ABSTRACT OF THE THESIS OF

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Title CONTINENTAL SHELF SEDIMENTS, COLUMBIA RIVER TO CAPE BLANCO, OREGON

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Sediments on the inner portion of the Oregon continental shelf consist of clean, well-sorted, detrital sand. This sand has an average median diameter of 2.53ϕ (.173 mm) and is both positively and negatively skewed. Deposits with median diameters in the coarse sand and gravel classes occur at depths of 20 to 40 fathoms and probably represent ancient beach or fluviatile deposits formed during lower stands of sea level.

The outer shelf and upper slope are covered by poorly sorted sediments with median diameters in the fine sand to fine silt classes. Mean diameters of the sediments are almost always smaller than their median diameters and the sediments are positively skewed.

The heavy mineral assemblages are dominated by the amphibole and pyroxene groups and the opaque-garnet association. Pyroxenes are most abundant in the coarser-grained sediments of

the inner shelf and decrease in abundance offshore. Amphiboles are most abundant in the finer-grained sediments of the outer shelf and upper slope. Highest concentrations of the opaque-garnet association also are found in the inshore samples.

Sediments of the continental shelf are derived from two principal sources, rivers and erosion of coastal terrace deposits. Rivers are probably contributing only fine-grained material to the shelf as much of the coarser fluviatile material is thought to be trapped in the estuaries. The terrace deposits are actively being eroded and are thought to contribute about 21,000,000 cubic feet (.00013 cubic miles) of sediment to the continental shelf annually.

Evidence suggests that much of the inner-shelf sand is probably a relict transgressive sheet sand that was deposited during the last rise in sea level. Most of the deposition of the modern sand on the shelf has been confined to the inner portion of the inner shelf. Finer-grained sediments have been deposited on the outer shelf and upper slope.

Characteristics of the sediments on the present continental shelves may be useful in identifying continental shelf deposits in the geologic column.

CONTINENTAL SHELF SEDIMENTS, COLUMBIA RIVER TO CAPE BLANCO, OREGON

by

ERWIN JOHN RUNGE, JR.

A THESIS

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INTRODUCTION

General Statement

The continental shelf is the shallow platform adjacent to the continent. It extends from the line of permanent immersion to the depth at which there is a marked increase in slope to greater depth. Variations in the textural parameters of shelf sediments may be used to indicate processes of sedimentation. A detailed study was made of the continental shelf and upper continental slope sediments off Oregon from the Columbia River to Cape Blanco. Five hundred and fifty samples were collected on a three-mile* grid out to a depth of 200 fathoms. **

The purpose of this study was (1) to describe the areal distribution of the sediments and their compositional and textural variations and (2) to use these variations as indicators of sedimentary processes on the continental shelf.

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* All distances will be expressed in nautical miles. One nautical mile equals 6076.12 feet.

** One fathom equals six feet.

Previous Work

Prior to this investigation no comprehensive study had been done on the sediments of the Oregon continental shelf. Cummings (1962) examined sediment samples from the continental shelf between the Umpqua and Coquille Rivers in connection with a study of the sediments of Coos Bay. Bushnell (1964) studied the distribution of sediments from the shelf and upper continental slope between $44^{\circ}20'$N to $44^{\circ}58'$N latitudes. His work was augmented by Maloney (1965) who studied sediments of the shelf from $43^{\circ}50'$N to $44^{\circ}40'$N latitudes in conjunction with a study of the sediments and rocks of the continental terrace. The data from these studies have been used to develop a sedimentary model of the continental terrace off the central Oregon coast (Byrne, Maloney, and Fowler, 1965).

REGIONAL GEOLOGY AND PHYSIOGRAPHY

The chief source of sediments for the shelf is the continental landmass to the east (Figure 1). Western Oregon is characterized by two north-trending mountain ranges, the Coast Range to the west and the Cascade Mountains to the east. The Coast Range extends from the Olympic Mountains on the north to the Klamath Mountains on the south and has an average crest elevation of about 1500 feet. Lithologically the Coast Range is composed of thick Eocene to Miocene volcanics, tuffaceous sedimentary rocks, and thick sequences of micaceous and arkosic sandstones and sandy siltstones. These have been cut by dioritic, basaltic and gabbroic dikes and sills (Baldwin, 1964). Numerous small rivers and streams drain the western slopes and empty directly into the Pacific Ocean, supplying sediments to the continental shelf.

The Klamath Mountains extend from southern Oregon into northern California and have 5000 to 8000 feet of relief. Paleozoic and Mesozoic metasedimentary and metavolcanic, as well as sedimentary rocks, have been cut and intruded by granitoid and ultrabasic rocks (Baldwin, 1964). These mountains are most likely the major source of metamorphic sediments for the continental shelf. The sediments are carried to the shelf mainly by the Umpqua, Rogue and Klamath Rivers.

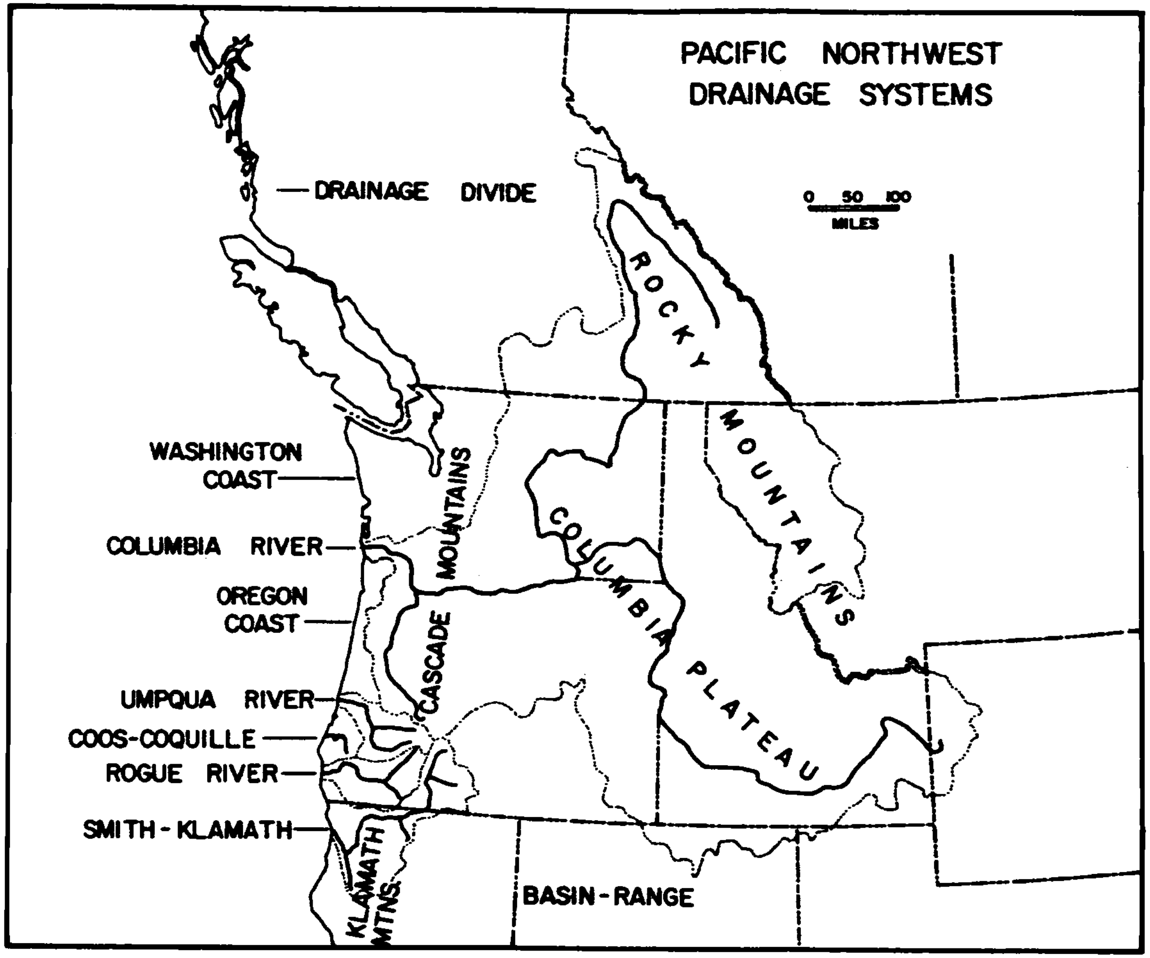

Figure 1. Major drainage systems of the Pacific Northwest.

The Oregon coastline is relatively straight, interrupted only by small bays and headlands. Well developed marine terraces which were probably formed during the Pleistocene and late Pliocene are prominent along the central and southern Oregon coast. At least six terrace levels have been recognized between Coos Bay and Cape Blanco; the highest occurs at elevations up to 1500-1600 feet (Baldwin, 1964). Deposits on these terraces usually consist of unconsolidated beach and dune sand. Sea stacks, common in some areas along the southern coast, often have terraced surfaces. It appears that at least the lowest terrace level was much more extensive before the coastline receded to its present position.

The Cascade Mountains are separated from the Coast Range and the Klamath Mountains by the Willamette Valley. Although the average crest elevation of the Cascades is about 5000 feet, the highest peak has a maximum elevation of 11, 245 feet (Mt. Hood). Rocks include basalt, basaltic andesite, dacite and welded tuffs as well as other pyroclastic material, and are Eocene to Pleistocene in age (Baldwin, 1964). The slopes are drained primarily by tributaries of the Columbia and Umpqua Rivers.

The Columbia River is the largest river in the area, and drains over 12 times the area of all the other neighboring systems combined, 259, 000 square miles. Its watershed covers several physiographic and geologic provinces, and dissects igneous, metamorphic and sedimentary rocks from portions of seven states as well as the southern part of British Columbia.

CLIMATE

Climate influences many of the oceanographic processes. Currents may be generated and maintained by winds. The magnitude and direction of the winds control sediment transport by littoral drift and the height of the waves which erode the coast. Also, the amount and rate of precipitation determine rates of subaerial erosion.

The climate of the Pacific Northwest is varied, with less variation in temperature and rainfall west of the Cascade Mountains than to the east. In July coastal temperatures average between 55°F and 62°F, whereas east of the Cascades the average temperatures range from about 58°F to 75°F. During the month of January temperatures average about 40°F on the coast while east of the Cascades the average temperature may be as low as 16°F.

Factors controlling rainfall distribution are proximity to the ocean and the location and elevation of mountain ranges. Cyclonic storms are a major cause of precipitation and move inland with the prevailing westerlies. Due to the elevation of the mountain ranges, there is higher rainfall on the western slopes of the Coast and Cascade Ranges than on the eastern slopes. The average annual precipitation along the southern and central Oregon coast is between 50 and 80 inches, but it is generally over 80 inches along the northern coast. East of the Cascades the annual rainfall is usually less than 20 inches. Most of the rainfall comes during the winter months, whereas the summer months are the driest.

OCEANOGRAPHY

Oceanographic processes control the distribution of sediments on the continental shelf. Waves are the most important agent in the movement of inshore sediments. A study of storm waves from the sector 225° to 315° off Yaquina Bay was prepared by National Marine Consultants, Inc. (1961). They calculated hind cast wave data for the period from 1940 to 1960. Significant heights* for storm waves during this time ranged from 5.8 to 9.6 meters and significant periods from 12 to 14 seconds.

The most extensive water mass off the Oregon coast is part of the sluggish southward-flowing California Current System. Rosenberg (1962) referred to this water as Modified Subarctic Water. It occurs at depths of 200 to 1000 meters. It consists mostly of Subarctic Water, with a temperature between 2° and 4°C and a salinity between 32‰ and 34‰, mixed with a small amount of Pacific Equatorial Water, with a temperature range between 8° and 15°C and a salinity between 34.6‰ and 35.2‰ (Sverdrup, Fleming, and Johnson, 1942). Inshore, in the vicinity of the continental terrace, the percentage of Equatorial Water increases and is referred to by Rosenberg (1962) as Coastal Water.

Winds are predominantly from the north-northwest during the spring and summer months. Since the wave regime generally

* Significant heights of waves are the statistical values for the highest 1/3 of the waves.

parallels the wind direction, the dominant current and littoral drift are to the south at this time of year. These northerly winds also cause the surface coastal water to be carried offshore by Ekman transport and produce upwelling (Smith, 1964). During the fall and winter the winds are predominantly from the south-southwest and littoral drift is to the north. Upwelling ceases and a countercurrent develops in the surface layers, the Davidson Current (Sverdrup, Fleming, and Johnson, 1942), and carries water from the south along the coast.

Tides along the Oregon coast are mixed semi-diurnal and have an average amplitude of about one meter at the coast. Little is presently known about tidal currents and tidal velocities on the shelf. A preliminary study has been initiated, but analysis of the data collected has not been completed.

PHYSIOGRAPHY OF THE CONTINENTAL SHELF AND UPPER SLOPE

The continental terrace consists of two geomorphic features, the continental shelf and the continental slope. The continental shelf extends from the coastline to the first marked increase in slope, and the continental slope extends from this break in slope to the edge of the abyssal plain.

The physiography of the continental terrace off the Oregon coast has been discussed in detail by Byrne (1962; 1963 a, b) and Maloney (1965). According to Byrne (1962) the shelf varies in width from 8 to 35 miles, varies in slope from $0^{\circ}08'$ to $0^{\circ}43'$, and the change in the slope occurs at a depth of 80 to 100 fathoms. Shepard (1963) studied the shelves of the world and found that they have an average width of 40 miles, and average slope of $0^{\circ}07'$, and the greatest change in slope occurs at an average depth of 72 fathoms. Compared to the world average, the Oregon continental shelf is narrower, has a steeper slope and is deeper.

For convenience of discussion, the shelf will be divided into three latitudinal sections. The northern section extends from the latitude of the Columbia River ($46^{\circ}20'$N) to approximately that of Cascade Head ($45^{\circ}06'$N). The portion of the shelf from Cascade Head to the latitude of Tahkenitch Lake ($43^{\circ}48'$N) is designated as the central section, and the southern section extends from Tahkenitch Lake to the latitude of Cape Blanco ($42^{o}50'N$). The area between 0 and 50 fathoms will be referred to as the inner shelf and the area between 50 and 100 fathoms, as the outer shelf. Physiographic features of the entire shelf are shown in Figure 2.

The general flatness of the shelf is broken by two types of physiographic features: canyons and shoals. Astoria Canyon begins about 10 miles west of the mouth of the Columbia River and is the only major submarine canyon off the Oregon coast. The canyon heads at about 70 fathoms and cuts roughly west some 50 miles across the outer shelf and slope to a depth of about 1000 fathoms. Its axial slope varies from about 2^{o} near its head to about 1^{o} beyond the shelf break.

Shoals occur primarily on the outer shelf. The Nehalem Banks in the northern section are located 23 miles west of Tillamook Head. In the central section several shoals are present; the largest of these are Heceta, Perpetua, and Stonewall Banks. Coquille Bank in the southern section is located five miles west of Cape Blanco. The banks trend roughly north-south, and vary from two to eight miles in width and from 6 to 18 miles in length. Heceta Bank has the greatest relief (40 fathoms) of all the banks (Byrne, 1963a). Samples of siltstone dredged from Stonewall and Heceta Banks are considered to be of Pliocene age (Byrne, 1962; Maloney, 1965).

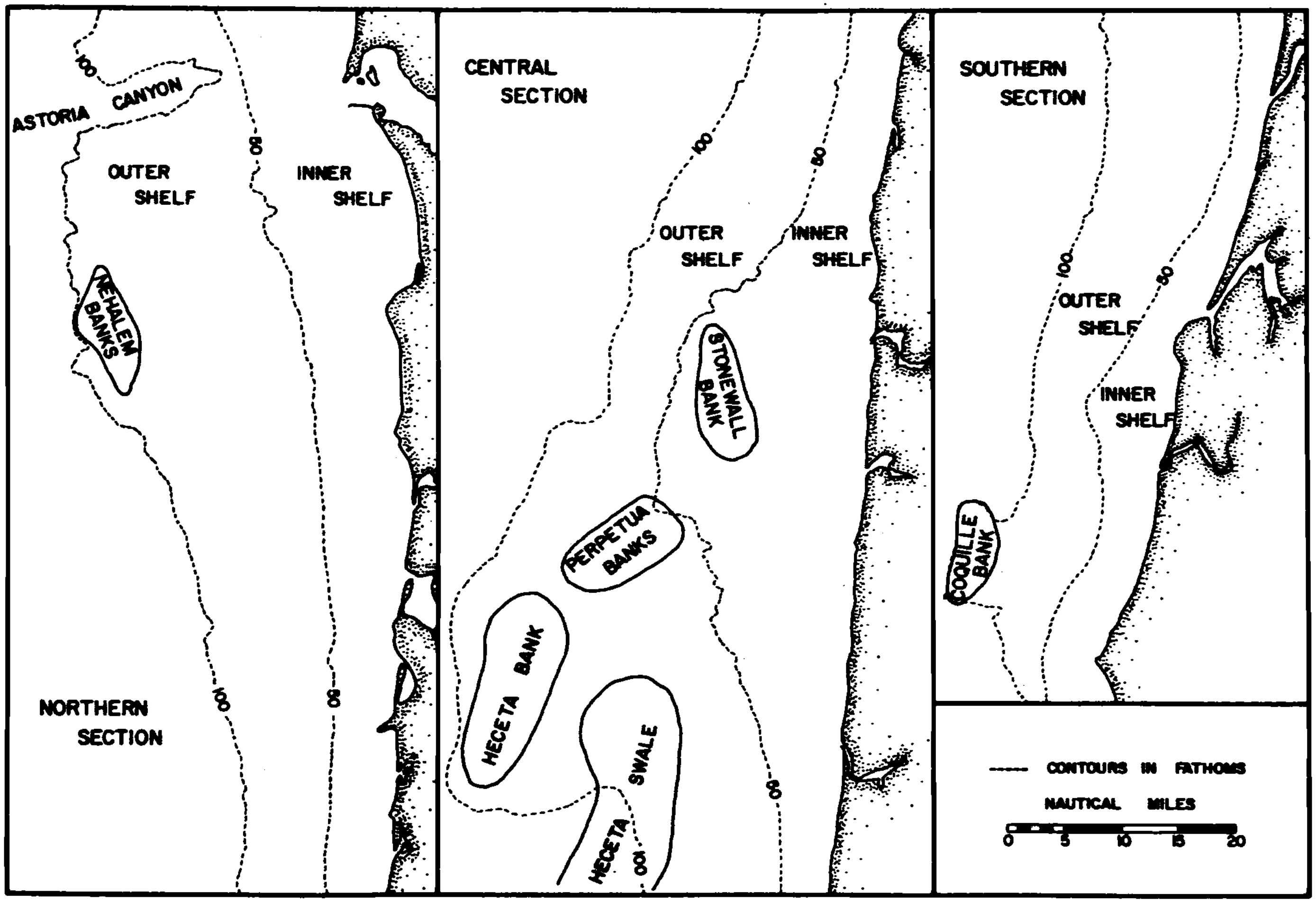

Figure 2. Geomorphic and geographic features of the continental shelf.

PROCEDURES

Sampling Methods

Five hundred and fifty samples of sediment were collected from the continental shelf and upper slope (Figure 3a, b, c) (Appendix 1). Of these samples, 540 were taken with a Dietz-LaFond grab and 10 were taken with a short gravity corer. The upper slope was sampled to study the transition between shelf and slope sediments. The samples were collected on a three-mile grid which allowed the shelf to be sampled rapidly and yet in some detail. Due to the narrowness of the southern end of the shelf, some samples were collected at two-mile intervals. Approximately 50 samples could be collected in a 24-hour day.

Methods of Analysis

All samples were analyzed following standard laboratory procedures. The Emery settling tube (Emery, 1938) as modified by Poole (1957) was used for textural analysis of the sand fraction. Samples which contained material too coarse for this method were sieved using Tyler screens, $1/4\phi$ intervals. Sea water was removed from sediments containing silt and clay with millipore filters; the sediment was then dispersed in a 0. 2 percent solution of Calgon (sodium hexametaphosphate) and analyzed by the soils hydrometer

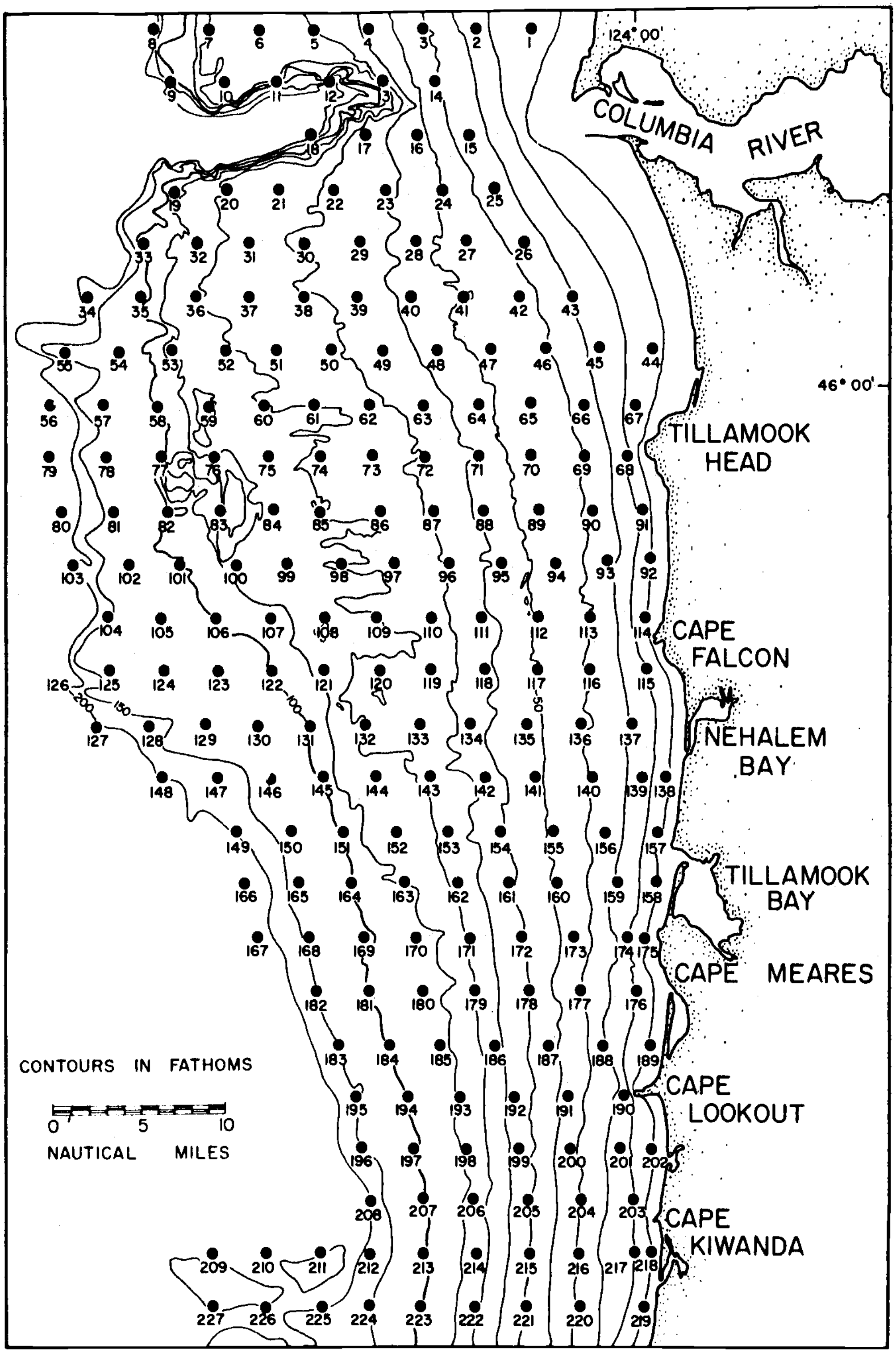

Figure 3a. Bathymetry and sample locations for the northern section of the continental shelf and upper continental slope.

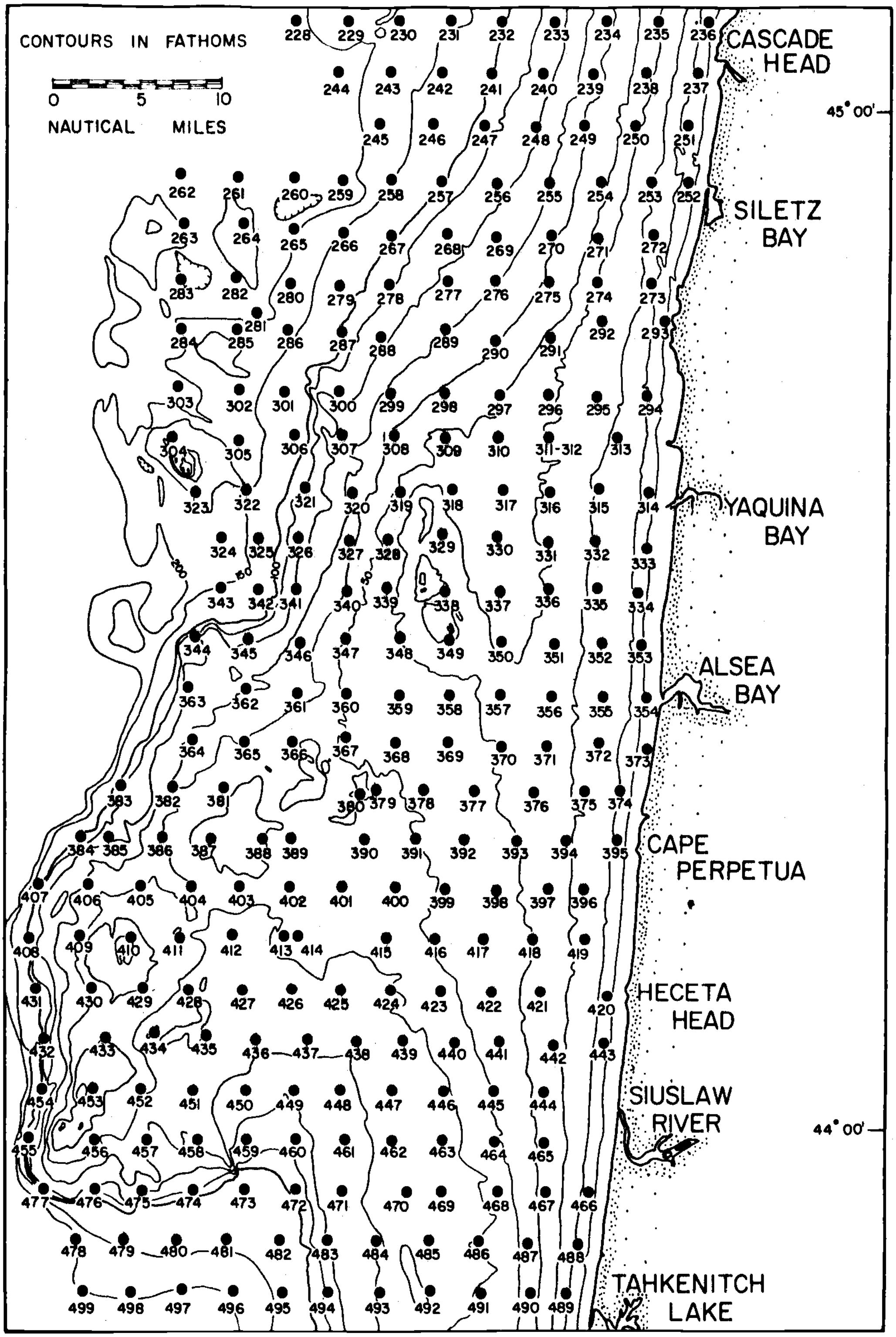

Figure 3b. Bathymetry and sample locations for the central section of the continental shelf and upper continental slope.

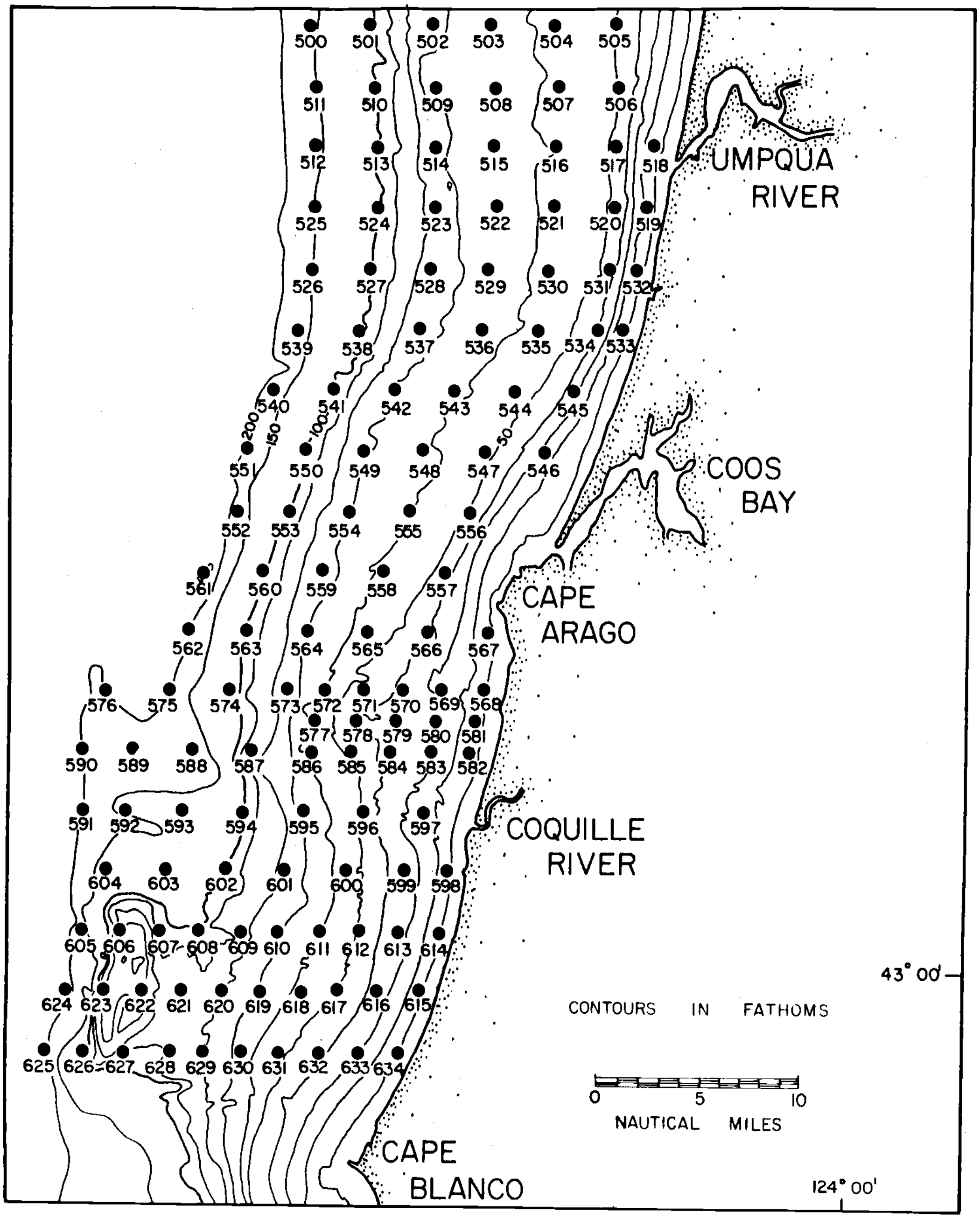

Figure 3c. Bathymetry and sample locations for the southern section of the continental shelf and upper continental slope.

technique suggested by the American Society for Testing Materials (1965).

Computation of Statistics

Cumulative curves and textural statistics were calculated by IBM 1410 and 1620 computers. Phi median diameter, phi mean diameter, phi deviation and phi skewness were calculated according to Inman (1952). Percentages of sand, silt, and clay for each sample were also calculated by an IBM 1620 computer. Scatter diagrams of mean versus sorting, mean versus skewness, and sorting versus skewness were plotted by an IBM 1620 computer and an X-Y plotter.

Sand Fraction Composition

Heavy mineral separations were performed by centrifuging as outlined by Fessenden (1959) and Livingston (1964). About three grams of sand were poured into 50 ml glass tubes filled with 25 ml of tetrabromoethane (sp. gr. = 2. 96). Samples were stirred and centrifuged for 10 minutes at about 1200 rpm. Freezing of the liquid was facilitated by using a mixture of dry ice and alcohol. Grain mounts were made with Canada balsam for examination with a petrographic microscope.

Compositional percentages of the light minerals were determined by spreading a split of the sand fraction from each sample on a sheet of paper. The grains were examined with the aid of a binocular microscope and the relative percentages of authigenic and detrital constituents in different fields of view were estimated.

TEXTURE

Sediment samples may be described and compared by their textural data. Size distributions of samples may be used to indicate the environmental conditions of transportation and deposition. Textural data are given in Appendix 2.

Phi Median Diameter

Phi median diameter is a measure of central tendency and can be used as an indicator of the grain size of sediments. The median diameter of the sediments from the Oregon continental shelf usually decreases offshore from fine sand size on the inner shelf to very fine sand and silt size on the outer shelf (Figure 4). In some areas deposits of coarse sand and gravel occur at depths of 20 to 40 fathoms. No size analyses were made of the gravel. The upper slope is covered by sediments with median diameters in the very fine sand to very fine silt classes.

