of Oregon have made this circuit many times. Some sands attain somewhat permanent deposition during the first circuit, either in the dunes or on the bottoms of the streams and bays. If there should be offshore winds at any time when the sands are dry, some sands of the dunes may be expected to return to beaches or to the sea and later start through a cycle of return to beaches and ultimately to dunes. After final deposition in the dunes, the travels may still not be ended as erosion by the sea may reach the dunes and again take the sands to the sea. This took place at Bayocean, a village resort on the foredune of the spit across Tillamook Bay; tens of thousands of cubic yards of sand were returned to the sea in a matter of a few hours. It is reported that several large buildings on the summit of the dune were undermined so rapidly that little could be saved. Some buildings remain on the unremoved part of the foredune in such positions that it would seem that their collapse onto the beach would be but a matter of a short time. Some of the sands eroded from this dune are now probably on the beach of Tillamook Bay spit and some may have been blown inland over other parts of the spit. Also, some very old dunes which have attained some degree of induration are being eroded by the waves of the sea, and sands are being returned to the beaches that they left a long time ago.

Thus, the sands may pass through several cycles in some sort of succession and may travel a long way without going far from sources. On the other hand, sands may remain below or at the lower limit of low tide level, may never be seized by the winds, and, although shuttled back and forth along the coast by currents, may never have gone far from the places of origin, and still have traveled long distances.

The spits across the bays are the results of deposition of sediments, largely sands, by waves and shore currents, and by winds. Some spits are built from the north shores of bays and others from south shores. It is believed that deposition by wind is largely responsible for the spits that originate on the north shores, and that waves and currents are largely responsible for those that originate on the south shores. Both wind and water, however, have participated in the building of all of the spits. Spits have been built southward from the north shores of Coos, Winchester, Alsea, Nestucca, and Nehalem bays, and from the south shores of Siuslaw, Siletz, Yaquina, Netarts, Tillamook, and Necanicum bays. If the waves and currents supply an abundance of sediments, the spits seem to originate from the south shores of the bays as the stronger shore currents are thought to have come from the south. This is true at Tillamook Bay where Cape Meares supplies large quantities of coarse and fine materials; at Seaside where the Necanicum River was certainly deflected to the north by the abundance of coarse and fine sediments derived from Tillamook Head; and at Netarts Bay where large supplies of sand were derived from erosion of Cape Lookout. On the other hand, spits seem to have been built southward from the north shores of the bays where large supplies of sands are available to the winds north of the bays. These spits on the north sides of the bays are generally wider than those originating from the south shores and it is noteworthy that these are broad dune areas which are lacking in coarse sediments. This is evident in the great spits on the north side of Coos Bay, and on the north side of Winchester Bay across the mouth of the Umpqua River which has been pushed to the south for a couple of miles. Heights of spits above high tide level are due to deposition by wind.

The work of the waves and currents of the sea tends to the development of what has been designated as the "profile of equilibrium," by which it is meant that the bottom of the sea and the slopes of the adjacent beaches remain at the same approximate level. This level is not lowered by erosion or raised by deposition. Occasional erosion or deposition may temporarily lower or raise a surface, but the original level will be restored after the passing of the conditions which brought about the lowering or raising. There may be general slow removal of sediments to the sea, but this will be balanced by introduction of new sediments to replace those removed. A bottom and a beach at the level of the profile of equilibrium slopes more or less gently seaward. Such a profile is attained after sea level has been stationary for a long time. Disturbance of equilibrium may be brought about by several factors, following which the surface of the sea bottom and the beach may be either eroded or sediments may be deposited. A great storm may temporarily disturb equilibrium; beach and sea bottom of the shallow waters may be swept bare of recently deposited sediments over one area and the sediments acquired may be deposited over another area; but, after the storm has passed, restoration of original conditions begins and after a time the work of the storm is erased. Equilibrium may also be disturbed by increasing or decreasing supply of sediments. Increasing supply raises the level of the bottom and the beach; decrease in supply brings about the opposite result. For example, the beach north of Boiler Bay is now flooded with sediments derived from the cliffs south of Boiler Bay, and a great beach ridge has been formed. If erosion of these cliffs could be prevented, the beach to the north would be affected by the decreased supply, the beach ridge would be eroded, the beach would become gently graded, and the shallow bottom would be deepened. If erosion of the cliffs could then be restored, the water of the shallow sea bottom to the north would receive sediments, and the beach ridge would be restored. Man-made structures may disturb equilibrium, may produce erosion or deposition where previously there had been none. Construction of the jetties north and south of the mouth of the Columbia River certainly produced deposition, and led to the formation of the extensive sand beaches and dune areas which border the jetties at their junctions with the land. The two jetties also influenced the development of Sand Island in the river. Local disturbance of equilibrium is illustrated by what is said usually takes place during the winter period on the south side of Cape Blanco south of Coos Bay. Conditions during the summer lead to the formation of a beach with the water gradually deepening from the beach outward. The winter storms are known to have removed the entire deposits of the beach and to have produced a greater depth of water than exists near the shore during the summer.

