UNITED STATES DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY . . . Water Resources Division

# SEDIMENT SOURCES AND HOLOCENE SEDIMENTATION HISTORY IN TILLAMOOK BAY, OREGON: Data And Preliminary Interpretations

Prepared In Cooperation With
The United States Department Of Agriculture
Soil Conservation Service

OPEN-FILE REPORT 78-680
Denver, Colorado
1978

UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY

# SEDIMENT SOURCES AND HOLOCENE SEDIMENTATION HISTORY IN TILLAMOOK BAY, OREGON: Data and Preliminary Interpretations

By J. L. Glenn

---

Open-file Rcport 78-680

Prepared in cooperation with the
United States Department of Agriculture
Soil Conservation Service

Denver, Colorado

1978

UNITED STATES DEPARTMENT OF THE INTERIOR

CECIL D. ANDRUS, Secretary

GEOLOGICAL SURVEY

H. William Menard, Director

For additional information write to:

U.S. Geological Survey
Water Resources Division
Mail Stop 413, Box 25046
Denver Federal Center
Denver, Colorado 80225

CONTENTS



ILLUSTRATIONS

TABLES

# SEDIMENT SOURCES AND HOLOCENE SEDIMENTATION HISTORY IN TILLAMOOK BAY, OREGON: DATA AND PRELIMINARY INTERPRETATIONS

By J. L. Glenn

## ABSTRACT

Surface and core sediments from Tillamook Bay, Oregon, have been analyzed to determine modern and Holocene sediment sources and sedimentation history. Heavy mineral analyses established three sediment sources: (1) the five major rivers draining the volcanic and associated sedimentary rocks of the Coast Range, (2) small streams draining the sedimentary uplands that form the shoreline adjacent to Tillamook Bay and erosion of the shoreline by waves and currents, and (3) marine sediments carried to Tillamook Bay by longshore drift from drainage basins north or south of the bay. Stratigraphic and radiocarbon analyses show that the Holocene fill in Tillamook Bay began to accumulate sometime before about 9,000 years ago in deep parts of prefill river valleys. The rate of accumulation generally coincided with the rate of world-wide sea-level rise--faster (greater than about 3 meters per 1,000 years) up to about 7,000 years ago and slower (less than about 2 meters per 1,000 years) since that time. The vertical rate of accumulation at one core site seems to have been about the same from 3,300 years B.P. (before present) to the present, as it was from about 5,200 years B.P. to 3,300.

## INTRODUCTION

The Water Resources Division of the U.S. Geological Survey (USGS) initiated a study of sedimentation problems in Tillamook Bay, Oreg., in 1974. This bay is typical of the many smaller bays that occur along the Pacific northwest coast of the United States. Tillamook Bay (fig. 1, map in pocket) was selected for detailed study because of its known sediment erosion and deposition problems (Brown and others, 1958; Terich and Komar, 1974; Percy and others, 1974, p. 211, and references therein) and because of the presence of nearby bays whose differing hydrologic characteristics (freshwater inflow, tidal influence, salinity, and so forth) facilitated comparisons and contrasts.

In 1976, the USGS and the U.S. Department of Agriculture (USDA), entered into a cooperative agreement under which the USDA would provide partial funding for work of mutual interest in the Tillamook Bay. Several agencies within the USDA (Soil Conservation Service; Forest Service; Economics, Statistics, and Cooperatives Service) were involved in a study whose purpose included identification of sources and supply rates of modern sediments to Tillamook Bay, particularly from agricultural and forest lands within the drainage basin. The cooperative USGS-USDA effort included collection of surface and core samples from Tillamook Bay, and analyses of these samples for compositional and stratigraphic characteristics. This report presents analyses of these samples and interprets modern and Holocene sediment sources and sedimentation history.

Tillamook Bay is located about 80 kilometers (km) south of the mouth of the Columbia River and 100 km west of Portland, Oreg. (fig. 1). The bay is about 10 km long in a southeast to northwest direction, 3 km wide, and less than 2 meters (m) in average depth (Percy and others, 1974, p. 207-208). A sand spit, Bayocean Spit, extends from the south to near the north side of the bay, where jetties have been constructed to facilitate entrance to the bay. Four large rivers, the Tillamook, Trask, Wilson, and Kilchis, enter the bay at the southeast end, and a fifth large river, the Miami, enters near the northeast end. During low river flow, brackish Pacific Ocean water extends up the bay to about the mouth of the combined Tillamook-Trask-Wilson Rivers (fig. 1).

The major rivers chiefly drain areas of volcanic and associated sedimentary rocks of Eocene age in the Oregon Coast Range (Wells and Peck, 1961). Small streams, and parts of the lower Tillamook and Miami Rivers, drain areas of sedimentary rocks of Oligocene to Miocene age (Schlicker and others, 1972, p. 13-27) in the rolling hills adjacent to the margins of Tillamook Bay. Gravels, sands, silts, and clays of Quaternary age (Frye, 1976, p. 45-72) underlie terraces and flood plains in the lowlands around the city of Tillamook (fig. 1), and crop out along the coast north and south of Tillamook Bay.

Sedimentation problems in estuaries (Schubel and Meade, 1977, p. 193-194) have natural and man-related components. Formation of existing estuaries began when the rising world-wide sea level (Kraft, 1971, p. 21-31; Schubel, 1971, p. III-3) entered river valleys carved out to depths determined by prerise level(s) of the sea and by local river and bedrock characteristics. Extensive farming and logging accompanying the settlement of estuarine drainage basins by man (particularly white man) have accelerated rates of sediment supply to estuaries (Schubel and Meade, 1977, p. 197-199), and construction of jetties to facilitate navigation at estuary mouths has resulted in shoreline erosion or deposition (Komar and Terich, 1976, p. 1809-1810).

## Sample Collection

Sediment samples were obtained at 52 surface sites and 17 core sites in and around Tillamook Bay (fig. 1). Surface sediments were collected either by a U.S. BM-54 sampler or by hand dipping a 454-gram (g) sample container to a maximum depth of 5 centimeters (cm) below the sediment surface. Ten samples of surface sediments were collected near the head of tides in the five major rivers entering Tillamook Bay, and an additional 11 samples were obtained from the tidally affected parts of these rivers. The remaining 31 samples are from intertidal to shallow subtidal environments within Tillamook Bay. The bay samples are assigned to one of four parts of the bay. These parts are called: (1) Southwestern Margin, (2) Western Margin, (3) Central Bay, and (4) Eastern Margin. The Western Margin and the Central Bay are divided into bay and ocean, and southern and northern parts, respectively. In general, the margin parts probably extend bayward from the shoreline to about the nearest deep tidal channel, and the central part includes all of the bay isolated from the shoreline by a deep channel or channels.

Core samples were obtained by augering to the sample depth, removing the center plug from the hollow stem of the auger, inserting a split-tube sampler about 46 cm long and 6 cm in diameter, and driving the tube into the sediments below the bottom of the auger. Core sites include 2 on land adjacent to the bay and 15 within Tillamook Bay (fig. 1). For purposes of comparing and analyzing core data, core sites also are assigned to the appropriate geographic part of the bay.

With the exception of core sites 9- and 13-76, core sites in the bay are all in intertidal environments very close to mean lower low water (MLLW), according to the most current bathymetric data (fig. 1). The sediment-water interface, which is used as a datum for sample depths at all core sites within the bay, ranges from 0.6 m (upper bay) to 0.9 m (lower bay) below the standard geodetic mean sea level (m.s.l.) datum. The sediment surface at core site 9-76 is considerably above MLLW and is only about 0.3 m below m.s.l.; at core site 13-76, which is in a small midbay channel, the sediment surface is about 2.7 m below m.s.l.

## Sample Analyses

To determine modern and Holocene sources of sediments in Tillamook Bay, sediment samples were analyzed for mineralogic composition and grain roundness of the nonopaque, heavy (specific gravity >2.96) fraction of the very fine sand (>62<125 micrometers, µm). Between 200 and 300 nonopaque grains were identified and counted by standard optical petrographic techniques in each surface sample, and in 55 samples from the cores.

To evaluate rates of sediment deposition and depositional history during the Holocene, compositional data were combined with field or laboratory observations of stratigraphic variations in sediment color, texture, organic content, and drilling characteristics. In addition, 13 core samples from various depths at five core sites were dated by the radiocarbon technique.

## Acknowledgments

Heavy mineral analyses reported herein were done by Wendy A. Niem or John Kachelmeyer at the Department of Geology, Oregon State University, Corvallis, Oreg. The author is responsible for interpretations and summaries of compositional data and for the more qualitative interpretations on grain roundness. Radiocarbon analyses were accomplished at the Radiocarbon Laboratory of the U.S. Geological Survey, Reston, Va., under the supervision of Meyer Rubin and Elliott Spiker. Acknowledgment is given for these data and for numerous consultations on their significance.

# PRESENTATION OF DATA-SURFACE SAMPLES

The percentages of nonopaque heavy components in surface sediments from Tillamook Bay rivers, tidal rivers, and parts of Tillamook Bay are shown in tables 1 through 6 and are summarized in table 7. (All tables are in the back of this report.) In table 7, the accessory minerals include garnet, zircon, kyanite, tourmaline, staurolite, epidote, sphene, and monazite; the other component contains biotite, muscovite, chlorite, rutile, feldspar, and unknown grains. Garnet and zircon are the abundant accessory minerals, and unknown grains are major constituents in the other component.

Pyroxene group minerals and rock fragments are the major components in sediments from Tillamook Bay rivers (table 1). Kulm and others (1968, p. 168-169) also noted the dominance of pyroxene group minerals, although they did not report the abundance of rock fragments. The clinopyroxenes, augite plus diopside, comprise the bulk of the pyroxene group, with only trace amounts of orthopyroxenes, chiefly hypersthene, noted. The rock fragments are grains with at least two constituents, usually a feldspar and (or) a pyroxene, and a fine-grained or opaque groundmass. The feldspar twinning, where observed, suggests a basic-to-intermediate composition, and most multiple-constituent grains are classified as volcanic rock fragments. Small amounts of amphibole group minerals and of olivine also occur in most river sediments.

The rivers entering Tillamook Bay do not show highly significant compositional differences (table 1). The Tillamook River may differ slightly from the other four rivers, and pyroxenes might decrease, and rock fragments increase progressively, from southern to northern rivers. Avolio (1973, p. 51-52), using X-ray patterns for heavy minerals from Tillamook Bay rivers, identified somewhat distinctive patterns for each river, with the Miami River seeming to differ significantly from the Trask, Wilson, and Kilchis Rivers.

The percentages of nonopaque components in sediments from tidally affected parts of Tillamook Bay rivers are shown in table 2. These sediments, on the average (table 7), show fewer rock fragments and pyroxenes and more amphibole and accessory minerals than river sediments show. However, on an individual river basis, only the Tillamook and the combined Tillamook-South Trask sediments differ greatly from river sediments. Tidal river sediments from downstream of the entrance of the main Trask River (fig. 1; 12- and 13-74) show only a river composition; those upstream of this entrance show the increased percentages of amphiboles and accessory minerals that are reflected in tidal river averages. In general, from the Trask to the Miami Rivers, analyses of sediments from tidal rivers indicate a continuation of the trends (decreasing pyroxenes, increasing rock fragments) suggested by analyses of river sediments.

Compositional data for surface sediments from the Southwestern Margin of Tillamook Bay are characterized by rather extreme local variability (table 3). Although two samples were collected in 1974 and two in 1977, the variability seems to be spatial rather than temporal. On the average (table 7), sediments from the Southwestern Margin show substantial increases in amphiboles, accessory minerals, and others over sediments from rivers or tidal rivers. These increases are chiefly at the expense of pyroxene group minerals, which average 12 to 15 percent less abundant than in sediments from rivers on tidal rivers. Even in those samples (14-74 and 4-77) where pyroxenes are as abundant as in many river samples, amphiboles and accessory minerals tend to be present in amounts greater than in river samples.

Compositions differ markedly between the Western Margin (table 4) of Tillamook Bay and Tillamook Bay rivers (table 1). The differences are (table 7): (1) An increase in accessory minerals, (2) a change in pyroxene group composition from almost 100 percent clinopyroxenes to about 70 percent clinopyroxene and 30 percent orthopyroxene, and (3) a decrease in rock fragments. In addition to these compositional changes, grain rounding increases. In sediments from rivers, most grains are angular to subangular (Pettijohn, 1957, p. 58-59); whereas, in the Western Margin, they are subrounded to well rounded. In addition, optically isotropic fringes, present on many grains in river samples, are very rare on grains from the Western Margin.

Sediments from the bay and those from the ocean sides of the Bayocean Spit (fig. 1) do not differ significantly in composition or grain rounding. In addition, the data do not show any significant compositional trends along Bayocean Spit.

The composition of sediments from the Central Bay (table 5) may be discussed by dividing this part into southern and northern parts, with an arbitrary boundary at approximately Sandstone Point (fig. 1). On the basis of composition alone, this boundary could be drawn between sample sites 33-74 and 31-74, but no significant difference in conclusions results from doing so.

The southern Central Bay has a composition generally similar to the composition in Tillamook Bay rivers, except that average clinopyroxene percentages are slightly higher and rock-fragment percentages are lower (table 7). These changes are accompanied by some increase in grain rounding, although most grains are still subangular to subrounded at best.

In the northern part of the Central Bay, the compositional changes include decreases in the average abundance of pyroxenes (and the appearance in most samples of measurable amounts of hypersthene), and increases in accessory minerals and amphiboles (table 7). These changes, in general, are accompanied by continued increase in grain rounding, particularly in those samples north and west of sample site 33-74.

The possibility of east-west compositional changes within the Central Bay cannot be established with the data presented here. In the southern part, however, such changes seem unlikely because of the similarity between samples on the eastern (28-76 and 13-75) and western (18-75) sides (also see data for core site 11-76). In the northern part, Avolio (1973, p. 51) noted a progressive change from east to west, with the X-ray pattern for an easternmost sample resembling a pattern for Miami River sediments, and the pattern for the westernmost sample similar to that for beach and dune sediments from Bayocean Spit.

The composition of sediments from the Eastern Margin (table 6) south of Kilchis Point (fig. 1) is basically the same as that of sediments from adjacent rivers and tidal rivers. In the central part of the Eastern Margin (from Kilchis Point to Hobsonville Point, fig. 1), some samples (44-77, 19-74, 15-75, also data for core samples 15-76-1a and 14-76-1a) located close to the shoreline have somewhat anomalous (less pyroxenes, more amphiboles and (or) accessory minerals) and highly variable compositions. Likewise, sample 35-76, in the Eastern Margin at the lower end of Miami Cove (fig. 1), differs from typical Miami River samples, most notably in the abundance of orthopyroxenes and amphiboles.

## Discussion

Compositional data for surface sediments establish three possible sources of modern sediments in Tillamook Bay. The five major rivers draining the Coast Range east of Tillamook Bay may be combined as one source, hereafter referred to as the river source. This source almost exclusively provides angular clinopyroxenes and volcanic rock fragments to the river deltas along the Eastern Margin of the bay. The second source of sediments is the shoreline and small streams draining sedimentary bedrock along the shoreline. This source, referred to as the shoreline source, supplies a mixture of generally angular clinopyroxenes and rock fragments and usually rounded accessory minerals and amphiboles to sediments along the Southwestern Margin and part of the Eastern Margin. The third source of sediments, called the marine source, provides substantial amounts of rounded orthopyroxenes, accessory minerals, and probably amphiboles to surface sediments along the Western Margin. Sediments from the marine source are derived (Kulm and others, 1968, p. 176-177; Scheidegger and others, 1971, p. 1112-1120) from drainage basins north or south (or both) of Tillamook Bay and are transported to the bay by longshore drift.