Northern Section

The characteristic sand of the inner shelf has a median diameter between 2ϕ (.250 mm) and 3ϕ (.125 mm) (Table 1). This sand occurs from the shoreline to depths ranging from 14 fathoms north of the Columbia River to about 70 fathoms off Cape Kiwanda. Several samples of coarse sand and gravel coarser than the

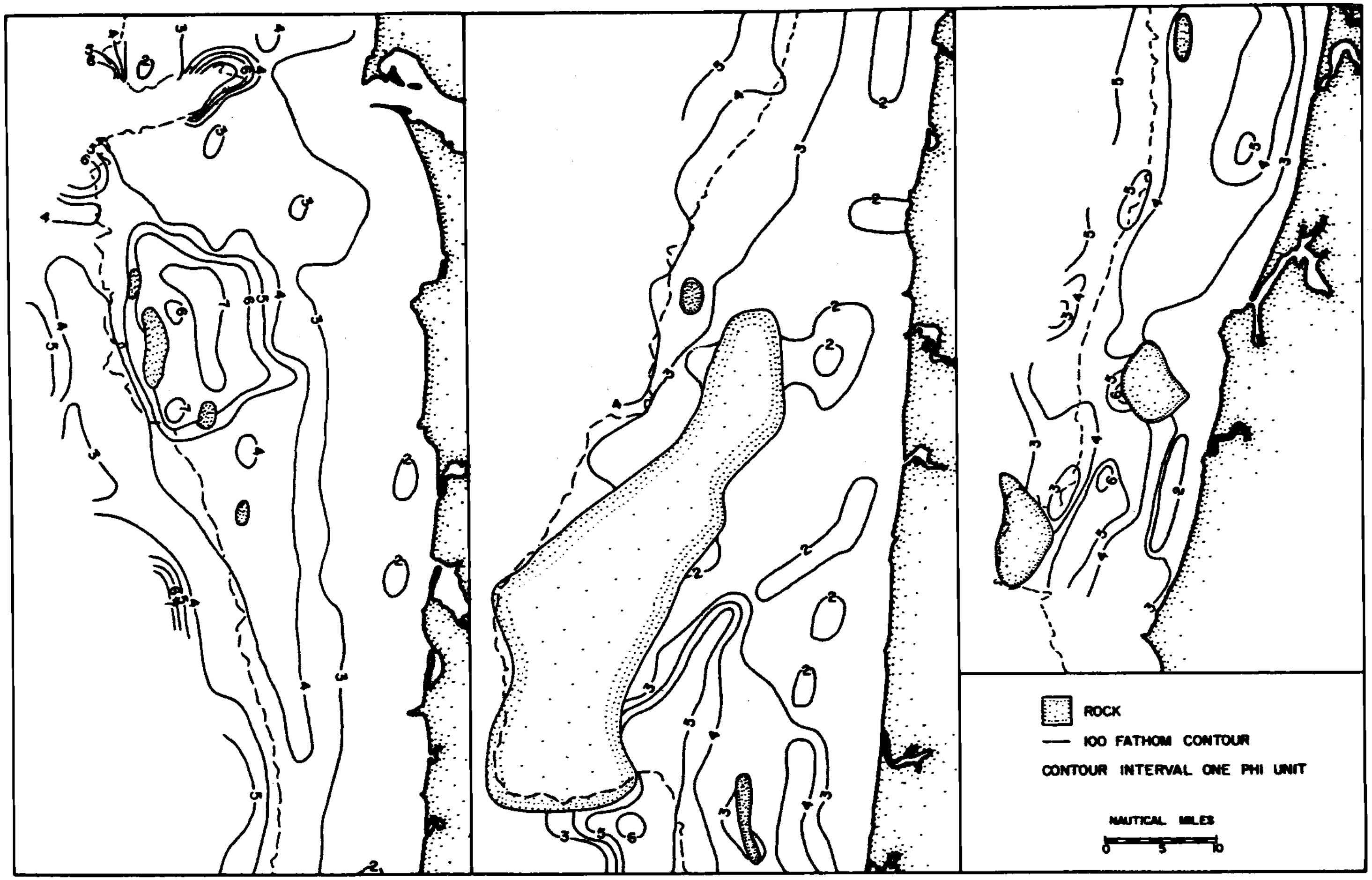

Figure 4. Distribution of phi median diameter values for continental shelf and upper continental slope sediments. Samples with median diameters of less than two phi were not contoured.

Table 1. Phi median diameters of the continental shelf and upper continental slope sediments. Numbers in parentheses indicate number of samples on which average is based.

	Inner Shelf			Outer Shelf			Upper Slope		
Section	Max	Min	Average	Max	Min	Average	Max	Min	Average
Northern	0.77	4.12	2.75(52)	2.86	7.32	4.19(102)	2.36	7.36	4.38(51)
Central	-0.81	3.26	2.23(78)	1.62	5.84	3.53(71)	1.97	8.53	4.35(43)
Southern	-0.54	4.36	2.85(31)	2.78	6.64	4.20(55)	1.94	5.85	3.90(28)

surrounding sediments were found off Nehalem and Tillamook Bays.

Seaward of the inner-shelf sand, the outer shelf is covered by sediments with a median diameter in the very fine sand and silt classes (Figure 5). The coarser-grained sediments are confined to the inner portion of the outer shelf and to the area north of the Nehalem Banks. East of the Nehalem Banks, the outer shelf is covered by sediments with a median diameter between 4ϕ (.062 mm) and 8ϕ (.004 mm). This band of fine material extends southward to the latitude of Cape Lookout, narrowing as the shelf narrows. Seaward, the shelf is covered by coarser-grained sediments. Over the shelf break and below the rim of Astoria Canyon, the sediments become finer with depth.

Central Section

In the central section the sand of the inner shelf is slightly coarser than it is in either the northern or southern section (Table 1). In most places it extends to about 50 to 70 fathoms or to the bank area. From the latitude of Heceta Head south, the depth at which this sand occurs gradually decreases to about 40 fathoms off Tahkenitch Lake. Scattered deposits of coarser sand occur on the inner shelf and do not appear to be confined to any specific area or depth. The more extensive deposits occur off Cascade Head, Yaquina Bay, and Cape Perpetua.

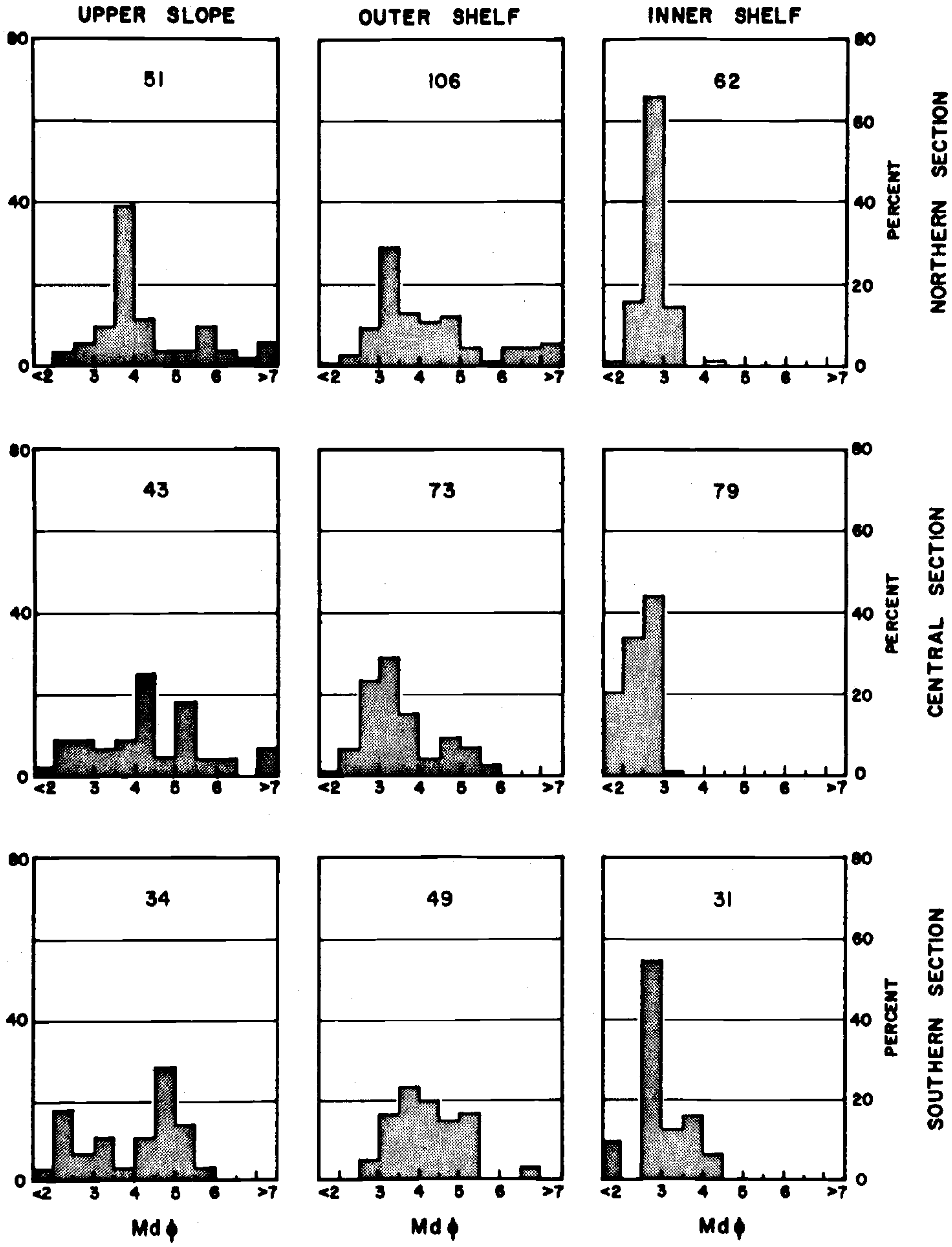

Figure 5. Frequency distributions of phi median diameter values. The number of samples is indicated above each histogram.

Two bands of sediments with median diameters finer than 4ϕ (.062 mm) were found on the outer shelf west of the Siuslaw River. The shallower band is approximately two miles wide, and lies at about 60 fathoms. It extends to about eight miles south of the Umpqua River. The deeper band is in Heceta Swale adjacent to Heceta Bank, and varies from three to nine miles in width. Sediments with a median diameter of 3ϕ (.125 mm) to 4ϕ (.062 mm) cover the shelf between these areas. On the upper slope, the sediments have a median diameter in the coarse and medium silt classes.

The values of the parameters in the hummocky areas of the upper slope northwest of Stonewall Bank and on the upper slope off Cascade Head were not contoured. This is due to the large variations of values between adjacent samples caused by the formation of authigenic glauconite on the highs. In several places median diameter values of adjacent samples three miles apart varied by as much as five phi units because one sample was taken in the glauconitic sand on the top of a hill while the other sample was taken in the clayey silt in an adjacent valley.

Southern Section

Sediments of the southern section are characterized by greater variation than the sediments of the sections to the north (Figure 4). Sand with a median diameter between 2ϕ (.250 mm) and 3ϕ (.125 mm) extends to a depth of 30 to 40 fathoms in the northern part, deepens to about 50 fathoms off Cape Arago, then shoals to about 10 fathoms north of Cape Blanco. The only known deposit of coarse sand and gravel occurs south of the mouth of the Coquille River at a depth of 25 to 35 fathoms.

An area which is free of sediments was found six miles southwest of Cape Arago. This area lies between 30 and 60 fathoms. Notations on the U. S. Coast and Geodetic Survey Chart 5802 show that "rip currents" are found in this area and are probably strong enough to prevent sediments from being deposited.

On the outer shelf east of Coquille Bank sediments with median diameters between 5ϕ (.031 mm) and 7ϕ (.008 mm) occur in a northeast-southwest trending band several miles wide. It lies between the 70 and 80 fathom isobaths and extends from about eight miles west of the Coquille River to the southern end of the section. These sediments are much finer than the surrounding sediments.

Discussion

Although the characteristic sediment of the inner shelf is sand with a median diameter between 2ϕ (.250 mm) and 3ϕ (.125 mm), some deposits of coarse sand and gravel occur at depths of 20 to 40 fathoms. This coarseness is due to the presence of large amounts of coarse sand in the sample; generally 75 percent of the sediment in these samples has a median diameter greater than .500 mm.

The characteristic inner-shelf sand usually extends out to a depth of about 50 to 60 fathoms. In the vicinities of the mouths of the Columbia and Umpqua Rivers it extends only to about 30 to 40 fathoms, and is replaced seaward by material with a median diameter in the very fine sand and coarse silt classes. This is probably due more to the addition of finer-grained material from the rivers than to the absence of sediment with a median diameter in the fine sand class.

The median diameter of the sediments of the outer shelf does not appear to be a function of water depth only. Sediments with a median diameter between 2ϕ (.250 mm) and 3ϕ (.125 mm) are found on the upper slopes, whereas the sediments east of the bank areas on the shelf have median diameters between 6ϕ (.016 mm) and 8ϕ (.004 mm). Some of the coarser sediments on the slope can be attributed to the formation of authigenic glauconite while the remainder are probably relict detrital sand. The occurrence of the fine material adjacent to the banks may be related to the dissipation of wave energy on the banks. This could create areas of quiescence behind the banks and allow suspended sediment to settle out.

Phi Mean Diameter

$$[M\phi = 1/2\ (\phi 16 + \phi 84)]$$

Phi mean diameter is also a measure of central tendency but differs from the median in that it is more influenced by the amount of material present in the fine and coarse fractions. The distribution of mean diameter values is shown in Figure 6. The average values of the median diameters (Table 1) and the mean diameters (Table 2) for the inner shelf are similar. Values for the northern and central sections are almost the same, while the mean diameter for the southern section is somewhat smaller. A comparison of the histograms of the mean (Figure 7) and median diameters (Figure 5) of the inner shelf sediments shows that the modes are about the same (between 2.5ϕ and 3.0ϕ). The exception to this is the mode for the mean diameter of the sediments from the central section which is between 2.0ϕ (.250 mm) and 2.5ϕ (.177 mm). A greater difference is found in the sediments of the outer shelf and upper slope. Several modes are present in each histogram, and the values for the mean are greater than those for the median.

The similarity between the average values of the mean and median diameters of the inner-shelf sediments indicates that these sands are fairly well sorted, and are composed of about the same sized material. In contrast, the sediment of the outer shelf and

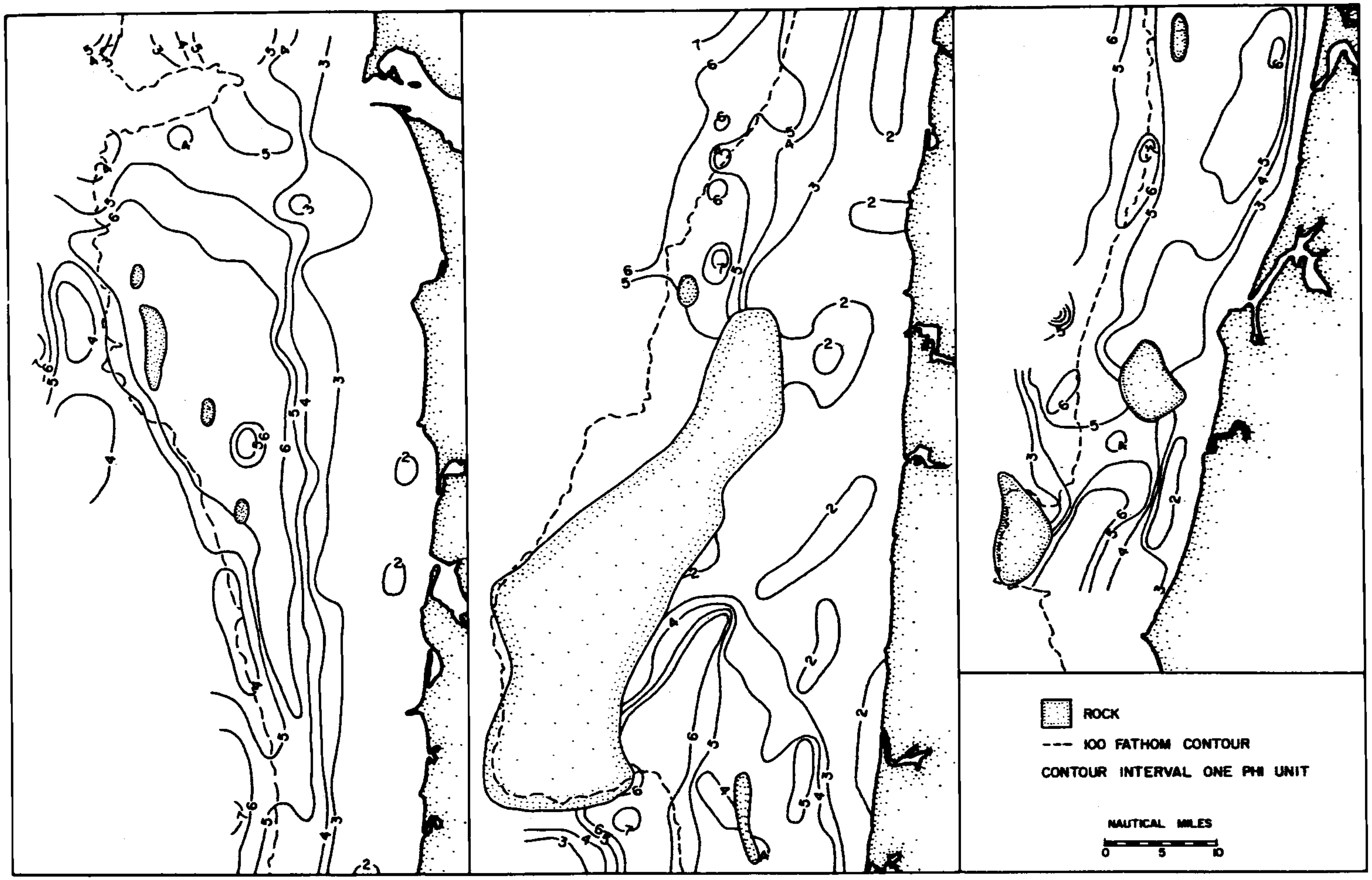

Figure 6. Map showing the variations of phi mean diameter values. Values less than two phi were not contoured.

Table 2. Phi mean diameters of the continental shelf and upper continental slope sediments. The number of samples represented is indicated in the parentheses.

	Inner Shelf			Outer Shelf			Upper Slope		
Section	Max	Min	Average	Max	Min	Average	Max	Min	Average
Northern	0.75	5.12	2.80 (62)	2.36	6.94	4.90 (87)	2.49	7.04	4.94 (43)
Central	-0.59	4.45	2.24 (78)	1.57	7.87	4.41 (68)	1.91	8.70	5.54 (39)
Southern	-0.62	5.25	3.06 (31)	2.67	6.41	5.08 (53)	2.42	7.05	5.11 (34)

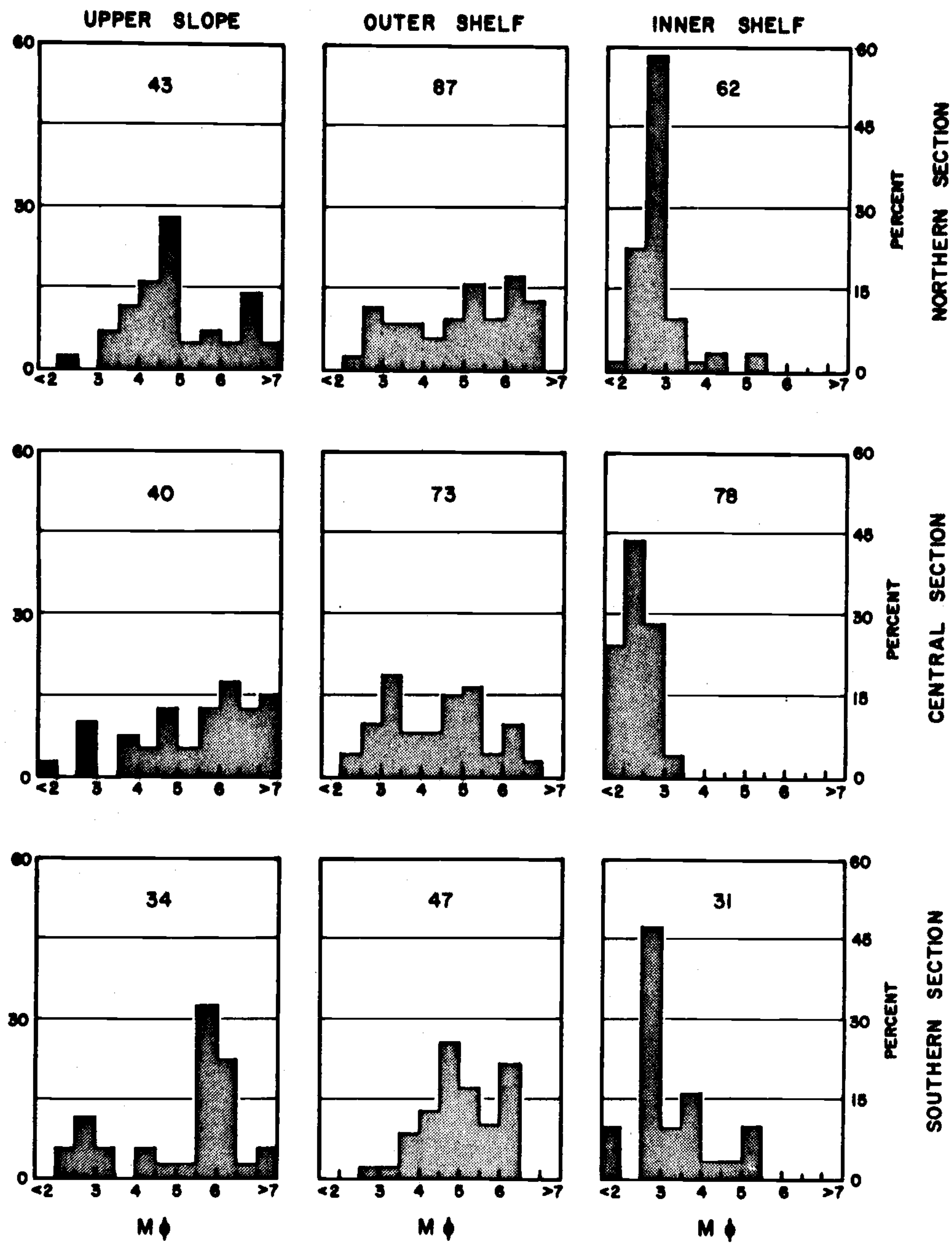

Figure 7. Histograms showing the variations of phi mean diameter values. The number of samples is indicated above each histogram.

upper slope have mean diameters which are smaller than their median diameters. This is due to the presence of silt and clay which are absent from the sediments of the inner shelf.

Phi Deviation

$$[\sigma\phi = 1/2\ (\phi 84 - \phi 16)]$$

Phi deviation may be used as a close approximation of the standard deviation of statistics. It is a measure of sediment sorting. The distribution of phi deviation values on the continental shelf and upper slope is shown in Figure 8. Sediments of the inner shelf are well sorted. This is shown by both the average sorting values (Table 3) and by the frequency distribution of sorting values (Figure 9). The sediments of the outer shelf are more poorly sorted with the boundary between the well-sorted sediments closely approximating the 3ϕ isopleth on the median diameter map (Figure 4). On the outer shelf the most poorly sorted sediments are located around Nehalem Bank, in Heceta Swale, and in the vicinity of Coquille Bank where the sediments are largely silt. The glauconitic sediments at the shelf break and on the upper slope generally are better sorted than the surrounding finer-grained sediments.

Sorting is a response to the total amount of energy in the depositing system and to the viscosity of the medium which controls the rate of settling. As the energy decreases the coarser material

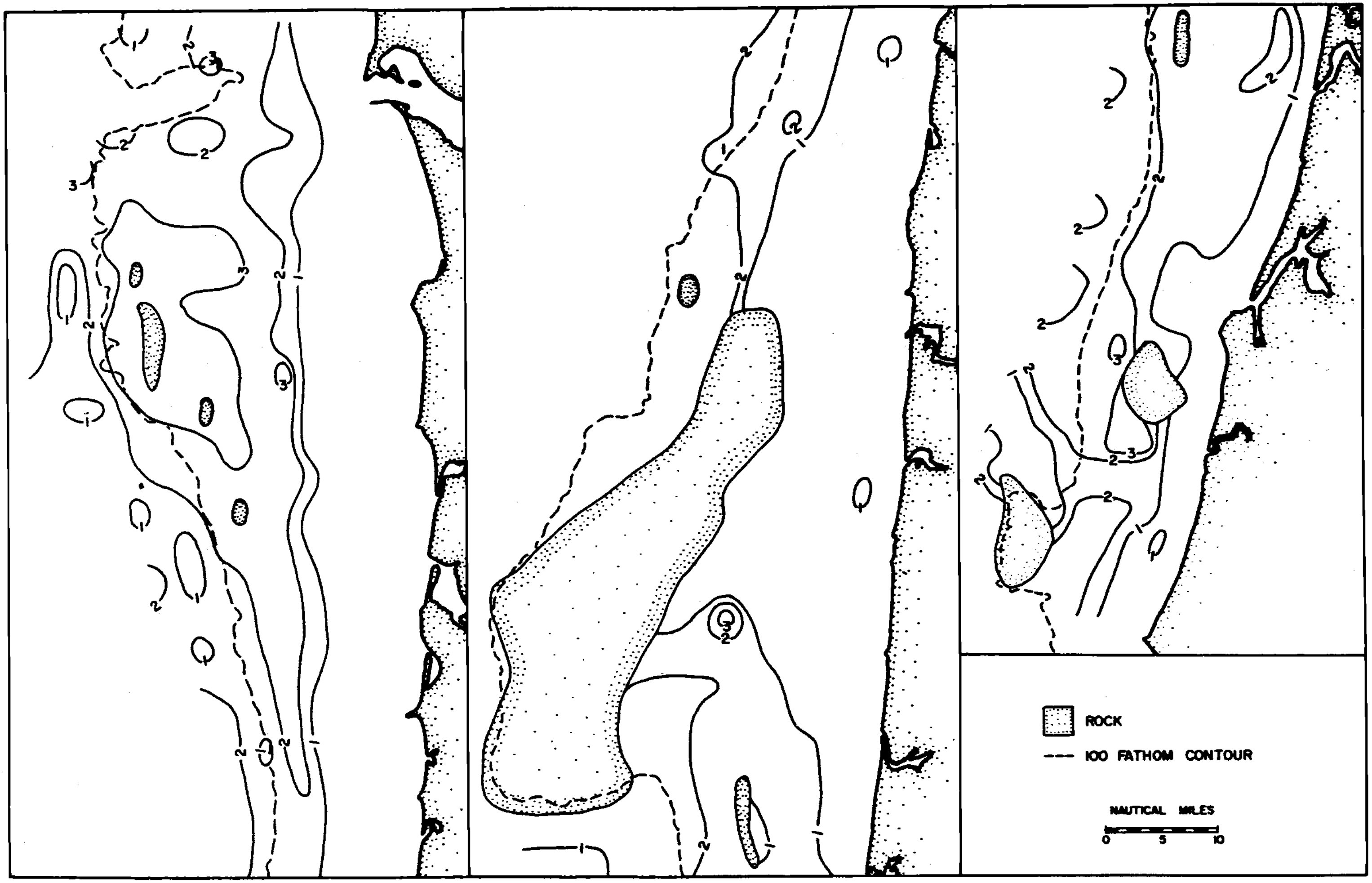

Figure 8. Distribution of phi deviation values on the continental shelf and upper continental slope.

Table 3. Phi deviation values of the continental shelf and upper continental slope sediments. Figures in parentheses indicate number of samples used.

	Inner Shelf			Outer Shelf			Upper Slope		
Section	Max	Min	Average	Max	Min	Average	Max	Min	Average
Northern	2.38	0.20	0.51(62)	3.63	0.22	2.16(102)	3.00	0.61	1.86(51)
Central	1.13	0.19	0.40(77)	4.93	0.16	1.60(64)	4.62	0.57	2.44(43)
Southern	3.90	0.20	0.71(31)	3.69	0.56	1.97(55)	2.55	0.39	1.83(27)

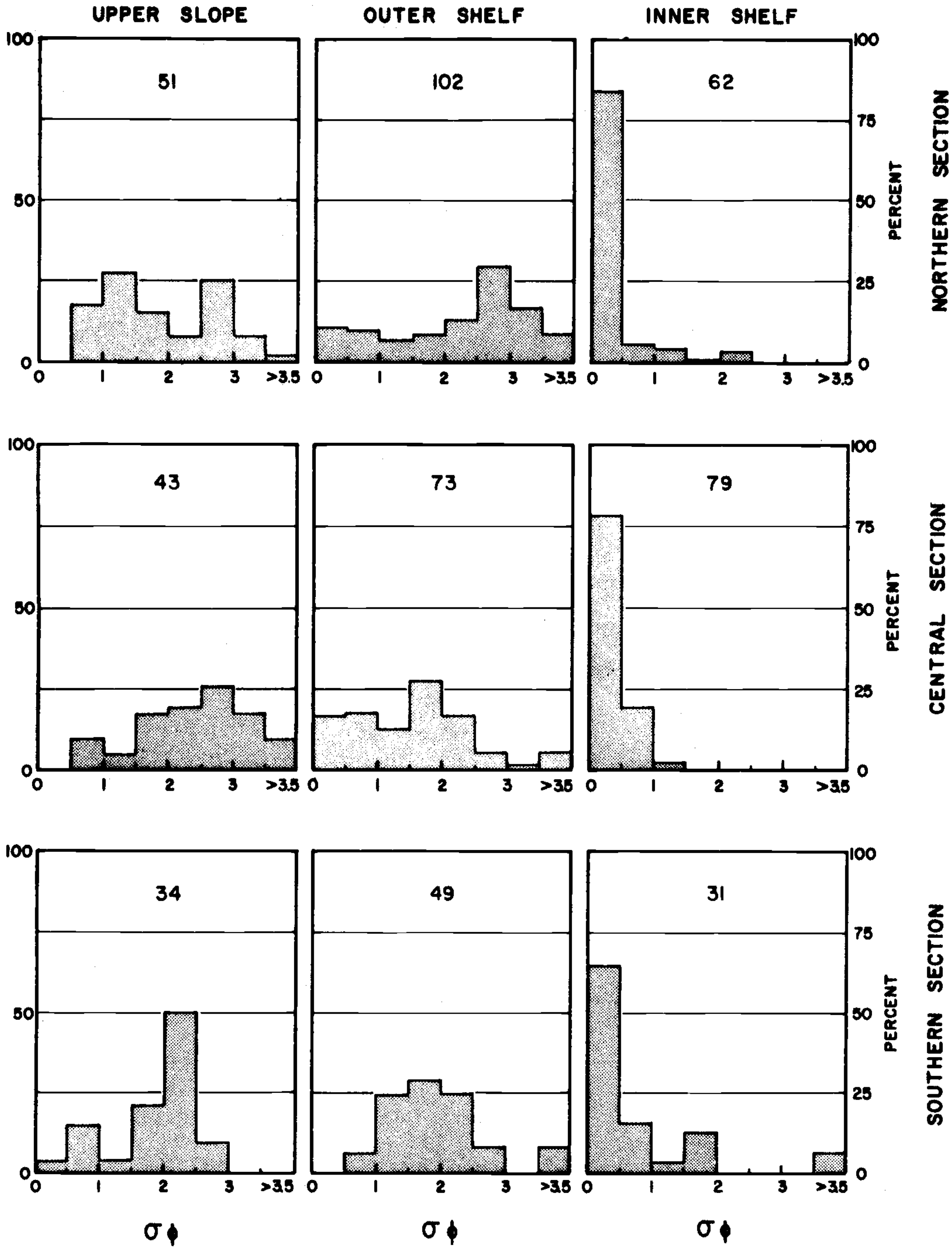

Figure 9. Frequency distributions of phi deviation values. The number above each histogram indicates the number of samples represented.

begins to settle out. Since the transporting fluid is not able to differentiate as easily between the smaller grains as it can the larger ones (Inman, 1949), the silt and clay are not as well sorted as the sand. Therefore the degree of sorting of these shelf sediments decreases with decrease in grain size.

Phi Skewness

$$[\alpha\phi = \frac{M\phi - Md\phi}{\sigma\phi}]$$

Skewness is a measure of the deviation of the mean from the median. When the phi mean diameter is larger than the phi median diameter, the value for skewness is positive. Conversely when the median diameter is larger than the mean diameter, the skewness value is negative.

The sand of the inner shelf is both positively (fine) and negatively (coarse) skewed (Figure 10). The largest modes of skewness values for the inner-shelf sand of the northern and southern sections occur between 0. 00 and +0. 20 (Figure 11). For the inner-shelf sand of the central section, the largest mode is between -0. 10 and -0. 20. Thus the average skewness value for the inner central shelf is negative and the average skewness values for the northern and southern inner-shelf sand are positive (Table 4).

On the outer shelf the fine-grained sediments are almost all positively skewed. Highest positive values occur on the central and

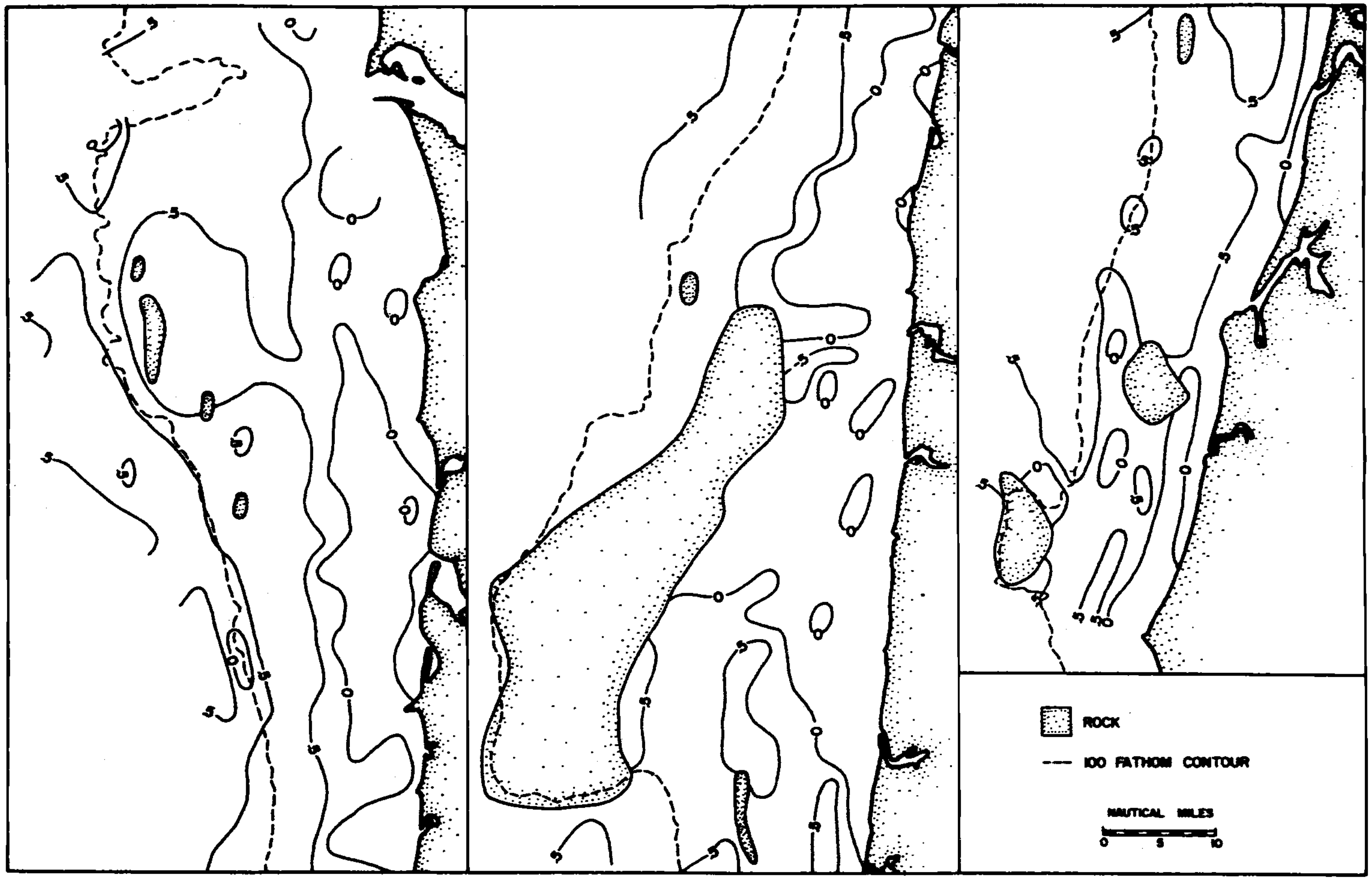

Figure 10. Variations of phi skewness values for the continental shelf and upper continental slope sediments.