It seems likely that, after the war is over, a program of internal and coastal improvement will be developed in which the building of jetties and sea walls on this and other coasts may be included. Jetties impede the movement of shore currents, leading to deposition over some parts of the bottom and erosion over other parts. Increased deposition may advance a beach seaward; erosion of the bottom may produce erosion of the shore and cause retreat of the shore line into the land. Ultimately equilibrium will be restored, but not until there have been changes in the shore line and development of more or less damage resulting from shallowing of water, building of beaches into the water, increasing the distance of structures on the land from the water, deepening of water, erosion of shores, and perhaps destruction of structures on the land. A seawall is built to prevent erosion of the shore. Prevention of erosion decreases the supply of sediments to the waves and currents. Equilibrium is disturbed and the waves, unable to neutralize their energies through erosion of the shores which are now protected, acquire sediments from the bottoms and beaches; thus the bottom is eroded, the water deepened, perhaps the beaches destroyed, and even the seawall undermined so that it collapses.

The dunes of the Oregon coast are constantly growing and will continue to do so as long as the winds blow inland and sands are available on the beaches. As long as a cover of vegetation can be maintained, the supply of sand merely results in raising the surface, provided the sands are not deposited so fast as to bury and destroy the vegetation. If the vegetation is destroyed - by plowing, grazing, or burning - equilibrium is disturbed and dunes will result, with the irregular surface characteristic of such conditions. At the present time much of the coast of Oregon is protected from the sea by a screen of vegetation. A coastal area about 2 miles wide extending from the town of Gearhart to the mouth of the Columbia River is underlain by loose sands which were deposited by wind. A plant growth was present over this area when white settlement of the country took place, and much of this plant growth is still present, but extensive parts are pastured and in places the plant cover is becoming very sparse so that blowouts (places where the sand is exposed and the winds are blowing it away) are possible. In a short time, this may turn a part of this area into a waste of drifting sand similar to that covering the Coos Bay and Umpqua spits.

Analyses of dune sands are presented in table 12, and with these analyses there are others of wind-lag deposits (nos 11, 14, 15, 17, 18). Two wind-deposited sands carrying high values of magnetite are represented by nos. 16 and 19. These deposits are near the jetties at the mouth of the Columbia River, and the high concentrations of these two minerals are due to the exposed positions which led to removal of the light-weight minerals. Nos. 1 to 9, and 12 and 13 are from typical dunes, and the analyses show that these sands are very low in olivine, epidote, zircon, magnetite, ilmenite, and chromite, and that they are mainly composed of quartz and rock. There is usually some feldspar and, locally, as in the sands about the mouth of the Columbia River, the quantity is significant. The analyses also show that particles of rock are invariably present in significant quantity. The rock is of wide variety, but is rarely if ever calcareous. In general, the sands of the dunes are the simplest in composition of any on the coast. The analyses also show that sands typical of the dunes are fine-grained, and that the dimensional grade of largest quantity is that between 1/8 and 1/4 mm. The grains are well rounded (fig. 13).