Mixtures of sediments from various sources are found in some parts of Tillamook Bay. The tidal rivers of the Tillamook and the Tillamook-South Trask have sediments from both the river and the shoreline sources, as do parts of the Southwestern and Eastern Margins. The almost total dominance of sediments from the river source in the combined Tillamook-Trask tidal river (samples 12- and 13-74), and in the Eastern Margin south of Kilchis Point (samples 40-, 41-, 42-, and 43-77), indicates that the rate of sediment supply from the river source far exceeds that from the shoreline source in much of Tillamook Bay. In the Central Bay, mixtures of sediments from river and marine sources are present. In general, the southern part of the Central Bay is dominated by sediments from the river source; whereas, the northern part and the Western Margin are dominated by sediments from the marine source.

## PRESENTATIONS OF DATA--CORE SAMPLES

Data from core samples include compositional analysis of heavy components, stratigraphic descriptions, and radiocarbon ages. Unlike the data from surface samples, which are most useful for showing present areal variations, data from core samples establish the nature of compositional and stratigraphic changes with time (depth) at each core site. The selection of core samples for analyses was based on the presence or absence of suitable materials, and on field or laboratory descriptions of the stratigraphy at each core site. Although not every core sample could be analyzed, the major changes with time at each site are believed to have been determined.

### Composition

The percentages of nonopaque heavy components in core samples from Tillamook Bay are shown in tables 8, 9, and 10. The description of these data will emphasize stratigraphic variations in composition at a core site and areal variations among the core sites. Direct comparisons among core sites are complicated by the fact that the samples may come from different depths and may be of different ages. For most cores, however, comparisons can be made between samples representative of near-surface, middle, and near-bottom stratigraphic intervals.

Areal and stratigraphic variations in composition at and among core sites are presented in tables 11 through 27, and are summarized in figure 1 by interpretations of the probable source(s) of sediments in each sample analyzed. The probable source of sediment is designated by "R" for river, "M" for marine, "S" for shoreline, or combinations of these letters (RM, RS, MR) for mixed sources, followed by the depth, in meters, of the sample below the sediment surface. The source of sediment is interpreted only for those samples from the Holocene part of the sediment fill in Tillamook Bay (tables 11 through 27).

The interpretations of sediment source cannot be made from quantitative data alone, particularly where mixed sources are indicated. At core site 7-76 (table 8), for example, sample 8C(20.3) has a composition indicative of a mixed source; a combined river-shoreline (RS) source was indicated because a scan of the grain mount indicated that the grains were mostly angular. At core site 11-76 (table 8), the sediment sources for samples 1a(0.2) and 5C(15.7) are designated MR and RM, respectively, in spite of quantitative compositional similarity, because grains in 1a(0.2) are mostly subrounded to well rounded, whereas those in 5C(15.7) are mostly subangular to subrounded. At the present time, the interpretations of sediment source on the basis of grain rounding are fairly subjective and should be regarded as preliminary.

Only a few cores from Tillamook Bay show no stratigraphic differences in sediment source. At core sites 2-, 4-, and 8-76 (fig. 1), only sediments from the river source were identified, and at core sites 1-, 13-, 14-, and 15-76, the Holocene sediment fill was relatively thin, and only a single sample may have been analyzed. Core sites with a uniform source of river sediment are generally located on the river deltas in the eastern side of Tillamook Bay, and they usually are remote from possible shoreline or marine sources. Cores from river deltas but near a shoreline (5- and 7-76) show a mixed river-plus-shoreline (RS) source, or a source that varies from river to river plus shoreline at different depths.

Compositional differences with depth at core sites in Tillamook Bay south of Sandstone Point are shown by data from core sites 9-, 16-, 10-, and 11-76. The general picture that emerges from these data includes: (1) A river source for deep samples, (2) a mixed source for samples from intermediate depths, (3) a river source for near-surface samples from the eastern side of the bay, and (4) a marine-plus-river source for the near-surface sample from the western side of bay.

North of Sandstone Point, strictly river-source sediments occur at depth only in cores from Miami Cover (fig. 1), where intermediate and near-surface samples show mixed river, river-plus-shoreline, or river-plus-marine sources. Core sediments from the main part of Tillamook Bay north of Sandstone Point typically start with a mixed river-plus-shoreline composition and seem to become more marine toward the surface.

## Discussion

Compositional analyses of core samples generally reveal the same sediment sources for different parts of Tillamook Bay as were established by analyses of surface samples (p. 6-7). They also indicate, however, that the sources of sediments at core sites downbay from the river deltas have changed with time. The changes suggest a transgressive-regressive sedimentation sequence in Tillamook Bay. Prior to the beginning of the transgression, local sediments from river and shoreline sources were being deposited. During the transgressive phase, sediments from the marine source moved into Tillamook Bay, only to be overlain by sediments from the river source as the rate of trangression slowed, or the regressive phase began, and the rivers started to build deltas out into the bay.

## Stratigraphy

Stratigraphic data and interpretations for cores from Tillamook Bay are presented in tables 11 through 27. The deposits beneath the bay can be divided into two units. The upper unit is the Holocene or modern fill in the bay; its source, stratigraphy, and depositional history are the primary concerns of this effort. The lower unit in Tillamook Bay is divisible into: (1) Pleistocene weathered gravels above less weathered gravels, sands, and silts, and (2) Oligocene to Miocene moderately weathered but very hard sandstones and (or) siltstones with rare conglomerate layers. One or both of these divisions of the lower unit were penetrated at core sites 1-, 3-, 5-, 10-, 13-, 14-, 15-, 16-, 17-, and 18-76 (tables 11, 13, 15, 19, 22-27). The best examples of the Pleistocene are the 14 m of weathered gravels at core site 18-76, and the 24+ m of relatively unweathered gravels, sands, and peaty silts and clays at core site 13-76. Core sites 5-76 and 14-76 contain the best examples of Oligocene to Miocene sedimentary rocks. In the Miami River valley (fig. 1), basalts and interbedded clays of Eocene age (table 12) underlie the Holocene deposits.

The depth to the boundary between Holocene and pre-Holocene deposits is shown on figure 1. This boundary is found in 11 of 17 cores and is very sharply defined by a change in drilling characteristics and (or) stratigraphy (tables 11-27); the deposits immediately below the boundary are frequently badly weathered and oxidized, but still are usually more difficult to penetrate than are sediments of the Holocene unit.

The thickness of the Holocene varies from about 1 to greater than 32 m (fig. 1). The unit is only 1-4 m thick (core sites 1-, 15-, and 14-76) along the Eastern Margin of the bay north of Kilchis Point, and only 4-8 m thick (core sites 13-, 17-, and 18-76) in the Central Bay west and north of Sandstone Point. The thickness exceeds 31 m in the major river deltas (core sites 3- and 4-76 in the Miami delta; 7-, 8-, and 9-76 in the Tillamook-Trask-Wilson-Kilchis delta), and toward the Western Margin (11- and 12-76) of the bay. In contrast, only 12 m are present at core site 2-76 along the margin of the Miami River valley above the Miami delta.

The stratigraphy of the Holocene (tables 11-27) is strongly depth dependent. The texture generally is fine-grained, relative to that of pre-Holocene deposits, with all analyzed samples averaging about 60 percent sand and 40 percent silt plus clay. In the river deltas where the Holocene is thick, basal samples may contain brown, gravel-size materials, and drilling data may indicate the presence of cobble- and (or) boulder-size materials. Similar coarse sediments are not present, however, in samples from comparable depths at core sites along the Western Margin of the bay.

Basal, coarse sediments are overlain by a 4- to 20-m thick sequence of chiefly well-stratified silt and clay with only minor amounts of sand. These sediments may form the basal part of the Holocene where the unit is thin, or they may overlie a thin layer that includes a mixture of silt and clay, some sand, and even fine gravels. Toward the Western Margin of the bay, the middle fine sediments are generally coarser than in the delta regions, although the sediments are still finer than surface sediments. In general, the top part of the Holocene is sandier and less well stratified than the middle part, regardless of the core location.

The Holocene sediments usually contain abundant organic materials. These materials are chiefly isolated small wood clasts (broken twigs or small branches), or woody to fibrous and very fine-grained organic layers, all detrital in origin. Occasional shell layers or zones are found, mostly toward the lower part of the Holocene at core sites where the Holocene fill is thin. In general, organic materials and shell layers are more abundant in cores from the delta and shoreline regions than in cores from sites toward the Western Margin of the bay.

## <u>Age</u>

The results of age determinations by the radiocarbon technique are shown in table 28 and are plotted in figure 2. All samples analyzed for age were small wood fragments or fibrous-to-fine woody organic materials; modern surface sediments with organic materials of this nature could give radiocarbon ages as old as several hundred years. The data show that the sedimentary fill beneath Tillamook Bay consists of materials older than about 38,000 years before present (B.P.) and younger than about 8,400±400 years B.P. (see tables 11-13, 15-16, and 18). The older samples came from pre-Holocene deposits; whereas, the younger dates came from samples of the Holocene or modern fill.

The Holocene fill in Tillamook Bay in the deep parts of the river deltas began to accumulate sometime before about 8,000 years B.P. In the Miami River delta (core site 3-76), a linear extrapolation of age-depth data (fig. 2) to the base of the fill (table 13) suggests that deposition there began between about 8,600 and 9,200 years B.P. At core site 5-76 (fig. 1), also in the Miami River delta, the base of the Holocene fill is only about 11 m below the sediment surface (about 12 m below m.s.l.), and the age of the basal materials is probably only about 6,500 to 7,000 years B.P. (fig. 2). The base of the Holocene fill in the combined Tillamook-Trask-Wilson-Kilchis delta was not defined by drilling data (table 18), but, at core site 9-76 the presence of coarse sands and hard gravels suggest that the base is not far from the termination of drilling at about 32.3 m (m.s.l.); thus, the age of the basal part of the modern fill at this delta core site also should not be more than about 9,000 years B.P. Presumably, Holocene deposits older than 9,000 years B.P. could be present in Tillamook Bay at locations west of the delta regions, or at core sites in the deltas where more than 32 m of sediment may be present.

The Holocene fill in Tillamook Bay is still accumulating. The radiocarbon technique, however, together with the detrital organic materials that form the bulk of datable samples, does not provide ages for the youngest deposits. At a depth of 6.9 m (m.s.l.), the age of the fill is 3,300±200 (table 28) years B.P.; no datable materials younger than 3,300±200 years were found.

Radiocarbon ages are plotted against sample depth below modern m.s.l. in figure 2. In addition, this figure shows a generalized curve of world-wide sea-level rise (from Kraft, 1971, p. 2155), which may or may not be applicable to the local Tillamook Bay area. A curve drawn through data points for core site 9-76 generally follows the trends of the curve of sea-level rise. The sediment curve for core site 9-76 should not be considered a curve of local sea-level rise, because the exact relationship between dated samples and sea level at the time of deposition is unknown. Stratigraphic data suggest, for example, deposition in deep or quiet water for sediments in the lower and middle parts of the Holocene fill. Deep water implies that sea level may have been considerably above the sediment surface during the early and middle periods of bay filling; considering the rapid rate of sea-level rise during these periods, such a relation would be expected.

Calculations of apparent deposition rates between dated horizons in Tillamook Bay cores are shown in table 29. The minimum and maximum rates were computed assuming the maximum and minimum age differences, respectively, between horizons; the average computation assumes that the age difference is equal to the measured value(s) without considering the possible stated error (table 28). The computed deposition rates do not take into account possible compaction or geometry changes, which are believed to be minimal, but which are not readily determinable with the available data. In general, the apparent deposition rates indicate rapid deposition up to 6,000 to 7,000 years B.P., and slower rates since that time; compaction alone would cause an opposite trend. The data suggest the possibility of somewhat slower rates in the Miami delta

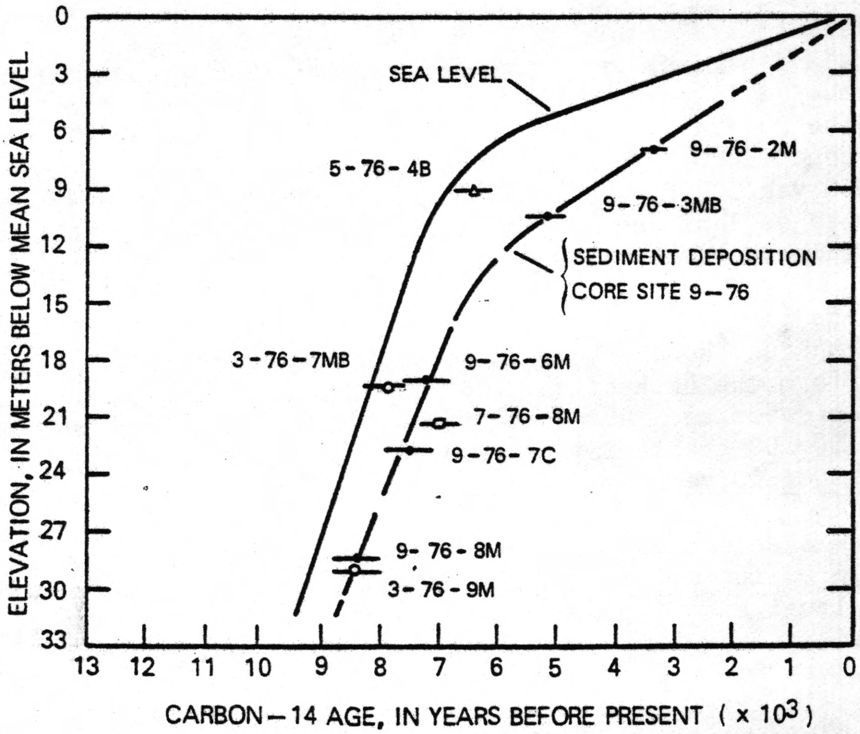


Figure 2. Generalized curve of world-wide sea-level rise (from Kraft, 1971) and curve of sediment deposition at core site 9-76.

than in the Tillamook-Trask-Wilson-Kilchis delta. There is little evidence to establish a change in deposition rate in either delta in historical time; the rate at core site 9-76 between about 5,200 and 3,300 years B.P. is basically the same as the rate between about 3,300 years B.P. and the present.

## Discussion

Stratigraphic and radiocarbon data indicate that Tillamook Bay, prior to the deposition of the Holocene fill, consisted of southern and northern deep river valleys separated by a ridge extending northwestward from about Sandstone Point. The deposits beneath the ridge and flanking the river valleys included materials that are interpreted as being Oligocene to Miocene sedimentary bedrock, similar to that cropping out along the nearby bay margins. In some places, the bedrock is overlain by a pre-Holocene fill that includes weathered surface gravels, unweathered gravels, and interbedded lacustrine, peaty deposits that are probably Pleistocene (greater than 38,000 years B.P.) in age. Similar deposits have been described by Frye (1976, p. 57-72), and have been found underlying terraces between Tillamook and Idaville, Oreg. (fig. 1).