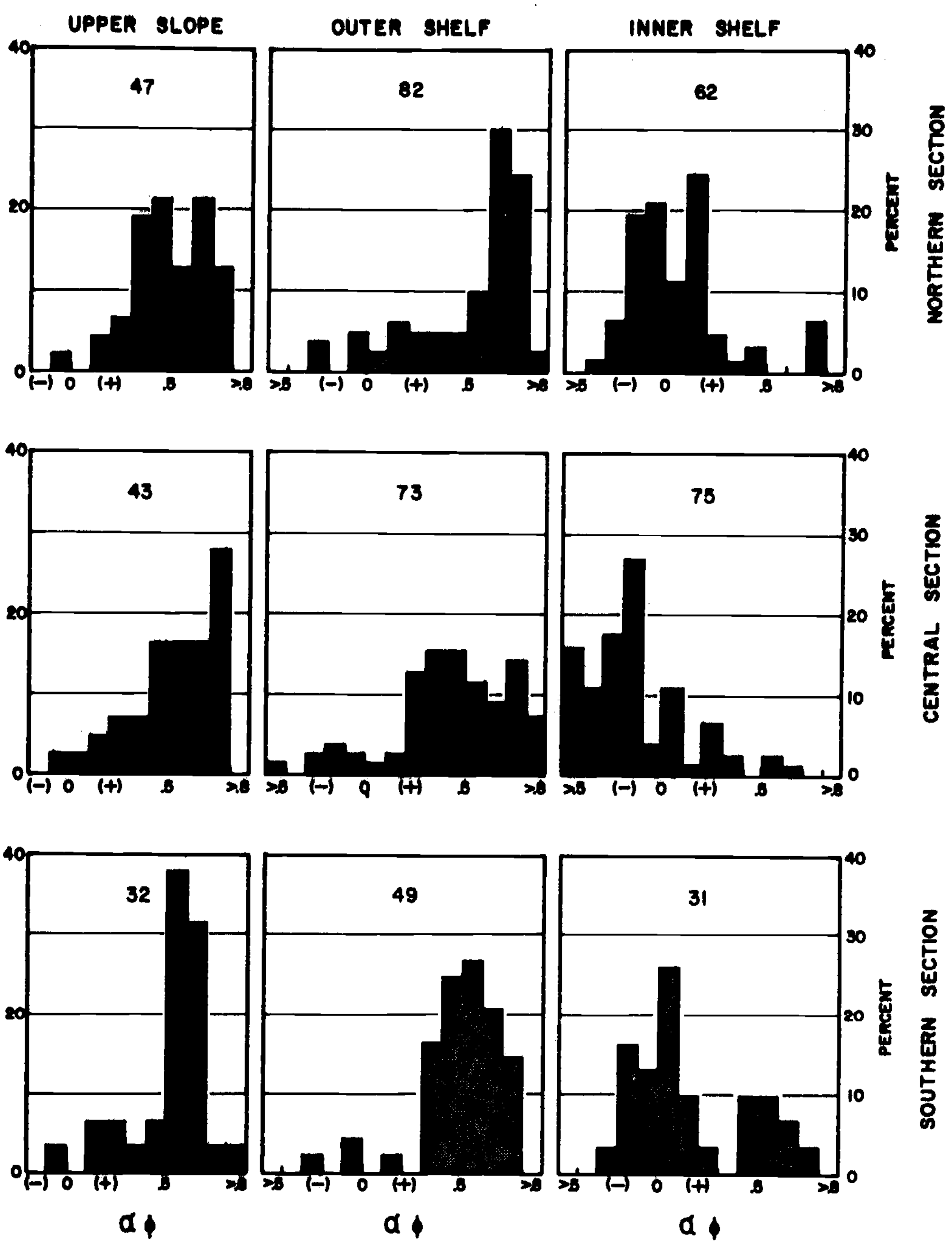

Figure 11. Histograms of phi skewness values. The number above each histogram indicates the number of samples represented.

Table 4. Phi skewness values for the continental shelf and upper continental slope sediments. The number of samples represented is indicated in the parentheses.

	Inner Shelf			Outer Shelf			Upper Slope		
Section	Max	Min	Average	Max	Min	Average	Max	Min	Average
Northern	0.76	-0.31	0.05 (62)	0.81	-0.26	0.50 (92)	0.75	-0.01	0.49 (47)
Central	0.64	-0.74	-0.15 (75)	0.93	-0.41	0.46 (72)	0.79	-0.09	0.51 (41)
Southern	0.71	-0.22	0.16 (31)	0.78	-0.20	0.52 (54)	0.85	0.16	0.53 (32)

outer portions of the outer shelf. The largest modes for the skewness values occur in the +0.40 to +0.80 range (Figure 11). Lower positive values occur in the vicinity of the bank areas and in Heceta Swale. The sediments of the upper slope generally have lower positive skewness values than the outer shelf sediments. With one exception the glauconitic sediments are positively skewed.

Negative skewness may result from an addition of coarse material or from the removal of fine material. In regard to the inner-shelf sands, the latter is thought to be the case. These sands are probably being reworked periodically. This reworking would remove silt and clay which may have been deposited and transport the material farther offshore, or prohibit silt and clay from being deposited. The high positive skewness values of the outer shelf and upper slope are due to the abundance of silt and clay.

Phi Mean Diameter Versus Phi Deviation

Most of the inner-shelf sands have a mean diameter between 2ϕ (.250 mm) and 3ϕ (.125 mm) and a phi deviation of 0.2 to 0.5 (Figure 12). As the mean grain size decreases, the sorting of the sediments becomes progressively poorer. The fine-grained sediments are the poorest sorted. Many of the scattered points represent sediments which are glauconitic or contain rock debris from the bank area.

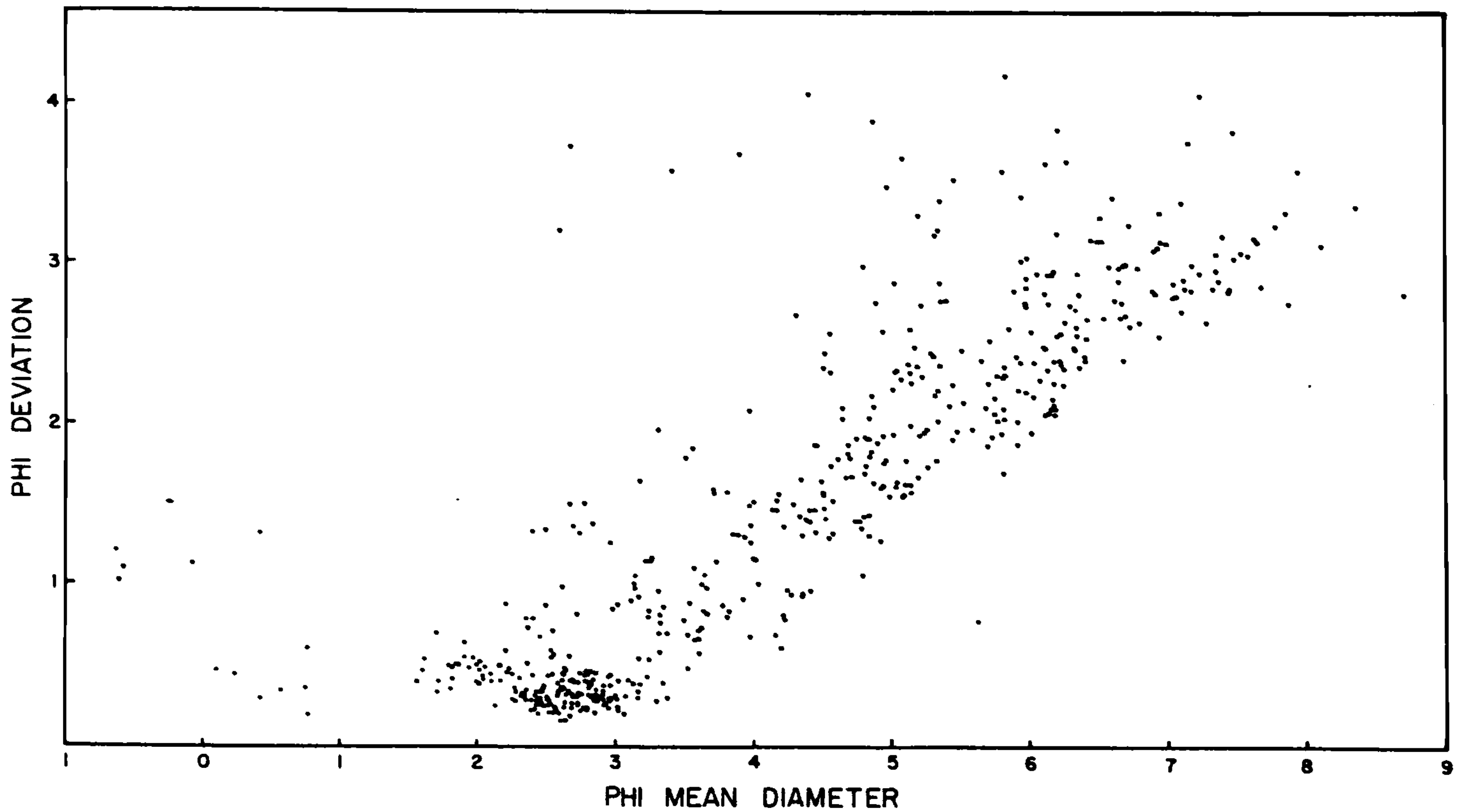

Figure 12. Diagram of phi mean diameter versus phi deviation values. General distribution approximates a straight line. (N = 550)

Phi Mean Diameter Versus Phi Skewness

The sand from the inner shelf is both positively and negatively skewed (Figure 13). Between the mean diameter values of 0ϕ (1 mm) and 5ϕ (.031 mm), skewness values increase as the mean grain size decreases. The maximum skewness appears to be at a mean diameter of approximately 5ϕ (.031 mm). Beyond this point the sediments become less positively skewed until at 8ϕ (.004 mm), the skewness values are about zero.

Phi Deviation Versus Phi Skewness

The best sorted sediments are both positively and negatively skewed (Figure 14). As the phi deviation values increase skewness values increase. Maximum positive skewness values appear to be at a sorting value between 2.0 and 2.2. With larger sorting values the sediments become less positively skewed.

Discussion

Textural parameters reflect the energy conditions in the environment of deposition of the sediments (Passega, 1957; Stewart, 1958; Friedman, 1961). In a low energy environment, sediments are fine grained, poorly sorted, and generally are positively skewed. Sediments in a higher energy environment are coarser grained,

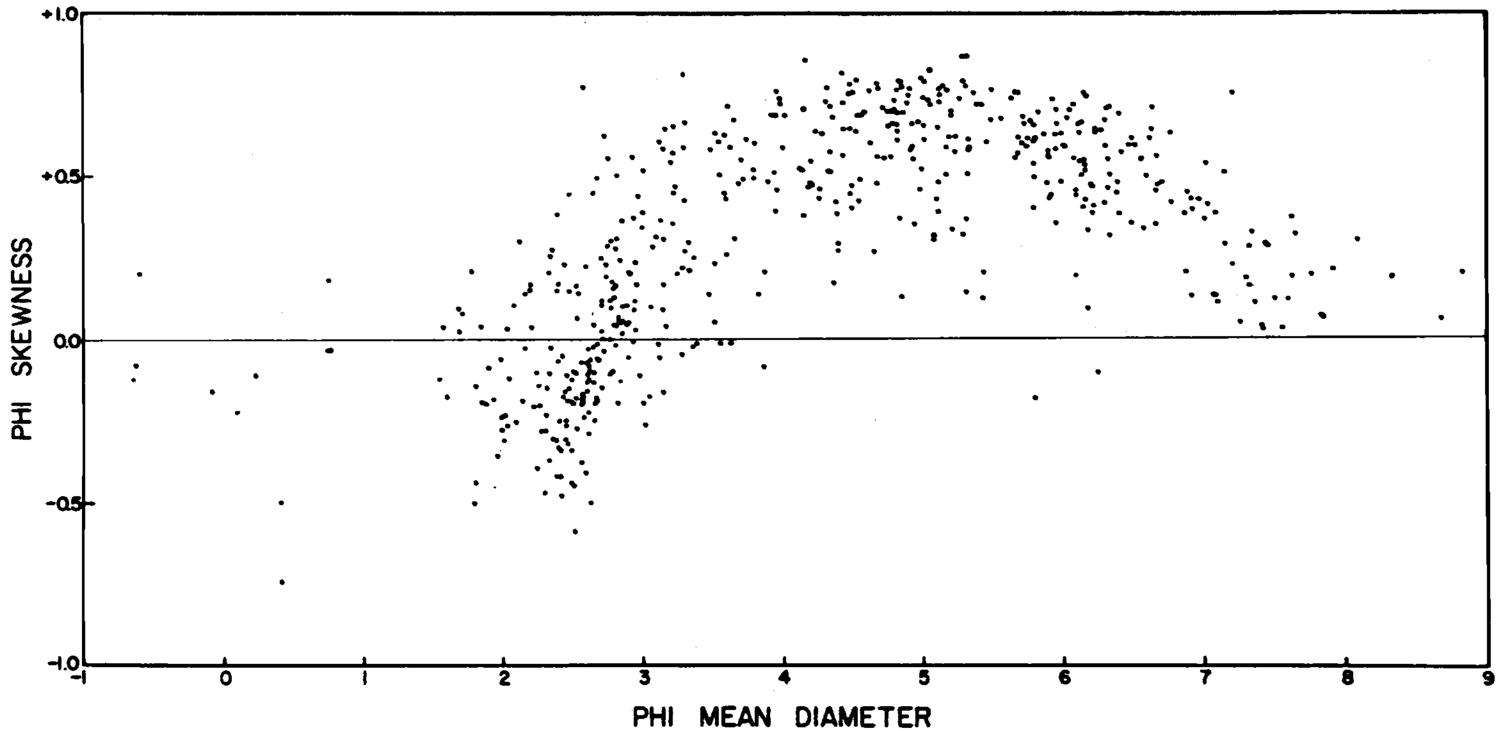

Figure 13. Diagram showing the relationship between phi mean diameter and phi skewness values. General distribution approximates a parabola. (N = 550)

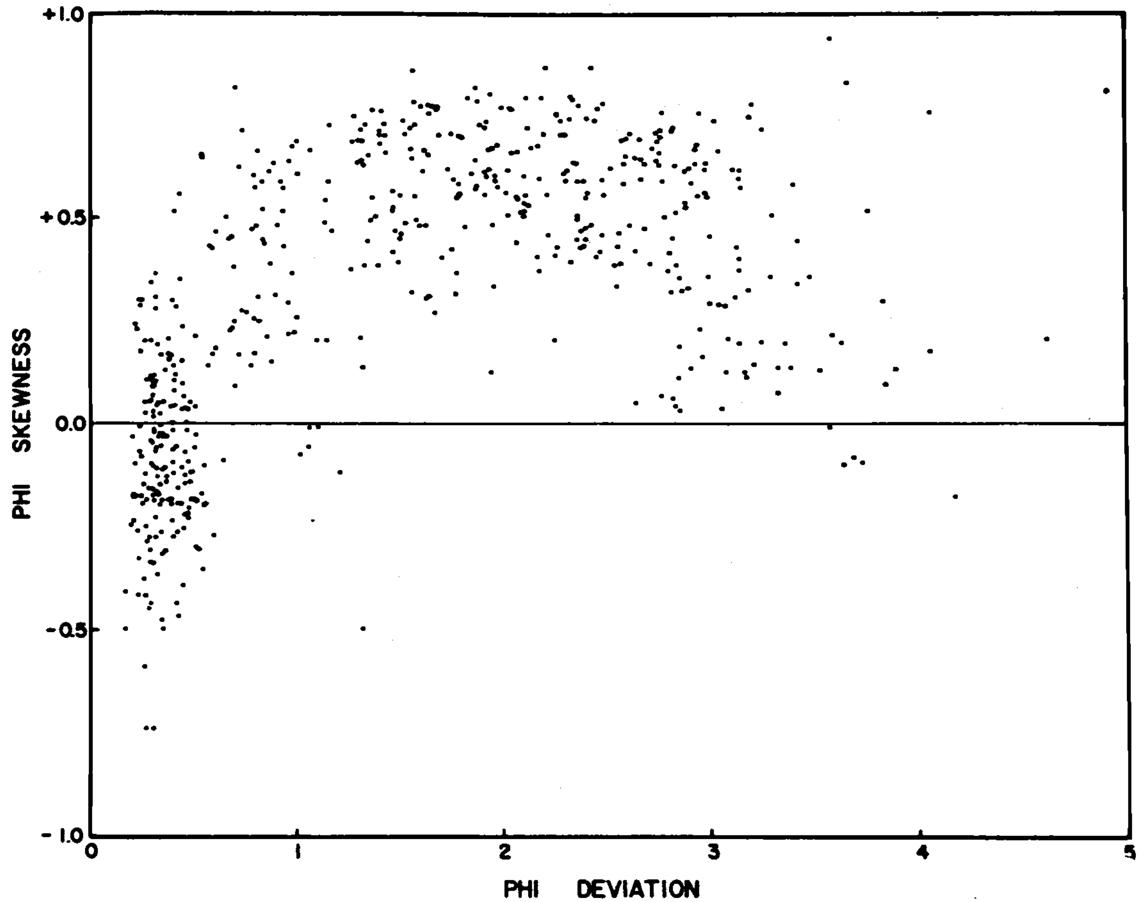

Figure 14. Plot of phi deviation versus phi skewness values. (N = 550)

better sorted, and may be either positively or negatively skewed.

Sorting is poorest in the sediments with the smaller mean diameters due to the presence of more size classes in the silt and clay fractions. This also causes them to be positively skewed (skewed to the fine). Because the fine-grained material is absent in the inner-shelf sand, it generally has negative or low positive skewness values.

The fine-grained sediments with low positive skewness values (Figure 13) are composed predominantly of silt with smaller quantities of sand and clay. In these sediments, sand is less abundant than clay. This small amount of sand-size material adds to the coarse "tail," and causes lower positive values or a tendency toward negative skewness. Because these sediments contain material ranging in size from sand to clay, they also have the poorest sorting.

Sand-Silt-Clay Components

Sediment names were assigned to the samples by using the compositional diagram as proposed by Shepard (1954). Based on the textural terms of the diagram (Figure 15a, b) sand is the dominant sediment type (Table 5). Of the 247 samples classified as sand, 158 samples are 100 percent sand. The second most abundant sediment type is silty sand and together with the sand constitute over 70 percent of the samples. The majority of the sediment samples

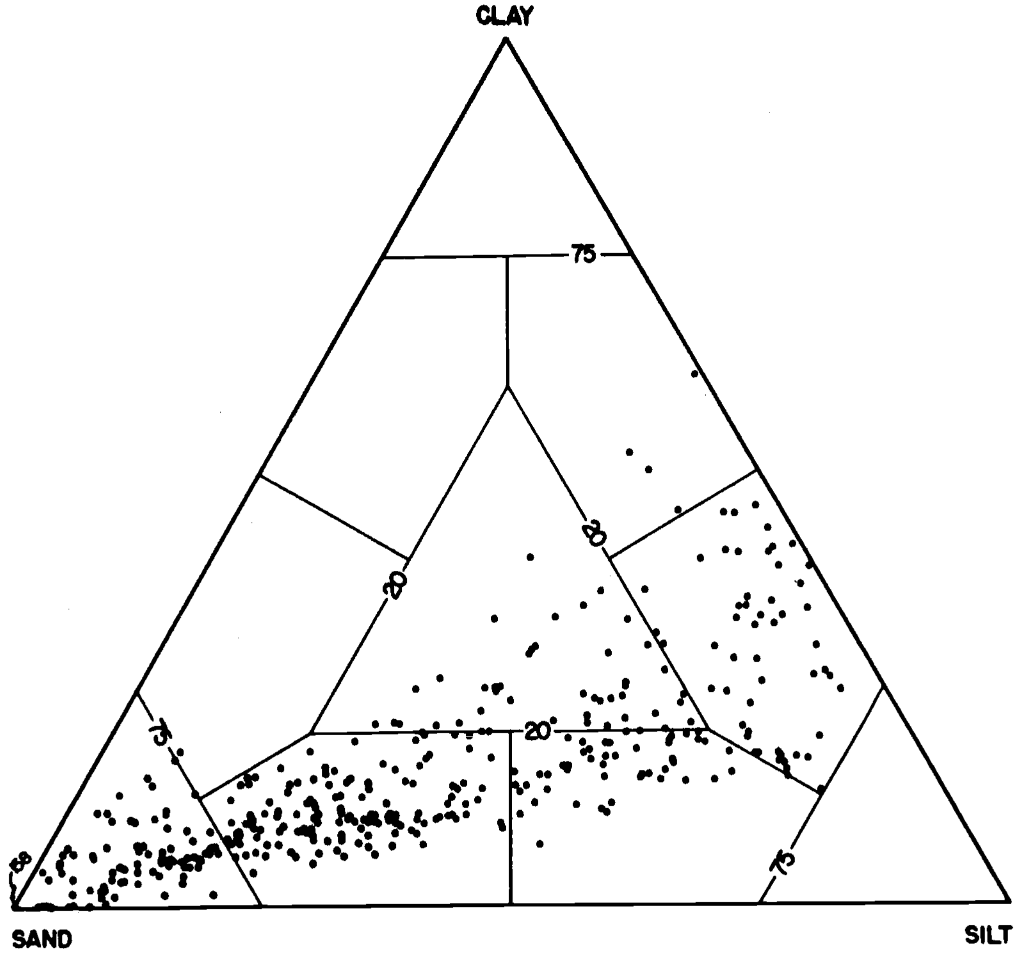

Figure 15a. Triangular diagram showing percentages of sand, silt, and clay in the sediment samples. (N = 550)

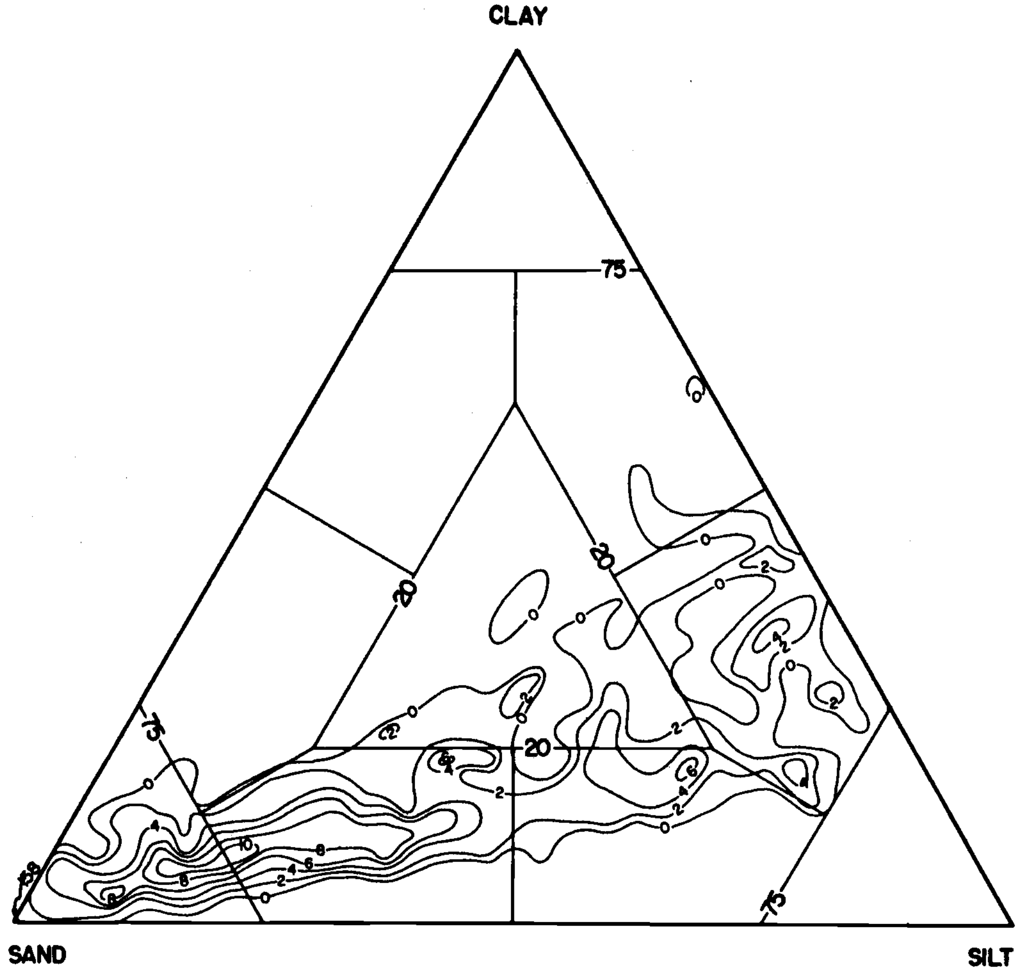

Figure 15b. Triangular diagram showing the percentages of sand, silt, and clay in the sediment samples. The diagram was divided into triangles representing compositional increments of five percent. The values representing the number of samples within each five percent triangle was placed in the center of each triangle and the values contoured. Samples that contained 100 percent sand were not used. (N = 550)

Table 5. General statistics of sediment types (N = 538)

Sediment types	Number of samples	Percentage
Clay	0	0
Sandy clay	0	0
Silty clay	5	0.9
Clayey sand	1	6.2
Sand-silt-clay	42	7.8
Clayey silt	50	9.3
Sand	247	45.9
Silty sand	141	26.2
Sandy silt	52	9.7
Silt	0	0

have a higher content of silt than clay. No samples contained more than 75 percent silt or clay. Many of the sediment samples classified as sand-silt-clay, clayey silt, and silty clay were collected from the lower portion of the upper slope, Heceta Swale, or from the fine-grained sediments to the east of the bank area.

Sand-Silt-Clay Distribution

The patterns of the distribution of the sand, silt, and clay components (Figures 16, 17, 18, respectively) are very similar to the pattern of the median diameter distribution. The inner shelf is covered by sand containing almost no silt or clay. Exceptions to this are the area off the mouth of the Columbia River and portions of the southern section. In these areas silt and clay are found at depths

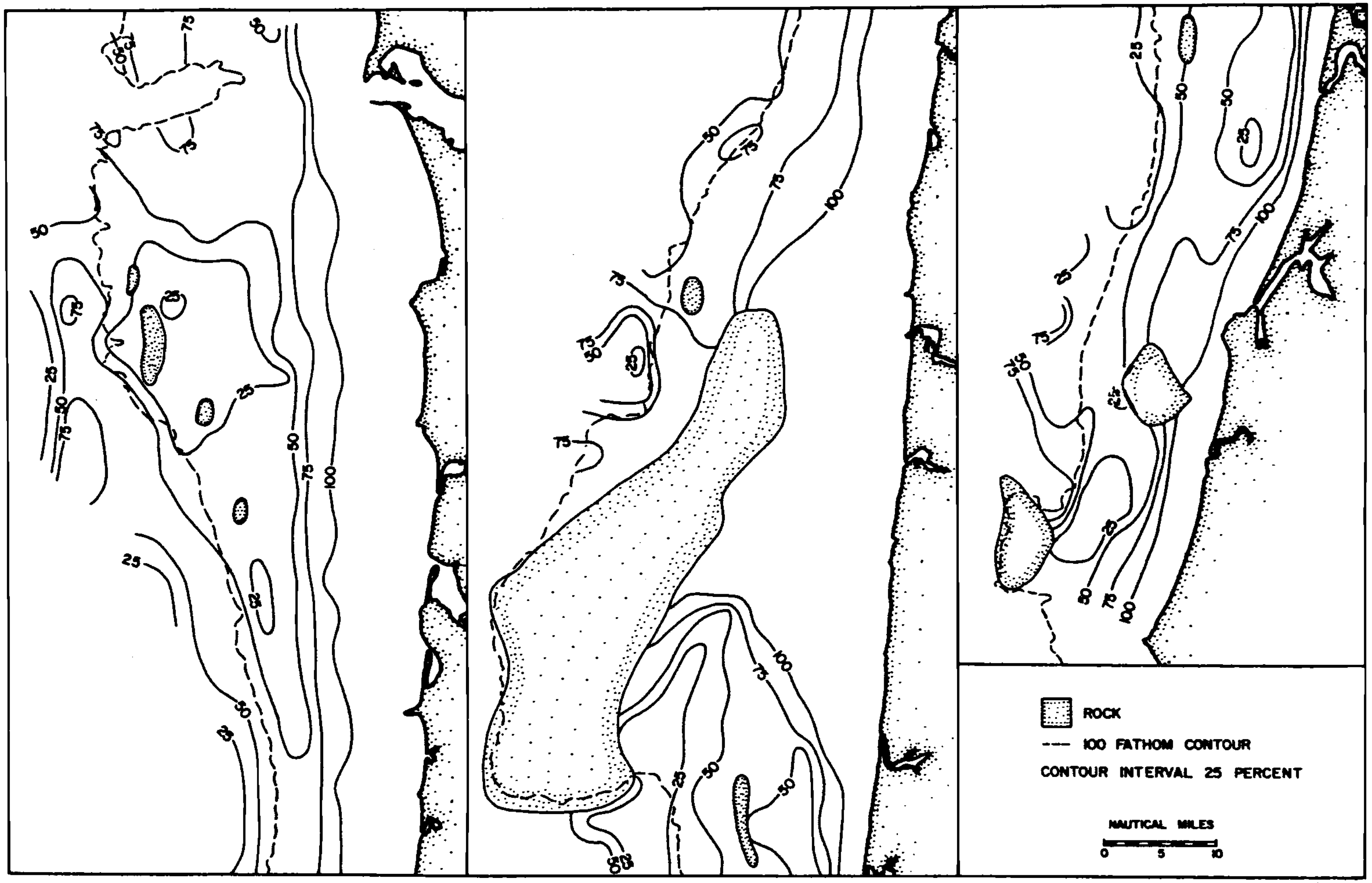

Figure 16. Percentages of sand in the sediments of the continental shelf and upper continental slope.

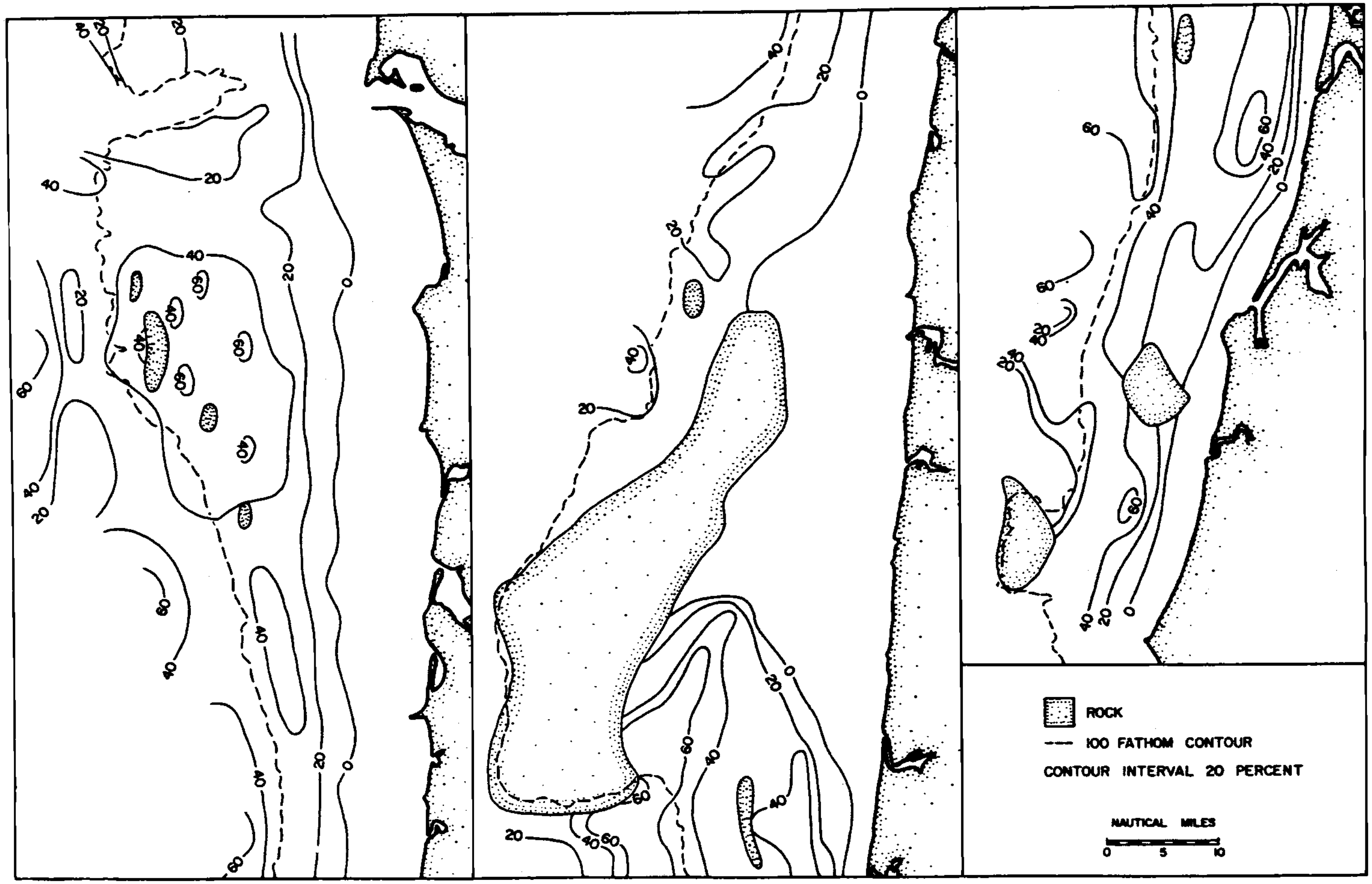

Figure 17. Map showing the amount of silt in the sediments. Note the high percentages of silt east of the bank areas.