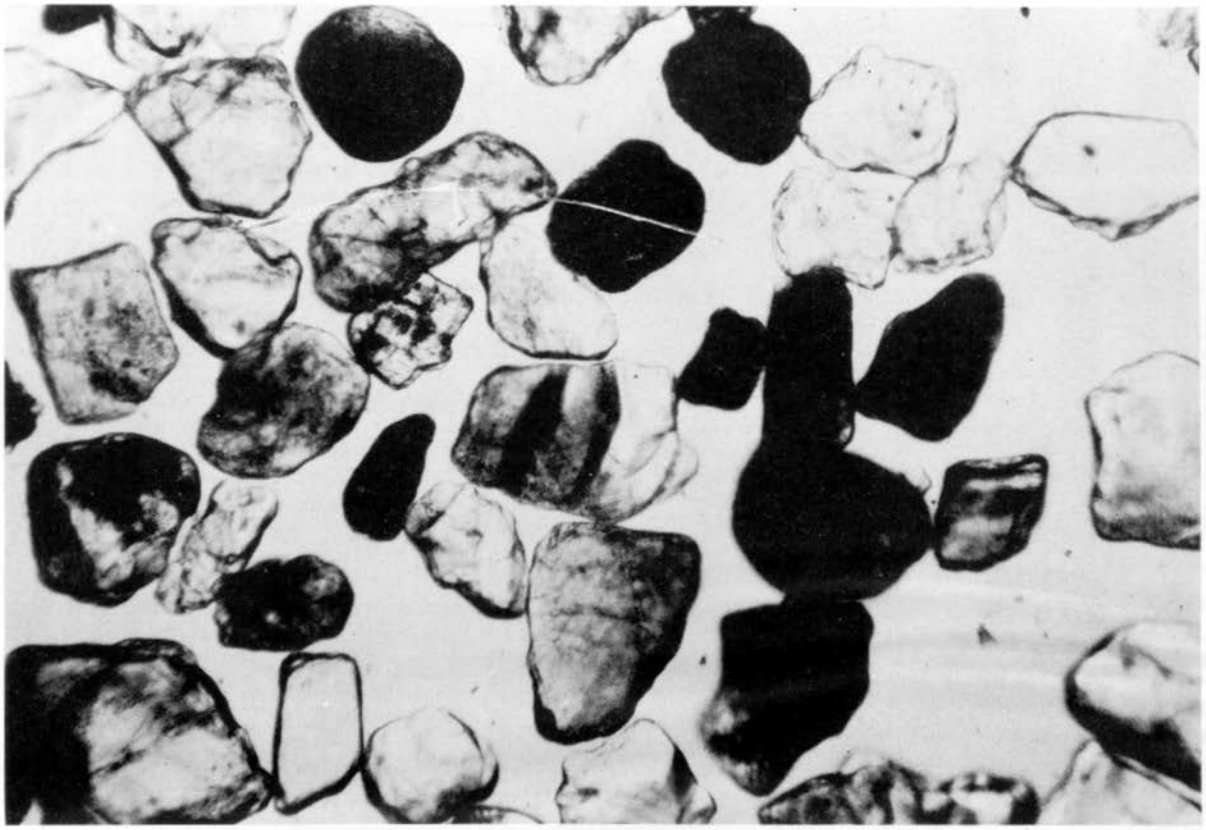

Fig. 13. Dune sand from dunes between Saunders Lake and the sea, collected about a mile inland. (X 80) This sand is typical of the dunes from Cape Falcon south. The dark grains are mostly pieces of rock. The light-colored grains are quartz with an occasional grain of feldspar. The quartz grains contain inclusions of which some are magnetic. Few grains are well rounded. The immediate parents of these dune sands are the sands of the beach. Dune sands from the mouth of the Columbia River to Seaside are composed of angular grains. Sands were immersed in liquid of index 1.63 when photographed.

Analyses of the Beach and Dune Sands

Mechanical analyses were made of all samples collected from the beaches and the dunes, and mineral counts were made of many. United States Standard screens were used and usually 20 grams were taken for analysis. Results are shown in tables 1 to 12 on earlier pages. The collected sample was split with a Jones sample splitter. Fractions were reduced for making counts by means of the Otto microsplit. Weighing was done on a triple beam balance. Mineral counts were made on most samples, usually at least two counts being made. This divided a fraction into parts based on numbers of grains. These may be considered in terms of weight if the minerals have approximately the same specific gravity. Samples in which heavy minerals were present in considerable quantity had the numbers reduced to weights by multiplying the number of grains of each mineral by its average specific gravity. Results are approximate. Magnetite was always determined by direct weighing. Each fraction of every sample analyzed for mineral content was tested for magnetic minerals by means of a strong permanent magnet, and where necessary a strong electromagnet was used for making differential separation of magnetic minerals. Feldspar is present in most samples but was not differentiated. It was counted with the quartz. Most samples contain rock particles in considerable variety of composition and color, and it was often difficult to state whether a particle should be counted as quartz or rock, this being particularly true if the particles of rock are of colors in the range from yellow to brown. Many samples contain particles of broken glass and there are also particles that seem to be obsidian. Olivine and epidote were not differentiated, and it is not unlikely that other green minerals may be included. Chromite and ilmenite are included together as they cannot be separated by means of magnets and they look very much alike under the microscope (figs. 1 - 7, 10 - 13). Determinations of chromic oxide content of selected black sands were made by Mr. L. L. Hoaglan of the Oregon Department of Geology and Mineral Industries. The equivalent of the oxide in terms of chromite cannot be estimated unless it is known how much iron is contained in the chromite in the sands. Results are given below. It will be noted that the percentages are of the same order of magnitude and that the chromite in the sands is not present in commercial quantity under current conditions. The analyses show that for the concentrates of ilmenite and chromite the part which is chromic oxide is relatively constant, and thus, if the quantities of those minerals in a sample are small, the quantity of chromic oxide is small.