The Holocene fill in Tillamook Bay began to accumulate sometime prior to 9,000 years ago when the unweathered gravels and sands in prefill river valleys rather abruptly changed to the sands, silts, and clays that characterize most of the Holocene fill. In general, the deposition and characteristics of the Holocene fill are related to the world-wide Holocene rise in sea level. During the early period of rapid rise, from before 9,000 to about 7,000 years B.P, deposition was rapid, and the deposits in much of the present estuary were well-stratified silts and clays. These characteristics suggest deposition in deep water at rates sufficiently rapid to prevent much winnowing or disturbance by burrowing organisms. The relatively rapid deposition rate during this period might be a reflection of the geometry of the depositional embayment, the rate of sediment supply, the source(s) of sediments, or an increase (over the present) in the sediment trap efficiency of the early Tillamook estuary. Relative to sediment sources, compositional data indicate initial contributions from the marine source during the period of relatively rapid sea-level rise. When the rate of sea-level rise began to decrease about 6,000 years B.P., the rate of sediment deposition also decreased. The younger sediments generally are coarser and not as well stratified as the sediments deposited prior to 6,000 years B.P. Presumably, these sediment characteristics reflect more winnowing and more time for organisms to "homogenize" the sediments. Sometime between about 5,000 and 3,000 years B.P., the ridge between southern and northern parts of Tillamook Bay should have been covered with water and (or) sediments, and the bay should have begun to develop its present configuration. At the present time, sediments from the river source are accumulating in the river deltas and are prograding into the bay over sediments from the marine source.

The vertical rate of accumulation of these sediments at one cone site seems to have been about the same from 3,300 years B.P. to the present as it was from 5,200 to 3,300 years B.P.

## SUMMARY

Compositional, stratigraphic, and radiocarbon data indicate the following conclusions relative to Holocene sedimentation in Tillamook Bay:

1. Modern sediments in the bay are derived from different sources, including: (a) Sediments from the major rivers draining the volcanic terranes of the Coast Range; (b) sediments from shoreline erosion and small streams draining sedimentary uplands adjacent to the bay; and (c) marine sediments from longshore transport to the bay from drainage basins north or south of the bay.

2. The sources of Holocene sediment deposited at some locations varied with time (depth), generally suggesting a transpressive-regressive sedimentation sequence; that is, older local river and shoreline sediments at depth overlain by sediments, reflecting a marine source, in part, and overlain by younger local sediments at the surface.

3. Holocene sediments are chiefly sands, silts, and clays that range in thickness from >32 m along the western side of the bay and in deep pre-Holocene river valleys to <1 m at a core site along the eastern side. Northwest of Sandstone Point, a ridge of pre-Holocene sediments with only 4-8 m of overlying Holocene fill separates a northern deep river valley from a southern deep river valley or valleys.

4. Holocene sands, silts, and clays began to accumulate in deep river valleys sometime before about 9,000 years ago. The rate of accumulation was apparently about the same as the rate of sea-level rise. The accumulation rate of one core site seems to have been virtually constant for the last 5,200 years.

## REFERENCES CITED

Ávolio, G. W., 1973, Granulometric analysis of recent sediments of Tillamook Bay, Oregon: Department of Earth Science, Portland State University, Portland, Oreg., M.S. Thesis 67 p.

Brown, H.E., Clark, G. D., and Pope, R. J., 1958, Closure of the breach in Bayocean Peninsula, Oregon: Journal of Waterways and Harbors Divison, American Society of Civil Engineers, WW1, paper 1516, 20 p.

Frye, W, H., 1976, Stratigraphy and petrology of Late Quaternary terrace deposits around Tillamook Bay, Oregon: Department of Geology, University of Oregon, Eugene, Oreg., M.S. Thesis 112 p.

Komar, P. D. and Terich, T. A., 1976, Changes due to jetties at Tillamook Bay, Oregon *in* Coastal Engineering Conference 15th, Honolulu, Hawaii, 1976, Proceedings, p. 1791-1811.

Kraft, J. C., 1971, Sedimentary environment facies patterns and geologic history of a Holocene marine transgression: Geological Society of America Bulletin, v. 82, no. 8, p. 2131-2158.

Kulm, L. D., Scheidegger, K. F., Byrne, J. V., and Spigai, J. J., 1968, A preliminary investigation of the heavy mineral suites of the coastal rivers and beaches of Oregon and northern California: The ORE BIN, State of Oregon Department of Geology and Mineral Industries, Portland, Oreg., v. 30, no., p. 165-180.

Percy, K. L., Sutterlin, C., Bella, D. A., and Klingeman, P. C., 1974, Oregon's estuaries: Oregon State University, Corvallis, Oreg., Sea College Program 294 p.

Pettijohn, F. J., 1957, Sedimentary rocks (2d ed.): New York, Harper, 718 p.

Scheidegger, K. F., Kulm, L. D., and Runge, E. J., 1971, Sediment sources and dispersal patterns of Oregon continental shelf sand: Journal of Sedimentary Petrology, v. 41, no. 4, p. 1112-1120.

Schlicker, H. G., Deacon, R. J., Beaulieu, J. D., and Olcott, G. W., 1972, Environmental geology of the coastal region of Tillamook and Clatsop Counties, Oregon: State of Oregon Department of Geology and Mineral Industries, Portland, Oreg., Bulletin 74, 164 p.

Schubel, J. R., 1971, The origin and development of estuaries, *in* The estuarine environment, estuaries and estuarine sedimentation: American Geological Institute, Washington, D.C., (Short course lecture notes, Wye Institute), Chapter III, p. 3-7.

Schubel, J. R. and Meade, R. H., 1977, Man's impact on estuarine sedimentation *in* Estuarine pollution control and assessment: U.S. Environmental Protection Agency, Office of Water Planning and Standards, Washington, D.C., v. 1, p. 193-209.

Terich, T. A. and Komar, P. D., 1974, Bayocean Spit, Oregon: History of development and erosional destruction: Shore and Beach, v. 42, p. 3-10.

Wells, F. G. and Peck, D. L., 1961, Geologic map of Oregon west of the 121st meridian: U.S. Geological Survey Miscellaneous Geologic Investigations Map I-325. Prepared in cooperation with the Oregon Department of Geology and Mineral Industries, Portland, Oreg.

Table 1.--Percentages of nonopaque heavy components in river sediments

["T" indicates that the component is present in amounts less than 1 percent. Analyses by Wendy A. Niem and John Kachelmeyer.]

| Component | River | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Tillamook | | Trask | | Wilson | | Kilchis | | Miami | |
| | Sample No. | | | | | | | | | |
| | 1-74 | 2-74 | 3-74 | 4-74 | 7-74 | 8-74 | 9-74 | 10-74 | 20-74 | 39-76 |
| Pyroxene group---------- | 78 | 81 | 87 | 88 | 78 | 72 | 66 | 61 | 62 | 73 |
| Clinopyroxenes-------- | 78 | 81 | 87 | 88 | 77 | 72 | 66 | 60 | 62 | 73 |
| Augite and diopside | ---- | 81 | --- | --- | ---- | 55 | --- | 54 | 62 | 73 |
| Titanaugite--------- | ---- | T | --- | --- | ---- | 17 | --- | 6 | ---- | ---- |
| Orthopyroxenes-------- | T | ---- | --- | --- | T | ---- | --- | T | ---- | ---- |
| Hypersthene--------- | T | ---- | --- | --- | T | ---- | --- | T | ---- | ---- |
| Enstatite----------- | ---- | ---- | --- | --- | ---- | ---- | --- | ---- | ---- | ---- |
| Amphibole group-------- | 3 | 1 | --- | --- | T | ---- | T | ---- | T | T |
| Hornblende------------ | 3 | 1 | --- | --- | T | ---- | T | ---- | T | T |
| Green--------------- | ---- | ---- | --- | --- | ---- | ---- | --- | ---- | T | T |
| Blue-green---------- | ---- | ---- | --- | --- | ---- | ---- | --- | ---- | ---- | ---- |
| Basaltic----------- | ---- | ---- | --- | --- | ---- | ---- | --- | ---- | ---- | ---- |
| Tremolite------------ | ---- | ---- | --- | --- | ---- | ---- | --- | ---- | ---- | ---- |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Amphibole group--Cont. | | | | | | | | | | |
| Glaucophane---------- | ---- | ---- | --- | --- | ---- | ---- | --- | ---- | ---- | ---- |
| Rock fragments---------- | 15 | 16 | 9 | 12 | 15 | 28 | 29 | 39 | 34 | 27 |
| Volcanic------------- | 15 | 16 | 9 | 12 | 15 | 28 | 29 | 39 | 34 | 24 |
| Unidentified--------- | ---- | ---- | --- | --- | ---- | ---- | --- | ---- | ---- | 3 |
| Biotite--------------- | ---- | T | --- | --- | ---- | ---- | --- | ---- | ---- | ---- |
| Muscovite------------- | ---- | ---- | --- | --- | ---- | ---- | --- | ---- | ---- | ---- |
| Chlorite-------------- | ---- | ---- | --- | --- | ---- | ---- | --- | ---- | ---- | ---- |
| Garnet---------------- | T | ---- | --- | --- | ---- | ---- | --- | ---- | T | ---- |
| Kyanite--------------- | ---- | ---- | --- | --- | ---- | ---- | --- | ---- | ---- | ---- |
| Zircon---------------- | ---- | T | --- | --- | ---- | ---- | --- | ---- | ---- | ---- |
| Tourmaline------------ | ---- | ---- | --- | --- | T | ---- | T | ---- | ---- | ---- |
| Staurolite------------ | ---- | ---- | --- | --- | ---- | ---- | --- | ---- | ---- | ---- |
| Olivine--------------- | 2 | ---- | 4 | --- | T | ---- | 4 | ---- | 3 | ---- |
| Epidote--------------- | T | ---- | --- | --- | ---- | ---- | --- | ---- | ---- | ---- |
| Sphene---------------- | ---- | ---- | --- | --- | ---- | ---- | --- | ---- | ---- | ---- |
| Monazite-------------- | ---- | ---- | --- | --- | ---- | ---- | --- | ---- | ---- | ---- |
| Rutile---------------- | ---- | T | --- | --- | ---- | ---- | --- | ---- | ---- | ---- |
| Feldspar-------------- | ---- | ---- | --- | --- | ---- | ---- | --- | ---- | ---- | ---- |
| Unknown--------------- | ---- | T | T | --- | 6 | ---- | --- | T | ---- | ---- |

Table 2.--Percentages of nonopaque heavy components in sediments from tidal rivers

["T" indicates that the component is present in amounts less than 1 percent.

Analyses by Wendy A. Niem and John Kachelmeyer.]

| Component | Tidal River | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Tillamook | Tillamook-South Trask | | | Tillamook-Trask | | Trask | Wilson | | Kilchis | Miami |
| | Sample No. | | | | | | | | | | |
| | 48-77 | 9-75 | 7-75 | 4-75 | 12-74 | 13-74 | 47-77 | 5-74 | 21-76 | 46-77 | 45-77 |
| Pyroxene group--------- | 36 | 69 | 70 | 69 | 91 | 88 | 83 | 78 | 81 | 65 | 63 |
| Clinopyroxenes-------- | 35 | 66 | 67 | 66 | 91 | 88 | 82 | 78 | 81 | 65 | 62 |
| Augite and diopside | 34 | 58 | 61 | 62 | --- | 87 | 76 | --- | 78 | 65 | 62 |
| Titanaugite--------- | 1 | 8 | 6 | 4 | --- | T | 6 | --- | 3 | --- | T |
| Orthopyroxenes-------- | 1 | 3 | 3 | 3 | --- | --- | T | --- | --- | --- | T |
| Hypersthene--------- | --- | 3 | 3 | 3 | --- | --- | T | --- | --- | --- | T |
| Enstatite----------- | 1 | --- | --- | --- | --- | --- | --- | --- | --- | --- | T |
| Amphibole group-------- | 25 | 7 | 5 | 6 | T | --- | T | 1 | T | T | T |
| Hornblende----------- | 25 | 7 | 5 | 6 | T | --- | T | 1 | T | T | T |
| Green-------------- | 23 | 4 | 5 | 6 | --- | --- | T | --- | T | T | T |
| Blue-green---------- | 2 | 3 | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Basaltic----------- | --- | T | --- | T | --- | --- | --- | --- | T | --- | --- |
| Tremolite----------- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Amphibole group--Cont. | | | | | | | | | | | |
| Glaucophane | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Rock fragments | 21 | 8 | 18 | 14 | 5 | 11 | 16 | 17 | 18 | 34 | 36 |
| Volcanic | 13 | 8 | 18 | 13 | 5 | 11 | 13 | 17 | 15 | 31 | 33 |
| Unidentified | 8 | ---- | ---- | T | ---- | ---- | 3 | ---- | 3 | 3 | 3 |
| Biotite | ---- | T | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Muscovite | ---- | T | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Chlorite | T | ---- | ---- | ---- | ---- | T | ---- | ---- | ---- | ---- | ---- |
| Garnet | 10 | 4 | T | 2 | T | ---- | T | ---- | ---- | ---- | ---- |
| Kyanite | ---- | 3 | 2 | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Zircon | 6 | ---- | ---- | T | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Tourmaline | 1 | ---- | T | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Staurolite | T | T | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Olivine | ---- | T | T | 4 | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Epidote | ---- | 3 | ---- | T | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Sphene | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Monazite | ---- | T | T | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Rutile | T | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Feldspar | ---- | ---- | ---- | T | T | ---- | ---- | ---- | T | ---- | ---- |
| Unknown | ---- | 4 | 3 | 2 | 2 | T | ---- | 3 | ---- | ---- | ---- |

Table 3.--Percentages of nonopaque heavy components in surface sediments from the Southwestern Margin of Tillamook Bay

["T" indicates that the component is present in amounts less than 1 percent. Analyses by Wendy A. Niem and John Kachelmeyer.]

| Component | Sample No. | | | |
| --- | --- | --- | --- | --- |
| | 7-77 | 14-74 | 4-77 | 15-74 |
| Pyroxene group | 32 | 82 | 77 | 48 |
| Clinopyroxenes | 31 | 82 | 75 | 48 |
| Augite and diopside | 31 | 81 | 71 | 47 |
| Titanaugite | ---- | T | 4 | T |
| Orthopyroxenes | T | T | 2 | T |
| Hypersthene | ---- | T | 2 | T |
| Enstatite | T | ---- | ---- | ---- |
| Amphibole group | 17 | 2 | 5 | 6 |
| Hornblende | 17 | 2 | 5 | 6 |
| Green | 11 | 2 | 2 | 3 |
| Blue-green | 6 | T | 2 | 3 |
| Basaltic | ---- | ---- | T | ---- |
| Tremolite | ---- | ---- | ---- | T |
| Glaucophane | ---- | ---- | ---- | ---- |

| | | | | |
|---|---|---|---|---|
| Rock fragments | 39 | 2 | 16 | 22 |
| Volcanic | 25 | 2 | 11 | 21 |
| Unidentified | 14 | ---- | 5 | 1 |
| Biotite | ---- | ---- | ---- | 2 |
| Muscovite | ---- | ---- | ---- | ---- |
| Chlorite | ---- | ---- | ---- | ---- |
| Garnet | 6 | 5 | 1 | 4 |
| Kyanite | ---- | ---- | ---- | ---- |
| Zircon | 2 | 3 | T | 1 |
| Tourmaline | T | 1 | ---- | 2 |
| Staurolite | T | T | ---- | ---- |
| Olivine | ---- | ---- | ---- | 1 |
| Epidote | ---- | ---- | ---- | ---- |
| Sphene | 1 | T | ---- | ---- |
| Monazite | ---- | T | ---- | T |
| Rutile | T | T | ---- | ---- |
| Feldspar | 2 | T | T | 6 |
| Unknown | T | ---- | ---- | 8 |