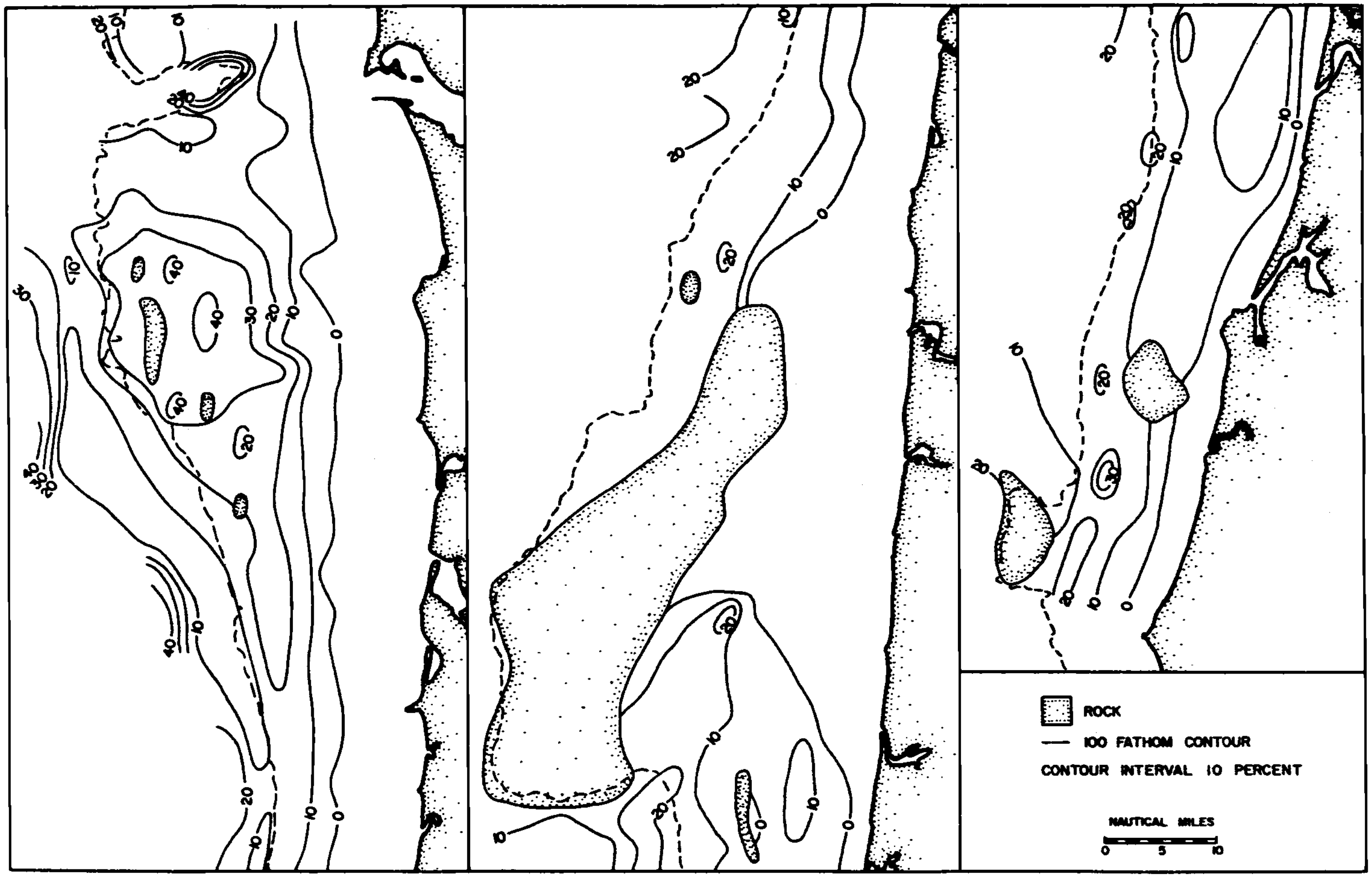

Figure 18. Percentages of clay in the sediment samples.

less than 40 fathoms.

Four areas are apparent on the outer shelf where the sediments have a lower sand content and a higher silt and clay content than other areas of similar depths. These are the areas to the east and southeast of the Nehalem Banks, Heceta Swale, east of Coquille Bank, and off the mouth of the Umpqua River.

Sediments of the upper slope generally contain a greater percentage of silt and clay than sand. Three areas exist on the upper slope where the sediments contain a relatively high percentage of sand—between the latitudes of Tillamook Head and Cape Lookout, immediately south of Heceta Bank, and the area north of Coquille Bank. The coarseness of the sediments in the last two areas is due primarily to authigenic glauconite but the coarseness on the northern upper slope is thought to be due to the presence of relict detrital sands in addition to glauconite.

Summary and Discussion

The texture of the sediments on the Oregon continental shelf are a result of the energy conditions in the environment of deposition of the sediments and also the nature of the material supplied to the area. The general decrease offshore in the size of the sediments reflects a corresponding decrease in energy. Sand of the inner shelf has an average median diameter of 2.53ϕ (.173 mm). Inman (1949) found that fine sand with a median diameter near .18 mm (2.47ϕ) is best sorted. Sediments with a larger or smaller median diameter tend to be less well sorted, with poorer sorting more pronounced in the finer material.

The sand of the inner shelf is relatively well sorted, with the average median diameter (.173 mm) closely approximating the average mean diameter (.168 mm). Most of the sand is free of silt and clay. These sediments are reworked periodically by storm waves and currents, which may remove any silt and clay that may have been deposited or may prevent the finer material from being deposited. Skewness values range from negative to positive. The negative and low positive values are probably due to the removal of the fine-grained material.

Some deposits with a median diameter in the coarse sand and gravel classes were found at depths of 20 to 40 fathoms. The gravel contains pebbles over a centimeter in length. Sundborg (1956) has shown that a current velocity of about 175 cm/sec (~3.5 knots) one meter above the bottom is needed to move material of this size. No velocities of this magnitude have been found at this depth. This material is thought to represent ancient beach or fluviatile deposits formed during lower stands of sea level.

Two areas were found where the characteristic sand of the inner shelf extends only to depths of 30 to 40 fathoms. These areas are off the Columbia and the Umpqua Rivers. In these areas the sediments seaward of the inner-shelf sand contain silt and clay. During periods of high runoff, plumes of sediment-laden river water extend into the ocean. These finer-grained sediments undoubtedly owe their origin to these nearby rivers.

Currents on the outer shelf and upper slope appear to be much weaker than they are on the inner shelf. The median diameters of the sediments fall in the fine sand to fine silt classes. Mean diameters of the sediments are almost always smaller than the median diameters. Thus the sediments are positively skewed. These sediments are less well sorted than the sands of the inner shelf due to the presence of silt and clay. In these sediments silt is more abundant than clay.

COMPOSITION OF THE SAND FRACTION

For the compositional study the sand fraction was divided into two components, the light fraction (sp. gr. < 2.96) and the heavy fraction (sp. gr. > 2.96). The light fraction was also subdivided. Transported sediments usually composed of quartz, feldspar, and rock fragments were grouped together as detrital material. The remaining material is composed of authigenic constituents, primarily glauconite. Biogenous material was not extensively investigated. The following discussion is based on only the sand fraction.

Light Fraction

Detrital Sand

Light components constitute between 79 and 100 percent of the sand fraction. Quartz and feldspar are the most common constituents; rock fragments are much less abundant. Bushnell (1964) used differential staining techniques in his investigation of the sand from a portion of the central section of the shelf. His results showed an average quartz-chert/feldspar-rock fragment ratio of 1.20 for eight samples which indicates that the sand is mineralogically immature. The composition of the inner-shelf sand falls within the normal range of an arkose (Williams, Turner, and Gilbert, 1958).

"Yellow grains" of Twenhofel (1946) occur in many of the inner-shelf sands. They also occur commonly in the beach, dune, and terrace sands along the coast. Twenhofel (1946) and Kulm (1965) studied them and found them to be of varied composition. Kulm (1965) stated that they are, in order of decreasing abundance, grains of feldspar, chert, volcanic rock, and other altered particles. Along the central coast Maloney (1965) noticed a decrease in the size and abundance of the yellow grains offshore to a depth of 50 fathoms. Beyond this depth they were absent. In the northern and southern sections, these grains are present to depths of only 30 to 40 fathoms (Figure 19).

The detrital sand content varies from 100 percent in the inshore samples to about zero percent in areas of high glauconite concentrations. The boundary between the 100 percent detrital sand and the beginning of the occurrence of glauconite is shown in Figure 19. Some inshore samples appear to contain traces of detrital glauconite.

Eleven samples of coarse sand and gravel were obtained from the inner shelf. Two of these samples are composed almost entirely of large pebbles. Sample 159 taken off Tillamook Bay at a depth of 26 fathoms is made up of large rounded basalt pebbles. Sample 599 collected at a depth of 31 fathoms off the mouth of the Coquille River

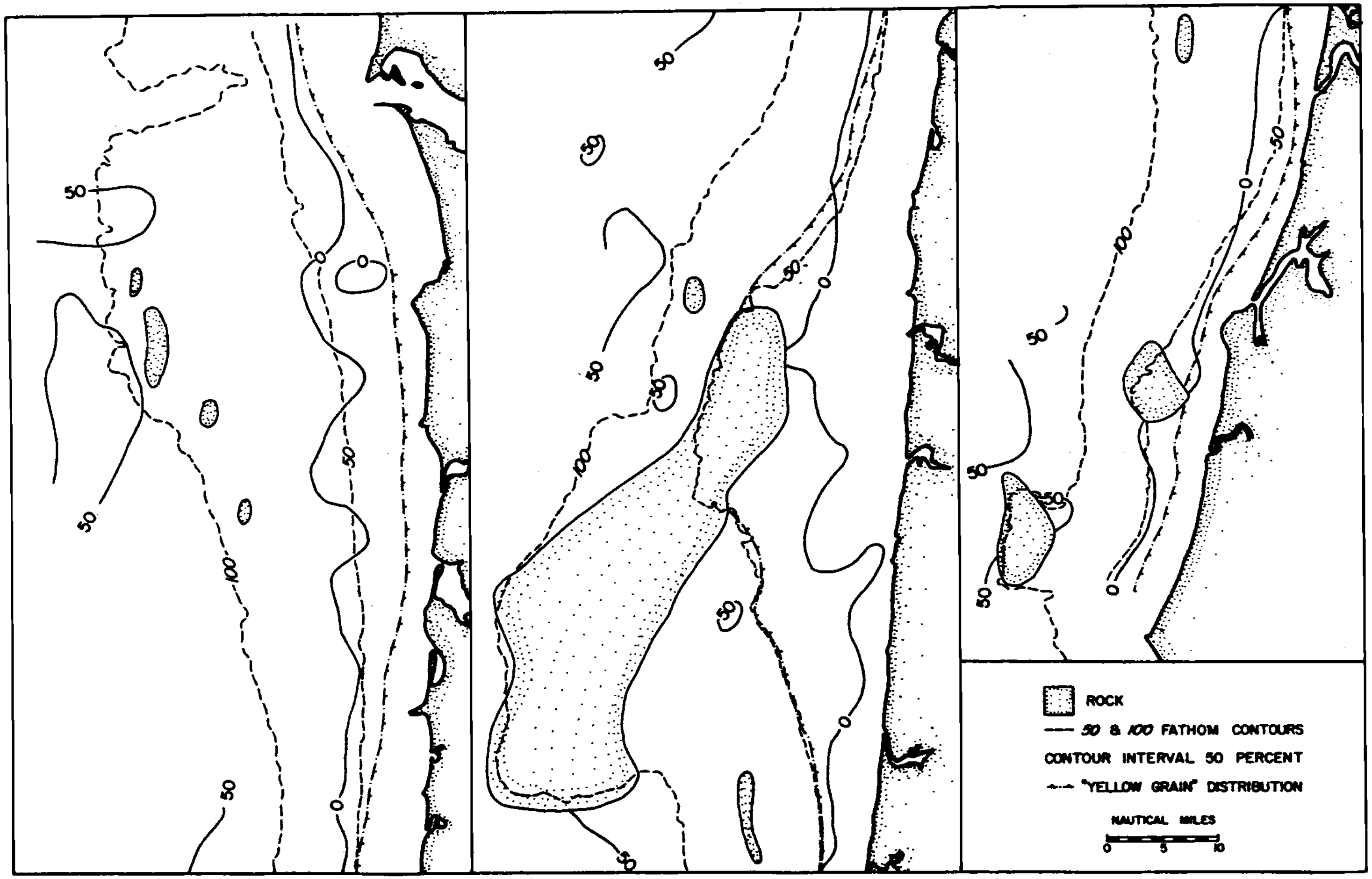

Figure 19. Areas where yellow grains occur on the continental shelf. The distribution of these grains extends from the coastline to the line indicated. Percentages of glauconite in the sediments of the continental shelf and upper continental slope are contoured with a solid line.

includes pebbles of assorted composition. Most of the pebbles are basalt and other volcanics, but one is a quartz pebble five centimeters long. Two other samples (372 and 616) with median diameters in the very coarse sand class also included pebbles up to two centimeters in length. The composition of many of these coarser sands differs from that of the characteristic sand of the inner shelf. Rock fragments are the dominant constituents and the sand generally has a lower percentage of heavy minerals.

Authigenic Sand

Glauconite is the most common authigenic constituent off the Oregon coast. Traces of pyrite, and gypsum were also noted. Glauconite is widely distributed over most of the outer shelf and upper slope. Little is found shallower than 50 fathoms. No estimate of the percentage of glauconite in the silt fraction was made as only the sand fraction was examined. The percentage of glauconite in the sand fraction varies from zero on the inner shelf to about 100 percent in some locations on the upper slope (Appendix 3). Areas where glauconite makes up more than 50 percent of the sand fraction are shown in Figure 19. These areas generally are in greater than 100 fathoms of water, just over the shelf break or on topographic highs.

Bushnell (1964) described two distinct types of glauconite off Yaquina Bay. The first is a "firm type glauconite," dark green to nearly black in color, with well developed radial cracks and mammillated surfaces. Some of the smaller grains are spherical or ovoid with smooth, hard surfaces. The second is a "spongy type glauconite," pale green to yellow-green. It is generally smaller and softer than the former, and radial cracks are less common. These types of glauconite occur in the rest of the outer shelf and upper slope off Oregon.

Glauconite is present in other forms. In the vicinity of the Nehalem Banks, siltstone fragments appeared to have been altered to glauconite. Also, some glauconite has formed in foraminiferal cavities. A few grains were found which had a layered appearance. These grains may have formed from the alteration of biotite (Galliher, 1935).

Several authigenic minerals were noted in very minor quantities. Pyrite occurs in two forms—as internal molds in foraminiferal tests, and as clusters of minute crystals in some of the stiff gray clay in the bottom of the gravity cores. A few selenite crystals were found in the sediments around the Nehalem Banks and may represent residual material which was derived from the banks.

Biogenous Sand

As a general rule the percentage of biogenous material present is inversely proportional to the percentage of detrital sand present. Biogenous material is almost entirely absent in the inner shelf with the exception of a small percentage of foraminifera. In the finer sediments on the outer shelf, planktonic and benthonic plant and animal remains are more abundant. The highest concentrations of biogenous material noted were in Heceta Swale and in the fine-grained sediments east of Nehalem Bank and on the upper slope. Maloney (1965) stated that the biogenous material in the sand fraction in Heceta Swale ranged from 2 to 32 percent. Sponge spicules and diatoms are the most abundant biological components. Radiolarians comprised only a small percentage of the sand fraction.

Heavy Minerals

A study was made of the heavy minerals present, and their abundance and distribution. Separations were made from the total sand sample. A total of 44 samples were examined. Forty one minerals species and varieties were noted. Less than half of these minerals occur frequently; the remainder are present in only minor quantities or as trace minerals (Appendix 5).

The heavy mineral assemblages are dominated by the amphibole and pyroxene groups and the opaque-garnet assemblage. Magnetite and ilmenite are the most abundant opaque minerals. Severe alteration of some of the more unstable mineral grains is common and presented a serious problem in identification. Percentages of weathered grains vary from 9. 6 to 43. 0 percent of the heavy mineral fractions and in general, increase offshore.

The percentage of heavy minerals varies from a maximum of 21 percent north of the mouth of the Columbia River to zero in an area of high glauconite concentration south of Heceta Bank (Figure 20) (Appendix 4). The average percentage of heavy minerals for 44 samples is 4. 18 percent. Many of the grains from the inshore samples are well rounded, with roundness decreasing offshore. General distribution of heavy minerals is shown in Figure 21.

Amphibole Group

The amphiboles are most abundant in the fine-grained sediments, with hornblende the dominant species (Figure 22). There is a general increase in the percentage of amphiboles offshore. Off Cape Kiwanda the amphiboles increase from less than 10 percent in the inshore sand to about 35 percent on the upper slope. The highest percentage of amphiboles in the inshore sand occurs off Tillamook Head, about 19 percent. The amphiboles are more abundant on the

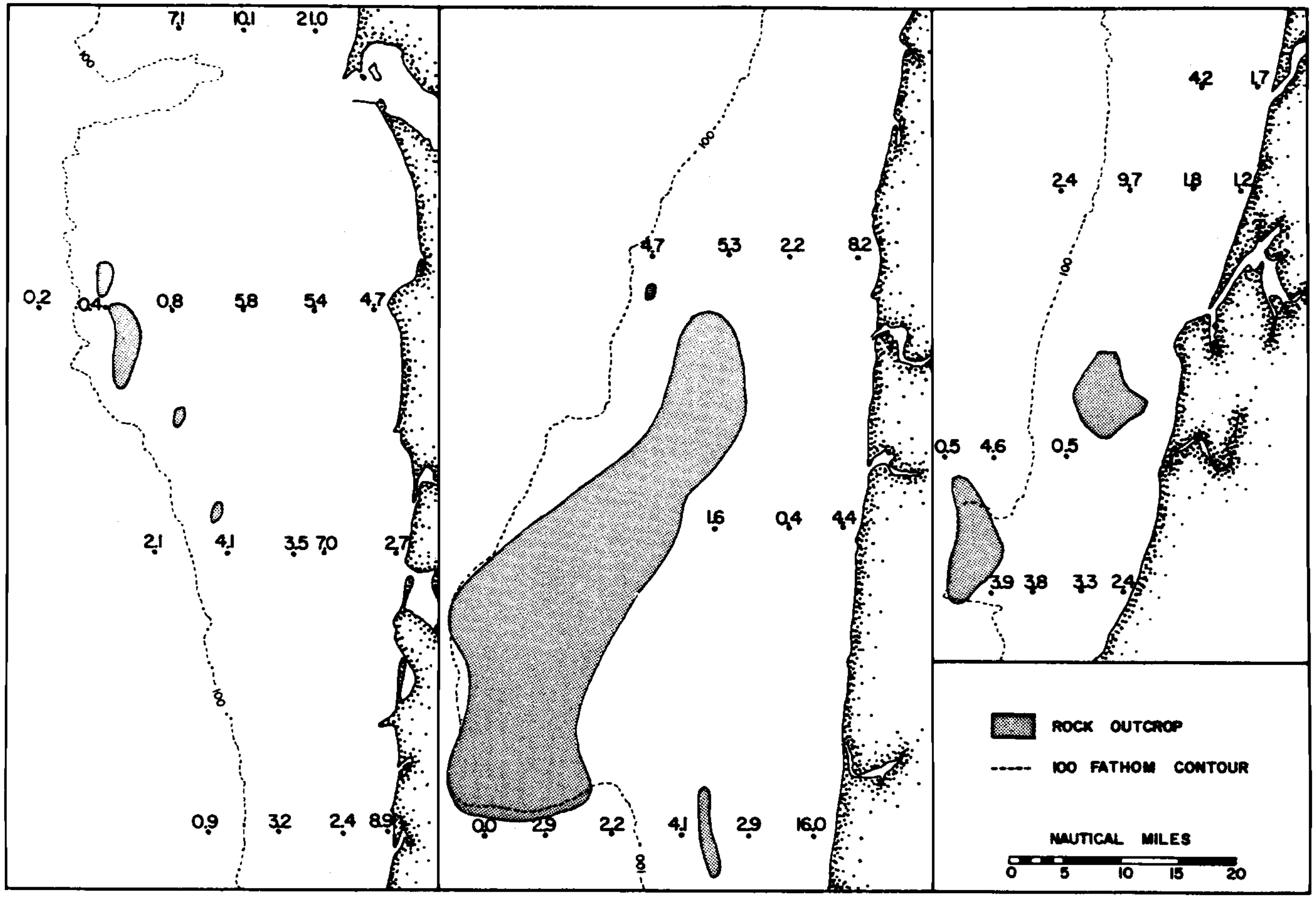

Figure 20. Map showing the percentages of heavy minerals for the samples used for heavy mineral analysis.

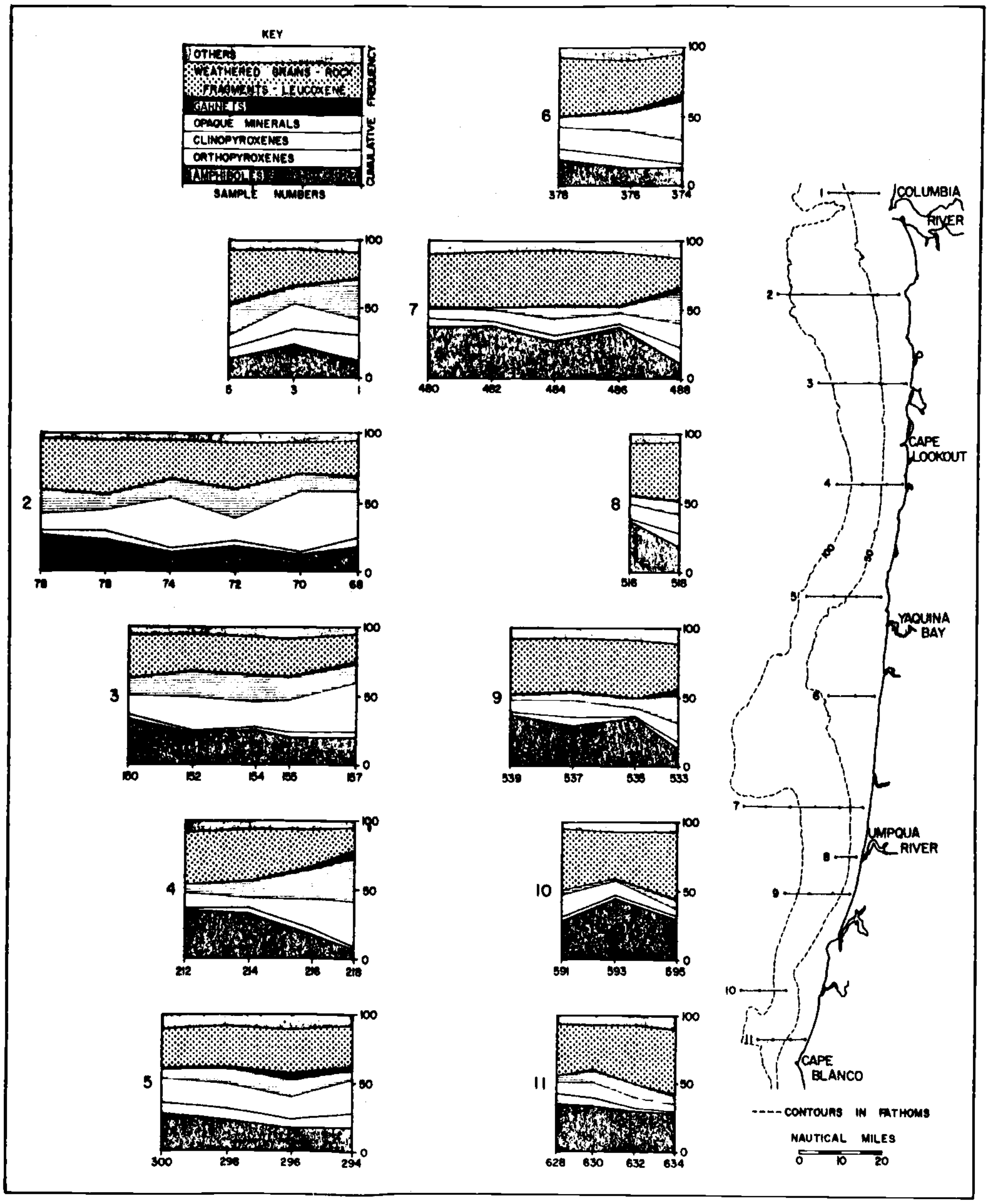

Figure 21. Distribution of dominant mineral assemblages on the continental shelf and upper continental slope. The index map at the right shows the locations of the samples used for heavy mineral analysis.

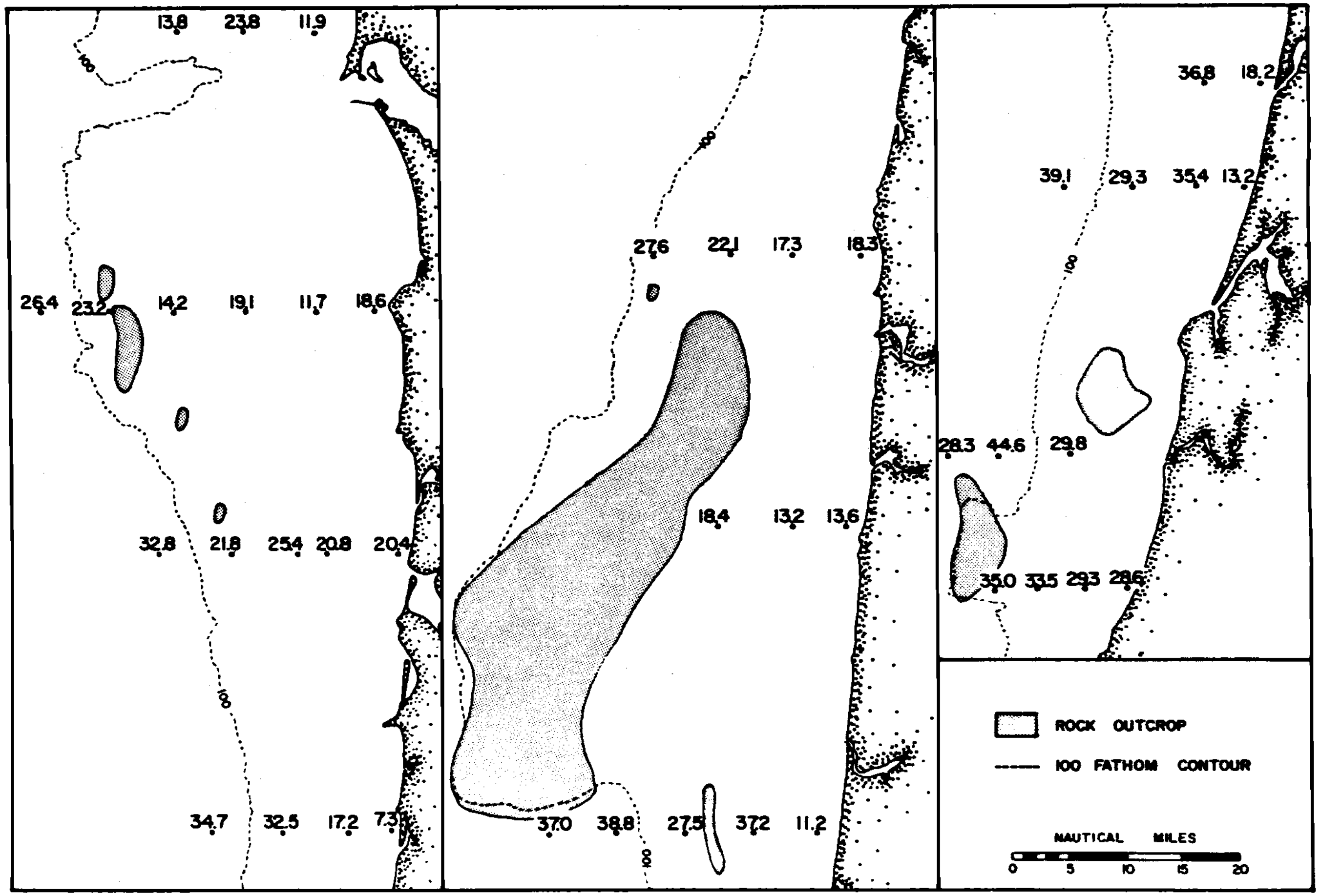

Figure 22. Distribution of the percentages of the amphibole group.

southern shelf than on the northern or central shelf. In the vicinity of the mouth of the Umpqua River the deposit of silty material contains a markedly higher percentage of amphiboles than do the surrounding sediments.

Of special interest is the distribution of the mineral glaucophane. Although usually present in only trace amounts, it was identified in 84 percent of the samples south of the Siuslaw River but in only 28 percent of the samples on the remainder of the shelf and upper slope. It appears that the main source of the amphiboles, especially glaucophane, is to the south.

Pyroxene Group

Pyroxenes are most abundant in the coarser-grained sediments inshore, and decrease offshore (Figure 23). Two exceptions occur in the central and southern sections. Off Cape Perpetua and Cape Blanco, the percentages of pyroxenes increase offshore. Compared with the northern shelf, the pyroxenes are much less prominent on the central and southern portions of the shelf.

Hypersthene is the most common orthopyroxene. The largest percentage occurs in sample one, just north of the mouth of the Columbia River, 18.4 percent. The grains are usually euhedral and commonly contain magnetite inclusions. Some of the grains still have rims of volcanic material, which indicates that they have

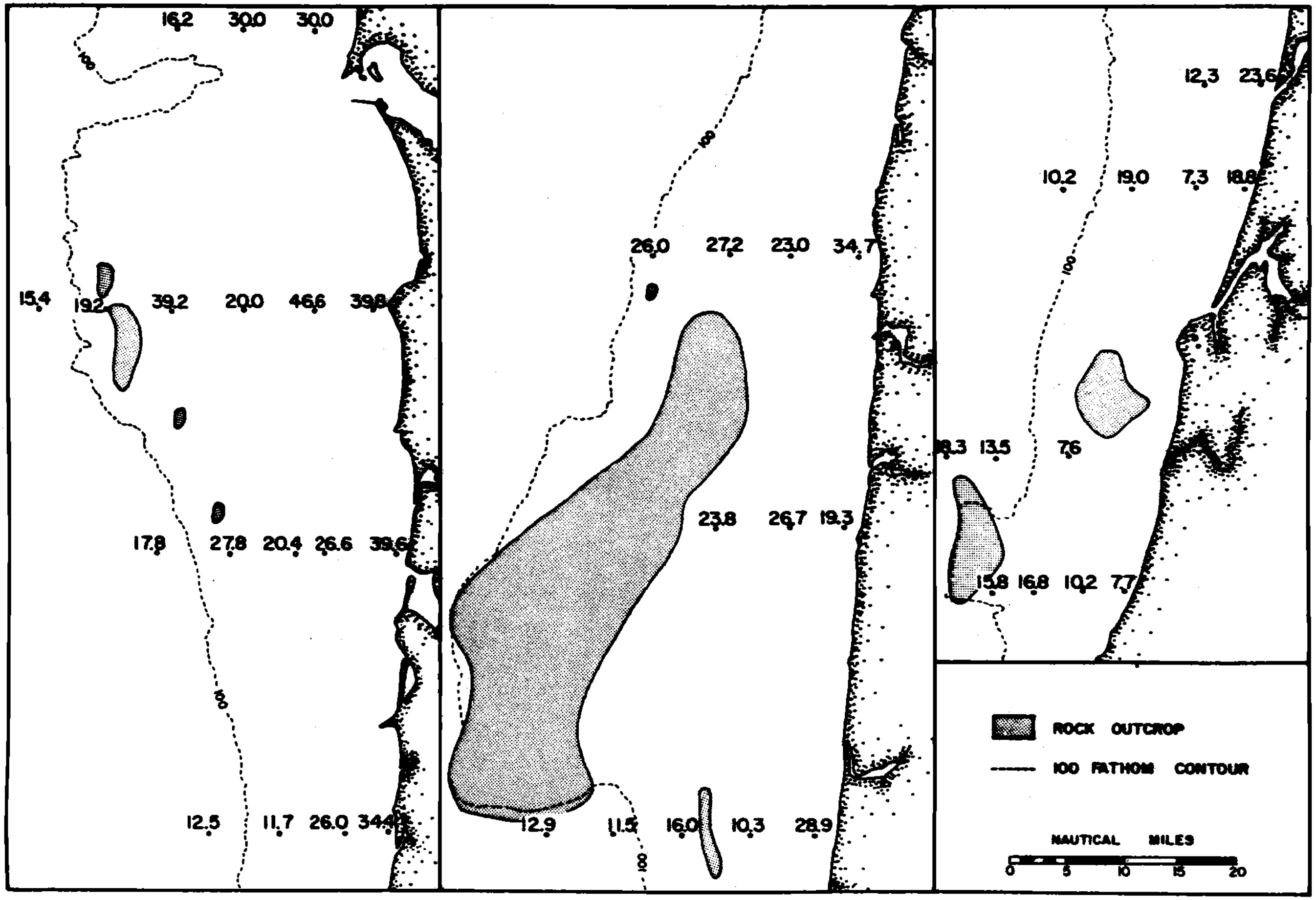

Figure 23. Map showing the distribution of the percentages of the pyroxene group.

undergone little abrasion. A few grains of hypersthene were observed in which the terminal ends of the crystals had been severely etched. These were probably locally derived from the terrace deposits.

Augite is the dominant clinopyroxene. It is most prevalent on the northern shelf where it reaches concentrations up to about 35 percent. Titan-augite and diopside also occur, but in much smaller percentages. The clinopyroxenes have probably been derived from the rocks of the Coast Range and the Columbia River drainage system.