Table 13.

Chromic Oxide Content of Some Black Sands

The mineral chromite is confined to black sands and is present in significant quantity only in those black sands south of Tillamook Head. Black sands north of Tillamook Head contain it only in very small quantities. The percentages pertain only to the quantity stated as ilmenite and chromite and not of the entire sand. The concentrates invariably contained small quantities of olivine, epidote, quartz with inclusions, and a little dark garnet. All beach sands are from high tide levels unless otherwise stated. Percentages are as follows:

Sample	C_2O_3 %
Composite of sands south of mouth of Sutton Creek	3.49
Garnet-black sands, Memorial Wayside Park	4.82
Black sands, Memorial Wayside Park	3.12
Third creek south of Big Creek, Yachats	4.53
First creek north of Big Creek, Yachats, top inch	4.74
Small creek at Coast Guard lookout, south side entrance to Alsea Bay	4.61 and 4.29
South of Seal Rock	3.26
Composite of South Beach fore dune	3.76 and 2.23
South Beach, composite from depth of 5 feet	2.47
South Beach, composite to depth of 5 feet	2.22
South Beach, channel sample, no. 28 of fig. 2	2.56
South Beach, channel sample, no. 29 of fig. 2	2.22
Beach at Newport pavilion	5.53
South end of rich deposits, Agate Beach at Big Creek	3.34
1000 feet south of Big Creek, Agate Beach	3.65
600 feet south of Big Creek, Agate Beach	4.52
600 feet south of Big Creek, Agate Beach	3.95

The zircon in the sands of the Oregon beaches contains hafnium, and thus is readily detected by means of ultra-violet light. In some samples, counts of zircon particles were made with the fraction of a sample immersed in nitrotoluol, and quartz and feldspar thus became invisible. In general, the percentages given for zircon are believed to be very close to accurate.

Detailed Descriptions of the Minerals of the Sands

Sands with few or no metallic black minerals have essentially the same character whether collected at low, mid. or high tide levels; from the back beach, or from the dunes. There is little variation at any place with respect to dimensions or composing minerals. The general color is a pale yellowish gray with dark specks; the abundance of the specks is controlled by nearness to coastal cliffs from which dark particles may be derived. Departures from this common color are found where the competencies of waves, currents, and winds are such as to concentrate particles of black rock, black minerals, olivine, epidote, or garnet, thus giving dark, green, or pink shades, respectively. Concentration is never so complete as to produce a deposit free from quartz and feldspar, but this condition is very closely approached in deposits on Sand Island in the Columbia River which consist of more than 90 percent ilmenite and magnetite or titaniferous magnetite. The beach sands north of Tillamook Head contain much feldspar but, compared to the associated quartz, the quantity is small. Both orthoclase and plagioclase are present. Feldspar is also present in the sands south of Tillamook Head but the quantity is commonly not significant.

The quartz and feldspar particles of the beaches north of Tillamook Head exhibit essentially no rounding. Rounding ranges from little to excellent on the quartz and feldspar particles south of Tillamook Head, but there are few quartz and feldspar sands that may be described as well-rounded. Olivine, epidote, garnet, magnetite, ilmenite, and chromite generally have dimensions ranging from 1/16 to 1/4 mm with most particles ranging from 1/16 to 1/8 mm. Particles of these minerals smaller than 1/16 mm are rare. Particles of magnetite and ilmenite larger than 1/4 mm are present in the deposits north of Tillamook Head. Also a sample collected near Delake contains particles of metallic black minerals larger than 1/4 mm. The metallic black minerals north of Tillamook Head are magnetite and ilmenite. There is very little or no chromite. Chromite is present in the black sands south of Tillamook Head, but the quantity is not large.