Table 4.--Percentages of nonopaque heavy components in surface sediments from the Western Margin of Tillamook Bay

["T" indicates that the component is present in amounts less than 1 percent. Analyses by Wendy A. Niem and John Kachelmeyer.]

| Component | Bay Samples | | | | Ocean Samples | |
|---|---|---|---|---|---|---|
| | Sample No. | | | | | |
| | 16-74 | 17-74 | 25-74 | 26-74 | 24-74 | 27-74 |
| Pyroxene group------------------- | 50 | 50 | 66 | 57 | 55 | 60 |
| Clinopyroxenes----------------- | 36 | 36 | 50 | 46 | 31 | 40 |
| Augite and diopside----------- | 36 | 36 | 45 | 41 | 31 | 38 |
| Titanaugite------------------- | ---- | ---- | 5 | 5 | ---- | 2 |
| Orthopyroxenes----------------- | 14 | 14 | 16 | 11 | 24 | 20 |
| Hypersthene------------------ | 14 | 14 | 16 | 11 | 22 | 20 |
| Enstatite-------------------- | ---- | ---- | ---- | ---- | 2 | ---- |
| Amphibole group------------------ | 11 | 8 | 5 | 10 | 16 | 8 |
| Hornblende--------------------- | 11 | 8 | 5 | 10 | 16 | 8 |
| Green----------------------- | 9 | 7 | 2 | 10 | 9 | 4 |
| Blue-green------------------ | 1 | T | 2 | ---- | 3 | 4 |
| Basaltic-------------------- | 1 | T | 1 | ---- | 4 | T |
| Tremolite--------------------- | ---- | ---- | ---- | ---- | ---- | ---- |
| Glaucophane------------------- | ---- | ---- | ---- | ---- | T | ---- |

| | | | | | | |
|---|---|---|---|---|---|---|
| Rock fragments | 4 | 2 | 9 | 9 | 2 | 7 |
| Volcanic | 4 | 2 | 8 | 8 | 2 | 6 |
| Unidentified | ---- | ---- | 1 | 1 | ---- | 1 |
| Biotite | ---- | ---- | ---- | ---- | ---- | ---- |
| Muscovite | ---- | ---- | ---- | ---- | ---- | ---- |
| Chlorite | ---- | ---- | ---- | ---- | ---- | ---- |
| Garnet | 19 | 17 | 12 | 7 | 11 | 13 |
| Kyanite | T | T | ---- | T | 1 | 2 |
| Zircon | 6 | 4 | 1 | T | 2 | 2 |
| Tourmaline | ---- | ---- | ---- | 2 | ---- | T |
| Staurolite | 1 | 2 | T | ---- | ---- | T |
| Olivine | ---- | ---- | ---- | 1 | ---- | ---- |
| Epidote | 2 | 5 | 3 | ---- | 3 | 3 |
| Sphene | ---- | 3 | T | 1 | T | T |
| Monazite | ---- | T | ---- | ---- | ---- | ---- |
| Rutile | ---- | T | ---- | ---- | ---- | T |
| Feldspar | 1 | ---- | ---- | 3 | ---- | T |
| Unknown | 4 | 7 | 1 | 6 | 8 | 4 |

Table 5.--Percentages of nonopaque heavy components in surface sediments from the Central Bay part of Tillamook Bay

["T" indicates that the component is present in amounts less than 1 percent. Analyses by Wendy A. Niem and John Kachelmeyer.]

| Component | Southern Central Bay | | | | | Northern Central Bay | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Sample No. | | | | | | | | | | |
| | 16-75 | 27-76 | 28-76 | 18-75 | 13-75 | 12-75 | 33-74 | 31-74 | 30-74 | 29-74 | 28-74 |
| Pyroxene group--------- | 87 | 81 | 88 | 92 | 80 | 87 | 64 | 70 | 71 | 56 | 49 |
| Clinopyroxenes------- | 87 | 80 | 88 | 92 | 80 | 85 | 64 | 59 | 69 | 46 | 34 |
| Augite and diopside | 86 | 73 | 80 | 88 | 78 | 85 | 60 | 57 | 67 | 44 | 34 |
| Titanaugite--------- | 1 | 7 | 8 | 4 | 2 | ---- | 4 | 2 | 2 | 2 | ---- |
| Orthopyroxenes--------- | ---- | 1 | T | ---- | T | 2 | T | 11 | 2 | 10 | 15 |
| Hypersthene----------- | ---- | 1 | T | ---- | T | 2 | T | 11 | 2 | 9 | 15 |
| Enstatite------------ | ---- | ---- | ---- | ---- | ---- | ---- | ---- | T | ---- | T | ---- |
| Amphibole group-------- | T | 1 | ---- | T | 3 | 7 | T | 6 | 7 | 6 | 12 |
| Hornblende----------- | T | 1 | ---- | T | 3 | 7 | T | 6 | 7 | 6 | 12 |
| Green-------------- | T | T | ---- | T | 2 | 6 | T | 2 | 2 | 3 | 12 |
| Blue-green--------- | ---- | T | ---- | T | 1 | ---- | T | 3 | 5 | 3 | ---- |
| Basaltic----------- | ---- | ---- | ---- | ---- | ---- | 1 | ---- | T | ---- | T | ---- |
| Tremolite------------ | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Glaucophane---------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Rock fragments---------- | 11 | 18 | 11 | 5 | 13 | 4 | 34 | 7 | 15 | 28 | 2 |
| Volcanic-------------- | 11 | 15 | 8 | 5 | 13 | 4 | 34 | 6 | 14 | 26 | ---- |
| Unidentified---------- | ---- | 3 | 3 | ---- | ---- | ---- | T | T | T | 2 | 2 |
| Biotite ---------------- | ---- | ---- | ---- | ---- | ---- | ---- | T | T | ---- | T | ---- |
| Muscovite-------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | T | ---- |
| Chlorite---------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Garnet------------------ | ---- | ---- | ---- | T | T | ---- | ---- | 6 | 1 | 3 | 17 |
| Kyanite----------------- | ---- | ---- | ---- | T | 1 | ---- | ---- | 1 | T | T | T |
| Zircon------------------ | ---- | ---- | ---- | T | ---- | ---- | T | 2 | T | 1 | 7 |
| Tourmaline------------- | T | ---- | T | ---- | ---- | ---- | ---- | T | T | T | ---- |
| Staurolite------------- | T | ---- | ---- | ---- | ---- | ---- | ---- | T | ---- | 1 | ---- |
| Olivine----------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | T |
| Epidote----------------- | ---- | ---- | ---- | ---- | T | ---- | ---- | 1 | ---- | 1 | ---- |
| Sphene------------------ | ---- | ---- | ---- | ---- | ---- | ---- | ---- | T | T | T | ---- |
| Monazite---------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | T | ---- | T | 2 |
| Rutile------------------ | T | ---- | ---- | ---- | ---- | ---- | ---- | T | ---- | ---- | ---- |
| Feldspar---------------- | ---- | ---- | T | T | T | ---- | ---- | T | T | T | ---- |
| Unknown----------------- | T | ---- | ---- | 2 | ---- | 2 | ---- | 4 | 4 | 2 | 8 |

Table 6.--Percentages of nonopaque heavy components in surface sediments from the Eastern Margin of Tillamook Bay

["T" indicates that the component is present in amounts less than 1 percent. Analyses by Wendy A. Niem and John Kachelmeyer.]

| Component | Sample No. | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 43-77 | 42-77 | 41-77 | 40-77 | 26-76 | 44-77 | 19-74 | 15-75 | 35-76 | 14-75 |
| Pyroxene group---------- | 81 | 77 | 79 | 80 | 77 | 66 | 68 | 82 | 68 | 77 |
| Clinopyroxenes-------- | 81 | 77 | 79 | 80 | 77 | 66 | 64 | 82 | 63 | 76 |
| Augite and diopside | 74 | 66 | 75 | 76 | 73 | 65 | 64 | 81 | 60 | 75 |
| Titanaugite--------- | 7 | 11 | 4 | 4 | 4 | 1 | ---- | 1 | 3 | T |
| Orthopyroxenes-------- | ---- | ---- | ---- | ---- | ---- | ---- | 4 | T | 5 | 1 |
| Hypersthene--------- | ---- | ---- | ---- | ---- | ---- | ---- | 4 | T | 5 | 1 |
| Enstatite---------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Amphibole group--------- | T | T | T | T | ---- | 1 | 7 | T | 4 | T |
| Hornblende----------- | T | T | T | T | ---- | 1 | 7 | T | 4 | T |
| Green-------------- | T | T | T | T | ---- | 1 | 7 | T | 4 | T |
| Blue-green---------- | ---- | ---- | T | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Basaltic----------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Tremolite------------ | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Glaucophane----------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Rock fragments---------- | 18 | 23 | 21 | 20 | 23 | 32 | 12 | 16 | 22 | 22 |
| Volcanic-------------- | 16 | 18 | 18 | 14 | 17 | 25 | 12 | 16 | 13 | 22 |
| Unidentified---------- | 2 | 5 | 3 | 6 | 6 | 7 | ---- | ---- | 9 | ---- |
| Biotite---------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Muscovite-------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Chlorite--------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Garnet----------------- | ---- | ---- | ---- | ---- | ---- | ---- | T | ---- | 3 | ---- |
| Kyanite---------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | T | ---- | ---- |
| Zircon----------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | T | 2 | T |
| Tourmaline------------- | ---- | ---- | ---- | ---- | ---- | ---- | T | ---- | ---- | ---- |
| Staurolite------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Olivine---------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Epidote---------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Sphene----------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Monazite--------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Rutile----------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Feldspar--------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | T | ---- |
| Unknown---------------- | ---- | ---- | ---- | ---- | ---- | ---- | 12 | T | ---- | T |

Table 7.--Average percentages of selected components in surface sediments from Tillamook Bay

["T" indicates that the average percentage of the component was less than 1 percent. Samples with "T" percentages of a component(s) (tables 1-6) were treated as if the components were totally absent.]

| Component | River | Tidal River | South-western Margin | Western Margin: Bay | Western Margin: All | Western Margin: Ocean | Central Bay: Southern | Central Bay: All | Central Bay: Northern | Eastern Margin |
|---|---|---|---|---|---|---|---|---|---|---|
| Number of samples | 10 | 11 | 4 | 4 | 6 | 2 | 5 | 11 | 6 | 10 |
| Pyroxene group------- | 75 | 72 | 60 | 56 | 56 | 58 | 86 | 75 | 66 | 76 |
| Clinopyroxenes----- | 75 | 71 | 59 | 42 | 40 | 36 | 85 | 71 | 59 | 75 |
| Orthopyroxenes----- | 0 | 1 | T | 14 | 16 | 22 | T | 4 | 7 | 1 |
| Amphibole group------ | T | 4 | 8 | 8 | 10 | 12 | 1 | 4 | 6 | 1 |
| Rock fragments------- | 22 | 18 | 20 | 6 | 6 | 4 | 12 | 13 | 15 | 21 |
| Olivine-------------- | 1 | T | T | T | T | 0 | 0 | 0 | 0 | 0 |
| Accessory minerals--- | 0 | 3 | 6 | 21 | 20 | 18 | T | 4 | 7 | T |
| Others--------------- | 1 | 1 | 2 | 5 | 5 | 6 | T | 2 | 3 | 1 |

Table 8.--Percentages of nonopaque heavy components in core samples from core sites along the Southwestern and Western Margins of Tillamook Bay

[Sample numbers include a number-letter combination followed by the approximate depth (in parenthesis) of the sample below the sediment surface. "T" indicates that the component is present in amounts less than 1 percent. Analyses by Wendy A. Niem and John Kachelmeyer.]

| Component | Southwestern Margin | | | Western Margin | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Core site 7-76 | | | Core site 11-76 | | | Core site 12-76 | | |
| | Sample No. | | | | | | | | |
| | 3M(3.5) | 8C(20.3) | 9C(24.8) | 1a(0.2) | 5C(15.7) | 10C(32.5) | 1a(0.2) | 6C(11.1) | 11W(32) |
| Pyroxene group---------- | 80 | 74 | 58 | 80 | 82 | 82 | 60 | 52 | 58 |
| Clinopyroxenes-------- | 79 | 68 | 57 | 75 | 74 | 82 | 43 | 43 | 42 |
| Augite and diopside | 78 | 54 | 46 | 69 | 56 | 80 | 40 | 41 | 35 |
| Titanaugite--------- | 1 | 14 | 11 | 6 | 18 | 2 | 3 | 2 | 7 |
| Orthopyroxenes-------- | T | 6 | T | 5 | 8 | ---- | 17 | 9 | 16 |
| Hypersthene--------- | T | 6 | T | 5 | 6 | ---- | 15 | 8 | 16 |
| Enstatite----------- | ---- | ---- | T | ---- | 2 | ---- | 2 | 1 | T |
| Amphibole group-------- | T | 4 | T | 9 | 6 | 9 | 15 | 12 | 18 |
| Hornblende----------- | T | 4 | T | 9 | 6 | 9 | 15 | 12 | 18 |
| Green-------------- | T | 3 | T | 8 | 6 | 7 | 11 | 8 | 16 |
| Blue-green--------- | ---- | T | ---- | ---- | ---- | ---- | 2 | 3 | 2 |
| Basaltic----------- | ---- | ---- | ---- | 1 | ---- | 2 | 2 | T | T |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Tremolite | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Glaucophane | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Rock fragments | 18 | 21 | 40 | 6 | 2 | 5 | 2 | 19 | 13 |
| Volcanic | 18 | 16 | 40 | 6 | 2 | 5 | 1 | 19 | 7 |
| Unidentified | ---- | 5 | ---- | ---- | ---- | ---- | 1 | ---- | 6 |
| Biotite | ---- | ---- | T | ---- | ---- | ---- | T | ---- | ---- |
| Muscovite | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Chlorite | T | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Garnet | ---- | ---- | T | 1 | T | ---- | ---- | ---- | ---- |
| Kyanite | ---- | ---- | ---- | ---- | ---- | ---- | 6 | 3 | 9 |
| Zircon | ---- | ---- | ---- | ---- | ---- | T | T | ---- | T |
| Tourmaline | T | ---- | T | T | ---- | ---- | 2 | T | 1 |
| Staurolite | ---- | ---- | ---- | ---- | ---- | ---- | ---- | T | ---- |
| Olivine | ---- | ---- | ---- | ---- | ---- | ---- | ---- | T | ---- |
| Epidote | ---- | ---- | T | T | 1 | T | ---- | ---- | ---- |
| Sphene | ---- | ---- | ---- | ---- | ---- | T | 3 | 2 | T |
| Monazite | ---- | ---- | ---- | ---- | ---- | T | 1 | T | ---- |
| Rutile | ---- | ---- | ---- | ---- | T | ---- | ---- | T | ---- |
| Feldspar | T | ---- | ---- | ---- | ---- | ---- | 2 | ---- | ---- |
| Unknown | T | ---- | ---- | 2 | 8 | 2 | 8 | 10 | T |

Table 9.--Percentages of nonopaque heavy components in core samples from the Central Bay part of Tillamook Bay