The relationship between the amphiboles and pyroxenes was determined by computing their ratio (Figure 24). It is readily apparent that the pyroxenes are more abundant inshore and on the northern and central shelf, and that the amphiboles are more abundant offshore and on the southern shelf. The highest amphibole/pyroxene ratios occur in the silty sediment off the mouth of the Umpqua River.

Opaque-Garnet Association

The distributional patterns of the opaque minerals and the garnets are essentially the same, although the garnets occur in much smaller percentages. Because their distribution is similar, only the distribution of the opaque minerals is shown (Figure 25).

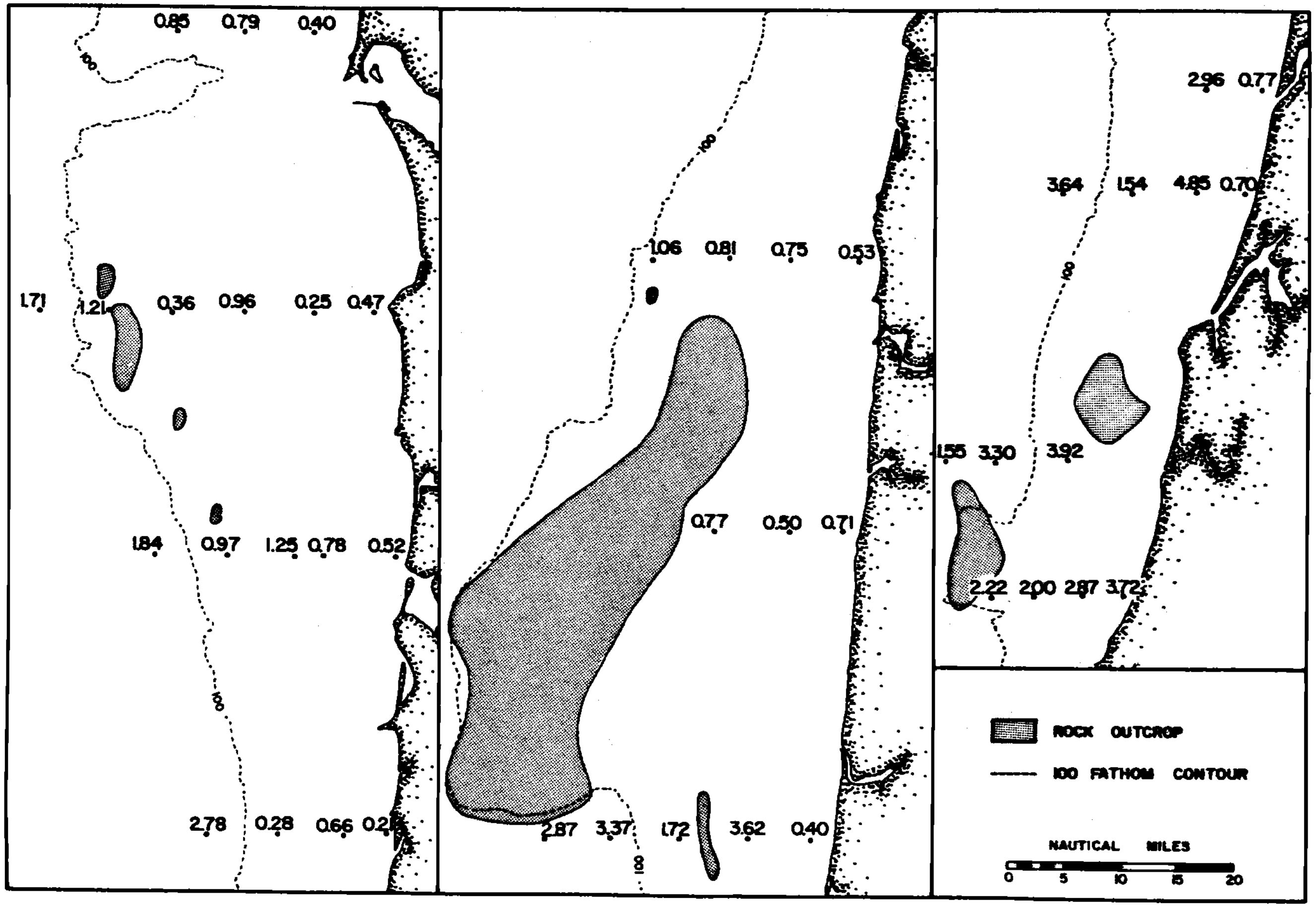

Figure 24. Amphibole/pyroxene ratios for the samples used for heavy mineral analysis.

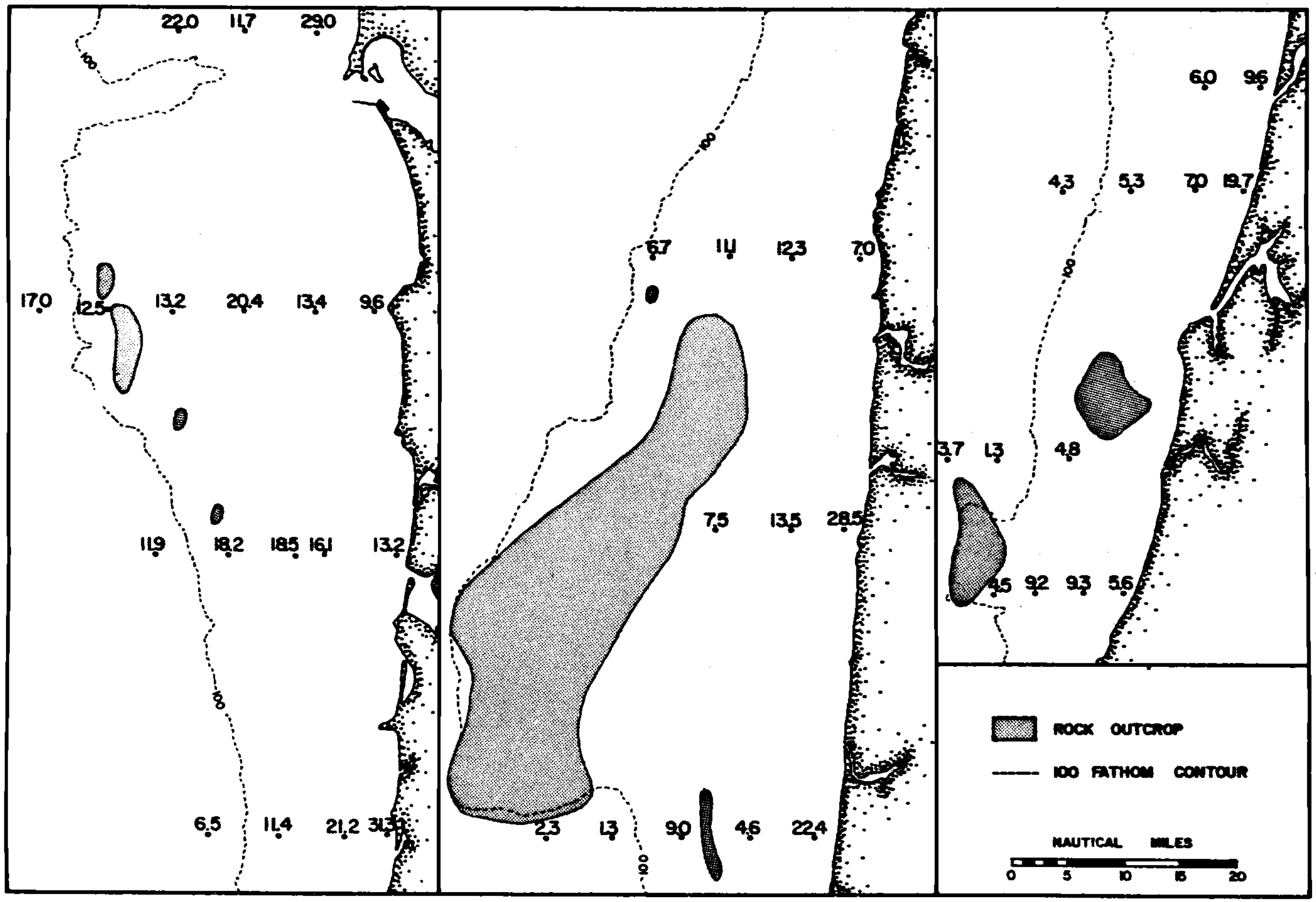

Figure 25. Distribution of the percentages of opaque minerals.

Magnetite and ilmenite are the main opaque minerals.

Highest concentrations of opaque minerals and garnets occur inshore and exhibit a marked decrease offshore. There are two areas of high concentrations: highest percentages occur in sample 218 off Cape Kiwanda--garnet 5.4 percent, opaque minerals 31.3 percent; the second area is adjacent to the coast and extends from about Alsea Bay to Cape Arago, interrupted only off the mouth of the Umpqua River. In this area percentages of garnets and opaque minerals range from 3.2 to 4.7 and 19.7 to 28.5 percent, respectively.

Summary and Discussion

Light constituents make up 79 to 100 percent of the sand fraction. Quartz and feldspar are more abundant than rock fragments with the exception of the coarse sand from the inner shelf where rock fragments may constitute up to 75 percent of the sample. The composition of the clean, inner-shelf sand falls well within the range of an arkose (Williams, Turner, and Gilbert, 1958).

Glauconite is the main authigenic constituent. Its distribution is confined mostly to the outer shelf and upper slope, where it may comprise up to 100 percent of the sand fraction. The highest accumulations are on the upper slopes, just over the shelf break and on topographic highs. Traces of pyrite and gypsum were also found.

Percentages of heavy minerals vary from about 0 to 21 percent, with an average of 4.18 percent for 44 samples. Heavy mineral assemblages are dominated by the amphibole and pyroxene groups and the opaque-garnet association. The percentage of amphiboles increases offshore; amphiboles are most abundant in the finer-grained sediments of the outer shelf and upper slope. Pyroxenes decrease offshore and are most abundant in the coarser sediments of the inner shelf.

The occurrence of garnets is closely associated with the opaque minerals and their distribution is essentially the same. Highest concentrations of opaque minerals and garnets occur only in the inshore samples along the coast, and decrease markedly offshore.

The relative distribution of the amphiboles and pyroxenes is thought to be due to selective sorting. Rittenhouse (1943) has shown that some heavy minerals are differentially sorted due to variations in their specific gravity, even though the material may be the same size. Amphiboles have about the same or slightly lower specific gravity than the pyroxenes (Berry and Mason, 1959). Therefore the lighter and finer-grained amphiboles would be transported into deeper water more easily than the coarser and heavier pyroxenes.

Differential weathering may, to a lesser extent, also affect the distribution. Goldich (1938) and Dryden and Dryden (1946) have shown that pyroxenes are weathered at a faster rate than the amphiboles. It may be that much of the finer-grained pyroxenes which could have been carried offshore have been destroyed.

SEDIMENT CORES

Ten short gravity cores were collected in the northern section, one on the inner shelf, three on the outer shelf, and six on the upper slope. Logs and descriptions of individual cores are presented in Appendix 6. The shallowest core was from seven miles off Tillamook Head at a depth of 47 fathoms (Sample 70). The core consisted of 3. 8 cm of fine sand underlain by 8. 6 cm of silty sand.

Of the three cores from the outer shelf, one was obtained at a depth of 66 fathoms (Sample 87). It consisted of brown silty sand. Total core length was 28 cm. The remaining two cores were taken in the silty area east of the Nehalem Banks at depths of 78 and 88 fathoms (Samples 86 and 99, respectively). They were composed of brownish-gray clayey silt with scattered shell fragments at a depth of 23 to 25. 5 cm. The lengths of these cores were about 30 cm.

Five of the cores on the upper slope were collected west and southwest of Nehalem Bank (Table 6). The top 8 to 18 cm were dark brownish-gray to black glauconitic sand. This sand was underlain by stiff gray clayey silt which contained abundant foraminifera and some pyrite. There appears to be an erosional surface between the sand and the underlying silt. Maloney (1965) described similar stiff gray clayey silt from several cores taken west of Stonewall Bank at a depth of 600 fathoms.

The remaining core (Sample 103) collected from a depth of 306 fathoms consisted of 12 cm of grayish-brown glauconitic clayey silt. No stiff gray clayey silt was found. It may be that the corer did not penetrate deep enough to encounter it.

Table 6. Water depths and lengths of five cores from the upper slope.

Sample number	Water depth (fathoms)	Length of cores (centimeters)
82	98	22.3
102	144	41.5
104	213	29.0
105	139	27.0
106	104	28.4

These cores indicate that the Holocene sediment cover is much thinner on the upper slope than on the continental shelf in this area, as this stiff gray clayey silt has not been encountered in cores of similar length from the shelf. Also, examination of Precision Depth Records shows secondary reflections in the area east of the Nehalem Banks. Based on the velocity of sound in sea water (4800 ft/sec), there appears to be at least 20 feet of sediments above the second layer. East and west of this area, this layer pinches out. Therefore the sediments are thickest in the central portion of the shelf and become progressively thinner shoreward and seaward.

ORIGIN OF THE SEDIMENT PATTERN

The origin of the sediment pattern on the continental shelf must be explained in terms of the physical and chemical processes operating in the ocean. The sediments of the shelf may be divided into two groups: (1) relict sediments which were deposited on the shelf during lower sea level, and (2) modern sediments which have been deposited since sea level reached its present level, about 3000 (Gould and McFarlan, 1959) to 5000 years ago (Fisk, 1959).

Two main sources of sediments are available, the rivers and the coastal deposits. Several large rivers as well as numerous small rivers and streams supply sediments to the shelf. Sediment transport in the estuaries of two of these rivers has been studied. Kulm (1965), in a comprehensive study of the hydrography and sedimentation of Yaquina Bay, found that most of the sand-size material derived from within the drainage system was being trapped in the estuary. Similar conditions were found to exist in the Columbia River estuary (Lockett, 1963). This indicates that the estuaries are undergoing a process of filling and much of the coarser fluviatile material never reaches the shelf. The numerous small streams and rivers of the Coast Range without estuaries probably supply small amounts of sand during periods of high runoff.

The sediment pattern on the shelf off the major rivers suggests that some sediments from the rivers are deposited. Relatively high percentages of sand are found off the mouth of the Columbia River at depths greater than 50 fathoms and extend to the outer edge of the shelf (Figure 16). The silt and clay at depths of 30 to 40 fathoms off the Columbia and Umpqua Rivers may be the result of deposition of fine-grained sediments at a faster rate than the oceanic processes are capable of transporting them into deeper water.

The heavy mineral distribution off the mouth of the Columbia River also suggests that some sand-size material is deposited. Sample one contains 18 percent hypersthene, a much higher percentage than any other sample. Some of these hypersthene grains are euhedral and still contain rims of volcanic glass. These rims are indicative of sediments that have not undergone much abrasion. Samples from the Columbia River have also been found to contain euhedral hypersthene crystals with rims of volcanic glass.

The sand in the fine-grained material in 50 to 60 fathoms of water off the mouth of the Umpqua River has a markedly higher amphibole to pyroxene ratio than the surrounding sediments (Figure 17). This rather isolated deposit is thought to be material from the Umpqua River that has been deposited below the depth at which the finer-grained sediments are reworked. Although the rivers may not be contributing large quantities of sand to the shelf, they appear to be contributing silt and clay.

The second main source of sediments is the terrace deposits. In places these deposits of beach and dune sand reach a thickness of 80 to 90 feet (Baldwin, 1964). North (1964) has shown that direct loss of land to the sea by landslides occurs along 47 percent of the northern 150 miles of Oregon coast. * Rates of erosion of 20 feet per year of marine terrace sand overlying sandstone and clay (Cape Meares) and 6.5 feet per year of marine terrace sand overlying mudstone and sandy shales (Yaquina Bay) were estimated.

Byrne (1963) estimated rates of erosion along the northern Oregon coast based on comparisons of charts and photographs. He found that the rates of erosion ranged from 2 feet per year for sedimentary rocks overlain by terrace deposits to 53 feet per year for unconsolidated sands and gravels. If the assumption is made that the average height of the sea cliffs along the Oregon coast is 20 feet and using the erosion rate of 2 feet per year, 40 cubic feet of material per foot of coastline with sea cliffs is added to the shelf each year. It is estimated that about 100 miles of the coast in the area studied is undergoing active erosion. This suggests that over 21,000,000 cubic feet (.00013 cubic miles) of material is added to the continental shelf each year. Hickson (1960) estimated that the Columbia River discharges approximately 310,000,000 cubic feet

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* Only the northern 150 miles of coastline was studied.

(. 002 cubic miles) of sediment annually, over 14 times the estimated amount of sediment that may be contributed by coastal erosion.

Maloney (1965) states that the abundance and size of the "yellow grains" decrease offshore. These grains are distinctive of the modern beach and terrace deposits. The presence of these grains on the shelf implies that material from the terraces has been transported offshore. The distribution of the opaque-garnet association also supports this conclusion. Some of the terrace sand contains abundant garnets and opaque minerals (Kulm, 1965). High percentages of these minerals occur in the inshore samples along the central and southern coast where the terraces are most prominant. It is thought that these minerals have been derived from the terrace sands.

Evidence suggests that much of the inner-shelf sand is probably a relict transgressive sheet sand deposited during the last rise of sea level. This conclusion has also been reached by other investigators who have studied sediments from continental shelves (Emery, 1952; Curray, 1960; Moore and Curray, 1964; van Andel, 1964). Most of the deposition of the modern sand on the Oregon continental shelf has been confined to the inner portions of the inner shelf.

If large quantities of sediments are being deposited on the shelf, the coarse sand and gravel on the inner shelf and the relict detrital sand on the outer shelf would have been covered by these modern sediments. Therefore it appears that the modern sedimentary processes have not greatly modified the relict sands.

Curray (1964) believes that very little sediment bypasses the modern continental shelf and reaches the slope. The sediment pattern on portions of the continental shelf supports this conclusion. Silt and clay have accumulated at depths of 50 to 60 fathoms off the mouth of the Umpqua River (Figure 17) and have not been transported into deeper water. Sediments which surround this deposit are coarser and are probably relict sediments which have not been covered by recent sediments. Glauconite, which is usually found in areas with low rates of sedimentation and low current velocities (Cloud, 1955; Galliher, 1935), also occurs on the shelf break and has not been covered.

National Marine Consultants, Inc. (1961) found that significant heights for storm waves off the Oregon coast ranged from 5. 8 to 9. 6 meters and significant periods from 12 to 14 seconds for the period from 1940 to 1960. Using these data Maloney (1965) calculated a maximum particle velocity of 37 cm/sec at a water depth of 100 meters (55 fathoms). Sundborg (1956) has shown that a velocity of 23 cm/sec 0. 01 m above the bottom is sufficient to erode fine sand. Therefore, during major storms fine sand and unconsolidated silt and clay shallower than 100 to 150 meters (55 to 82 fathoms) may be subject to wave action periodically (Maloney, 1965). These velocities are also of sufficient magnitude to prevent the finer sediments from being deposited on the tops of the banks and to remove any sediments which may have been deposited.

There is some evidence to support these theoretical considerations. Three samples (235, 238, 250) of sand with median diameters in the coarse sand class were collected off Cascade Head during the September 1963 cruise at depths between 40 and 47 fathoms. The area was resampled in November 1963 after a three-week period of storms. Traces of the coarse sand were found at only the shallowest station. The remaining two stations apparently had been covered by the characteristic fine sand of the inner shelf.

The accumulation of fine-grained sediments east of the bank area may be a result of a "sheltering effect" by the banks from incoming waves. O'Brien (1951) examined wave measurements taken over a three-year period (1933 to 1936) from a lightship off the mouth of the Columbia River. During this period waves were predominantly from the southwest, west, and northwest. Bushnell (1964) and Maloney (1965) have shown from theoretical calculations that large storm waves "feel" bottom at depths greater than the shoal depths of the banks (about 30 to 60 fathoms). Thus wave energy may be expended on these banks. This could create areas of quiescence behind them that would allow the fine-grained material carried in suspension to be deposited.

Some inferences regarding the sources of the sediments on the continental shelf can be made, based on mineralogy. The abundance of pyroxenes, primarily augite and hypersthene, on the northern and central shelf indicates that much of this material was derived from the basic and intermediate intrusives and extrusives of the Coast Range, the Cascade Mountains, and the Columbia Plateau. On the southern shelf, the distribution of amphiboles, especially glaucophane, suggests that some of the sediments were derived from metamorphic rocks, probably from the Klamath Mountains.

GEOLOGICAL SIGNIFICANCE

The characteristics of the sediments in this study may be useful in identifying continental shelf sediments in the geologic column. Although some of the characteristics of the sediments may be changed by lithification and diagenesis, especially in the finer-grained sediments, such features as the size, shape, and trend of the deposits as well as the relationship to adjacent sediments should remain the same.

The exact geometry of the sediments on the Oregon continental shelf is not known but some inferences can be made. The deposit of sediments varies from 8 to 35 miles in width and is at least several hundred miles long parallel to the coast. This deposit is thought to be lens-shaped with the greatest thickness occurring in the central portion of the shelf. Toward the shoreline and the shelf break, the sediments become progressively thinner. At the shoreline and on portions of the outer shelf, the Holocene sediments pinch out entirely. From acoustic-reflection studies of the southern California continental shelf, Moore (1960) found up to 60 feet of "Recent sediments." Similar thicknesses probably occur on the Oregon continental shelf.

Upon lithification, the sediments of the shelf would be represented by two main lithofacies, a sandstone facies and a shale facies with a complete graduation between them. A third but minor conglomerate facies may also be present within the sandstone facies. The sand of the sandstone facies will be well sorted, and both positively and negatively skewed. No gradation in size or sorting offshore within the inner-shelf sand should be found. The composition of this particular sandstone is that of an arkose (Williams, Turner, and Gilbert, 1958).

Offshore, the rocks presumably will grade from argillaceous sandstone and arenaceous shales on the outer shelf to shales on the upper slope. The silty sediments east of the bank areas will also presumably be lithified into shale. These rocks of the outer shelf would be much finer grained than the nearshore rocks and would contain glauconite. The rocks which represent the sediments on the shelf break and upper portion of the upper slope could be recognized by their high glauconite content in the sand fraction.

The deposits could be preserved most easily by subsidence of the shelf and burial. As the depth of water increased, the sediments overlying the sands should become progressively finer grained. Therefore vertically, there should be a gradation from a clean sandstone to an arenaceous shale. The base of the deposit is probably represented by an erosional unconformity.

Difficulty may be experienced in determining the direction of the shoreline from examination of only the textural analysis of the sand. No systematic variation in texture within the inner-shelf sand is likely to exist. Heavy mineral associations may show trends. The highest percentages of the pyroxene group and the opaque-garnet association occurred nearshore, and decreased in abundance offshore. Also the general thickness of the deposit is thought to decrease near shore.

Two biofacies may also be present, with the boundary between them essentially the same as the boundary between the sandstone and the finer-grained rocks. The main fossil content of the sandstone facies should be Foraminifera and some pelecypods and gastropods. In the finer-grained rocks diatoms, radiolarians, and sponge spicules would occur in addition to the Foraminifera.

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APPENDICES

APPENDIX 1. SAMPLE LOCATIONS AND DEPTHS.

No.	OSU Sample number	Latitude	Longitude	Depth in fathoms
1	6403-251	46°20.0'	124°07.7'	14
2	6403-250	46 20.0	124 13.0	25
3	6403-249	46 20.0	124 17.3	41
4	6403-248	46 20.0	124 21.7	60
5	6403-247	46 20.0	124 26.0	71
6	6403-246	46 20.0	124 30.3	74
7	6403-245	46 20.0	124 34.5	79
8	6403-244	46 20.0	124 38.8	297
9	6403-243	46 17.0	124 37.6	240
10	6403-242	46 17.0	124 33.2	84
11	6403-241	46 17.0	124 29.0	118
12	6403-240	46 17.0	124 25.1	197
13	6403-239	46 17.0	124 20.6	118
14	6403-238	46 17.0	124 16.3	47
15	6403-237	46 14.0	124 13.6	35
16	6403-236	46 14.0	124 17.8	55
17	6403-235	46 14.0	124 22.1	79
18	6403-234	46 14.0	124 26.3	194
19	6403-233	46 11.0	124 37.4	91
20	6403-232	46 11.0	124 33.1	83
21	6403-231	46 11.0	124 28.8	74
22	6403-230	46 11.0	124 24.5	71
23	6403-229	46 11.0	124 20.3	62
24	6403-228	46 11.0	124 16.0	50
25	6403-227	46 11.1	124 11.7	36
26	6403-226	46 08.0	124 09.5	39
27	6403-225	46 08.0	124 13.8	48
28	6403-224	46 08.0	124 18.1	51
29	6403-223	46 08.0	124 22.5	69
30	6403-222	46 08.0	124 26.7	70
31	6403-221	46 08.0	124 31.1	79
32	6403-220	46 08.0	124 35.1	88
33	6403-219	46 08.0	124 39.6	214
34	6403-218	46 05.0	124 44.2	214
35	6403-217	46 05.0	124 40.0	114
36	6403-216	46 05.0	124 35.6	88
37	6403-215	46 05.0	124 31.4	78
38	6403-214	46 05.0	124 27.0	73
39	6403-213	46 05.0	124 22.7	66
40	6403-212	46 05.0	124 18.3	61
41	6403-211	46 05.0	124 13.9	51

No.	OSU Sample number	Latitude	Longitude	Depth in fathoms
42	6403-210	46°05.0'	124°09.1'	43
43	6403-209	46 05.0	124 05.1	28
44	6309-208	46 02.0	123 59.0	18
45	6309-207	46 02.0	124 03.3	26
46	6309-206	46 02.0	124 07.6	45
47	6309-205	46 02.2	124 11.9	54
48	6309-204	46 02.0	124 16.2	62
49	6309-203	46 02.0	124 20.5	69
50	6309-202	46 02.0	124 24.8	75
51	6309-201	46 02.0	124 29.0	80
52	6309-200	46 02.0	124 33.3	87
53	6309-199	46 02.0	124 37.6	95
54	6309-198	46 02.0	124 41.9	115
55	6309-197	46 02.0	124 46.2	178
56	6309-196	45 59.0	124 47.3	271
57	6309-195	45 59.0	124 43.0	179
58	6309-194	45 59.0	124 38.7	109
59	6309-193	45 59.0	124 34.4	74
60	6309-192	45 59.0	124 30.1	87
61	6309-191	45 59.0	124 25.8	82
62	6309-190	45 59.0	124 21.5	74
63	6309-189	45 59.0	124 17.2	66
64	6309-188	45 59.0	124 12.9	52
65	6309-187	45 59.0	124 08.6	44
66	6309-186	45 59.0	124 04.4	35
67	6309-185	45 59.0	124 00.1	17
68	6309-184	45 56.0	124 01.0	25
69	6309-183	45 56.0	124 04.3	40
70	6309-182	45 56.0	124 08.6	47
71	6309-181	45 56.0	124 12.9	60
72	6309-180	45 56.0	124 17.2	70
73	6309-179	45 56.0	124 21.5	78
74	6309-178	45 56.0	124 25.7	83
75	6309-177	45 56.0	124 30.0	85
76	6309-176	45 56.0	124 34.3	93
77	6309-175	45 56.0	124 38.6	109
78	6309-174	45 56.0	124 42.9	131
79	6309-173	45 56.0	124 47.2	354
80	6309-172	45 53.0	124 46.2	323
81	6309-171	45 53.0	124 42.0	139
82	6309-170	45 53.0	124 37.8	98
83	6309-169	45 53.0	124 33.6	92
84	6309-168	45 53.0	124 29.4	84

No.	OSU Sample number	Latitude	Longitude	Depth in fathoms
85	6309-167	45°53.0'	124°25.6'	82
86	6309-166	45 53.0	124 20.8	78
87	6309-165	45 53.0	124 16.6	90
88	6309-164	45 53.0	124 12.4	60
89	6309-163	45 53.0	124 08.1	48
90	6309-162	45 53.0	124 03.9	40
91	6309-161	45 53.0	123 59.6	21
92	6309-160	45 50.2	123 59.4	20
93	6309-159	45 50.0	124 02.5	34
94	6309-158	45 50.0	124 06.8	47
95	6309-157	45 50.0	124 11.1	60
96	6309-156	45 50.0	124 15.4	77
97	6309-155	45 50.0	124 19.7	81
98	6309-154	45 50.0	124 24.0	83
99	6309-153	45 50.0	124 28.3	87
100	6309-152	45 50.0	124 32.5	82
101	6309-151	45 50.0	124 36.8	104
102	6309-150	45 50.0	124 41.1	144
103	6309-149	45 50.0	124 45.4	306
104	6309-148	45 47.0	124 42.7	213
105	6309-147	45 47.0	124 38.4	139
106	6309-146	45 47.0	124 34.1	104
107	6309-145	45 47.0	124 29.8	98
108	6309-144	45 47.0	124 25.5	82
109	6309-143	45 47.0	124 21.2	81
110	6309-142	45 47.0	124 16.9	79
111	6309-141	45 47.0	124 12.6	68
112	6309-140	45 47.0	124 08.3	53
113	6309-139	45 47.0	124 04.0	43
114	6309-138	45 47.0	123 59.7	12
115	6309-137	45 44.0	123 59.6	23
116	6309-136	45 44.0	124 03.9	44
117	6309-135	45 44.0	124 08.2	55
118	6309-134	45 43.4	124 12.5	68
119	6309-133	45 44.0	124 16.8	80
120	6309-132	45 44.0	124 21.0	71
121	6309-131	45 44.0	124 25.3	92
122	6309-130	45 44.0	124 29.6	101
123	6309-129	45 44.0	124 33.9	111
124	6309-128	45 44.0	124 38.2	131
125	6309-127	45 44.0	124 42.5	143
126	6309-126	45 44.0	124 46.8	339

No.	OSU Sample number	Latitude	Longitude	Depth in fathoms
127	6309-125	45°41.0'	124°43.6'	301
128	6309-124	45 41.0	124 39.3	175
129	6309-123	45 41.0	124 35.0	134
130	6309-122	45 41.0	124 30.7	109
131	6309-121	45 41.0	124 26.4	102
132	6309-120	45 41.0	124 22.1	84
133	6309-119	45 41.0	124 17.8	78
134	6309-118	45 41.0	124 13.6	70
135	6309-117	45 41.0	124 09.3	57
136	6309-116	45 41.0	124 05.1	42
137	6309-115	45 41.0	124 00.7	29
138	6309-114	45 38.0	123 57.7	18
139	6309-113	45 38.0	123 59.8	24
140	6309-112	45 38.0	124 04.0	40
141	6309-111	45 38.0	124 08.3	50
142	6309-110	45 38.0	124 12.6	64
143	6309-109	45 38.0	124 16.9	82
144	6309-108	45 38.0	124 21.2	87
145	6309-107	45 38.0	124 25.5	104
146	6309-106	45 38.0	124 29.8	121
147	6309-105	45 38.0	124 34.1	153
148	6309-104	45 38.0	124 38.4	199
149	6309-103	45 35.0	124 32.3	197
150	6309-102	45 35.0	124 28.1	122
151	6309-101	45 35.0	124 23.9	104
152	6309-100	45 35.0	124 19.7	92
153	6309-99	45 35.0	124 15.5	83
154	6309-98	45 35.0	124 11.3	68
155	6309-97	45 35.0	124 07.3	52
156	6309-96	45 35.0	124 02.8	36
157	6309-95	45 35.0	123 58.5	15
158	6309-94	45 32.1	123 58.9	15
159	6309-93	45 32.0	124 01.5	26
160	6309-92	45 32.0	124 06.1	46
161	6309-91	45 32.0	124 10.5	62
162	6309-90	45 32.0	124 14.7	80
163	6309-89	45 32.0	124 19.7	93
164	6309-88	45 32.0	124 23.2	102
165	6309-87	45 32.0	124 27.5	125
166	6309-86	45 32.0	124 31.6	249
167	6309-85	45 29.0	124 30.8	254
168	6309-84	45 29.0	124 26.6	148
169	6309-83	45 29.0	124 22.3	95

No.	OSU Sample number	Latitude	Longitude	Depth in fathoms
170	6309-82	45°29.0'	124°18.0'	98
171	6309-81	45 29.0	124 13.7	83
172	6309-80	45 29.0	124 09.5	66
173	6309-79	45 29.0	124 05.2	48
174	6309-78	45 29.0	124 00.9	23
175	6309-77	45 29.0	123 59.7	14
176	6309-76	45 26.0	124 00.5	19
177	6309-75	45 26.0	124 04.8	48
178	6309-74	45 26.0	124 09.0	56
179	6309-73	45 26.0	124 13.3	87
180	6309-72	45 26.0	124 17.5	96
181	6309-71	45 26.0	124 21.8	100
182	6309-70	45 26.0	124 26.1	150
183	6309-69	45 23.0	124 24.3	145
184	6309-68	45 23.0	124 20.2	100
185	6309-67	45 23.0	124 16.0	45
186	6309-66	45 23.0	124 11.2	75
187	6309-65	45 23.0	124 07.4	51
188	6309-64	45 23.0	124 03.2	31
189	6309-63	45 23.0	123 59.5	15
190	6309-62	45 20.0	124 01.5	27
191	6309-61	45 20.0	124 05.8	49
192	6309-60	45 20.0	124 10.1	70
193	6309-59	45 20.0	124 14.4	92
194	6309-58	45 20.0	124 18.6	104
195	6309-57	45 20.0	124 22.8	175
196	6309-56	45 17.0	124 22.4	192
197	6309-55	45 17.0	124 18.2	101
198	6309-54	45 17.0	124 14.0	83
199	6309-53	45 17.0	124 09.8	63
200	6309-52	45 17.0	124 05.6	43
201	6309-51	45 17.0	124 01.4	20
202	6309-50	45 17.0	123 59.0	10
203	6309-49	45 14.0	124 00.6	21
204	6309-48	45 14.0	124 04.7	41
205	6309-47	45 14.0	124 09.2	65
206	6309-46	45 14.0	124 13.1	81
207	6309-45	45 14.0	124 17.4	93
208	6309-44	45 14.0	124 21.6	175
209	6309-43	45 11.0	124 34.1	200
210	6309-42	45 11.0	124 29.8	200
211	6309-41	45 11.0	124 25.7	200
212	6309-40	45 11.0	124 21.5	165