A sample of an average black sand south of Cape Falcon generally has the particles larger than 1/4 mm composed of particles of rock, quartz, and occasionally olivine or epidote. The fraction from 1/8 to 1/4 mm is composed largely of quartz, rock, olivine, epidote, garnet, and some, but usually not many, black minerals. There is usually no zircon. The fraction between 1/16 and 1/8 mm is composed of angular grains of quartz, rounded (some angular) grains of olivine and epidote, angular (a few round) grains of pink and red garnet, rounded grains of magnetite, ilmenite, and chromite, and ellipsoidally rounded grains of zircon; with the last, there are usually some little-worn crystals of zircon. Coarse-grained sands rarely contain olivine, garnet, and metallic black minerals: they contain no zircon. Some particles among the metallic black minerals have crystal faces and some are octahedrons. Olivine and epidote are generally well-rounded, garnet is usually angular, and metallic black minerals are commonly well rounded. Inclusions of black metallic minerals are abundant in the quartz grains of the beach and dune sands north of Tillamook Head. They are less commonly present in the quartz grains south of that headland.

The character of the minerals in the beach and other sands described on foregoing pages permits additional suggestions respecting origin. It is fairly safe to assume that the sands of the beaches north of Tillamook Head were brought to the sea largely by the Columbia River. No other source seems possible. The quartz and feldspar in the sands south of Tillamook Head could have come from several sources, and there is little doubt that the Tertiary and Pleistocene sandstones in coastal cliffs made large contributions. The varied character of the particles of these minerals indicate a complex origin. The commonly well-rounded grains of magnetite and ilmenite imply long transportation, but it is possible that the grains were somewhat equidimensional in the parent rock. Not infrequently particles of magnetite and ilmenite show crystal faces and some particles are perfect octahedrons. These indicate recent release from parent rocks or transportation by a method that did not produce abrasion. The magnetite and ilmenite may have been derived in part from the igneous rocks exposed in the coastal cliffs, in part from Tertiary and Pleistocene sandstone in the same cliffs, and in part from basic and ultrabasic rocks on the coast of southern Oregon and northern California and the Coast Range inland. The Tertiary and Pleistocene sandstones of the coastal cliffs are not believed to be sources of the metallic minerals as no magnetite and ilmenite were seen in these sandstones in the coastal exposures. Moreover, these two minerals would have great difficulty in existing under the humid and warm conditions of the coast coupled with the additional fact that these sandstones are full of circulating water. Ilmenite, magnetite and iron-bearing chromite would be likely to be oxidized and destroyed. They may originally have been present in these sandstones and there may be places where they are still present. The writer does not know the source of the zircon. Neither the igneous rocks of the coast nor the ultrabasic rocks of the coastal range of southern Oregon and northern California may be considered. Zircon may have been derived from some of the schists of the Coast Range. It was thought that the immediate source might be found in the Tertiary and Pleistocene sandstones of the coastal cliffs, but examination of samples of these sandstones showed no trace of zircon. However, before any decision could be reached respecting these sandstones as a source, many thousands of samples from all parts of the coast should be studied. The association of well-rounded grains with crystals that show little to no wear suggests that new additions of zircon are being made.

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ERRATA

Bulletin 30

Mineralogical and Physical Composition of the Sands
of the
Oregon Coast from Coos Bay to the Mouth of the Columbia River
by
W. H. Twenhofel

Page

4, line 2, read "Heceta Beach", for Hecata Beach.

6, line 1, read "These minerals may also have been brought . . ."

7, end of next to bottom line, read "ellipsoids".

19, line 8, read "rich deposits".

line 17, read "1/8 to 1/4 mm - 55.75 %".

30, table of mineral analyses, under Zircon, 4th column, asterisks (*) mean "very common".

36, third line below (3) Beaches from Boiler Bay to Cascade Head, read "Siletz" for Siltez.

51, table of mineral analyses, No. 5, column 8, read "Muscovite" for Muscarite.

62, table 13, 2nd column heading, read "Cr_2O_3" for C_2O_3.