[Sample numbers include a number-letter combination followed by the approximate depth (in parenthesis) of the sample below the sediment surface. "T" indicates that the component is present in amounts less than 1 percent. Analyses by Wendy A. Niem and John Kachelmeyer.]

| Component | Southern Central Bay | | | | | | Northern Central Bay | | |
|---|---|---|---|---|---|---|---|---|---|
| | Core site 8-76 | | | Core site 10-76 | | | Core site 13-76 | | |
| | Sample No. | | | | | | | | |
| | 1a(0.2) | 7C(20.3) | 9C(29.4) | 1a(0.3) | [1]5C(17.2) | 9C(32.5) | 2C(4.5) | 6M(13.1) | 10M(26.6) |
| Pyroxene group---------- | 69 | 58 | 73 | 71 | 39 | 67 | 52 | 78 | 57 |
| Clinopyroxenes-------- | 69 | 58 | 73 | 71 | 36 | 67 | 47 | 78 | 57 |
| Augite and diopside | 68 | 58 | 73 | 71 | 34 | 67 | 44 | 70 | 52 |
| Titanaugite--------- | 1 | ---- | ---- | ---- | 2 | T | 3 | 8 | 5 |
| Orthopyroxenes-------- | ---- | ---- | ---- | ---- | 3 | T | 5 | T | T |
| Hypersthene--------- | ---- | ---- | ---- | ---- | 2 | ---- | 4 | ---- | T |
| Enstatite----------- | ---- | ---- | ---- | ---- | T | T | 1 | T | ---- |
| Amphibole group--------- | T | 1 | ---- | T | 12 | ---- | 19 | 1 | 1 |
| Hornblende----------- | T | 1 | ---- | T | 12 | ---- | 19 | 1 | 1 |
| Green--------------- | T | T | ---- | T | 12 | ---- | 12 | 1 | T |
| Blue-green---------- | ---- | ---- | ---- | T | ---- | ---- | 5 | ---- | T |
| Basaltic------------ | ---- | T | ---- | ---- | ---- | ---- | 2 | ---- | ---- |
| Tremolite------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Glaucophane---------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Rock fragments--------- | 30 | 39 | 26 | 27 | 47 | 32 | 22 | 17 | 41 |
| Volcanic------------- | 30 | 39 | 26 | 27 | 12 | 32 | 22 | 17 | 41 |
| Unidentified--------- | ---- | ---- | ---- | ---- | 35 | ---- | ---- | T | ---- |
| Biotite--------------- | ---- | T | ---- | ---- | T | T | 3 | ---- | ---- |
| Muscovite------------- | ---- | ---- | ---- | ---- | ---- | ---- | T | ---- | ---- |
| Chlorite-------------- | ---- | ---- | ---- | T | ---- | ---- | T | ---- | ---- |
| Garnet---------------- | ---- | ---- | ---- | ---- | T | ---- | ---- | T | T |
| Kyanite--------------- | ---- | ---- | ---- | ---- | ---- | ---- | T | ---- | ---- |
| Zircon---------------- | T | T | T | ---- | T | ---- | T | ---- | ---- |
| Tourmaline------------ | ---- | ---- | T | ---- | T | ---- | ---- | ---- | ---- |
| Staurolite------------ | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Olivine--------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Epidote--------------- | ---- | ---- | ---- | ---- | T | ---- | T | T | ---- |
| Sphene---------------- | ---- | ---- | ---- | ---- | ---- | ---- | T | ---- | ---- |
| Monazite-------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Rutile---------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Feldspar-------------- | ---- | T | ---- | T | ---- | ---- | ---- | ---- | ---- |
| Unknown--------------- | ---- | ---- | ---- | ---- | ---- | T | 2 | 2 | ---- |

Table 9.--Percentages of nonopaque heavy components in core samples from the Central Bay part of Tillamook Bay--Continued

| Component | Northern Central Bay | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Core site 17-76 | | | | | | Core site 18-76 | | |
| | Sample No. | | | | | | | | |
| | 1b(0.5) | 2C(3.1) | 3B(10.3) | 4M(14.8) | 5C(19.3) | 6C(26.9) | 1a(0.3) | [2]4C(8.1) | 6C(15.7) |
| Pyroxene group-------- | 75 | 69 | 45 | 43 | 20 | 15 | 48 | 27 | 44 |
| Clinopyroxenes------ | 70 | 64 | 37 | 40 | 20 | 14 | 30 | 25 | 41 |
| Augite and diopside | 62 | 53 | 33 | 39 | 20 | 14 | 28 | 23 | 40 |
| Titanaugite-------- | 8 | 11 | 4 | T | ---- | T | 2 | 2 | T |
| Orthopyroxenes------ | 5 | 5 | 8 | 3 | ---- | T | 18 | 2 | 3 |
| Hypersthene-------- | 4 | 5 | 7 | 3 | ---- | T | 17 | 2 | 3 |
| Enstatite---------- | T | ---- | 1 | ---- | ---- | ---- | 1 | ---- | ---- |
| Amphibole group------- | 9 | 10 | 24 | 11 | T | 4 | 8 | 7 | 8 |
| Hornblende---------- | 9 | 10 | 24 | 11 | T | 4 | 8 | 7 | 8 |
| Green-------------- | 9 | 8 | 15 | 9 | ---- | 3 | 7 | 4 | 6 |
| Blue-green--------- | ---- | 1 | 7 | 2 | ---- | ---- | ---- | 3 | 1 |
| Basaltic----------- | ---- | T | 2 | ---- | T | T | 1 | ---- | 1 |
| Tremolite----------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Glaucophane--------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Rock fragments-------- | 13 | 19 | 19 | 28 | 79 | 79 | 20 | 38 | 28 |
| Volcanic------------ | 12 | 17 | 19 | 28 | 79 | 79 | 20 | 38 | 28 |
| Unidentified-------- | 1 | 2 | ---- | ---- | ---- | ---- | ---- | T | T |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Biotite | 1 | ---- | ---- | 16 | ---- | ---- | ---- | 15 | 17 |
| Muscovite | ---- | ---- | ---- | T | ---- | ---- | T | 4 | ---- |
| Chlorite | ---- | ---- | ---- | ---- | ---- | ---- | ---- | 1 | T |
| Garnet | T | 1 | T | ---- | ---- | 2 | 12 | T | ---- |
| Kyanite | ---- | T | T | ---- | ---- | ---- | 1 | T | ---- |
| Zircon | 1 | ---- | T | T | ---- | ---- | T | ---- | ---- |
| Tourmaline | ---- | ---- | 2 | T | ---- | ---- | ---- | ---- | T |
| Staurolite | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Olivine | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Epidote | T | ---- | T | ---- | ---- | ---- | 2 | T | ---- |
| Sphene | ---- | ---- | ---- | ---- | ---- | ---- | T | ---- | ---- |
| Monazite | ---- | ---- | T | ---- | ---- | ---- | ---- | T | ---- |
| Rutile | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Feldspar | ---- | T | T | ---- | ---- | ---- | T | 3 | T |
| Unknown | ---- | ---- | 7 | T | ---- | ---- | 6 | 5 | 1 |

[1]Depth may be incorrect by ±1.5 m.

[2]Depth may be 1.5 m too deep.

Table 10.--Percentages of nonopaque heavy components in core samples from the Eastern Margin of Tillamook Bay

[Sample numbers include a number-letter combination followed by the approximate depth (in parenthesis) of the sample below the sediment surface. "T" indicates that the component is present in amounts less than 1 percent. Analyses by Wendy A. Niem and John Kachelmeyer.]

| Component | Core site 9-76 | | | | Core site 16-76 | | | |
|---|---|---|---|---|---|---|---|---|
| | Sample No. | | | | | | | |
| | 1a(0.2) | 3C(11.1) | 6M(18.7) | 8M(27.9) | 1a(0.2) | 7M(14.2) | 8B(17.2) | 9C(32.5) |
| Pyroxene Group---------- | 52 | 75 | 60 | 53 | 78 | 52 | 19 | 41 |
| Clinopyroxenes-------- | 52 | 70 | 58 | 53 | 77 | 47 | 19 | 41 |
| Augite and diopside | 49 | 59 | 53 | 53 | 77 | 47 | 19 | 40 |
| Titanaugite--------- | 3 | 11 | 5 | ---- | ---- | ---- | ---- | 1 |
| Orthopyroxenes-------- | ---- | 5 | 2 | T | T | 5 | ---- | ---- |
| Hypersthene--------- | ---- | 5 | 2 | T | T | 5 | ---- | ---- |
| Enstatite----------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Amphibole group--------- | T | 1 | 2 | T | 2 | 4 | T | ---- |
| Hornblende------------ | T | 1 | 2 | T | 2 | 4 | T | ---- |
| Green--------------- | T | 1 | 2 | T | 2 | 2 | T | ---- |
| Blue-green---------- | ---- | ---- | ---- | T | ---- | 2 | ---- | ---- |
| Basaltic------------ | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Tremolite------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Glaucophane---------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Rock fragments--------- | 48 | 23 | 37 | 44 | 20 | 36 | 80 | 59 |
| Volcanic------------ | 39 | 17 | 27 | 44 | 20 | 35 | 80 | 49 |
| Unidentified--------- | 9 | 6 | 10 | ---- | ---- | T | ---- | 10 |
| Biotite--------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Muscovite------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Chlorite-------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Garnet---------------- | ---- | ---- | ---- | T | ---- | ---- | ---- | ---- |
| Kyanite--------------- | ---- | ---- | ---- | ---- | ---- | 1 | ---- | ---- |
| Zircon---------------- | ---- | ---- | ---- | T | ---- | 1 | ---- | ---- |
| Tourmaline------------ | ---- | ---- | ---- | T | ---- | ---- | ---- | ---- |
| Staurolite------------ | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Olivine--------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Epidote--------------- | ---- | ---- | ---- | ---- | ---- | T | ---- | ---- |
| Sphene---------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Monazite-------------- | ---- | ---- | ---- | T | ---- | ---- | ---- | ---- |
| Rutile---------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Feldspar-------------- | ---- | T | ---- | T | ---- | ---- | ---- | ---- |
| Unknown--------------- | ---- | ---- | ---- | ---- | T | 5 | ---- | ---- |

Table 10.--Percentages of nonopaque heavy components in core samples from the Eastern Margin of Tillamook Bay--Continued

| Component | Core site 1-76 (Kilchis Point) | | | Core site 15-76 | | | Core site 14-76 | | |
|---|---|---|---|---|---|---|---|---|---|
| | Sample No. | | | | | | | | |
| | 1B(0.5) | 7M(10.2) | 8C(10.8) | 1a(0.2) | 5C(11.1) | 7M(17.2) | 1a(0.2) | 3C(6.2) | 4C(11.1) |
| Pyroxene group | 71 | 47 | 69 | 62 | 24 | 72 | 69 | 56 | 58 |
| Clinopyroxenes | 65 | 46 | 68 | 62 | 24 | 72 | 68 | 55 | 58 |
| Augite and diopside | 65 | 46 | 68 | 55 | 23 | 66 | 63 | 52 | 56 |
| Titanaugite | ---- | ---- | ---- | 7 | T | 6 | 5 | 3 | 2 |
| Orthopyroxenes | 6 | T | T | T | ---- | ---- | T | T | ---- |
| Hypersthene | 6 | T | T | T | ---- | ---- | T | T | ---- |
| Enstatite | ---- | ---- | ---- | T | ---- | ---- | T | ---- | ---- |
| Amphibole group | 17 | T | 3 | 2 | T | T | 3 | 8 | 1 |
| Hornblende | 17 | T | 3 | 2 | T | T | 3 | 8 | 1 |
| Green | 15 | T | 3 | 1 | T | T | 2 | 7 | T |
| Blue-green | 1 | ---- | ---- | T | ---- | ---- | T | ---- | ---- |
| Basaltic | 1 | ---- | ---- | T | T | ---- | ---- | 1 | T |
| Tremolite | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Glaucophane | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Rock fragments | T | 53 | 26 | 35 | 76 | 27 | 26 | 31 | 39 |
| Volcanic | T | 53 | 26 | 34 | 76 | 27 | 26 | 30 | 39 |
| Unidentified | ---- | ---- | ---- | T | ---- | ---- | ---- | T | ---- |
| Biotite | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | T |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Muscovite---------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Chlorite----------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | 1 |
| Garnet------------------- | ---- | ---- | ---- | T | ---- | ---- | T | 2 | ---- |
| Kyanite------------------ | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Zircon------------------- | 2 | ---- | T | ---- | ---- | ---- | ---- | ---- | ---- |
| Tourmaline--------------- | 6 | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Staurolite--------------- | T | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Olivine------------------ | T | ---- | T | ---- | ---- | ---- | ---- | ---- | ---- |
| Epidote------------------ | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | T |
| Sphene------------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Monazite----------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Rutile------------------- | ---- | ---- | ---- | ---- | ---- | ---- | T | ---- | ---- |
| Feldspar----------------- | 3 | ---- | T | ---- | ---- | ---- | T | 2 | ---- |
| Unknown------------------ | ---- | ---- | ---- | ---- | ---- | ---- | T | T | ---- |

| Component | Core site 5-76 | | | | | Core site 3-76 | | |
|---|---|---|---|---|---|---|---|---|
| | Sample No. | | | | | | | |
| | 1a(0.5) | 4M(8.1) | 5C(15.7) | 8T(27.9) | 9B(31.5) | 3T(4.7) | 6M(14.2) | 9M(27.9) |
| Pyroxene group---------- | 65 | 50 | 7 | 38 | 37 | 53 | 27 | 88 |
| Clinopyroxenes-------- | 61 | 49 | 7 | 37 | 32 | 51 | 27 | 84 |
| Augite and diopside | 60 | 47 | 7 | 37 | 28 | 51 | 27 | 76 |
| Titanaugite--------- | 1 | 2 | --- | T | 4 | ---- | ---- | 8 |
| Orthopyroxenes | 4 | 1 | --- | 1 | 5 | 2 | ---- | 4 |