No.	OSU Sample number	Latitude	Longitude	Depth in fathoms
213	6309-39	45°11.0'	124°17.3'	94
214	6309-38	45 11.0	124 13.1	77
215	6309-37	45 11.0	124 08.9	56
216	6309-36	45 11.0	124 04.7	39
217	6309-35	45 11.0	124 00.5	17
218	6309-34	45 11.0	123 59.2	8
219	6309-33	45 08.3	123 59.7	12
220	6309-32	45 08.0	124 04.8	37
221	6309-31	45 08.0	124 09.0	51
222	6309-30	45 08.0	124 13.3	77
223	6309-29	45 08.0	124 17.5	95
224	6309-28	45 08.3	124 21.5	150
225	6309-27	45 08.2	124 25.4	180
226	6309-26	45 08.3	124 30.2	188
227	6309-25	45 08.0	124 34.0	178
228	6309-24	45 05.3	124 35.1	200
229	6309-23	45 05.2	124 31.0	180
230	6309-22	45 05.0	124 26.2	176
231	6309-21	45 05.0	124 22.3	142
232	6309-20	45 05.0	124 18.3	95
233	6309-19	45 05.0	124 14.1	80
234	6309-18	45 05.0	124 09.9	58
235	6309-17	45 05.0	124 05.7	40
236	6309-16	45 05.0	124 01.5	18
237	6309-15	45 02.5	124 02.5	14
238	6309-14	45 02.0	124 06.7	47
239	6309-13	45 02.0	124 10.9	60
240	6309-12	45 02.0	124 15.2	79
241	6309-11	45 02.0	124 19.4	94
242	6309-10	45 02.0	124 23.6	131
243	6309-9	45 02.0	124 27.8	178
244	6309-8	45 02.0	124 32.0	210
245	6309-7	44 59.0	124 28.5	180
246	6309-6	44 59.0	124 24.2	130
247	6309-5	44 59.0	124 20.0	94
248	6309-4	44 59.0	124 15.8	80
249	6309-3	44 59.0	124 11.9	64
250	6309-2	44 59.0	124 07.4	45
251	6309-1	44 59.0	124 03.2	19
252	6107-121	44 55.8	124 03.1	17
253	6107-120	44 55.8	124 06.1	30
254	6107-119	44 55.6	124 10.4	53
255	6107-118	44 55.5	124 14.5	70

No.	OSU Sample number	Latitude	Longitude	Depth in fathoms
256	6107-117	44°55.6'	124°18.8'	81
257	6107-116	44 55.7	124 23.3	96
258	6107-115	44 55.8	124 27.4	147
259	6107-114	44 55.7	124 31.5	218
260	6107-113	44 55.8	124 35.6	224
261	6107-112	44 55.8	124 40.2	207
262	6107-111	44 56.1	124 44.8	250
263	6107-110	44 53.0	124 44.4	200
264	6107-109	44 53.1	124 39.8	213
265	6107-108	44 52.8	124 35.7	200
266	6107-107	44 52.7	124 31.6	130
267	6107-106	44 52.5	124 27.4	100
268	6107-105	44 52.6	124 23.1	86
269	6107-104	44 52.5	124 18.8	76
270	6107-103	44 52.6	124 14.5	60
271	6107-102	44 52.3	124 10.4	45
272	6107-101	44 52.6	124 06.0	26
273	6107-100	44 49.8	124 06.0	23
274	6107-99	44 49.8	124 10.5	35
275	6107-98	44 49.8	124 14.5	53
276	6107-97	44 49.8	124 18.9	68
277	6107-96	44 49.8	124 23.0	75
278	6107-95	44 49.7	124 27.8	119
279	6107-94	44 49.7	124 31.8	120
280	6107-93	44 49.7	124 35.8	172
281	6107-92.5	44 47.8	124 38.6	200
282	6107-92	44 50.0	124 40.2	200
283	6107-91	44 49.7	124 44.8	239
284	6107-30	44 46.9	124 44.5	192
285	6107-29	44 46.9	124 40.0	165
286	6107-28	44 46.9	124 35.8	138
287	6107-27	44 46.8	124 31.6	100
288	6107-26	44 46.6	124 28.4	77
289	6107-25	44 47.0	124 23.2	70
290	6107-24	44 46.6	124 18.8	62
291	6107-23	44 46.7	124 14.5	50
292	6107-22	44 47.6	124 10.2	34
293	6107-21	44 47.6	124 05.1	20
294	6107-20	44 43.3	124 06.3	18
295	6107-19	44 43.3	124 10.5	36
296	6107-18	44 43.3	124 14.6	40
297	6107-17	44 43.3	124 18.6	54

No.	OSU Sample number	Latitude	Longitude	Depth in fathoms
298	6107-16	44°43.3'	124°23.1'	59
299	6107-15	44 43.3	124 27.4	68
300	6107-14	44 43.3	124 31.6	81
301	6107-13	44 43.3	124 36.1	140
302	6107-12	44 43.5	124 40.0	157
303	6107-11	44 43.7	124 44.9	200
304	6107-10	44 40.7	124 45.3	117
305	6107-9	44 40.5	124 40.0	174
306	6107-8	44 40.8	124 35.7	124
307	6107-7	44 40.8	124 31.5	80
308	6107-6	44 40.8	124 27.0	53
309	6107-5	44 40.8	124 23.0	46
310	6107-4	44 40.8	124 18.6	45
311	6107-3	44 40.8	124 14.5	39
312	6107-2	44 40.8	124 14.5	40
313	6107-1	44 40.8	124 07.0	17
314	6107-90	44 37.6	124 06.3	18
315	6107-89	44 37.8	124 10.2	26
316	6107-88	44 37.6	124 14.3	40
317	6107-87	44 37.7	124 18.2	41
318	6107-86	44 37.7	124 22.5	49
319	6107-85	44 37.5	124 26.7	50
320	6107-84	44 37.3	124 30.7	67
321	6107-83	44 37.7	124 34.4	94
322	6107-82	44 37.6	124 39.3	132
323	6107-81	44 37.4	124 43.4	117
324	6107-40	44 34.7	124 41.3	190
325	6107-39	44 34.7	124 38.2	160
326	6107-38	44 34.7	124 35.0	81
327	6107-37	44 34.5	124 30.8	63
328	6107-36	44 34.7	124 27.5	45
329	6107-35	44 35.0	124 23.1	38
330	6107-34	44 34.8	124 18.5	45
331	6107-33	44 34.6	124 14.2	39
332	6107-32	44 34.9	124 10.1	28
333	6107-31	44 34.4	124 05.8	6
334	6107-50	44 31.7	124 07.1	19
335	6107-49	44 31.9	124 10.3	29
336	6107-48	44 31.8	124 14.4	40
337	6107-47	44 31.6	124 18.2	47
338	6107-46	44 31.6	124 23.1	27
339	6107-45	44 31.8	124 27.5	44
340	6107-44	44 31.7	124 30.8	59

No.	OSU Sample number	Latitude	Longitude	Depth in fathoms
341	6107-43	44°31.7'	124°35.0'	73
342	6107-42	44 31.7	124 38.2	117
343	6107-41	44 31.7	124 41.3	180
344	6107-60	44 28.8	124 43.6	84
345	6107-59	44 28.7	124 39.2	80
346	6107-58	44 28.6	124 35.0	67
347	6107-57	44 28.8	124 31.2	50
348	6107-56	44 28.8	124 26.8	40
349	6107-55	44 28.8	124 22.6	34
350	6107-54	44 28.7	124 18.4	40
351	6107-53	44 28.5	124 13.8	35
352	6107-52	44 28.7	124 10.0	25
353	6107-51	44 28.6	124 06.5	15
354	6107-70	44 25.6	124 06.2	8
355	6107-69	44 25.6	124 10.0	27
356	6107-68	44 25.6	124 14.1	35
357	6107-67	44 25.6	124 18.4	38
358	6107-66	44 25.6	124 22.6	42
359	6107-65	44 25.6	124 26.8	42
360	6107-64	44 25.6	124 31.2	49
361	6107-63	44 25.7	124 35.2	61
362	6107-62	44 25.8	124 39.3	69
363	6107-61	44 25.8	124 43.9	72
364	6107-80	44 22.8	124 43.6	74
365	6107-79	44 22.7	124 39.3	60
366	6107-78	44 22.8	124 35.4	51
367	6107-77	44 23.0	124 31.0	58
368	6107-76	44 22.7	124 27.0	45
369	6107-75	44 22.8	124 22.7	44
370	6107-74	44 22.6	124 18.2	39
371	6107-73	44 22.6	124 14.4	37
372	6107-72	44 26.8	124 10.2	27
373	6107-71	44 22.6	124 06.0	15
374	6301-2-10	44 20.0	124 08.3	21
375	6301-2-9	44 20.0	124 11.2	27
376	6301-2-8	44 19.9	124 15.4	37
377	6301-2-7	44 19.8	124 19.7	42
378	6301-2-6	44 20.0	124 24.5	48
379	6301-2-5	44 19.9	124 28.3	50
380	6301-2-4	44 19.7	124 30.0	50
381	6301-2-3	44 20.0	124 41.0	53
382	6301-2-2	44 20.0	124 45.2	75
383	6301-2-1	44 20.0	124 49.4	95

No.	OSU Sample number	Latitude	Longitude	Depth in fathoms
384	6301-2-22	44°17.0'	124°52.7'	100
385	6301-2-21	44 17.0	124 50.3	87
386	6301-2-20	44 17.0	124 46.0	71
387	6301-2-19	44 17.0	124 42.0	41
388	6301-2-18	44 17.0	124 37.9	45
389	6301-2-17	44 17.0	124 35.5	54
390	6301-2-16	44 17.0	124 29.4	55
391	6301-2-15	44 17.0	124 25.2	51
392	6301-2-14	44 17.0	124 21.1	45
393	6301-2-13	44 17.0	124 16.8	39
394	6301-2-12	44 17.0	124 12.7	33
395	6301-2-11	44 17.0	124 08.5	18
396	6301-2-34	44 14.2	124 11.1	26
397	6301-2-33	44 14.2	124 14.2	37
398	6301-2-32	44 14.1	124 18.4	44
399	6301-2-31	44 14.1	124 22.6	48
400	6301-2-30	44 14.2	124 26.8	55
401	6301-2-29	44 14.2	124 31.0	53
402	6301-2-28	44 14.2	124 35.3	55
403	6301-2-27	44 14.2	124 39.5	57
404	6301-2-26	44 14.2	124 43.6	59
405	6301-2-25	44 14.2	124 47.7	57
406	6301-2-24	44 14.2	124 52.0	66
407	6301-2-23	44 14.2	124 56.2	100
408	6301-2-46	44 11.0	124 56.8	100
409	6301-2-45	44 11.1	124 52.6	67
410	6301-2-44	44 11.1	124 48.4	37
411	6301-2-43	44 11.1	124 44.4	53
412	6301-2-42	44 11.3	124 40.0	63
413	6301-2-41	44 11.3	124 35.8	59
414	6301-2-40	44 11.3	124 34.7	57
415	6301-2-39	44 11.2	124 27.5	57
416	6301-2-38	44 11.2	124 23.3	50
417	6301-2-37	44 11.2	124 19.4	46
418	6301-2-36	44 11.2	124 15.2	39
419	6301-2-35	44 11.2	124 11.1	28
420	6301-2-58	44 07.8	124 09.3	18
421	6301-2-57	44 08.0	124 14.6	37
422	6301-2-56	44 08.0	124 18.7	43
423	6301-2-55	44 08.0	124 22.9	52
424	6301-2-54	44 08.0	124 27.0	56
425	6301-2-53	44 08.0	124 31.2	65
426	6301-2-52	44 08.1	124 35.2	65

No.	OSU Sample number	Latitude	Longitude	Depth in fathoms
427	6301-2-51	44°08.0'	124°39.2'	66
428	6301-2-50	44 08.0	124 43.5	60
429	6301-2-49	44 08.0	124 47.5	54
430	6301-2-48	44 08.0	124 51.6	63
431	6301-2-47	44 08.0	124 56.0	100
432	6301-2-70	44 05.0	124 55.4	133
433	6301-2-69	44 05.1	124 50.5	48
434	6301-2-68	44 05.5	124 46.3	63
435	6301-2-67	44 05.2	124 42.2	63
436	6301-2-66	44 05.0	124 38.1	68
437	6301-2-65	44 05.0	124 34.0	70
438	6301-2-64	44 05.0	124 29.9	68
439	6301-2-63	44 05.0	124 25.9	63
440	6301-2-62	44 05.0	124 21.8	57
441	6301-2-61	44 05.0	124 17.7	44
442	6301-2-60	44 04.8	124 13.6	35
443	6301-2-59	44 05.0	124 09.4	16
444	6301-2-81	44 02.0	124 14.3	38
445	6305-2-80	44 02.0	124 18.3	50
446	6301-2-79	44 02.0	124 22.6	63
447	6301-2-78	44 02.0	124 26.8	76
448	6301-2-77	44 02.0	124 31.0	74
449	6301-2-76	44 02.0	124 34.9	78
450	6301-2-75	44 02.0	124 39.0	74
451	6301-2-74	44 02.0	124 43.0	56
452	6301-2-73	44 02.0	124 47.4	61
453	6301-2-72	44 02.0	124 51.5	35
454	6301-2-71	44 02.0	124 55.5	100
455	6301-2-92	43 59.0	124 56.7	100
456	6301-2-91	43 59.0	124 51.0	54
457	6301-2-90	43 59.0	124 46.9	66
458	6301-2-89	43 59.0	124 42.8	71
459	6301-2-88	43 59.0	124 38.7	81
460	6301-2-87	43 59.0	124 34.7	92
461	6301-2-86	43 59.0	124 30.6	77
462	6301-2-85	43 59.0	124 26.6	70
463	6301-2-84	43 59.0	124 22.5	63
464	6301-2-83	43 59.0	124 18.3	57
465	6301-2-82	43 59.0	124 14.3	37
466	6301-2-104	43 56.0	124 10.6	14
467	6301-2-103	43 56.0	124 14.0	35
468	6301-2-102	43 56.0	124 18.0	56

No.	OSU Sample number	Latitude	Longitude	Depth in fathoms
469	6301-2-101	43°56.0'	124°22.5'	59
470	6301-2-100	43 56.0	124 25.4	65
471	6301-2-99	43 56.0	124 30.8	74
472	6301-2-98	43 56.0	124 34.7	105
473	6301-2-97	43 56.0	124 38.8	109
474	6301-2-96	43 56.0	124 43.0	89
475	6301-2-95	43 56.0	124 47.2	76
476	6301-2-94	43 56.0	124 51.3	87
477	6301-2-93	43 56.0	124 55.4	100
478	6403-255	43 53.0	124 52.8	229
479	6403-254	43 53.0	124 48.7	153
480	6403-253	43 53.0	124 44.5	140
481	6403-252	43 53.0	124 40.3	145
482	6301-2-111	43 53.0	124 36.1	131
483	6301-2-110	43 53.0	124 31.9	88
484	6301-2-109	43 53.0	124 27.8	36
485	6301-2-108	43 53.0	124 23.7	63
486	6301-2-107	43 53.0	124 19.4	61
487	6301-2-106	43 53.0	124 15.4	47
488	6301-2-105	43 53.0	124 11.4	15
489	6301-2-118	43 50.0	124 12.4	22
490	6301-2-117	43 50.0	124 15.2	48
491	6301-2-116	43 50.0	124 19.3	58
492	6301-2-115	43 50.0	124 23.4	59
493	6301-2-114	43 50.0	124 27.5	74
494	6301-2-113	43 50.0	124 31.8	94
495	6301-2-112	43 50.0	124 35.8	144
496	6403-259	43 50.0	124 39.8	202
497	6403-258	43 50.0	124 44.0	191
498	6403-257	43 50.0	124 48.2	219
499	6403-256	43 50.0	124 52.3	213
500	6403-260	43 47.0	124 37.2	186
501	6403-261	43 47.0	124 33.0	109
502	6403-262	43 47.0	124 28.8	74
503	6403-263	43 47.0	124 24.7	66
504	6403-264	43 47.0	124 20.3	57
505	6403-265	43 47.0	124 16.3	48
506	6403-266	43 44.0	124 16.2	52
507	6403-267	43 44.0	124 20.3	57
508	6403-268	43 44.0	124 24.4	67
509	6403-269	43 44.0	124 28.5	66
510	6403-270	43 44.0	124 32.6	105
511	6403-271	43 44.0	124 36.7	175

No.	OSU Sample number	Latitude	Longitude	Depth in fathoms
512	6403-272	43°41.0'	124°36.7'	166
513	6403-273	43 41.0	124 32.6	104
514	6403-274	43 41.0	124 28.5	75
515	6403-275	43 41.0	124 24.4	65
516	6403-276	43 41.0	124 20.3	60
517	6403-277	43 41.0	124 16.2	48
518	6403-278	43 41.0	124 13.9	19
519	6403-279	43 38.0	124 14.3	16
520	6403-280	43 38.0	124 16.2	48
521	6403-281	43 38.0	124 20.3	56
522	6403-282	43 38.0	124 24.4	66
523	6403-283	43 38.0	124 28.5	90
524	6403-284A	43 38.0	124 32.6	105
525	6403-284B	43 38.0	124 36.7	164
526	6403-285A	43 35.0	124 37.1	170
527	6403-285B	43 35.0	124 33.0	114
528	6403-286	43 35.0	124 28.9	79
529	6403-287	43 35.0	124 24.8	66
530	6403-288	43 35.0	124 20.7	61
531	6403-289	43 35.0	124 16.6	44
532	6403-290	43 35.0	124 14.8	13
533	6403-291	43 32.0	124 15.6	13
534	6403-292	43 32.0	124 17.3	39
535	6403-293	43 32.0	124 21.3	57
536	6403-294	43 32.0	124 25.4	66
537	6403-295	43 32.0	124 29.5	79
538	6403-296	43 32.0	124 33.6	109
539	6403-297	43 32.0	124 37.8	175
540	6403-298	43 29.0	124 39.4	191
541	6403-299	43 29.0	124 35.3	109
542	6403-300	43 29.0	124 31.2	79
543	6403-301	43 29.0	124 27.1	66
544	6403-302	43 29.0	124 23.0	52
545	6403-303	43 29.0	124 13.9	36
546	6403-304	43 26.0	124 20.9	30
547	6403-305	43 26.0	124 25.0	52
548	6403-306	43 26.0	124 29.1	63
549	6403-307	43 26.0	124 33.2	79
550	6403-308	43 26.0	124 37.3	115
551	6403-309	43 26.0	124 41.3	214
552	6404-310	43 23.0	124 41.8	232
553	6404-311	43 23.0	124 38.3	122
554	6404-312	43 23.0	124 34.2	74

No.	OSU Sample number	Latitude	Longitude	Depth in fathoms
555	6404-313	43°23.0'	124°30.1'	57
556	6404-314	43 23.0	124 26.0	48
557	6404-315	43 20.0	124 27.8	48
558	6404-316	43 20.0	124 31.9	104
559	6404-317	43 20.0	124 36.0	74
560	6404-318	43 20.0	124 40.1	109
561	6404-319	43 20.0	124 44.2	170
562	6404-320	43 17.0	124 45.2	229
563	6404-321	43 17.0	124 41.1	107
564	6404-322	43 17.0	124 37.0	68
565	6404-323	43 17.0	124 32.9	54
566	6404-324	43 17.0	124 28.8	39
567	6404-325	43 17.0	124 24.7	11
568	6404-326	43 14.0	124 25.0	11
569	6404-327	43 14.0	124 27.7	27
570	6404-328A	43 14.0	124 30.4	36
571	6404-328B	43 14.0	124 33.1	44
572	6404-329	43 14.0	124 35.8	57
573	6404-330	43 14.0	124 38.5	76
574	6404-331	43 14.0	124 42.5	181
575	6404-332	43 14.0	124 46.6	214
576	6404-333	43 14.0	124 50.8	191
577	6404-346	43 12.5	124 36.5	55
578	6404-345	43 12.5	124 33.7	44
579	6404-344A	43 12.5	124 31.0	34
580	6404-344B	43 12.5	124 28.8	34
581	6404-343	43 12.5	124 25.7	17
582	6404-342	43 11.0	124 25.9	11
583	6404-341	43 11.0	124 28.6	26
584	6404-340	43 11.0	124 31.3	35
585	6404-339	43 11.0	124 34.0	48
586	6404-338	43 11.0	124 36.7	57
587	6404-337	43 11.0	124 40.8	86
588	6404-336	43 11.0	124 44.9	170
589	6404-335	43 11.0	124 49.0	164
590	6404-334	43 11.0	124 52.5	175
591	6404-353	43 08.0	124 52.4	208
592	6404-352	44 08.0	124 49.4	153
593	6404-351	43 08.0	124 45.4	145
594	6404-350	43 08.0	124 41.3	87
595	6404-349	43 08.0	124 37.2	66
596	6404-348	43 08.0	124 33.1	49
597	6404-347	43 08.0	124 29.0	25

No.	OSU Sample number	Latitude	Longitude	Depth in fathoms
598	6404-404	43 05.0	124 27.3	16
599	6404-359	43 05.0	124 30.2	31
600	6404-358	43 05.0	124 34.3	62
601	6404-357	43 05.0	124 38.4	79
602	6404-356	43 05.0	124 42.5	96
603	6404-355	43 05.0	124 46.6	118
604	6404-354	43 05.0	124 50.8	109
605	6404-368	43 02.0	124 52.4	246
606	6404-367	43 02.0	124 49.6	93
607	6404-366	43 02.0	124 47.0	66
608	6404-365	43 02.0	124 44.3	93
609	6404-364	43 02.0	124 41.5	87
610	6404-363	43 02.0	124 38.9	74
611	6404-362	43 02.0	124 36.1	66
612	6404-361	43 02.0	124 33.5	52
613	6404-360	43 02.0	124 30.8	35
614	6404-403	43 02.0	124 28.1	16
615	6404-378	42 59.0	124 29.2	13
616	6404-377	42 59.0	124 32.0	31
617	6404-376	42 59.0	124 34.6	43
618	6404-375	42 59.0	124 37.3	52
619	6404-374	42 59.0	124 40.0	70
620	6404-373	42 59.0	124 42.7	82
621	6404-372	42 59.0	124 45.4	83
622	6404-371	42 59.0	124 48.1	66
623	6404-370	42 59.0	124 50.8	
624	6404-369	42 59.0	124 53.5	205
625	6404-388	42 56.0	124 54.9	325
626	6404-387	42 56.0	124 52.2	158
627	6404-386	42 56.0	124 49.5	123
628	6404-385	42 56.0	124 46.3	109
629	6404-384	42 56.0	124 44.1	87
630	6404-383	42 56.0	124 41.4	74
631	6404-382	42 56.0	124 38.7	57
632	6404-381	42 56.0	124 36.0	44
633	6404-380	42 56.0	124 33.3	33
634	6404-379	42 56.0	124 30.6	13

APPENDIX 2. TEXTURAL ANALYSES OF SEDIMENT SAMPLES

Sample number	$Md\phi$	$M\phi$	σ_ϕ	$\alpha\phi$	$\alpha 2\phi$	$\beta\phi$	Percent sand	Percent silt	Percent clay
1	3.1667	3.1822	0.3862	0.0401	0.2084	0.7424	96.84	3.15	0.00
2	3.3824	3.3762	0.3049	-.0204	-.0818	.6752	100.00	0.00	0.00
3	4.1172	5.1229	2.3759	.4232	1.2271*	.9249*	48.74	37.62	13.63
4	3.4551	5.1401	2.2616	.7450	1.4704*	.8146*	58.29	29.22	12.47
5	3.4898	5.2818	2.4469	.7323	1.3638*	.7753*	58.68	26.59	14.72
6	2.5985	3.2154	1.1440	.5392	2.8745	2.6831	80.21	12.25	07.53
7	2.1553	2.3581	.7980	.2541	2.7869	3.1843	86.65	8.83	4.51
8	4.4364	5.9357	3.4204	.4383	.5589*	.4388*	38.14	38.43	23.41
9	6.5728	5.8185*	4.1797*	-.1804*	-.3116*	.4305*	21.73	45.33	32.92
10	1.9139	2.7396	1.3279	.6217	2.2900	1.9597	83.09	10.68	6.22
11	2.0249	2.6963	1.3623	.4928	2.0109	1.9499	84.04	9.68	6.27
12	7.4743	7.5767*	3.0549*	.0335*	.1067*	.2677*	2.62	54.14	43.22
13	6.8668	7.3434*	2.9649*	.1607*	.2813*	.3210*	6.23	58.77	34.98
14	2.9291	3.9703	1.3702	.7597	1.9715	1.4130	69.81	23.11	7.07
15	2.8823	3.9985	1.5210	.7337	1.7140	1.1853	72.39	21.28	6.31
16	3.0950	4.1638	1.5265	.7001	1.9514	1.4233	73.27	18.56	8.15
17	3.3439	5.2192	2.7462	.6828	1.1057*	.5749*	59.94	24.50	15.54
18	7.6929	7.8722*	2.7607*	.0649*	.0323*	.3833*	2.60	52.43	44.96
19	3.2079	3.1466	1.0611	-.0578	1.9857	2.4051	81.92	11.74	6.32
20	3.3859	4.6436	2.1046	.5975	1.0341*	1.3838*	70.80	18.60	10.59
21	3.0953	3.9652	1.2740	.6828	2.2603	1.8628	75.76	15.65	8.57
22	2.9250	4.4406	1.8706	.8102	1.6854	1.0227	73.02	17.04	9.92
23	3.2365	5.1611	2.4853	.7743	1.2340*	.5840*	57.88	28.00	14.11

* Denotes data calculated by the computer for the open end of the curve.

Sample number	Mdϕ	Mϕ	σϕ	αϕ	α2ϕ	βϕ	Percent sand	Percent silt	Percent clay
24	3.3019	5.0192	2.3285	.7375	1.2841*	.6643*	60.69	26.60	12.70
25	2.8328	2.8485	.2885	.0544	-.0830	.6668	100.00	0.00	0.00
26	3.0661	3.0180	.2464	-.1952	-.3361	1.0095	100.00	0.00	0.00
27	3.2920	4.3268	1.4275	.7249	1.8969	1.4580	71.75	19.65	8.58
28	3.0637	4.3398	1.6650	.7663	1.6698	1.0705	68.85	22.69	8.44
29	3.0867	4.6378	2.0354	.7620	1.4508	.8443	69.23	19.99	10.77
30	3.2007	4.8638	2.1163	.7858	1.4065	.7508	68.41	19.89	11.68
31	3.4601	5.1326	2.5951	.6444	.9863*	.7029*	64.00	21.45	14.54
32	3.5117	5.0113	2.8854	.5196	.3816*	1.0463*	60.96	23.73	15.29
33	6.3074	7.1710*	2.9983*	.2880*	.4014*	.3515*	10.72	56.31	32.95
34	3.7313	5.3520	2.7697	.5851	.9680*	.6457*	60.53	23.22	16.24
35	3.5276	4.5101	2.4538	.4003	1.1086*	.9055*	64.36	23.58	12.04
36	4.6478	6.4412	3.1514	.5690	.7762*	.4191*	38.76	36.51	24.71
37	3.5170	5.3434	2.3701	.7705	1.3221*	.6762*	62.19	23.11	14.69
38	3.3927	5.0617	2.2803	.7318	1.3270*	.7308*	65.26	21.88	12.84
39	3.2044	5.0398	2.3428	.7834	1.4230*	.7711*	63.99	23.42	12.58
40	3.2303	4.6919	1.8760	.7791	1.7753*	1.1080*	70.98	18.94	10.07
41	2.8589	2.9628	.4414	.2352	3.8903	4.3868	88.46	8.28	3.24
42	3.3024	3.2904	.2881	-.0415	-.0171	.9864	97.38	2.61	0.00
43	3.0920	3.0570	.2024	-.1732	.0582	.7993	100.00	0.00	0.00
44	2.9535	2.9622	.2980	.0290	.2933	.6573	100.00	0.00	0.00
45	2.8763	2.9071	.2940	.1047	.5118	.4275	100.00	0.00	0.00
46	3.0450	3.0771	.3134	.1022	.4150	.9923	96.34	3.65	0.00
47	3.0693	3.3196	.5890	.4249	3.8115	3.8229	84.94	9.99	5.06
48	3.6154	5.2207	2.3011	.6975	1.3869*	.7955*	57.48	28.80	13.71
49	4.2861	5.9715	2.9127	.5786	.9256*	.4482*	42.76	37.32	19.90
50	3.9709	5.9758	3.0457	.6582	.9599*	.4100*	50.47	28.58	20.94

Sample number	Mdϕ	Mϕ	σϕ	αϕ	α2ϕ	βϕ	Percent sand	Percent silt	Percent clay
51	5.3453	6.5075	3.2936	.3528	.4914*	.3275*	33.63	37.65	28.71
52	6.4973	6.9344*	3.3248*	.1314*	.2464*	.2796*	25.16	40.23	34.60
53	4.5925	6.5150	3.1443	.6114	.8269*	.3979*	38.10	36.78	25.10
54	4.2101	6.1504	2.9293	.6623	.9286*	.5578*	46.74	32.54	20.70
55	No sample								
56	4.8204	6.6422	2.9786	.6116	.8721*	.4617*	30.43	45.49	24.07
57	3.8295	4.2155	.8098	.4766	3.4364	3.3714	72.11	18.37	9.51
58	4.3622	6.3519	2.8168	.7063	.9523*	.4773*	41.90	36.09	21.99
59	Rock								
60	7.0425	7.3890*	3.1745*	.1091*	.1941*	.2823*	11.19	49.06	39.73
61	7.1521	7.5265*	3.0759*	.1217*	.2653*	.2898*	2.61	60.37	37.01
62	6.2665	6.8952*	3.0833*	.2038*	.3186*	.3204*	19.45	48.71	31.82
63	4.2407	5.9636	2.7544	.6254	.9522*	.4965*	44.25	36.54	19.19
64	2.7602	2.8241	.3859	.1655	.2955	1.0326	96.87	3.12	0.00
65	2.8256	2.7785	.4426	-.1063	-.1281	.8618	97.60	2.39	0.00
66	2.7388	2.8345	.3127	.3060	.2691	.9192	100.00	0.00	0.00
67	2.8982	2.9619	.3770	.1689	.4099	.6273	100.00	0.00	0.00
68	2.4539	2.4398	.2967	-.0476	.4701	.8932	100.00	0.00	0.00
69	2.6596	2.6773	.4073	.0436	.2343	.6500	100.00	0.00	0.00
70	2.1096	2.2094	.5889	.1693	.2097	.6093	100.00	0.00	0.00
71	3.3807	3.4903	.7828	.1399	2.4138	2.8978	77.83	16.75	5.40
72	4.2908	6.1349	2.9333	.6286	.9105*	.4501*	44.31	34.53	21.15
73	6.8022	7.1172*	2.8498*	.1105*	.1981*	.2872*	8.43	55.98	35.57
74	7.3200	7.4350*	2.8291*	.0406*	.1230*	.2697*	4.04	55.29	40.66
75	5.4439	6.5926*	3.4183*	.3361*	.4904*	.3077*	32.77	37.47	29.75

Sample number	Mdϕ	Mϕ	σϕ	αϕ	α2ϕ	βϕ	Percent sand	Percent silt	Percent clay
76	6. 6431	7. 0951*	3. 3876*	. 1334*	. 1790*	. 3471*	18. 28	45. 40	36. 30
77	3. 5941	5. 3439	2. 8799	. 6075	. 8843*	. 5536*	54. 45	28. 85	16. 68
78	3. 0979	3. 3068	. 9628	. 2169	2. 1656	2. 3770	78. 93	15. 48	5. 57
79	5. 8037	6. 8841	2. 8360	. 3809	. 5338*	. 3237*	14. 67	55. 69	29. 62
80	5. 5034	7. 0370*	2. 8837*	. 5317*	. 7344*	. 3619*	10. 64	60. 72	28. 62
81	3. 3819	3. 9643	1. 4966	. 3891	1. 7521	1. 6816	71. 94	18. 80	9. 24
82	3. 3930	5. 3474	3. 3977	. 5752	. 4434*	. 9317*	9. 88	55. 97	34. 13
83	5. 4121	6. 1121	3. 6322	. 1927	. 2793*	. 3087*	33. 63	37. 53	28. 82
84	6. 4720	7. 3413*	3. 0731*	. 2828*	. 4384*	. 3149*	8. 97	56. 86	34. 15
85	7. 2352	7. 6193*	3. 1638*	. 1213*	. 2449*	. 2586*	3. 33	55. 80	40. 85
86	6. 7262	7. 1090*	2. 9061*	. 1316*	. 2921*	. 2788*	7. 27	60. 38	32. 34
87	3. 5879	4. 8402	1. 8080	. 6926	1. 5435*	1. 0915*	66. 06	23. 15	10. 77
88	3. 4812	3. 9191	. 9132	. 4794	2. 9739	3. 1035	73. 18	18. 93	7. 88
89	2. 8390	2. 8006	. 3955	-. 0970	-. 2909	. 9292	100. 00	0. 00	0. 00
90	2. 7656	2. 8123	. 3625	. 1287	. 0974	. 8641	100. 00	0. 00	0. 00
91	2. 7491	2. 7921	. 4442	. 0965	. 1240	. 5827	100. 00	0. 00	0. 00
92	2. 8426	2. 9197	. 3759	. 2049	. 3055	. 7191	100. 00	0. 00	0. 00
93	2. 7399	2. 8273	. 3148	. 2777	. 1943	1. 0026	100. 00	0. 00	0. 00
94	2. 7274	2. 7022	. 3968	-. 0633	-. 1485	. 7284	100. 00	0. 00	0. 00
95	3. 3653	3. 5251	. 6871	. 2324	2. 8640	3. 3644	81. 20	13. 43	5. 36
96	5. 6988	6. 9412*	3. 1416*	. 3954*	. 5841*	. 3400*	21. 69	48. 70	29. 59
97	6. 5601	7. 2277*	2. 9488*	. 2263*	. 3941*	. 2966*	8. 15	58. 54	33. 29
98	7. 0467	7. 6443*	3. 1392*	. 1903*	. 3276*	. 2832*	3. 51	57. 58	38. 90
99	6. 6132	7. 4759*	3. 0411*	. 2836*	. 4669*	. 3050*	3. 09	62. 66	34. 23
100	Rock								