Table 10.--Percentages of nonopaque heavy components in core samples from the Eastern Margin in Tillamook Bay--Continued

| Component | Core site 5-76--continued | | | | | Core site 3-76--continued | | |
|---|---|---|---|---|---|---|---|---|
| | Sample No. | | | | | | | |
| | 1a(0.5) | 4M(8.1) | 5C(15.7) | 8T(27.9) | 9B(31.5) | 3T(4.7) | 6M(14.2) | 9M(27.9) |
| Hypersthene | 2 | T | ---- | 1 | 5 | 2 | ---- | 4 |
| Enstatite | 2 | T | ---- | ---- | ---- | ---- | ---- | ---- |
| Amphibole group | 5 | 3 | ---- | 4 | T | 3 | 4 | 4 |
| Hornblende | 5 | 3 | ---- | 4 | T | 3 | 4 | 4 |
| Green | 5 | 2 | ---- | 2 | T | 2 | 3 | 4 |
| Blue-green | ---- | ---- | ---- | 1 | ---- | 1 | 1 | ---- |
| Basaltic | ---- | 1 | ---- | T | ---- | ---- | ---- | ---- |
| Tremolite | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Glaucophane | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Rock fragments | 28 | 45 | 93 | 50 | 62 | 41 | 64 | 8 |
| Volcanic | 28 | 45 | 93 | 50 | 48 | 41 | 64 | 3 |
| Unidentified | ---- | ---- | ---- | ---- | 14 | ---- | ---- | 5 |
| Biotite | 2 | T | ---- | T | ---- | ---- | 1 | ---- |
| Muscovite | ---- | ---- | ---- | ---- | ---- | ---- | 1 | ---- |
| Chlorite | T | ---- | ---- | 1 | ---- | ---- | T | ---- |
| Garnet | ---- | ---- | ---- | T | ---- | 1 | ---- | ---- |
| Kyanite | ---- | ---- | ---- | T | ---- | ---- | ---- | ---- |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Tourmaline---------------- | ---- | ---- | ---- | T | ---- | ---- | T | ---- |
| Staurolite---------------- | ---- | T | ---- | T | ---- | ---- | T | ---- |
| Olivine------------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Epidote------------------- | ---- | ---- | ---- | T | ---- | ---- | ---- | ---- |
| Sphene-------------------- | ---- | ---- | ---- | T | ---- | ---- | ---- | ---- |
| Monazite------------------ | ---- | ---- | ---- | T | ---- | ---- | ---- | ---- |
| Rutile-------------------- | ---- | ---- | ---- | ---- | ---- | ---- | ---- | ---- |
| Feldspar------------------ | T | T | ---- | T | ---- | T | T | ---- |
| Unknown------------------- | ---- | 1 | ---- | T | ---- | T | ---- | ---- |

| Component | Core site 4-76 | | | Core site 2-76 (Miami River) | |
|---|---|---|---|---|---|
| | Sample No. | | | | |
| | 1T(0.3) | 3M(8.7) | 7M(32.5) | 1B(0.5) | 3B(7.2) |
| Pyroxene group----------- | 38 | 48 | 27 | 42 | 34 |
| Clinopyroxenes-------- | 38 | 47 | 27 | 42 | 33 |
| Augite and diopside | 38 | 45 | 27 | 42 | 30 |
| Titanaugite--------- | ---- | 2 | T | ---- | 3 |
| Orthopyroxenes----------- | ---- | T | ---- | ---- | T |
| Hypersthene----------- | ---- | T | ---- | ---- | T |
| Enstatite------------- | ---- | ---- | ---- | ---- | ---- |
| Amphibole group---------- | T | T | ---- | T | T |
| Hornblende-------------- | T | T | ---- | T | T |
| Green---------------- | ---- | T | ---- | ---- | ---- |

Table 10.--Percentages of nonopaque heavy components in core samples from the Eastern Margin in Tillamook Bay--Continued

| Component | Core site 4-76--continued | | | Core site 2-76 (Miami River)--Con. | |
|---|---|---|---|---|---|
| | Sample No. | | | | |
| | 1T(0.3) | 3M(8.7) | 7M(32.5) | 1B(0.5) | 3B(7.2) |
| Blue-green---------- | ---- | T | ---- | ---- | T |
| Basaltic------------ | ---- | ---- | ---- | ---- | ---- |
| Tremolite------------- | ---- | ---- | ---- | ---- | ---- |
| Glaucophane----------- | ---- | ---- | ---- | ---- | ---- |
| Rock fragments---------- | 62 | 51 | 72 | 58 | 66 |
| Volcanic-------------- | 62 | 51 | 72 | 58 | 50 |
| Unidentified---------- | ---- | ---- | ---- | ---- | 16 |
| Biotite---------------- | ---- | ---- | ---- | ---- | ---- |
| Muscovite-------------- | ---- | ---- | ---- | ---- | ---- |
| Chlorite--------------- | ---- | ---- | ---- | ---- | ---- |
| Garnet----------------- | ---- | T | ---- | ---- | ---- |
| Kyanite---------------- | ---- | ---- | ---- | ---- | ---- |
| Zircon----------------- | ---- | ---- | ---- | ---- | ---- |
| Tourmaline------------- | ---- | ---- | ---- | ---- | ---- |
| Staurolite------------- | ---- | ---- | ---- | ---- | ---- |
| Olivine---------------- | ---- | ---- | ---- | ---- | ---- |
| Epidote---------------- | ---- | ---- | ---- | ---- | ---- |
| Sphene----------------- | ---- | ---- | ---- | ---- | ---- |
| Monazite--------------- | ---- | ---- | ---- | ---- | ---- |
| Rutile----------------- | ---- | ---- | ---- | ---- | ---- |
| Feldspar--------------- | ---- | ---- | ---- | ---- | ---- |
| Unknown---------------- | T | T | ---- | ---- | ---- |

## Tables 11-27.--Stratigraphic data and interpretations for cores from Tillamook Bay

### Explanation

Samples are designated by a sequence number followed by a letter. Letter meanings are as follows:

a: Top few centimeters (or entire sample) of a surface core.

b: Bottom few centimeters of a surface core.

T: Top ≈15 cm of a drive core.

M: Middle ≈15 cm of a drive core.

B: Bottom ≈15 cm of a drive core.

C: A 2- to 5-cm long sample from the cutting head of a drive core.

A: Auger sample obtained during cleaning of the augers when pulling out of the drill hole.

W: Wash sample obtained by collecting, at the top of the drill stem, water pumped through the drive corer and up the drill stem to remove sediments from the bottom few meters or centimeters of the hollow stem auger.

Depth: The approximate depth in meters below the sediment surface of the bottom of a sample or of the boundary between stratigraphic units.

Penetration data: The approximate number of blows to drive the corer 1 m with a 63.5-kg hammer.

Texture: Sand = weight percentage of particles >62 μm; silt and clay = weight percentage of particles <62 μm.

Sediment source: R, river; S, shoreline; M, marine; RS, river and shoreline; RM, river and marine; MR, marine and river.

Table 11.--Stratigraphic data and interpretations for core site 1-76

[Probable sediment sources and depositional environments were determined only for deposits of Holocene age]

| Sample Designation | Depth (m) | Penetration (blows/m) | Texture percentage: Sand | Texture percentage: Silt and clay | Stratigraphy: Depth (m) | Stratigraphy: Description | Interpretations: Probable depositional environment | Interpretations: Probable sediment source | Interpretations: Probable age |
|---|---|---|---|---|---|---|---|---|---|
| 1B | 0.5 | 59 | 10 | 90 | 0-1 | Brown (surface) to black (at depth) clayey silt | High tidal marsh | S | Holocene |
| 2B | 1.1 | 33 | -- | -- | | | | --- | |
| 3B | 2.6 | 190 | -- | -- | 1-4 | Red, brown, and yellow gravels with medium to coarse sand layers | | | Pleistocene |
| 4B | 4.1 | 370 | -- | -- | | | | | |
| 5M | ([1]) | 75 | -- | -- | 4-6 | Blue-gray to black organic-rich (wood) silts and interbedded gravels | | | |
| 5B | 5.6 | | -- | -- | | | | | |
| 5C | ([1]) | | -- | -- | | | | | |
| 6B | 7.0 | 449 | -- | -- | 6-8 | Hard, coarse gravels | | | |
| 7M | ([1]) | 92 | [1]80 | 20 | 8-11 | Red to yellow-brown gravels and interbedded blue-gray organic-rich pebbly clay | | | |
| 7B | 10.2 | | -- | -- | | | | | |
| 8B | 10.8 | 128 | -- | -- | | | | | |
| 8C | ([1]) | | [2]4 | 96 | | | | | |
| 10A | ≈13 | --- | -- | -- | 11-13+ | Very hard, red to yellow-brown sands, clays, and fine gravels | | | Oligocene-Miocene |
| 9B | 13.3 | 489 | -- | -- | | | | | |
| 9C | ([1]) | | -- | -- | | | | | |

[1]See headnotes on page 60.

[2]Sample contains some material >2,000 μm in size.

## Table 12.--Stratigraphic data and interpretations for core site 2-76

[Probable sediment sources and depositional environments were determined only for deposits of Holocene age]

| Sample Designation | Depth (m) | Penetration (blows/m) | Texture percentage: Sand | Texture percentage: Silt and clay | Stratigraphy: Depth (m) | Stratigraphy: Description | Interpretations: Probable depositional environment | Interpretations: Probable sediment source | Interpretations: Probable age |
|---|---|---|---|---|---|---|---|---|---|
| 1B | 0.5 | 66 | 37 | 63 | 0-1 | Brown stratified silts and fine sands. | Natural levee | R | Holocene |
| 2B | 3.0 | 89 | -- | -- | 1-3 | Hard, brown sandy gravels | Fluvial channel | --- | |
| 3W | ≈7 | --- | -- | -- | 3-11 | Brown, coarse gravelly sand; becomes finer at depth | | --- | |
| 3B | 7.2 | 122 | [1]88 | 12 | | | | R | |
| | | | | | 11-12 | Hard, sandy gravel with large cobbles and (or) boulders | | | |
| 4B | 13.7 | ≈328 | -- | -- | 12-17+ | Gray to black zeolitic basalts with red clay interbeds | | | Eocene |
| 4C | ([2]) | | -- | -- | | | | | |
| 5B | 14.4 | ≈460 | -- | -- | | | | | |
| 7A | ≈16 | --- | -- | -- | | | | | |
| 8A | ≈17 | --- | -- | -- | | | | | |
| 6A | ≈17+ | --- | -- | -- | | | | | |

[1]Sample contains some material >2000 μm in size.

[2]See headnotes on page 60.

Table 13.--Stratigraphic data and interpretations for core site 3-76

[Probable sediment sources and depositional environments were determined only for deposits of Holocene age]

| Sample Designation | Depth (m) | Penetration (blows/m) | Texture percentage: Sand | Texture percentage: Silt and clay | Stratigraphy: Depth (m) | Stratigraphy: Description | Interpretations: Probable depositional environment | Interpretations: Probable sediment source | Probable age |
|---|---|---|---|---|---|---|---|---|---|
| 2B | 1.7 | 66 | -- | -- | 0-8 | Blue-gray interbedded organic-rich clayey silts and greenish clayey and silty sands. Occasional medium to coarse sand layers------- | Estuarine intertidal flat and associated channel---- | -------- | Holocene |
| 3T | ([1]) | --- | 84 | 16 | | | | RM or RS | |
| 3M | ([1]) | | -- | -- | | | | -------- | |
| 3B | 4.7 | | -- | -- | | | | -------- | |
| 4M | ([1]) | 26 | -- | -- | 8-21 | Blue-black clayey silts and silty clays. Occasional butter clam shells in the top 2-3 m. Well-developed laminations and thin beds at the bottom----------------- | Estuarine intertidal or deep water subtidal flat-------- | -------- | |
| 4B | 8.1 | | -- | -- | | | | -------- | |
| 4C | ([1]) | | -- | -- | | | | -------- | |
| 5M | ([1]) | 69 | -- | -- | | | | -------- | |
| 5B | 11.1 | | -- | -- | | | | -------- | |
| 6M | ([1]) | 49 | 4 | 96 | | | | RM or RS | |
| 6B | 14.2 | | -- | -- | | | | -------- | |
| 7W | ≈18 | ---- | -- | -- | | | | -------- | |
| 7M[2] | ([1]) | 52 | -- | -- | | | | -------- | |
| 7B[2] | 18.5 | | -- | -- | | | | -------- | |
| | | | | | 21-26 | Black medium to coarse sands interbedded with black organic-rich gravelly clays and silty gravels. Some broken shells (clam?)--------- | Estuarine channel and associated intertidal flat--- | | |
| 8C | 23.3 | 69 | -- | -- | | | | -------- | |
| 9T | ([1]) | --- | -- | -- | 26-31 | Brown interbedded sands, fine gravels, and clays at the top to blue-gray organic-rich, clays, sands, and gravels at the bottom-------------- | Fluvial(?) to estuarine channel and associated environments------------ | -------- | |
| 9M[2] | ([1]) | | 11 | 89 | | | | R | |
| 9B | 27.9 | | -- | -- | | | | -------- | |
| 10C | 30.9 | 328 | -- | -- | 31+ | Very hard gravels and (or) bedrock---- | | | Pleistocene or Oligocene-Miocene |

[1]See headnotes on page 60.

[2]Sample analyzed for radiocarbon age. See table 28.

Table 14.--Stratigraphic data and interpretations for core site 4-76

| Sample Designation | Depth (m) | Penetration (blows/m) | Texture percentage: Sand | Texture percentage: Silt and clay | Stratigraphy: Depth (m) | Stratigraphy: Description | Interpretations: Probable depositional environment | Interpretations: Probable sediment source | Interpretations: Probable age |
|---|---|---|---|---|---|---|---|---|---|
| 1T | 0.3 | 46 | 28 | 72 | 0-4 | Blue-black organic-rich sandy clay or silt to 0.3 m. Interbedded clayey granule gravels and clayey sands below 0.3 m | Estuarine intertidal flat to tidal channel at depth | R | Holocene |
| 1B | .9 | | -- | -- | | | | --- | |
| 2M | ([1]) | 108 | -- | -- | | | | --- | |
| 2B | 3.5 | | -- | -- | | | | --- | |
| 3M | ([1]) | 33 | 42 | 58 | 4-22 | Blue-black sandy clay and silt with rare fine to medium sand interbeds. Unit appears to become coarser at the bottom | Estuarine intertidal to deep water subtidal flat | R | |
| 3B | 8.7 | | -- | -- | | | | --- | |
| 4B | 12.6 | 43 | -- | -- | | | | --- | |
| 5W | ≈18 | --- | -- | -- | | | | --- | |
| 6B | 21.8 | 79 | -- | -- | | | | --- | |
| 7M | ([1]) | 148 | [2]81 | 19 | 22-32+ | Brown pebble to cobble gravels with interbeds of softer sand, silt, or clay | Fluvial channel | R | |
| 7B | 32.5 | | -- | -- | | | | --- | |
| 7C | ([1]) | | -- | -- | | | | --- | |

[1]See headnotes on page 60.

[2]Sample contains some material >2000 μm in size.

Table 15.--Stratigraphic data and interpretations for core site 5-76

[Probable sediment sources and depositional environments were determined only for deposits of Holocene age]

| Sample Designation | Depth (m) | Penetration (blows/m) | Texture percentage: Sand | Texture percentage: Silt and clay | Stratigraphy: Depth (m) | Stratigraphy: Description | Interpretations: Probable depositional environment | Interpretations: Probable sediment source | Interpretations: Probable age |
|---|---|---|---|---|---|---|---|---|---|
| 1a | 0.5 | --- | 53 | 47 | 0-2 | Blue-gray clayey and silty sands with many butter clam shells------ | Estuarine intertidal flat-------------- | RS | Holocene |
| 2C | 3.5 | 134 | -- | -- | 2-5 | Mottled yellow-brown to blue-gray sandy and silty gravels----------- | Estuarine tidal channel----------- | -- | |
| 4M | ([1]) | 43 | 10 | 90 | 5-11 | Blue-black organic-rich clayey silts and interbedded fine sands-- | Estuarine intertidal to deep water subtidal flat----- | RS | |
| 4B[2] | 8.1 | | -- | -- | | | | -- | |
| 5C | 15.7 | 331 | [3]81 | 19 | 11-16 | Reddish-yellow to brown hard cobble gravels with sandy interbeds-------------- | | | Pleistocene |
| 6T | ([1]) | 348 | -- | -- | 16-32+ | Blue-gray to black interbedded hard sands and clays. No coarse gravels and abundant wood clasts---------------------- | | | Pleistocene or Oligocene-Miocene |
| 6M[2] | ([1]) | | -- | -- | | | | | |
| 6B | 20.3 | | -- | -- | | | | | |
| 7M | ([1]) | 164 | -- | -- | | | | | |
| 7B | 23.3 | | -- | -- | | | | | |
| 8T | ([1]) | 164 | 26 | 74 | | | | | |
| 8B | 27.9 | | -- | -- | | | | | |
| 9T | ([1]) | 380 | -- | -- | | | | | |
| 9B | 31.5 | | 83 | 17 | | | | | |

[1]See headnotes on page 60.