Sample number	Mdϕ	Mϕ	σϕ	αϕ	α2ϕ	βϕ	Percent sand	Percent silt	Percent clay
101	3.5304	5.1900	3.3014	.5026	.4439*	.8377*	51.31	25.65	17.81
102	3.8245	4.6888	1.8183	.4753	1.2043	.9893	57.09	32.94	9.96
103	5.6614	6.9868*	3.1304*	.4233*	.5512*	.3786*	19.80	50.29	29.89
104	2.7862	3.1415	.9822	.3617	2.8564	2.8145	80.78	12.48	6.73
105	3.3637	3.6202	1.0004	.2564	2.5522	2.7245	71.67	20.60	7.72
106	3.1362	4.7923	2.9793	.5558	.2059*	1.5389*	61.29	24.86	13.84
107	7.1778	7.9391*	3.5852*	.2123*	.2914*	.2973*	11.18	44.53	44.28
108	Rock								
109	4.9427	6.5755	2.9878	.5464	.8020*	.4689*	29.53	46.81	23.65
110	4.5113	6.3217	2.7211	.6653	.9345*	.4268*	31.32	46.96	21.70
111	3.4146	3.6655	.8179	.3067	2.4376	3.0837	76.29	17.39	6.30
112	2.5943	2.5381	.5514	-.1019	-.1389	.5324	100.00	0.00	0.00
113	2.6801	2.6153	.4149	-.1559	-.2340	.7206	100.00	0.00	0.00
114	2.6899	2.7521	.3246	.1916	.2588	.8051	100.00	0.00	0.00
115	2.5187	2.5481	.4488	.0654	.1961	.6596	100.00	0.00	0.00
116	2.6025	2.5161	.4391	-.1968	-.2843	.6704	100.00	0.00	0.00
117	2.7021	2.5395	.5968	-.2724	-.4320	.6161	100.00	0.00	0.00
118	3.3847	3.8176	.8375	.5168	3.3186	3.1669	77.96	14.47	7.55
119	4.8540	6.6390	2.8988	.6157	.9247*	.4227*	27.97	48.32	23.69
120	3.7409	4.9599	3.4821	.3500	.4547*	.5948*	49.99	29.47	17.65
121	4.9149	6.7847	2.9792	.6276	.8915*	.3847*	25.58	48.68	25.72
122	4.7030	6.6602	2.7627	.7084	.9377*	.4349*	20.50	55.33	24.15
123	No sample								
124	No sample								
125	No sample								

Sample number	Mdϕ	Mϕ	σϕ	αϕ	α2ϕ	βϕ	Percent sand	Percent silt	Percent clay
126	7.6139	7.8526*	3.3284*	.0717*	.1051*	.3257*	10.20	44.63	45.16
127	2.4426	3.5584	1.8494	.6033	1.8473*	1.4746*	80.92	8.87	10.20
128	2.7077	3.2531	1.1729	.4650	1.9723	1.8522	78.05	16.53	5.41
129	3.9529	4.9854	1.5571	.6630	1.3659	1.1480	54.02	36.86	9.10
130	4.0541	4.8570	2.1787	.3684	.9665*	.8752*	48.59	39.52	11.87
131	4.5793	6.4104	2.6607	.6881	1.0460*	.4706*	31.98	46.99	21.02
132	4.7304	6.3445	2.9428	.5484	.6536*	.4655*	26.61	49.39	23.98
133	4.5470	6.2921	2.7447	.6358	.9401*	.4306*	34.97	43.73	21.28
134	3.8981	5.4195	2.1213	.7171	1.3394*	.7404*	53.74	32.26	13.98
135	2.9315	2.9127	.3417	-.0552	.3952	1.6971	100.00	0.00	0.00
136	2.6600	2.6127	.3663	-.1292	-.2135	.7678	100.00	0.00	0.00
137	.7651	.7536	.3643	-.0317	.1964	.9526	100.00	0.00	0.00
138	2.9153	2.8565	.4569	-.1288	-.2275	.6363	100.00	0.00	0.00
139	2.0258	2.0402	.4397	.0329	.2135	.8592	100.00	0.00	0.00
140	2.6628	2.6249	.3572	-.1060	-.0902	.7136	100.00	0.00	0.00
141	2.8206	2.8409	.2997	.0677	-.0981	1.1999	100.00	0.00	0.00
142	3.3612	3.6090	.5792	.4276	3.8243	3.8038	79.76	14.72	5.51
143	4.3295	6.1315	2.7550	.6540	1.0006*	.4759*	41.99	37.99	20.01
144	Rock								
145	4.1543	5.7043	2.5207	.6149	.9658*	.7151*	43.83	39.54	16.61
146	3.8747	4.4091	1.3976	.3823	1.7025	1.7381	59.07	31.15	9.77
147	3.9114	4.1939	.6098	.4632	3.7515	3.8078	61.24	31.64	7.11
148	3.9975	4.8340	1.3170	.6351	1.8849	1.8976	50.64	39.36	9.98
149	4.0918	4.7964	1.0658	.6610	2.2584	1.8942	46.51	44.80	8.68
150	3.8742	4.2762	.9405	.4273	2.7175	2.8503	60.77	30.81	8.41

Sample number	Mdϕ	Mϕ	σϕ	αϕ	α2ϕ	βϕ	Percent sand	Percent silt	Percent clay
151	4.0884	5.5125	2.1407	.6652	1.1748*	.8580*	47.44	38.21	14.34
152	4.1236	5.8887	2.8340	.6228	.8800*	.5182*	46.04	34.73	19.22
153	4.0745	6.0518	2.9380	.6729	1.0486*	.5067*	48.63	31.43	19.93
154	3.3374	3.8158	.7982	.5992	4.0474	3.7496	78.02	13.61	8.35
155	2.7300	2.6298	.4489	-.2231	-.3703	.7723	100.00	0.00	0.00
156	2.6690	2.6609	.3355	-.0240	-.0651	.9438	100.00	0.00	0.00
157	2.5001	2.4478	.2975	-.1760	.1183	.5931	100.00	0.00	0.00
158	2.6883	2.7247	.3084	.1182	.0476	.8143	100.00	0.00	0.00
159	Gravel								
160	2.6962	2.6915	.3057	-.0153	-.2325	1.0103	100.00	0.00	0.00
161	2.0751	2.2082	.8823	.1507	-.1711	.6849	100.00	0.00	0.00
162	4.0901	6.1032	2.8203	.7137	1.1123*	.4913*	48.34	31.91	19.74
163	4.9461	6.6558	2.6714	.6399	.8548*	.3783*	17.44	57.83	24.72
164	3.6119	3.8859	1.3136	.2085	1.6432	1.6378	66.05	26.39	7.55
165	3.8986	4.1611	.6964	.3769	2.7606	2.9964	60.84	33.05	6.10
166	7.1449	7.2743*	2.6405*	.0490*	.1264*	.2771*	1.85	60.18	37.95
167	7.3600	7.4408*	2.8541*	.0283*	.1125*	.2590*	1.16	57.28	41.54
168	3.9038	4.7813	1.3540	.6480	1.7295	1.3724	58.40	31.95	9.64
169	3.6654	3.8469	1.3192	.1375	1.6455	1.7287	67.05	24.79	8.15
170	4.9609	6.5313	2.6642	.5894	.8394*	.3966*	21.01	55.73	23.24
171	3.8742	5.6500	2.4076	.7375	1.1983*	.5620*	53.50	30.59	15.89
172	3.2195	3.3373	.3948	.2981	4.2716	4.6038	85.44	10.61	3.93
173	2.6589	2.5874	.3892	-.1838	-.3162	.7792	100.00	0.00	0.00
174	2.4407	2.4200	.3130	-.0662	.0991	.8458	100.00	0.00	0.00
175	2.6343	2.6231	.3489	-.0320	.0583	.7110	100.00	0.00	0.00

Sample number	Mdϕ	Mϕ	σϕ	αϕ	α2ϕ	βϕ	Percent sand	Percent silt	Percent clay
176	2.7357	2.7845	.4069	.1199	.1483	.6699	100.00	0.00	0.00
177	2.6601	2.6411	.3198	-.0594	-.1851	.9767	100.00	0.00	0.00
178	3.0849	3.0264	.2226	-.2628	-.3619	1.0575	100.00	0.00	0.00
179	3.6085	5.1353	1.9944	.7654	1.5341*	.8915*	61.15	26.08	12.76
180	4.5075	6.3388	2.6160	.7000	.9804*	.4199*	27.74	50.96	21.29
181	3.6553	3.6441	1.0655	-.0104	1.7917	2.0716	68.47	24.96	6.55
182	3.8778	4.3547	.9322	.5115	2.3896	2.4806	62.97	28.91	8.10
183	3.9611	4.9138	1.2774	.7457	1.9828	1.4443	54.26	35.95	9.77
184	3.5768	3.5666	1.1064	-.0091	1.8263	2.0490	70.89	22.15	6.94
185	4.5512	6.2477	2.6423	.6420	.9607*	.4644*	30.14	49.33	20.52
186	3.3443	4.0294	1.0040	.6823	2.6887	2.2337	74.74	17.68	7.56
187	2.9525	2.9505	.2335	-.0085	-.5193	.8304	100.00	0.00	0.00
188	2.3671	2.3583	.3467	-.0253	-.1312	.8001	100.00	0.00	0.00
189	2.7543	2.8127	.3752	.1556	.1114	.7535	100.00	0.00	0.00
190	2.5133	2.4749	.3461	-.1109	.2130	.7807	100.00	0.00	0.00
191	2.6366	2.5829	.3196	-.1678	-.2413	.9044	100.00	0.00	0.00
192	3.1343	3.1614	.3035	.0894	1.1718	1.7400	89.14	9.33	1.52
193	4.3877	6.0080	2.5836	.6271	.9723*	.4352*	34.66	46.33	19.00
194	3.8255	4.5629	1.7499	.4213	1.3162	1.1455	61.01	28.57	10.41
195	4.4381	5.9808	2.2044	.6998	1.2281*	.7253*	36.30	47.26	16.42
196	5.6516	6.9094	2.8184	.4462	.6496*	.3319*	13.69	58.08	28.21
197	3.8208	4.3563	.9398	.5697	2.6702	2.8175	66.50	24.83	8.66
198	4.0577	5.8494	2.5973	.6898	1.1065*	.5331*	49.26	33.09	17.63
199	3.1087	3.1656	.3402	.1670	6.4121	6.7681	87.19	8.10	4.70
200	2.5849	2.4740	.3584	-.3094	-.4558	.9652	100.00	0.00	0.00

Sample number	Mdϕ	Mϕ	σϕ	αϕ	α2ϕ	βϕ	Percent sand	Percent silt	Percent clay
201	2.1213	2.1776	.4024	.1399	.2255	.7730	100.00	0.00	0.00
202	2.9219	2.8410	.4177	-.1937	-.3091	.6671	100.00	0.00	0.00
203	2.2059	2.2223	.4574	.0358	-.1214	.7071	100.00	0.00	0.00
204	2.0587	2.1014	.4036	.1056	.4656	1.0023	100.00	0.00	0.00
205	2.6986	2.7495	.2217	.2294	-.1211	1.4928	100.00	0.00	0.00
206	3.5907	5.3158	2.1880	.7884	1.4845*	.8062*	59.22	26.78	13.98
207	3.9138	5.1918	1.6813	.7601	1.6801*	1.0705*	56.39	31.81	11.79
208	5.4313	6.6908	2.6851	.4690	.7412*	.3883*	16.34	59.39	24.25
209	2.7911	4.5520	2.5751	.6837	1.2200*	.6715*	71.72	16.01	12.25
210	5.6258	6.6757	2.9941	.3506	.4803*	.3197*	25.34	45.27	29.37
211	7.1380	7.7779*	3.2453*	.1971*	.2926*	.3125*	7.86	51.33	40.80
212	6.0135	7.0359	2.7978	.3654	.5817*	.2987*	4.54	66.08	29.36
213	3.8013	4.7995	1.4308	.6975	1.9456	1.4398	61.90	27.95	10.14
214	3.4633	5.0126	1.9420	.7977	1.6001*	.9237*	63.92	23.95	12.12
215	2.7469	2.8611	.3157	.3617	1.4629	2.1441	90.47	9.22	0.29
216	2.1880	2.1744	.5072	-.0268	-.1615	.6240	100.00	0.00	0.00
217	2.6520	2.6199	.4548	-.0705	-.0632	.5127	100.00	0.00	0.00
218	2.6884	2.6437	.4711	-.0949	-.0982	.4912	100.00	0.00	0.00
219	2.6906	2.6327	.4818	-.1202	-.1533	.5206	100.00	0.00	0.00
220	2.3311	2.2327	.4758	-.2068	-.3808	.6662	100.00	0.00	0.00
221	2.6611	2.5849	.3858	-.1975	-.1756	1.2878	96.42	4.58	0.00
222	3.4064	4.8515	1.8329	.7883	1.5874	.9433	63.90	25.32	10.76
223	3.7875	4.7667	1.4041	.6973	2.0577	1.5344	60.82	29.35	9.82
224	4.7680	6.2512	2.3566	.6293	.9878*	.5145*	20.95	60.21	18.83
225	6.4188	7.3612*	2.8960*	.3253*	.4786*	.3252*	5.98	60.56	33.45

Sample number	Mdϕ	Mϕ	σϕ	αϕ	α2ϕ	βϕ	Percent sand	Percent silt	Percent clay
226	5.3391	6.6896	3.0020	.4498	.6509*	.3440*	28.12	44.64	27.23
227	2.3635	2.4944	.8758	.1494	2.0817	2.4220	88.18	8.17	3.64
228	4.2915	5.3080	3.1843	.3192	.5731*	.4140*	44.81	36.96	18.21
229	2.9417	3.7023	1.5964	.4764	1.6916	1.4741	73.31	18.45	8.22
230	5.7270	7.1686	2.8356	.5083	.7951*	.4036*	5.33	67.77	26.89
231	4.4802	6.0714	2.2806	.6976	1.1686*	.6033*	32.81	49.92	17.25
232	3.7452	4.7396	1.4055	.7075	1.9941	1.3902	64.55	25.30	10.13
233	3.4499	4.5182	1.4148	.7550	1.9203	1.3915	68.32	22.80	8.87
234	2.6982	2.7271	.2702	.1070	.6711	3.1773	100.00	0.00	0.00
235	.6500	.7601	.6064	.1815	.5971	1.2242	100.00	0.00	0.00
236	2.7273	2.7281	.3949	.0020	-.0086	.6349	100.00	0.00	0.00
237	2.8017	2.7348	.4551	-.1468	-.1197	.5438	100.00	0.00	0.00
238	.0967	-.0794	1.1278	-.1562	.1197	.9248	80.33	0.00	0.00
239	2.7009	2.7695	.2422	.2829	1.6122	3.0040	93.23	6.76	0.00
240	3.4136	4.7048	1.6841	.7666	1.7281	1.1195	68.14	21.54	10.31
241	3.6955	4.9255	1.6047	.7664	1.7953	1.1482	63.89	24.93	11.16
242	4.2519	5.5811	1.9757	.6728	1.3597*	.8305*	42.40	43.69	13.89
243	5.2268	6.6117	2.7825	.4977	.7283*	.3586*	25.69	49.27	25.02
244	5.4770	6.7247	2.6194	.4763	.6680*	.3683*	12.30	62.03	25.66
245	4.2893	5.7441	2.1704	.6702	1.1557*	.7537*	41.83	42.83	15.32
246	4.0676	5.4370	1.9136	.7156	1.4533*	.8782*	48.57	38.18	13.23
247	4.0186	5.2071	1.9367	.6136	1.3818*	.8922*	49.85	37.92	12.22
248	3.6051	4.8707	1.6421	.7707	1.7349	1.1074	67.70	21.42	10.87
249	2.7188	2.7886	.2327	.2998			93.94	5.96	0.08
250	.5720	.5708	.3401	-.0035	1.3178	2.0325	100.00	0.00	0.00

Sample number	Mdϕ	Mϕ	σϕ	αϕ	α2ϕ	βϕ	Percent sand	Percent silt	Percent clay
251	2.8893	2.9045	.3207	.0476	.0923	.7223	100.00	0.00	0.00
† 252	No sample								
253	2.00	1.90	.55	-.20	-.31	.40	100.00	0.00	0.00
254	2.55	2.52	.21	-.10	.88	1.78	95.00	0.00	5.00
255	2.83	3.17	.54	.64			85.00	4.00	11.00
256	3.43	5.33	2.21	.86			68.00	17.00	15.00
257	3.25	4.49	1.64	.75			75.00	12.00	13.00
258	3.96	6.17	2.95	.75			51.00	28.00	21.00
259	4.26	9.70	5.90	2.17			29.00	38.00	33.00
260	8.53	8.70	2.82	.06			1.00	38.00	61.00
261	2.99	4.88	2.76	.69			79.00	6.00	15.00
262	6.36	7.46	3.83	.29			23.00	41.00	36.00
263	1.97	1.91	.64	-.09	.42	1.18	95.00	1.00	4.00
264	No sample								
265	4.18	7.22	4.06	.75			44.0	30.00	26.00
266	4.00	5.70	2.26	.75			51.00	33.00	16.00
267	3.00	3.66	.98	.67			80.00	11.00	9.00
268	3.53	4.90	1.89	.72			65.00	21.00	14.00
269	3.16	3.60	.72	.62			83.00	4.00	13.00
270	2.75	3.31	.70	.81	6.20	5.65	84.00	9.00	7.00
271	2.53	2.42	.26	-.42	-.89	.80	100.00	0.00	0.00
272	2.29	2.26	.29	-.10	-.37	.48	100.00	0.00	0.00
273	2.63	2.59	.20	-.24	-.69	1.02	100.00	0.00	0.00
274	2.11	2.01	.39	-.24	-.50	.62	100.00	0.00	0.00
275	2.66	2.60	.16	-.41	11.01	12.72	93.00	2.00	5.00

†The data for samples 252-373 are from Bushnell (1964).

Sample number	Mdϕ	Mϕ	σϕ	αϕ	α2ϕ	βϕ	Percent sand	Percent silt	Percent clay
276	3.10	3.62	.74	.71			83.00	7.00	10.00
277	3.41	4.81	1.92	.73			70.00	16.00	14.00
278	3.86	6.19	3.19	.74			56.00	25.00	19.00
279	3.74	5.94	3.02	.73			61.00	21.00	18.00
280	5.09						12.00	36.00	52.00
281	5.79						28.00	32.00	40.00
282	7.93	8.85	4.62	.20			11.00	39.00	50.00
283	No sample								
284	7.12	8.36	3.36	.19			5.00	50.00	45.00
285	2.43	2.56	.57	.14	4.77	5.31	92.00	2.00	6.00
286	4.39	6.71	3.25	.71	.99	.39	40.00	35.00	25.00
287	4.03	5.97	2.74	.70			50.00	31.00	19.00
288	3.22	5.30	2.43	.86	1.55	.80	69.00	16.00	15.00
289	3.51	4.50	1.56	.64			74.00	8.00	18.00
290	2.82	3.02	.40	.51			93.00	3.00	4.00
291	2.48	2.44	.20	-.18	-.60	.92	100.00	0.00	0.00
292	1.96	1.86	.51	-.19	-.30	.47	100.00	0.00	0.00
293	1.69	1.72	.40	.08	.20	.50	100.00	0.00	0.00
294	2.67	2.57	.25	-.38	-.57	.88	100.00	0.00	0.00
295	2.39	2.32	.31	-.23	-.40	.49	100.00	0.00	0.00
296	2.52	2.43	.28	-.34	-.48	.63	100.00	0.00	0.00
297	2.58	2.57	.23	-.07	-.52	.86	100.00	0.00	0.00
298	2.91	3.01	.29	.34			95.00	2.00	3.00
299	3.92	7.87	4.93	.80			53.00	26.00	21.00
300	3.65	5.51	2.46	.76			68.00	18.00	16.00

Sample number	Mdϕ	Mϕ	σϕ	αϕ	α2ϕ	βϕ	Percent sand	Percent silt	Percent clay
301	5.01	6.92	3.11	.61			21.00	52.00	27.00
302	No sample								
303	Rock								
304	No sample								
305	2.70	4.55	2.33	.79			79.00	7.00	14.00
306	3.66	4.94	1.93	.66			69.00	17.00	14.00
307	Rock								
308	2.47	5.80	3.58	.93			63.00	18.00	19.00
309	2.80	2.85	.21	.24	.16	.68	100.00	0.00	0.00
310	2.46	2.34	.32	-.37	-1.02	1.04	100.00	0.00	0.00
311	2.48	2.42	.26	-.25	-.61	.83	100.00	0.00	0.00
312	2.52	2.48	.25	-.15	-.41	.65	100.00	0.00	0.00
313	2.71	2.63	.27	-.29	-.50	.79	100.00	0.00	0.00
314	2.65	2.63	.24	-.08	-.61	.93	100.00	0.00	0.00
315	1.78	2.79	.46	.00	-.03	.47	100.00	0.00	0.00
316	1.64	1.70	.70	.09	.16	.22	100.00	0.00	0.00
317	2.29	2.35	.29	.20	-.13	.68	100.00	0.00	0.00
318	Rock								
319	Rock								
320	3.31	5.39	2.77	.75	1.26	.62	65.00	19.00	16.00
321	3.16	4.00	1.16	.72			79.00	10.00	11.00
322	5.24	7.14	3.76	.51	.69	.26	35.00	32.00	33.00
323	2.40	2.61	.99	.22	4.50	4.52	86.00	3.00	11.00
324	4.62	6.49	3.14	.59			39.00	36.00	25.00
325	7.42						6.00	49.00	45.00

Sample number	Mdϕ	Mϕ	σϕ	αϕ	α2ϕ	βϕ	Percent sand	Percent silt	Percent clay
326	3.17	3.35	.86	.21			79.00	10.00	11.00
327	1.90	2.49	1.34	.44	3.20	3.16	83.00	7.00	10.00
328	Rock								
329	Rock								
330	.58	.23	.44	-.11	-.21	.82	100.00	0.00	0.00
331	2.68	2.53	.26	-.59	-1.14	1.04	100.00	0.00	0.00
332	1.98	1.81	.35	-.50	-.92	.77	100.00	0.00	0.00
333	Rock								
334	2.36	2.28	.28	-.28	-.44	.74	100.00	0.00	0.00
335	2.40	2.32	.31	-.28	-.70	.74	100.00	0.00	0.00
336	1.69	1.79	.50	.21	.34	.48	100.00	0.00	0.00
337	2.70	2.51	.26	-.74	-1.26	1.04	100.00	0.00	0.00
338	2.49	2.41	.23	-.33	-.63	.75	100.00	0.00	0.00
339	1.64	.42	.30	-.74	-1.45	1.02	100.00	0.00	0.00
340	2.09	5.07	3.66	.82			75.00	8.00	17.00
341	2.89	3.24	.54	.65	6.96	6.55	87.00	6.00	7.00
342	4.12	2.59	3.20	.77			47.00	28.00	25.00
343	No sample								
344	1.88	2.40	1.33	.38	2.44	2.44	85.00	5.00	10.00
345	2.98	3.09	.41	.28	6.62	6.88	91.00	2.00	7.00
346	2.34	2.40	.44	.15	4.95	5.64	93.00	2.00	5.00
347	-2.94	-2.70	1.94	.12			89.00	6.00	5.00
348	1.07	.41	1.32	-.50	-.71	.56	100.00	0.00	0.00
349	Rock								
350	2.58	2.54	.21	-.18	-.65	.99	100.00	0.00	0.00

Sample number	Mdϕ	Mϕ	σϕ	αϕ	α2ϕ	βϕ	Percent sand	Percent silt	Percent clay
351	2.73	2.68	.24	-.18	-.54	.90	100.00	0.00	0.00
352	2.57	2.47	.34	-.32	-.69	.62	100.00	0.00	0.00
353	2.52	2.46	.26	-.25	-.38	.58	100.00	0.00	0.00
354	2.48	2.39	.22	-.42	-.66	1.00	100.00	0.00	0.00
355	2.60	2.50	.30	-.34	-.76	.62	100.00	0.00	0.00
356	2.64	2.52	.28	-.45	-.86	1.16	100.00	0.00	0.00
357	2.59	2.43	.34	-.48	-.80	.75	100.00	0.00	0.00
358	2.72	2.64	.16	-.50	-.92	1.01	100.00	0.00	0.00
359	Rock								
360	Rock								
361	Rock								
362	2.83	2.82	.46	-.02	6.02	6.90	91.00	3.00	6.00
363	2.90	4.41	5.55	.27			67.00	14.00	19.00
364	3.08	3.23	.43	.35	6.79	6.92	89.00	5.00	6.00
365	Rock								
366	Rock								
367	-.48	-.64	1.21	-.12	-.66	.99	100.00	0.00	0.00
368	2.52	2.31	.42	-.47	-.78	.73	100.00	0.00	0.00
369	2.62	2.50	.29	-.44	-.70	.65	100.00	0.00	0.00
370	2.47	2.39	.28	-.31	-.60	.69	100.00	0.00	0.00
371	2.38	2.33	.33	-.15	-.40	.59	100.00	0.00	0.00
372	-.81	-.59	1.10	.20	1.03	1.10	100.00	0.00	0.00
373	2.72	2.67	.19	-.25	-.12	.75	100.00	0.00	0.00
††374	2.2469	2.1539	.5020	-.1850	-.4333	.6576	100.00	0.00	0.00
375	1.6993	1.7072*	.3338*	.0235*	.2113*	.5036*	100.00	0.00	0.00

††The data for samples 374-477, 482-495 are from Maloney (1965).

Sample number	Mdϕ	Mϕ	σϕ	αϕ	α2ϕ	βϕ	Percent sand	Percent silt	Percent clay
376	2.0276	1.9987	.5018	-.0575	-.2309	.5030	100.00	0.00	0.00
377	2.1844	2.0240	.5203	-.3081	-.4295	.5497	100.00	0.00	0.00
378	2.5215	2.3681	.5059	-.3031	-.6462	.6873	100.00	0.00	0.00
379	Rock								
380	Rock								
381	Rock								
382	3.6888	4.3864	4.0576	.1719	.2358*	.6243*	43.17	31.20	17.42
383	No sample								
384	3.2011	3.3744	.6953	.2492	3.9800	4.1969	83.40	9.41	7.17
385	3.0247	2.6605	3.7319	-.0976	.1533	.7261	50.82	21.81	10.06
386	Rock								
387	Rock								
388	Rock								
389	Rock								
390	1.6184	1.5707	.4022	-.1186	-.1200	.4638	100.00	0.00	0.00
391	2.1383	2.0294	.4708	-.2312	-.4476	.6135	100.00	0.00	0.00
392	2.1580	2.0479	.4184	-.2630	-.2847	.4908	100.00	0.00	0.00
393	1.7156	1.6228	.5362	-.1730	-.1562	.5458	100.00	0.00	0.00
394	No sample								
395	2.5502	2.4798	.3765	-.1871	-.5632	.8857	100.00	0.00	0.00
396	2.1185	2.0079	.3990	-.2770	-.3669	.5319	100.00	0.00	0.00
397	2.0663	2.1390*	.2431*	.2986*	.6547*	.5830*	100.00	0.00	0.00
398	2.1593	2.2053	.4666	-.1393	-.1940	.5428	100.00	0.00	0.00
399	1.8386	1.8592	.5040	.0409	-.0184	.5260	100.00	0.00	0.00
400	2.6430	2.5858	.3292	-.1738	-.4466	.9543	100.00	0.00	0.00

Sample number	Mdϕ	Mϕ	σϕ	αϕ	α2ϕ	βϕ	Percent sand	Percent silt	Percent clay
401	2.2173	2.1022	.4502	-.2555	-.3043	.4207	100.00	0.00	0.00
402	Rock								
403	Rock								
404	Rock								
405	Rock								
406	Rock								
407	Rock								
408	Rock								
409	Rock								
410	Rock								
411	Rock								
412	Rock								
413	Rock								
414	2.6798	3.0157	.8715	.3853	1.8580	1.8197	85.98	11.16	2.84
415	5.8424	6.1957	3.8437	.0919	.2778*	.5535*	29.26	47.03	23.69
416	2.5047	2.4604	.2775	-.1596	-.3954*	.9484*	100.00	0.00	0.00
417	2.5563	2.4655	.3419	-.2657	-.8781	1.0195	100.00	0.00	0.00
418	1.5821	1.5985	.4690	.0349	.2257	.5022	100.00	0.00	0.00
419	2.3488	2.2823	.3334	-.1995	-.3944	.9117	100.00	0.00	0.00
420	2.5601	2.5021	.3077	-.1883	-.7294	1.0581	100.00	0.00	0.00
421	2.0395	1.9487	.4888	-.1856	-.1609*	.4305*	100.00	0.00	0.00
422	2.3272	2.2752	.3641	-.1427	-.4854	1.0354	100.00	0.00	0.00
423	2.5268	3.1342	1.0065	.6034	1.2765*	.8549*	79.02	19.49	1.48
424	3.0263	3.8056	1.5813	.4927	1.6997*	1.4175*	64.74	28.13	7.11
425	5.0772	6.0121	1.9542	.4783	1.1432*	1.0880*	14.65	69.74	15.59

Sample number	Mdϕ	Mϕ	σϕ	αϕ	α2ϕ	βϕ	Percent sand	Percent silt	Percent clay
426	3.8283	4.5713	1.5299	.4856	2.1761*	1.9010*	56.86	33.41	9.71
427	2.6215	3.1622	.9272	.5832	1.7576	1.4192	81.33	15.84	2.82
428	Rock								
429	Rock								
430	Rock								
431	2.6110	2.9792	.8460	.4351	1.6574	1.4375	87.51	9.59	2.88
432	3.1217	3.3264	.7624	.2684	2.7063	3.1338	81.89	12.70	5.40
433	Rock								
434	Rock								
435	Rock								
436	2.9018	3.9655	2.0896	.5090	1.4003	1.0717	57.58	34.33	8.08
437	5.2387	6.4011	2.4292	.4785	.8338*	.6561*	16.63	64.07	19.29
438	4.9906	5.4457	2.2536	.2019	.9501*	.8286*	29.46	55.79	14.74
439	3.3665	4.1336	1.4708	.5215	1.5876	1.2280	58.51	34.91	6.57
440	3.0205	3.2518	1.1472	.2015	1.1607	1.4827	73.93	22.28	3.78
441	1.8916	1.8230	.4827	-.1420	-.3056	.4930	100.00	0.00	0.00
442	2.3843	2.3526	.3020	-.1050	-.5476	.9412	100.00	0.00	0.00
443	2.1659	1.9712	.5453	-.3571	-.5356	.4832	100.00	0.00	0.00
444	2.1173	2.0586	.4903	-.1196	-.1656*	.3739*	100.00	0.00	0.00
445	2.8331	3.1133	.9028	.3102	1.7256	2.0368	83.95	12.00	4.03
446	3.5949	4.2843	1.5093	.4567	1.8190	1.5553	55.27	36.60	8.12
447	3.7023	4.6970	1.7931	.5547	1.6710*	1.3550*	58.42	31.14	10.43
448	4.6820	5.3263	1.7795	.3620	1.3219*	1.1974*	34.01	54.29	11.69
449	5.3285	6.2402	2.2557	.4041	.8831*	.8006*	16.43	66.00	17.56
450	5.3363	6.6777	2.4109	.5564	1.0645*	.8542*	9.37	71.29	19.33

Sample number	Mdϕ	Mϕ	σϕ	αϕ	α2ϕ	βϕ	Percent sand	Percent silt	Percent clay
451	Rock								
452	Rock								
453	Rock								
454	Rock								
455	Rock								
456	Rock								
457	Rock								
458	Rock								
459	5.0981	6.1802	2.1047	.5141	.9472*	.8393*	12.97	70.27	16.75
460	5.2171	6.1156	2.0696	.4341	.8156*	.8364*	14.98	68.65	16.36
461	4.6039	5.1008	1.6332	.3042	1.1490	1.2280	35.24	53.88	10.86
462	3.3406	4.0155	1.1577	.5829	1.3221	1.7192	67.50	27.66	4.83
463	3.0491	3.9393	1.3000	.6847	1.8695	1.3612	66.25	27.80	5.93
464	4.5433	5.0984	1.7731	.3130	1.2076*	1.2097*	42.01	46.50	11.47
465	2.5476	2.5158	.2593	-.1225	-.3626	.7726	100.00	0.00	0.00
466	2.0041	1.8226	.4150	-.4373	-.3066*	.6027*	100.00	0.00	0.00
467	2.7131	2.9509	.4294	.5537	1.2168	1.3364	90.69	8.18	1.12
468	4.5940	5.2398	1.9551	.3302	1.0797*	.9942*	42.45	44.45	13.09
469	3.4126	4.1657	1.4672	.5132	1.5159	1.2164	60.88	32.27	6.83
470	Rock								
471	3.1773	3.7326	1.1404	.4869	1.9227	1.7595	71.86	22.46	5.67
472	5.6990	6.7961	2.6414	.4153	.6568*	.5275*	14.48	62.23	23.28
473	4.9017	5.9294	2.3961	.4288	.8883*	.6467*	31.96	51.08	16.94
474	4.8751	5.3250	3.2068	.1402	.4156*	.4711*	33.61	48.30	18.07
475	Rock								

Sample number	Mdϕ	Mϕ	σϕ	αϕ	α2ϕ	βϕ	Percent sand	Percent silt	Percent clay
476	Rock								
477	Rock								
478	2.6190	4.3032	2.6854	.6271	1.1329	.6081	61.38	27.60	11.01
479	3.4523	4.4973	2.3576	.4432	1.0118	.7206	56.90	32.83	10.25
480	5.1051	6.1534	2.1034	.4983	.9101*	.6375*	14.62	68.44	16.93
481	6.0556	7.0997	2.7129	.3848	.6672*	.4200*	4.93	68.97	26.09
482	5.3561	6.1962	2.5524	.3291	.4766*	.6779*	22.64	57.88	19.47
483	4.2320	5.1329	2.3266	.3872	.9226*	.6710*	46.17	40.43	13.39
484	2.6758	3.1765	1.6429	.3047	1.2341	1.2431	73.51	20.96	5.52
485	4.1306	4.4109	.9603	.2918	.6913	.9554	45.81	55.87	0.00
486	4.5949	5.0903	1.5654	.3164	1.2130	1.1976	35.00	54.47	10.52
487	2.7798	3.2359	.8019	.5687	2.3229	2.1949	83.62	12.96	3.41
488	2.4343	2.2581	.4453	-.3957	-1.0115	.9298	100.00	0.00	0.00
489	2.7179	2.7245	.2615	.0253	.1071	.9562	100.00	0.00	0.00
490	3.2558	4.4507	1.8712	.6385	1.3736	.8603	64.51	26.10	9.37
491	4.2232	4.6723	1.6741	.2682	1.1412	1.0303	46.27	44.59	9.13
492	2.8690	3.2428	.8394	.4453	2.5492	2.7346	82.71	12.23	5.04
493	3.9812	4.9556	1.7815	.5469	1.3032	.9835	51.31	38.28	10.40
494	4.6553	5.8144	2.3622	.4906	.8805*	.5553*	33.84	49.71	16.43
495	5.3351	6.4006	2.4024	.4435	.6458*	.5854*	16.19	63.63	20.17
496	5.2964	6.1652	2.1684	.4006	.7781*	.6064*	16.62	66.03	17.34
497	2.4677	3.5045	1.7911	.5788	1.3479	.9734	68.48	25.82	5.68
498	2.1404	2.8336	1.3840	.5007	1.5351	1.2631	80.69	15.51	3.78
499	1.9980	2.6680	1.5044	.4453	1.5702	1.3707	79.96	15.35	4.67
500	5.8493	6.9348	2.5546	.4249	.7200*	.4364*	4.71	70.96	24.31