[2]Sample analyzed for radiocarbon age. See Table 28.

[3]Sample contains some material >2000 μm in size.

Table 16.--Stratigraphic data and interpretations for core site 7-76

| Sample Designation | Depth (m) | Penetration (blows/m) | Texture percentage: Sand | Texture percentage: Silt and clay | Stratigraphy: Depth (m) | Stratigraphy: Description | Interpretations: Probable depositional environment | Interpretations: Probable sediment source | Interpretations: Probable age |
|---|---|---|---|---|---|---|---|---|---|
| 2B | 2.0 | 66 | -- | -- | 0-19 | Brown medium to coarse sands and interbedded black to gray silts. Becomes mostly silt and fine sand at depth. Abundant wood fragments throughout. Shell (clam) layers at about 10 and 16 m | Estuarine channel and near channel intertidal flat near the surface to possibly deep water subtidal flat at depth | --- | Holocene |
| 3M | ([1]) | 98 | 81 | 19 | | | | R | |
| 3B | 3.5 | | -- | -- | | | | --- | |
| 4M | ([1]) | 134 | -- | -- | | | | --- | |
| 4B | 6.6 | | -- | -- | | | | --- | |
| 5B | 9.6 | 88 | -- | -- | | | | --- | |
| 5C | ([1]) | | -- | -- | | | | --- | |
| 6M | ([1]) | 108 | -- | -- | | | | --- | |
| 6B | 12.6 | | -- | -- | | | | --- | |
| 7M | ([1]) | 144 | -- | -- | | | | --- | |
| 7B | 15.7 | | -- | -- | | | | --- | |
| 8M[2] | ([1]) | 46 | -- | -- | 19-22 | Gray to black silty clayey fine gravel and coarse sand with abundant shells (clam) | Estuarine channel and near channel flat | --- | |
| 8B | 20.3 | | -- | -- | | | | --- | |
| 8C | ([1]) | | [3]34 | 66 | | | | RS | |
| 9B | 24.8 | 75 | -- | -- | 22-30+ | Greenish fine to medium sands with gray silty interbeds. Rare wood or shell clasts "Compact" at top of unit but "mobile" and coarser at depth | Estuarine channel to possibly fluvial channel at depth | --- | |
| 9C | ([1]) | | 63 | 37 | | | | R | |
| 10A | ≤30 | --- | -- | -- | | | | --- | |

[1]See headnotes on page 60.

[2]Sample analyzed for radiocarbon age. See Table 28.

[3]Sample contains some material >2000 μm in size.

Table 17.--Stratigraphic data and interpretations for core site 8-76

| Sample Designation | Depth (m) | Penetration (blows/m) | Texture percentage: Sand | Texture percentage: Silt and clay | Stratigraphy: Depth (m) | Stratigraphy: Description | Interpretations: Probable depositional environment | Interpretations: Probable sediment source | Interpretations: Probable age |
|---|---|---|---|---|---|---|---|---|---|
| 1a | 0.2 | --- | 85 | 15 | | | | R | Holocene |
| 1b | .3 | --- | -- | -- | | | | ------ | |
| 2B | 2.0 | 23 | -- | -- | | | | ------ | |
| 2C | ([1]) | | -- | -- | | | | ------ | |
| 3M | ([1]) | | -- | -- | | | | ------ | |
| 3B | 4.1 | 88 | -- | -- | 0-10 | Brown fine to medium sand at the surface to gray silty fine sand at depth. Interbeds of fine and coarse sediments with large wood clasts at depth-------------------- | Estuarine intertidal flat to channel at depth--------------- | ------ | |
| 3C | ([1]) | | -- | -- | | | | ------ | |
| 4B | 9.6 | 85 | -- | -- | | | | ------ | |
| 4C | ([1]) | | -- | -- | | | | ------ | |
| 6T | ([1]) | | -- | -- | | | | ------ | |
| 6M | ([1]) | 52 | -- | -- | | | | ------ | |
| 6B | 15.7 | | -- | -- | | | | ------ | |
| 7M | ([1]) | | -- | -- | 10-28 | Gray to black silty and clayey sands with abundant wood clasts and rare sandy layers--------------------- | Estuarine low energy intertidal or deep water subtidal flat | ------ | |
| 7B | 20.3 | 56 | -- | -- | | | | ------ | |
| 7C | ([1]) | | 13 | 87 | | | | R | |
| 8M | ([1]) | | -- | -- | | | | ------ | |
| 8B | 26.4 | 56 | -- | -- | | | | ------ | |
| 8C | ([1]) | | -- | -- | | | | ------ | |
| 9B | 29.4 | 108 | -- | -- | | | | ------ | |
| 9C | ([1]) | | 76 | 24 | 28-29+ | Gray to black, "mobile" medium to coarse sands----------------------- | Estuarine channel to possibly fluvial channel at depth---- | R | |

[1]See headnotes on page 60.

Table 18.--Stratigraphic data and interpretations for core site 9-76

| Sample Designation | Depth (m) | Penetration (blows/m) | Texture percentage: Sand | Texture percentage: Silt and clay | Stratigraphy: Depth (m) | Stratigraphy: Description | Interpretations: Probable depositional environment | Interpretations: Probable sediment source | Interpretations: Probable age |
|---|---|---|---|---|---|---|---|---|---|
| 1a | 0.2 | --- | 51 | 49 | | | | R | Holocene |
| 2M[1] | ([2]) | 102 | -- | -- | 0-11 | Brown silty and clayey sand to gray-black interbedded silts and sands at depth. Abundant wood clasts and woody layers--------- | Estuarine at the bottom to deltaic fluvial-estuarine at the surface--- | ----- | |
| 2B | 6.6 | | -- | -- | | | | ----- | |
| 3M[1] | ([2]) | | -- | -- | | | | ----- | |
| 3B[1] | 11.1 | 207 | -- | -- | | | | ----- | |
| 3C | ([2]) | | 71 | 29 | | | | RM(?) | |
| 5M | ([2]) | 72 | -- | -- | | | | ----- | |
| 5B | 14.8 | | -- | -- | | | | ----- | |
| 6T | ([2]) | | -- | -- | | | | ----- | |
| 6M[1] | ([2]) | 56 | 37 | 63 | | | | R | |
| 6B | 18.7 | | -- | -- | 11-28 | Gray to black silty clay with rare sandy zones or layers. Abundant wood clasts and woody layers-------------------- | Estuarine low energy intertidal flat or subtidal flat------------- | ----- | |
| 7T | ([2]) | | -- | -- | | | | ----- | |
| 7M | ([2]) | --- | -- | -- | | | | ----- | |
| 7B | 23.3 | | -- | -- | | | | ----- | |
| 7C[1] | ([2]) | | -- | -- | | | | ----- | |
| 8T | ([2]) | | -- | -- | | | | ----- | |
| 8M[1] | ([2]) | 56 | 33 | 67 | | | | R | |
| 8B | 27.9 | | -- | -- | | | | ----- | |
| | | | | | 28-32+ | Brown sand (in wash sample) associated with coarse, hard gravels-------------------- | Fluvial channel---- | | |

[1]Sample analyzed for radiocarbon age. See Table 28.

[2]See headnotes on page 60.

Table 19.--Stratigraphic data and interpretations for core site 10-76

[Probable sediment sources and depositional environments were determined only for deposits of Holocene age]

| Sample Designation | Depth (m) | Penetration (blows/m) | Texture percentage | | Stratigraphy | | Interpretations | | |
|---|---|---|---|---|---|---|---|---|---|
| | | | Sand | Silt and clay | Depth (m) | Description | Probable depositional environment | Probable sediment source | Probable age |
| 1a | 0.3 | --- | 72 | 28 | 0-3 | Brown silty or clayey sands over gray-black silty sands. Contains more sand at depth------------------ | Estuarine intertidal flat---------------- | R | Holocene |
| 2C | 2.0 | 26 | -- | -- | | | | ------ | |
| 3M | ([1]) | 220 | -- | -- | 3-18 | Light gray to grayish-green sand and silty sand. Shell fragments but no wood------------------------------- | | ------ | |
| 3B | [2]8.1 | | -- | -- | | | | ------ | |
| 5M | ([1]) | 121 | -- | -- | | | | ------ | |
| 5B | [2]17.2 | | -- | -- | | | | ------ | |
| 5C | ([1]) | | 77 | 23 | | | | MR | |
| 6M | ([1]) | 62 | -- | -- | 18-22 | Gray to black clayey silt with rare sandy silt layers------------------- | Estuarine intertidal or subtidal flat--- | ------ | |
| 6B | [2]20.3 | | -- | -- | | | | ------ | |
| 7T | ([1]) | 420 | -- | -- | 22-29 | Red to yellow-brown clayey gravels with finer interbeds at depth------ | | | Pleistocene |
| 7M | ([1]) | | -- | -- | | | | | |
| 7B | [2]23.3 | | -- | -- | | | | | |
| 7C | ([1]) | | -- | -- | | | | | |
| 9T | ([1]) | 279 | -- | -- | 29-32+ | Gray-black, very hard, laminated silt with subconchoidal fracture-------- | | | |
| 9M | ([1]) | | -- | -- | | | | | |
| 9B | 32.5 | | -- | -- | | | | | |
| 9C | ([1]) | | 4 | 96 | | | | | |

[1]See headnote on page 60.

[2]Depth may be off by 1.5 m.

Table 20.--Stratigraphic data and interpretations for core site 11-76

| Sample Designation | Depth (m) | Penetration (blows/m) | Texture percentage: Sand | Texture percentage: Silt and clay | Stratigraphy: Depth (m) | Stratigraphy: Description | Interpretations: Probable depositional environment | Interpretations: Probable sediment source | Interpretations: Probable age |
|---|---|---|---|---|---|---|---|---|---|
| 1a | 0.2 | --- | 86 | 14 | | | | MR | Holocene |
| 1b | .3 | --- | -- | -- | | | | -- | |
| 2M | (1) | | -- | -- | | | | -- | |
| 2B | 2.0 | 13 | -- | -- | | Gray to greenish gray inter- | | -- | |
| 2C | (1) | | -- | -- | | bedded uniform fine | | -- | |
| 4W | ≈11 | --- | -- | -- | | sands and gray to black | | -- | |
| 5M | (1) | | -- | -- | | clayey and silty sands. No | | -- | |
| 5B | 15.7 | 164 | -- | -- | | distinct unit boundaries, | | -- | |
| 5C | (1) | | 68 | 32 | | but sediments are finer | Estuarine intertidal | RM | |
| 6M | (1) | | -- | -- | 0-33+ | and contain more organic | to possible sub- | -- | |
| 6B | 18.7 | 154 | -- | -- | | matter at depth. Broken | tidal flats at | -- | |
| 6C | (1) | | -- | -- | | clam shells are common | depth------------ | -- | |
| 8B | 23.3 | --- | -- | -- | | in "wash" samples. Organic | | -- | |
| 9M | (1) | | -- | -- | | matter is mostly fibrous | | -- | |
| 9B | 27.9 | 197 | -- | -- | | and fine, rather than | | -- | |
| 9C | (1) | | -- | -- | | coarse and woody, and is | | -- | |
| 10T | (1) | | -- | -- | | confined to thin layers---------- | | -- | |
| 10M | (1) | | -- | -- | | | | -- | |
| 10B | 32.5 | 108 | -- | -- | | | | -- | |
| 10C | (1) | | 56 | 44 | | | | R | |

[1]See headnotes on page 60.

Table 21.--Stratigraphic data and interpretations for core site 12-76

| Sample Designation | Depth (m) | Penetration (blows/m) | Texture percentage: Sand | Texture percentage: Silt and clay | Stratigraphy: Depth (m) | Stratigraphy: Description | Interpretations: Probable depositional environment | Interpretations: Probable sediment source | Interpretations: Probable age |
|---|---|---|---|---|---|---|---|---|---|
| 1a | 0.2 | --- | 93 | 7 | 0-32+ | Gray-green uniform fine to medium sand. No silty or clay layers were observed, and no shells were present in drive or wash samples. Some fibrous to woody organic materials in near bottom and bottom wash samples----------------- | Estuarine(?) high energy intertidal flat---------------- | M | Holocene |
| 1b | .4 | --- | -- | -- | | | | ------ | |
| 2B | 2.0 | --- | -- | -- | | | | ------ | |
| 4W | ≈6 | --- | -- | -- | | | | ------ | |
| 4B | 6.6 | 131 | -- | -- | | | | ------ | |
| 6B | 11.1 | 240 (6B and 6C) | -- | -- | | | | ------ | |
| 6C | ([1]) | | 85 | 15 | | | | MR | |
| 7W | ≈15 | --- | -- | -- | | | | ------ | |
| 8W | ≈18 | --- | -- | -- | | | | ------ | |
| 9W | ≈23 | --- | -- | -- | | | | ------ | |
| 10W | ≈27 | --- | -- | -- | | | | ------ | |
| 11W | ≈32 | --- | [2]98 | [2]2 | | | | M | |

[1]See headnote on page 60.

[2]Texture and sediment source data for "wash" samples may not be representative.

Table 22.--Stratigraphic data and interpretations for core site 13-76

[Probable sediment sources and depositional environments were determined only for deposits of Holocene age]

| Sample Designation | Depth (m) | Penetration (blows/m) | Texture percentage: Sand | Texture percentage: Silt and clay | Stratigraphy: Depth (m) | Stratigraphy: Description | Interpretations: Probable depositional environment | Interpretations: Probable sediment source | Interpretations: Probable age |
|---|---|---|---|---|---|---|---|---|---|
| 1B | 1.3 | 23 | -- | -- | 0-6 | Greenish-gray sands and rare brownish gray silty sands. Broken shells common-------------- | Estuarine channel-- | --- | Holocene |
| 1C | ([1]) | | -- | -- | | | | --- | |
| 2B | 4.5 | 98 | -- | -- | | | | --- | |
| 2C | ([1]) | | 79 | 21 | | | | M | |
| 3T | ([1]) | 39 | -- | -- | 6-7 | Alternating blue-gray clay and brown to light gray, laminated and thinly bedded, peaty silt----- | | | Pleistocene |
| 3M[2] | ([1]) | | -- | -- | | | | | |
| 3B | 6.1 | | -- | -- | | | | | |
| 3C | ([1]) | | -- | -- | | | | | |
| 4T | ([1]) | 584 | -- | -- | 7-10 | Gray sands and hard gravels up to 2 to 3 cm--------------------- | | | |
| 4M | ([1]) | | -- | -- | | | | | |
| 4B | 7.8 | | -- | -- | | | | | |
| 4C | ([1]) | | -- | -- | | | | | |
| 5M | ([1]) | 112 | -- | -- | 10-16 | Brown interbedded peat and laminated to thinly bedded silt. One to two cm thick volcanic ash layer at 11 m. Logs common at the bottom-------------------- | | | |
| 5B | 11.2 | | -- | -- | | | | | |
| 5C[2] | ([1]) | | -- | -- | | | | | |
| 6T | ([1]) | 88 | -- | -- | | | | | |
| 6M | ([1]) | | 9 | 91 | | | | | |
| 6B | 13.1 | | -- | -- | | | | | |
| 7T | ([1]) | 131 | -- | -- | | | | | |
| 7B | 14.8 | | -- | -- | | | | | |
| 7C[2] | ([1]) | | -- | -- | | | | | |

Table 22.--Stratigraphic data and interpretations for core site 13-76--Continued

| Sample Designation | Depth (m) | Penetration (blows/m) | Texture percentage: Sand | Texture percentage: Silt and clay | Stratigraphy: Depth (m) | Stratigraphy: Description | Interpretations: Probable depositional environment | Interpretations: Probable sediment source | Interpretations: Probable age |
|---|---|---|---|---|---|---|---|---|---|
| 8T | ([1]) | 522 | -- | -- | 16-30+ | Gray medium to coarse sands and gravelly sands with logs to 20 cm at the top. Rare organic-rich (woody) silt layers. Gray coarse, sandy, hard gravels at the bottom-------- | | | Pleistocene--Continued |
| 8M | ([1]) | | -- | -- | | | | | |
| 8B | 17.5 | | -- | -- | | | | | |
| 8C | ([1]) | | -- | -- | | | | | |
| 9M | ([1]) | 203 | -- | -- | | | | | |
| 9B | 21.6 | | -- | -- | | | | | |
| 9C | ([1]) | | -- | -- | | | | | |
| 10M | ([1]) | 164 | 72 | 28 | | | | | |
| 10B | 26.6 | | -- | -- | | | | | |
| 11B | 30.3 | ≈574 | -- | -- | | | | | |
| 11C | ([1]) | | -- | -- | | | | | |

[1]See headnotes on page 60.

[2]Sample analyzed for radiocarbon age. See table 28.

Table 23.--Stratigraphic data and interpretations for core site 14-76

[Probable sediment sources and depositional environments were determined only for deposits of Holocene age]

| Sample Designation | Depth (m) | Penetration (blows/m) | Texture percentage: Sand | Texture percentage: Silt and clay | Stratigraphy: Depth (m) | Stratigraphy: Description | Interpretations: Probable depositional environment | Interpretations: Probable sediment source | Interpretations: Probable age |
|---|---|---|---|---|---|---|---|---|---|
| 1a | 0.2 | --- | 71 | 29 | 0-4 | Grayish-green, silty and clayey sands at the surface to gray-black silty sands at depth. Rare broken shell fragments------------------------- | Estuarine intertidal flat-------------- | RS | Holocene |
| 1b | .4 | --- | -- | -- | | | | -------- | |
| 2M | ([1]) | 30 | -- | -- | | | | -------- | |
| 2B | 2.0 | | -- | -- | | | | -------- | |
| 3T | ([1]) | 105 | -- | -- | 4-16+ | Yellow-brown to gray silty clays and clayey silts with occasional layers of gray medium to coarse granule sands. Sediments are well stratified and moderately hard. Isolated black wood fragments are common---- | | | Oligocene-Miocene |
| 3M | ([1]) | | -- | -- | | | | | |
| 3B | 6.2 | | -- | -- | | | | | |
| 3C | ([1]) | | 24 | 76 | | | | | |
| 4T | ([1]) | 115 | -- | -- | | | | | |
| 4M | ([1]) | | -- | -- | | | | | |
| 4B | 11.1 | | -- | -- | | | | | |
| 4C | ([1]) | | 42 | 58 | | | | | |
| 5T | ([1]) | 82 | -- | -- | | | | | |
| 5M | ([1]) | | -- | -- | | | | | |
| 5B | 15.7 | | -- | -- | | | | | |
| 5C | ([1]) | | -- | -- | | | | | |

[1]See headnote on page 60.

Table 24.--Stratigraphic data and interpretations for core site 15-76

[Probable sediment sources and depositional environments were determined only for deposits of Holocene age]

| Sample Designation | Depth (m) | Penetration (blows/m) | Texture percentage: Sand | Texture percentage: Silt and clay | Stratigraphy: Depth (m) | Stratigraphy: Description | Interpretations: Probable depositional environment | Interpretations: Probable sediment source | Interpretations: Probable age |
|---|---|---|---|---|---|---|---|---|---|
| 1a | 0.2 | --- | 91 | 9 | 0-4 | Greenish-black fine sands at surface to black silty sands at depth. Thin woody layers and isolated small shells | Estuarine intertidal flat | R | Holocene |
| 1b | .5 | --- | -- | -- | | | | ------ | |
| 2B | 2.0 | 23 | -- | -- | | | | ------ | |
| 2C | ([1]) | | -- | -- | | | | ------ | |
| 3M | ([1]) | 367 | -- | -- | 4-13 | Red and yellow-brown, weathered sandy gravels | | | Pleistocene |
| 3B | 5.0 | | -- | -- | | | | | |
| 4M | ([1]) | 190 | -- | -- | | | | | |
| 4B | 8.1 | | -- | -- | | | | | |
| 5T | ([1]) | 161 | -- | -- | | | | | |
| 5M | ([1]) | | -- | -- | | | | | |
| 5B | 11.1 | | -- | -- | | | | | |
| 5C | ([1]) | | 64 | 36 | | | | | |
| 6M | ([1]) | 95 | -- | -- | 13-22+ | Black to blue-green granule-bearing coarse sands with isolated wood clasts. Becomes greenish sandy gravel at depth | | | Pleistocene or Oligocene-Miocene |
| 6B | 15.7 | | -- | -- | | | | | |
| 7M | ([1]) | 279 | 65 | 35 | | | | | |
| 7B | 17.2 | | -- | -- | | | | | |
| 8B | ([1]) | --- | -- | -- | | | | | |
| 8C | 21.8 | | -- | -- | | | | | |

[1]See headnotes on page 60.

Table 25.--Stratigraphic data and interpretations for core site 16-76

[Probable sediment sources and depositional environments were determined only for deposits of Holocene age]

| Sample Designation | Depth (m) | Penetration (blows/m) | Texture percentage: Sand | Texture percentage: Silt and clay | Stratigraphy: Depth (m) | Stratigraphy: Description | Interpretations: Probable depositional environment | Interpretations: Probable sediment source | Interpretations: Probable age |
|---|---|---|---|---|---|---|---|---|---|
| 1a | 0.2 | ----- | 86 | 14 | 0-9 | Brownish-green silty fine sands and gray to black silts. Becomes finer and well stratified at depth. Fibrous woody lenses are common at top, and micas are abundant toward the bottom------------------ | Estuarine intertidal flat-------------- | R | Holocene |
| 1b | .4 | | -- | -- | | | | ----- | |
| 3M | ([1]) | 30 | -- | -- | | | | ----- | |
| 3B | 3.5 | | -- | -- | | | | ----- | |
| 5T | ([1]) | 20 | -- | -- | | | | ----- | |
| 5M | ([1]) | | -- | -- | | | | ----- | |
| 5B | 8.1 | | -- | -- | | | | ----- | |
| 6M | 11.1 | 72 | -- | -- | | | | ----- | |
| 7M | ([1]) | ----- | 62 | 38 | 9-17 | Green to black silty and clayey sands, containing at least one and possibly three clam shell beds----- | Estuarine subtidal intertidal flat--- | MR | |
| 7B | 14.2 | | -- | -- | | | | ----- | |
| 7C | ([1]) | | -- | -- | | | | ----- | |
| 8T | ([1]) | ----- | -- | -- | 17-18(?) | Tan to buff, hard gravels in silty sand matrix------------------------ | Fluvial channel | ----- | Holocene or Pleistocene |
| 8M | ([1]) | | -- | -- | | | | ----- | |
| 8B | 17.2 | 1,017 | [2]89 | 14 | | | | R | |
| 9W | ≈32 | ----- | -- | -- | 18(?)-32+ | Red to yellow hard, but weathered gravels or bedrock(?)-------------- | | | Pleistocene or Oligocene-Miocene |
| 9B | 32.5 | 656 | -- | -- | | | | | |
| 9C | ([1]) | | [2]88 | 18 | | | | | |

[1]See headnote on page 60.

[2]Sample contains some material >2,000 μm in size.

Table 2.--Stratigraphic data and interpretations for core site 17-78

[Probable sediment sources and depositional environments were determined only for deposits of Holocene age]

| Sample Designation | Depth (m) | Penetration (blows/m) | Texture percentage: Sand | Texture percentage: Silt and clay | Stratigraphy: Depth (m) | Stratigraphy: Description | Interpretations: Probable depositional environment | Interpretations: Probable sediment source | Probable age |
|---|---|---|---|---|---|---|---|---|---|
| 1a | 0.3 | ----- | -- | -- | 0-11 | Gray-brown, clean medium sand at the surface becoming finer and green to gray-green at depth. Organic matter is very rare----------------------- | Estuarine high energy inter-tidal flat or channel------- | -- | Holocene |
| 1b | .5 | ----- | 96 | 4 | | | | MR | |
| 2B | 3.1 | ----- | -- | -- | | | | -- | |
| 2C | ([1]) | | 95 | 5 | | | | RM | |
| 3W | ≈10 | ----- | -- | -- | | | | -- | |
| 3T | ([1]) | 361 | -- | -- | | | | -- | |
| 3M | ([1]) | | -- | -- | | | | -- | |
| 3B | 10.3 | | 92 | 8 | | | | MR | |
| 4T | ([1]) | 39 | -- | -- | 11-16 | Gray to blackish green sandy silt with large clam shells. Thin brown fibrous organic layers--------------------- | Estuarine inter-tidal to sub-tidal flat---- | -- | |
| 4M | ([1]) | | 17 | 83 | | | | RS | |
| 4B | 14.8 | | -- | -- | | | | -- | |
| 4C | ([1]) | | -- | -- | | | | -- | |
| 5W | ≈19 | ----- | -- | -- | 16-25 | Brown to yellow brown hard gravels in sandy and silty matrix---------------------- | | | Pleistocene |
| 5B | 19.3 | 784 | -- | -- | | | | | |
| 5C | ([1]) | | 76 | 24 | | | | | |
| 6C | 26.9 | 2,139 | 83 | 17 | 25-27+ | Gray very hard sand or sandstone----- | | | Oligocene-Miocene |

[1]See headnotes on page 60.

Table 27.--Stratigraphic data and interpretations for core site 18-76

[Probable sediment sources and depositional environments were determined only for deposits of Holocene age]

| Sample Designation | Depth (m) | Penetration (blows/m) | Texture percentage: Sand | Texture percentage: Silt and clay | Stratigraphy: Depth (m) | Stratigraphy: Description | Interpretations: Probable depositional environment | Interpretations: Probable sediment source | Interpretations: Probable age |
|---|---|---|---|---|---|---|---|---|---|
| 1a | 0.3 | ----- | 89 | 11 | 0-5 | Tan to gray-brown, very uniform medium sand. Gray to grayish green at depth | Estuarine high energy channel or inter-tidal flat | M | Holocene |
| 3W | ≈5 | ----- | -- | -- | | | | ------ | |
| 4W | ≈8 | ----- | -- | -- | 5-8 | Gray to greenish medium to fine sand and silty sand with numerous clam shells and (or) shelly beds. Occasional isolated basalt pebbles and thin brown fibrous woody layers | Estuarine flat and associated tidal channel | ------ | |
| 4B | 8.1 | ----- | -- | -- | | | | ------ | |
| 4C | ([1]) | | 80 | 20 | | | | RS | |
| 5W | ≈10 | ----- | -- | -- | 8-22 | Red to maroon, weathered fine gravels | | | Pleistocene |
| 5T | ([1]) | | -- | -- | | | | | |
| 5M | ([1]) | 590 | -- | -- | | | | | |
| 5B | 11.1 | | -- | -- | | | | | |
| 6M | ([1]) | | -- | -- | | | | | |
| 6B | 15.7 | 131 | -- | -- | | | | | |
| 6C | ([1]) | | [2]73 | 27 | | | | | |
| 7M | ([1]) | | -- | -- | | | | | |
| 7B | 20.3 | 328 | -- | -- | | | | | |
| 7C | ([1]) | | -- | -- | | | | | |
| | | 3,280 | | | 22+ | Very hard bedrock or very coarse cobbles and boulders | | | Oligocene-Miocene |

[1]See headnote on page 60.

[2]Sample contains some material >2,000 μm in size.

Table 28.—$^{14}C$ age of selected segments from Tillamook Bay cores

| Field sample no. | USGS laboratory no. | $^{14}C$ age* (yr B.P.) | Approximate depth below sediment surface (m) |
|---|---|---|---|
| 3-76-7MB | W-3796 | 7,850±300 | 18.5 |
| 3-76-9M | W-3795 | 8,310±300 | 27.9 |
| 5-76-4B | W-3651 | 6,360±300 | 8.1 |
| 5-76-6M | W-3660 | >40,000 | 20.3 |
| 7-76-8M | W-3810 | 6,970±250 | 20.3 |
| 9-76-2M | W-3658 | 3,300±200 | 6.6 |
| 9-76-3MB | W-3729 | 5,190±300 | 11.1 |
| 9-76-6M | W-3668 | 7,230±350 | 18.7 |
| 9-76-7C | W-3654 | 7,450±400 | 23.3 |
| 9-76-8M | W-3669 | 8,400±400 | 27.9 |
| 13-76-3M | W-3645 | >40,000 | 6.1 |
| 13-76-5C | W-3643 | >38,000 | 11.2 |
| 13-76-7C | W-3642 | >40,000 | 14.8 |

*Analyses were done in the Radiocarbon Laboratory of the U.S. Geological Survey, Reston, Va. The $^{14}C$ dates are based on the Libby half-life (5,570 years) and are referenced to the year A.D. 1950. The error stated, always larger than the standard one-sigma statistical counting error commonly used, takes into account replicate sample variability.

Table 29.—Range in apparent deposition rates at core sites 5-76 and 9-76

| Sample designation | Depth below MSL (m) | Age (yr B.P.)[1] | Apparent "Deposition Rate" (m/1,000 yr) Minimum | Average | Maximum |
|---|---|---|---|---|---|
| **Core site 5-76** | | | | | |
| Surface | 0.9 | [2]0 | 1.2 | 1.3 | 1.3 |
| 4B | 9.0 | 6,360±300 | | | |
| **Core site 9-76** | | | | | |
| Surface | .3 | [2]0 | 1.9 | 2.0 | 2.1 |
| 2M | 6.9 | 3,300±200 | | | |
| 2M | 6.9 | 3,300±200 | 1.9 | 2.4 | 3.2 |
| 3MB | 11.4 | 5,190±300 | | | |
| 3MB | 11.4 | 5,190±300 | 2.8 | 3.7 | 5.5 |
| 6M | 19.0 | 7,230±350 | | | |
| 6M | 19.0 | 7,230±350 | 4.7 | 20.9 | — |
| 7C | 23.6 | 7,450±400 | | | |
| 7C | 23.6 | 7,450±400 | 2.6 | 4.8 | 5.4 |
| 8M | 28.2 | 8,400±400 | | | |
| 6M | 19.0 | 7,230±350 | 4.8 | 7.9 | 21.9 |
| 8M | 28.2 | 8,400±400 | | | |

[1]See table 28.

[2]Actual age not determined by radiocarbon technique. The radiocarbon age could be as much as several hundred years.