Sample number	Mdϕ	Mϕ	σϕ	αϕ	α2ϕ	βϕ	Percent sand	Percent silt	Percent clay
501	4.5356	5.7765	2.0281	.6118	1.1163*	.6835*	29.01	56.19	14.78
502	Rock								
503	3.8170	4.5081	1.4819	.4663	1.4609	1.1981	55.67	36.28	8.04
504	3.7897	4.3998	1.4679	.4156	1.3443	1.1901	55.27	37.82	6.89
505	4.3229	5.3426	2.0254	.5034	1.1449*	.9032*	41.59	44.89	13.51
506	4.7267	6.0979	2.4892	.5508	.9397*	.6198*	30.95	50.78	18.25
507	4.3542	5.1312	1.6260	.4778	1.4662*	1.3082*	37.63	50.99	11.37
508	3.4687	4.2135	1.3708	.5433	1.5850	1.3231	64.19	29.24	6.56
509	Rock								
510	4.2945	5.4739	1.9657	.5999	1.2338*	.7675*	39.65	47.19	13.14
511	5.0470	6.1771	2.0695	.5460	1.0471*	.6642*	11.96	71.28	16.74
512	4.8374	5.9142	1.8765	.5738	1.2130*	.8274*	14.94	70.24	14.81
513	4.5197	5.6820	2.1116	.5504	1.1243*	.7174*	32.98	52.17	14.84
514	3.4250	4.3768	1.4083	.6758	1.8400	1.4052	67.34	24.64	8.01
515	3.6224	4.4447	1.4707	.5591	1.7301	1.3407	60.15	31.95	7.88
516	4.6898	5.8131	2.1046	.5337	1.1486*	.9057*	26.83	57.73	15.43
517	4.1304	5.2547	1.9746	.5693	1.2018*	.9226*	47.06	40.74	12.19
518	2.7944	2.8093	.3243	.0458	.1206	.8654	100.00	0.00	0.00
519	2.7484	2.7372	.3303	-.0339	-.1317	.6932	100.00	0.00	0.00
520	3.9669	5.0786	1.5560	.7144	1.6373	1.1763	52.54	37.41	10.03
521	4.6386	5.6974	1.8708	.5659	1.3105*	.9120*	25.18	60.76	14.04
522	3.9037	4.9438	1.7637	.5897	1.3970	1.0114	54.11	35.17	10.70
523	3.6233	4.8044	1.6923	.6979	1.5717	1.0741	59.54	30.50	9.94
524	4.7866	5.9120	2.0190	.5573	1.0469*	.7060*	20.14	64.55	15.29
525	5.0159	6.1378	2.0772	.5400	1.0079*	.6498*	14.11	69.23	16.64

Sample number	Mdϕ	Mϕ	σϕ	αϕ	α2ϕ	βϕ	Percent sand	Percent silt	Percent clay
526	4. 7009	5. 9245	2. 2168	.5519	.9931*	.6101*	25. 25	58. 43	16. 30
527	5. 9018	7. 0495	2. 8057	.4090	.6961*	.3843*	6. 63	67. 00	26. 36
528	3. 4863	4. 4497	1. 3347	.7217	1. 9091	1. 3357	65. 71	26. 65	7. 62
529	4. 0425	5. 0281	1. 6130	.6109	1. 4392	1. 0335	49. 14	40. 56	10. 29
530	5. 1305	5. 8124	1. 7055	.3998	1. 1256*	1. 0151*	12. 17	74. 42	13. 39
531	3. 8514	4. 2216	.7896	.4688	2. 4549	2. 4124	64. 20	30. 16	5. 62
532	2. 6490	2. 5849	.3439	-.1862	-.2361	.8480	100. 00	0. 00	0. 00
533	2. 7224	2. 6800	.3231	-.1309	-.2036	.7605	100. 00	0. 00	0. 00
534	3. 4998	3. 5247	.4845	.0514	.6844	1. 4033	84. 10	14. 45	1. 44
535	4. 0022	5. 1442	1. 5776	.7238	1. 6945	1. 2293	50. 35	39. 08	10. 56
536	3. 6759	4. 5792	1. 3205	.6840	1. 9858	1. 5473	65. 51	26. 01	8. 46
537	3. 5901	4. 8176	1. 7535	.7000	1. 5551	.9826	58. 26	32. 27	9. 45
538	5. 1769	6. 3588	2. 3619	.5003	.8639*	.5665*	16. 73	63. 96	19. 30
539	4. 7420	6. 0283	2. 1777	.5906	1. 1209*	.6338*	25. 43	58. 01	16. 55
540	4. 5865	5. 7328	1. 9232	.5960	1. 3261*	.8794*	27. 67	57. 96	14. 35
541	5. 1639	6. 3368	2. 5604	.4580	.8294*	.5308*	24. 08	55. 93	19. 98
542	3. 2783	4. 5007	1. 5720	.7775	1. 8818	1. 2218	66. 48	25. 15	8. 35
543	3. 4187	4. 3527	1. 3138	.7109	2. 1722	1. 6437	70. 67	20. 88	8. 44
544	3. 8931	4. 8353	1. 4369	.6556	1. 8845	1. 4411	56. 48	34. 61	8. 90
545	2. 9284	2. 9614	.2885	.1144	.2753	1. 1066	100. 00	0. 00	0. 00
546	2. 8755	2. 9279	.2610	.2006	.2488	1. 0412	100. 00	0. 00	0. 00
547	3. 7254	4. 5435	1. 2965	.6309	1. 8391	1. 4517	63. 05	29. 08	7. 85
548	3. 2402	3. 5701	.6584	.5009	3. 0845	2. 8865	79. 03	16. 47	4. 49
549	3. 6703	4. 8340	1. 9141	.6079	1. 3879	.8858	56. 16	33. 21	10. 61
550	4. 4794	5. 8145	2. 0437	.6532	1. 1864*	.7249*	28. 29	56. 67	15. 02

Sample number	Mdϕ	Mϕ	σϕ	αϕ	α2ϕ	βϕ	Percent sand	Percent silt	Percent clay
551	5.0512	6.1745	2.1260	.5283	.9415*	.6184*	14.58	68.28	17.12
552	4.4989	5.7964	1.9511	.6649	1.1929*	.7635*	20.86	64.34	14.80
553	4.7548	5.9130	2.4274	.4771	.8863*	.6289*	30.91	51.90	17.18
554	3.3628	4.6098	1.7928	.6955	1.5258	1.0520	62.31	28.09	9.58
555	3.2381	3.7699	.8736	.6087	2.9184	2.6134	76.83	16.64	6.52
556	3.1476	3.6382	.8380	.5854	3.0602	2.7026	77.64	16.15	6.19
557	2.7801	3.3199	.8144	.6627	3.0966	2.7896	82.03	12.47	5.48
558	2.9738	3.5316	.8891	.6272	2.7783	2.5830	77.25	16.73	6.00
559	3.9971	5.0029	2.2213	.4527	.9541	.7846	50.46	37.29	12.24
560	4.4251	5.8132	2.2999	.6035	1.0022*	.5978*	32.70	51.24	16.05
561	1.9426	2.7758	1.5073	.5527	1.7395	1.4159	80.75	14.10	5.14
562	4.4080	5.8247	2.3166	.6115	1.0635*	.6553*	36.11	47.65	16.23
563	4.4148	5.7637	2.3078	.5845	.9875*	.5983*	36.46	47.58	15.94
564	3.4440	3.4007	3.5749	-.0121	.1445	.5914	46.78	31.68	11.54
565	Rock								
566	2.8529	3.7163	1.5744	.5483	1.2245	1.8067	73.67	16.47	7.67
567	2.9066	2.9198	.2588	.0509	-.0788	.7595	100.00	0.00	0.00
568	2.8539	2.8691	.2841	.0537	-.1422	.8850	100.00	0.00	0.00
569	2.7355	2.6862	.2649	-.1862	-.3400	1.0549	100.00	0.00	0.00
570	Rock								
571	Rock								
572	Rock								
573	4.9705	5.9725	2.8557	.3508	.5866*	.5362*	27.85	52.37	19.76
574	4.8576	6.1701	2.4017	.5464	.9507*	.5739*	24.91	56.86	18.22
575	4.3794	5.7453	2.0742	.6584	1.3210*	.7502*	39.63	45.38	14.98

Sample number	Mdϕ	Mϕ	σϕ	αϕ	α2ϕ	βϕ	Percent sand	Percent silt	Percent clay
576	2.5137	2.7173	.8215	.2478	1.5440	1.6778	87.72	9.53	2.74
577	6.6420	6.2640*	3.6391*	-.1038*	-.4215*	.6523*	15.23	47.20	32.85
578	Rock								
579	Rock								
580	Rock								
581	2.9227	2.9495	.2986	.0896	.0670	.8982	100.00	0.00	0.00
582	2.8435	2.8617	.3504	.0516	-.2850	.9969	100.00	0.00	0.00
583	2.7153	2.6916	.4076	-.0581	-.2935	1.0706	99.51	0.48	0.00
584	Rock								
585	Rock								
586	4.9955	5.4404	3.5267	.1261	-.0689*	.7187*	26.06	46.48	21.37
587	3.8054	5.1876	2.3601	.5856	1.1957*	.6878*	52.77	33.32	13.90
588	4.6546	6.1327	2.3441	.6305	1.0196*	.5562*	28.64	53.35	17.99
589	2.3043	2.4579	.6766	.2268	2.4967	2.6773	89.53	7.79	2.66
590	2.2792	2.4161	.7983	.1713	.8569	1.2277	90.02	7.91	2.06
591	2.4846	2.9572	1.2674	.3728	1.8293	1.7204	81.47	13.22	5.30
592	2.4305	2.5480	.7145	.1643	.8365	1.0095	90.13	7.95	1.91
593	3.6353	4.2469	.9630	.6351	2.5934	2.2172	73.33	18.65	8.01
594	3.2847	4.8394	2.0437	.7607	1.4748	.8159	61.21	27.28	11.50
595	4.1944	3.8809	3.6897	-.0849	.0563*	.5899*	37.06	41.85	13.64
596	4.3640	4.8665	3.8970	.1289	.1542*	.4844*	40.07	35.53	19.87
597	.7765	.7701	.1981	-.0320	.0986	.7090	100.00	0.00	0.00
598	2.8127	2.8263	.3146	.0432	-.0980	.7152	100.00	0.00	0.00
599	Gravel								
600	4.1860	5.2549	1.7356	.6157	1.3448	.9232	43.80	45.63	10.56

Sample number	Mdϕ	Mϕ	σϕ	αϕ	α2ϕ	βϕ	Percent sand	Percent silt	Percent clay
601	6.4840	7.6453	3.1433	.3694	.5307*	.4220*	9.41	58.29	32.28
602	2.8408	4.1816	1.5713	.8532	1.9061	1.2357	74.81	17.35	7.82
603	3.1335	3.1262	.3892	-.0185	.6181	1.4817	91.05	6.93	2.01
604	Rock								
605	4.8560	6.3176	2.4820	.5888	1.0480*	.5918*	24.00	56.95	19.03
606	Rock								
607	Rock								
608	2.7756	2.6670	.5561	-.1952	.2484	1.2897	92.92	5.13	1.93
609	5.0916	6.2178	2.4015	.4689	.8657*	.5566*	24.47	56.93	18.59
610	5.1205	6.2257	2.3812	.4641	.8310*	.5396*	21.94	59.31	18.73
611	5.2194	6.1749	2.2635	.4221	.8784*	.6465*	19.16	63.23	17.60
612	3.9674	5.0354	1.6452	.6491	1.5327	1.1531	52.07	37.66	10.25
613	.2095	.1049	.4739	-.2207	-.4046	.8924	100.00	0.00	0.00
614	2.8697	2.8748	.3041	.0168	-.0987	.7919	100.00	0.00	0.00
615	2.8338	2.8644	.3045	.1004	.0165	.7088	100.00	0.00	0.00
616	-.5409	-.6175	1.0192	-.0751	-.0435	.4305	66.65	0.00	0.00
617	3.6658	3.9750	.6845	.4516	3.0354	2.9435	74.95	19.50	5.54
618	3.8692	4.9398	1.6200	.6608	1.6724	1.1729	56.89	32.82	10.27
619	5.3042	6.3265	2.4704	.4138	.9567*	.6920*	21.27	59.06	19.66
620	5.4412	6.4133	2.5426	.3823	.7172*	.4797*	21.73	57.45	20.81
621	Rock								
622	Rock								
623	Rock								
624	No sample								
625	No sample								

Sample number	Mdϕ	Mϕ	σϕ	αϕ	α2ϕ	βϕ	Percent sand	Percent silt	Percent clay
626	2.1569	3.3074	1.9636	.5859	1.3063	1.2137	70.96	20.28	6.67
627	Rock								
628	4.6366	6.0347	2.3917	.5845	1.0402*	.5900*	34.30	48.15	17.53
629	5.2356	6.2267	2.5707	.3855	.6712*	.4427*	28.35	52.06	19.57
630	4.9913	6.1134	2.4800	.4524	.8764*	.5688*	31.00	50.21	18.78
631	3.6929	4.7462	1.9149	.5500	1.4456	1.0604	56.93	33.06	10.00
632	3.2966	3.5967	.6714	.4469	2.8675	2.7987	80.45	15.12	4.41
633	3.2122	3.1634	.3026	-.1614	-.2057	.6249	100.00	0.00	0.00
634	3.0323	2.9976	.3150	-.1101	-.2116	.6631	100.00	0.00	0.00

APPENDIX 3. GLAUCONITE PERCENTAGES

Sample number	Per-cent	Sample number	Per-cent	Sample number	Per-cent	Sample number	Per-cent	Sample number	Per-cent
1	0	41	5	81	80	121	15	161	2
2	0	42	4	82	80	122	15	162	5
3	5	43	3	83	5	123	20	163	5
4	10	44	0	84	10	124	60	164	10
5	5	45	0	85	0	125	85	165	10
6	5	46	0	86	5	126	20	166	5
7	60	47	5	87	10	127	90	167	20
8	5	48	5	88	5	128	90	168	15
9	5	49	10	89	0	129	20	169	10
10	15	50	15	90	0	130	40	170	5
11	5	51	10	91	0	131	10	171	5
12	2	52	15	92	0	132	40	172	2
13	2	53	50	93	0	133	1	173	0
14	5	54	50	94	1	134	2	174	0
15	0	55	--	95	10	135	0	175	0
16	15	56	15	96	2	136	0	176	0
17	5	57	30	97	1	137	0	177	0
18	10	58	25	98	1	138	0	178	1
19	25	59	--	99	15	139	0	179	5
20	40	60	15	100	--	140	2	180	5
21	25	61	2	101	70	141	1	181	15
22	15	62	10	102	70	142	1	182	20
23	2	63	10	103	70	143	10	183	20
24	3	64	0	104	95	144	--	184	15
25	2	65	1	105	85	145	30	185	5
26	5	66	1	106	50	146	40	186	3
27	5	67	0	107	10	147	10	187	3
28	5	68	0	108	--	148	10	188	0
29	5	69	0	109	5	149	20	189	0
30	15	70	0	110	5	150	15	190	0
31	20	71	2	111	5	151	15	191	0
32	25	72	5	112	0	152	30	192	2
33	20	73	5	113	0	153	5	193	4
34	90	74	0	114	0	154	10	194	8
35	90	75	30	115	0	155	10	195	10
36	60	76	30	116	0	156	0	196	20
37	40	77	30	117	0	157	0	197	20
38	20	78	80	118	5	158	0	198	10
39	10	79	10	119	2	159	0	199	5
40	5	80	5	120	10	160	0	200	0

Sample number	Per-cent	Sample number	Per-cent	Sample number	Per-cent	Sample number	Per-cent	Sample number	Per-cent
201	0	241	10	281	27	321	25	361	--
202	0	242	10	282	36	322	40	362	26
203	0	243	15	283	--	323	98	363	30
204	0	244	15	284	20	324	20	364	21
205	1	245	25	285	99	325	17	365	9
206	5	246	10	286	38	326	11	366	--
207	15	247	10	287	20	327	28	367	0
208	15	248	15	288	14	328	--	368	5
209	99	249	2	289	7	329	--	369	5
210	95	250	0	290	8	330	0	370	3
211	70	251	0	291	1	331	0	371	0
212	15	*252	--	292	0	332	0	372	0
213	15	253	0	293	0	333	--	373	0
214	10	254	0	294	0	334	0	†374	0
215	0	255	7	295	0	335	0	375	0
216	0	256	--	296	1	336	0	376	0
217	0	257	23	297	3	337	4	377	15
218	0	258	14	298	4	338	8	378	17
219	0	259	--	299	13	339	8	379	--
220	0	260	--	300	25	340	41	380	--
221	1	261	--	301	65	341	69	381	--
222	5	262	--	302	--	342	19	382	58
223	15	263	96	303	--	343	--	383	--
224	15	264	--	304	--	344	93	384	62
225	40	265	27	305	77	345	12	385	30
226	85	266	28	306	25	346	33	386	--
227	99	267	41	307	--	347	--	387	--
228	99	268	18	308	--	348	3	388	--
229	99	269	14	309	4	349	--	389	--
230	10	270	7	310	2	350	1	390	18
231	5	271	0	311	0	351	0	391	12
232	10	272	0	312	0	352	0	392	16
233	5	273	0	313	0	353	2	393	4
234	2	274	0	314	0	354	0	394	15
235	0	275	2	315	0	355	0	395	7
236	0	276	2	316	0	356	3	396	1
237	0	277	11	317	1	357	4	397	1
238	0	278	14	318	--	358	1	398	23
239	1	279	28	319	--	359	--	399	20
240	5	280	17	320	13	360	--	400	20

Sample number	Per-cent	Sample number	Per-cent	Sample number	Per-cent	Sample number	Per-cent	Sample number	Per-cent
401	20	441	10	481	15	521	2	561	99
402	--	442	8	482	6	522	5	562	5
403	--	443	5	483	32	523	5	563	5
404	--	444	11	484	30	524	2	564	8
405	--	445	8	485	5	525	5	565	--
406	--	446	19	486	5	526	10	566	5
407	--	447	9	487	5	527	5	567	0
408	--	448	0	488	0	528	5	568	0
409	--	449	14	489	0	529	5	569	1
410	--	450	25	490	25	530	2	570	--
411	--	451	--	491	24	531	0	571	--
412	--	452	--	492	24	532	0	572	--
413	--	453	--	493	13	533	0	573	15
414	28	454	--	494	18	534	0	574	2
415	76	455	--	495	11	535	2	575	4
416	25	456	--	496	5	536	5	576	99
417	19	457	--	497	99	537	15	577	5
418	10	458	--	498	99	538	5	578	--
419	16	459	26	499	99	539	5	579	--
420	7	460	10	500	2	540	5	580	--
421	14	461	17	501	5	541	5	581	1
422	14	462	40	502	--	542	15	582	0
423	14	463	21	503	2	543	5	583	1
424	8	464	6	504	5	544	1	584	--
425	2	465	0	505	0	545	0	585	--
426	13	466	0	506	0	546	0	586	1
427	19	467	0	507	5	547	1	587	5
428	--	468	13	508	5	548	5	588	3
429	--	469	20	509	--	549	10	589	99
430	--	470	--	510	5	550	5	590	99
431	64	471	34	511	2	551	1	591	95
432	30	472	12	512	5	552	2	592	98
433	70	473	17	513	5	553	2	593	20
434	--	474	2	514	5	554	5	594	5
435	--	475	--	515	2	555	5	595	2
436	44	476	--	516	2	556	5	596	0
437	10	477	--	517	0	557	1	597	0
438	4	478	98	518	0	558	5	598	0
439	25	479	90	519	0	559	8	599	0
440	9	480	25	520	0	560	5	600	2

Sample number	Per-cent
601	2
602	8
603	15
604	--
605	5
606	--
607	--
608	50
609	5
610	2
611	1
612	2
613	0
614	0
615	0
616	0
617	1
618	2
619	3
620	5
621	--
622	--
623	--
624	--
625	--
626	99
627	--
628	4
629	3
630	3
631	1
632	0
633	0
634	0

* The data for samples 252-373 are from Bushnell (1964).
† The data for samples 374-477, 482-495 are from Maloney (1965).

APPENDIX 4. PERCENT HEAVY MINERALS IN THE SAND FRACTION OF SELECTED SAMPLES.

Sample number	Percent	Sample number	Percent
1	21.0	378	1.6
3	10.1	478	0.0
5	7.1	479	0.3
7	6.1	480	2.9
25	11.0	481	2.4
43	15.0	482	2.2
68	4.7	483	5.7
70	5.4	484	4.1
72	5.8	485	4.1
74	0.8	486	2.9
76	0.4	487	7.6
78	0.2	488	16.0
150	2.1	516	4.2
152	4.1	518	1.7
154	3.5	532	1.2
155	7.0	533	0.6
157	2.7	535	1.8
212	0.9	537	9.7
214	3.2	539	2.4
216	2.4	591	0.5
218	8.9	593	4.6
294	8.2	595	0.5
296	2.2	597	1.2
298	5.3	628	3.9
300	4.7	630	3.8
374	4.4	632	3.3
376	0.4	634	2.4

APPENDIX 5. HEAVY MINERAL COUNTS OF SELECTED SAMPLES*

(Numbers are in percents)

Sample number:	1	3	5	68	70	72	74
Actinolite	1. 3	3. 3	0. 6	5. 0	1. 0	3. 5	3. 2
Apatite	0. 3	2. 3	1. 0	--	0. 3	1. 6	1. 0
Augite**	10. 3	15. 0	9. 4	27. 2	33. 9	16. 3	35. 8
Basaltic hornblende	1. 6	1. 0	--	T	T	--	T
Diopside	1. 3	3. 6	--	8. 0	9. 8	--	--
Enstatite	T	0. 7	--	0. 6	0. 3	0. 3	0. 5
Epidote	T	0. 3	0. 3	--	0. 3	0. 3	--
Garnet	0. 6	1. 3	1. 6	1. 5	T	0. 6	0. 7
Glaucophane	--	--	--	--	--	0. 3	--
Hematite	1. 0	0. 7	1. 0	1. 2	1. 0	1. 3	0. 7
Hornblende	8. 4	19. 5	12. 6	13. 0	10. 8	14. 4	10. 5
Hypersthene	18. 4	10. 7	6. 8	4. 0	2. 6	3. 4	2. 9
Kyanite	T	0. 3	--	0. 3	0. 3	0. 3	T
Olivine	T	--	0. 3	T	T	0. 6	--
Opaque minerals***	28. 0	11. 0	21. 0	8. 4	12. 4	19. 1	12. 5
Rutile	--	--	--	--	--	0. 3	0. 2
Sphene	3. 9	1. 0	1. 9	0. 6	1. 0	0. 6	--
Spinel	--	--	0. 6	--	--	--	--
Staurolite	0. 3	T	--	0. 3	0. 7	0. 3	--
Tourmaline	--	--	--	--	0. 3	--	--
Tremolite	0. 6	--	0. 3	--	--	0. 9	0. 5
Zircon	T	T	--	0. 3	0. 3	T	--
Undifferentiated	2. 9	1. 3	3. 9	2. 8	2. 3	2. 2	2. 2
Composite grains	7. 7	12. 4	7. 1	3. 1	4. 6	4. 1	1. 5
Weathered grains and leucoxene	11. 9	14. 1	30. 3	22. 6	17. 3	28. 5	26. 0
Total grains counted	310	307	308	323	306	319	408

*Also identified but not included with the counts are: Andalusite, antigorite, biotite, chlorite, clinozoisite, cummingtonite, monazite, muscovite, pyrite, sillimanite, spodumene, topaz, and zoisite.

**Titan-augite is included with augite.

***Magnetite, ilmenite, and chromite.

"T" denotes trace.

Sample number:	76	78	150	152	154	155	157
Actinolite	4.9	4.1	4.6	5.3	4.0	2.8	1.8
Apatite	0.9	1.6	1.3	T	1.0	0.3	--
Augite**	12.4	11.6	14.3	24.2	17.8	19.2	21.3
Basaltic hornblende	0.3	0.6	0.7	T	--	T	0.3
Diopside	0.3	--	--	0.3	0.3	4.0	14.4
Enstatite	0.3	--	2.3	1.0	0.3	--	0.3
Epidote	--	--	--	--	--	0.6	T
Garnet	0.6	0.3	0.7	0.6	0.7	0.9	1.8
Glaucophane	--	--	0.3	--	0.3	--	-
Hematite	1.9	0.6	0.3	1.0	0.7	0.3	1.2
Hornblende	17.7	21.1	26.8	16.2	20.8	17.7	18.0
Hypersthene	6.2	3.8	1.3	2.3	2.0	3.4	3.6
Kyanite	T	--	--	--	--	--	T
Olivine	--	--	--	--	--	--	0.3
Opaque minerals***	10.6	16.4	11.6	17.2	17.8	0.6	12.0
Rutile	--	--	-	0.3	--	T	--
Sphene	0.6	0.3	0.3	1.0	0.3	3.4	1.8
Spinel	--	--	--	--	--	--	--
Staurolite	T	--	T	--	0.3	0.3	0.3
Tourmaline	--	--	--	--	T	--	--
Tremolite	0.3	0.6	0.7	0.3	0.3	0.3	0.3
Zircon	0.6	--	--	0.7	0.7	T	--
Undifferentiated	2.8	1.6	2.7	1.7	3.3	2.8	1.8
Composite grains	1.9	4.4	3.0	2.6	2.0	3.4	4.2
Weathered grains and leucoxene	36.8	31.5	27.3	23.1	25.4	23.5	15.3
Total grains counted	321	317	301	302	303	323	333

Sample number:	212	214	216	218	294	296	298
Actinolite	12.2	3.9	0.3	--	2.3	2.3	2.9
Apatite	0.6	T	T	--	0.3	0.7	0.7
Augite**	10.6	7.1	17.5	25.7	14.0	10.0	17.3
Basaltic hornblende	T	0.3	T	T	0.3	--	--
Diopside	--	--	4.4	6.7	10.7	6.7	0.7
Enstatite	0.6	1.0	0.3	T	1.0	--	1.0
Epidote	--	--	0.6	T	0.7	1.3	--
Garnet	--	0.3	2.2	5.4	2.6	5.3	1.0
Glaucophane	--	T	--	--	--	T	--
Hematite	0.9	1.0	0.6	T	0.3	1.0	1.0
Hornblende	--	26.7	16.9	7.3	15.7	14.0	19.2
Hypersthene	1.3	3.6	3.8	2.0	9.0	6.3	8.2
Kyanite	T	--	0.9	T	--	--	--
Olivine	--	0.7	0.3	0.3	--	0.3	0.7
Opaque minerals***	5.6	10.4	20.6	31.3	6.7	11.3	10.1
Rutile	0.3	0.3	--	--	--	0.3	1.0
Sphene	--	0.3	T	1.0	1.0	0.7	0.7
Spinel	--	--	--	0.3	--	--	--
Staurolite	--	--	0.3	0.7	0.3	0.3	--
Tourmaline	--	--	--	--	--	--	0.3
Tremolite	0.6	1.6	--	--	--	--	--
Zircon	--	--	T	1.3	--	0.7	--
Undifferentiated	3.8	2.6	1.9	1.7	3.7	2.3	2.9
Composite grains	7.8	2.7	4.4	6.7	12.0	3.3	9.2
Weathered grains and leucoxene	29.6	30.0	22.5	9.6	18.6	29.0	21.3
Total grains counted	320	307	320	300	300	300	306

Sample number:	300	374	376	378	480	482	484
Actinolite	8. 3	0. 3	1. 9	2. 3	16. 3	14. 3	3. 3
Apatite	0. 7	0. 3	T	T	T	--	--
Augite**	16. 7	8. 3	14. 5	9. 5	6. 0	8. 2	11. 0
Basaltic hornblende	--	--	0. 3	0. 7	T	--	0. 3
Diopside	0. 7	8. 6	4. 2	6. 2	--	--	1. 0
Enstatite	3. 3	--	--	0. 3	4. 3	2. 0	T
Epidote	T	0. 3	0. 3	1. 3	--	--	0. 7
Garnet	0. 7	4. 7	1. 3	0. 6	--	T	0. 3
Glaucophane	T	--	--	T	T	T	T
Hematite	0. 7	--	0. 3	1. 0	0. 3	T	0. 7
Hornblende	17. 0	13. 2	10. 0	15. 1	18. 0	22. 8	23. 6
Hypersthene	5. 3	2. 4	8. 0	7. 8	2. 6	1. 3	4. 0
Kyanite	--	--	T	--	0. 3	0. 3	--
Olivine	--	--	0. 6	--	T	--	--
Opaque minerals***	6. 0	28. 5	13. 2	6. 5	2. 0	1. 3	8. 3
Rutile	0. 3	0. 3	0. 3	0. 3	0. 7	0. 3	0. 7
Sphene	1. 0	0. 3	1. 0	0. 3	1. 7	0. 7	0. 3
Spinel	--	--	--	--	--	--	--
Staurolite	--	1. 0	0. 6	0. 3	T	--	0. 3
Tourmaline	0. 3	--	--	--	--	--	--
Tremolite	1. 3	--	1. 0	0. 3	2. 7	1. 0	0. 3
Zircon	0. 3	0. 3	T	0. 3	T	--	0. 3
Undifferentiated	5. 0	2. 4	3. 5	2. 9	2. 0	3. 4	2. 7
Composite grains	6. 0	4. 1	3. 2	4. 6	4. 3	3. 4	4. 0
Weathered grains and leucoxene	22. 7	24. 4	32. 5	38. 2	33. 9	37. 2	36. 6
Total grains counted	300	291	311	306	300	293	300

Sample number:	486	488	516	518	533	535	537
Actinolite	13.4	0.6	9.7	3.0	1.5	11.4	9.0
Apatite	T	0.3	0.7	T	T	1.0	--
Augite**	8.4	6.2	10.0	9.8	6.8	6.0	11.3
Basaltic hornblende	0.3	T	0.3	--	0.9	0.3	0.3
Diopside	--	11.5	0.7	3.9	7.4	--	1.0
Enstatite	1.3	0.9	0.3	0.7	0.9	0.6	1.0
Epidote	--	2.4	0.7	1.3	2.2	0.3	1.3
Garnet	0.3	3.2	0.7	0.7	4.3	T	1.0
Glaucophane	0.7	T	T	--	T	0.6	T
Hematite	1.0	--	1.3	1.0	0.3	0.3	0.3
Hornblende	22.5	9.4	24.1	15.2	10.5	20.9	19.0
Hypersthene	1.6	10.3	1.3	9.2	3.7	1.0	5.7
Kyanite	0.3	T	--	--	--	--	--
Olivine	--	--	--	--	--	0.6	T
Opaque minerals***	3.6	22.4	4.7	8.6	19.4	6.7	5.0
Rutile	0.7	0.6	0.3	0.3	2.2	0.3	1.3
Sphene	1.0	0.6	0.3	0.3	2.2	1.3	--
Spinel	--	T	0.3	0.3	--	--	0.3
Staurolite	--	T	--	0.3	--	--	--
Tourmaline	--	0.3	--	--	--	--	--
Tremolite	0.3	1.5	2.7	--	0.3	2.2	1.0
Zircon	--	2.4	T	0.3	0.9	--	--
Undifferentiated	3.3	5.3	3.3	2.3	1.5	2.9	2.7
Composite grains	5.9	5.0	8.0	10.9	2.5	7.6	9.7
Weathered grains and leucoxene	33.5	15.9	29.0	31.2	29.8	34.2	28.7
Total grains counted	307	340	300	304	325	315	300

Sample number:	539	591	593	595	628	630	632	634
Actinolite	10. 3	9. 3	16. 4	7. 9	7. 8	8. 2	7. 0	9. 0
Apatite	T	T	--	T	--	T	0. 3	0. 3
Augite**	7. 9	15. 0	10. 5	5. 5	7. 1	9. 5	7. 3	6. 0
Basaltic hornblende	T	T	T	--	T	--	1. 0	--
Diopside	--	--	--	--	1. 6	1. 6	0. 3	0. 7
Enstatite	1. 3	1. 3	2. 3	0. 7	4. 2	1. 9	0. 3	0. 3
Epidote	--	T	--	T	T	0. 3	0. 3	0. 3
Garnet	0. 3	--	--	0. 7	--	0. 3	T	0. 7
Glaucophane	T	T	T	T	--	--	T	0. 3
Hematite	0. 3	--	--	--	T	0. 7	1. 0	0. 3
Hornblende	22. 5	18. 0	25. 6	20. 2	25. 6	22. 8	20. 3	16. 3
Hypersthene	1. 3	2. 0	0. 7	1. 7	2. 9	3. 8	2. 3	0. 7
Kyanite	--	--	--	0. 3	--	--	--	--
Olivine	--	0. 3	0. 3	0. 3	0. 3	--	0. 3	--
Opaque minerals***	4. 0	3. 7	1. 3	4. 8	4. 5	8. 5	8. 3	5. 3
Rutile	T	0. 3	T	0. 7	0. 3	0. 9	T	1. 7
Sphene	--	--	--	--	--	--	0. 3	0. 3
Spinel	--	--	--	T	--	--	--	--
Staurolite	--	--	0. 3	--	--	--	--	--
Tourmaline	--	--	--	--	--	--	--	--
Tremolite	4. 3	1. 0	2. 6	1. 4	1. 6	2. 5	1. 0	1. 7
Zircon	--	--	--	--	--	--	T	1. 3
Undifferentiated	5. 0	3. 0	3. 9	3. 4	3. 2	3. 2	3. 7	3. 3
Composite grains	6. 0	3. 3	4. 3	9. 3	8. 4	6. 9	7. 3	5. 7
Weathered grains and leucoxene	34. 4	42. 0	29. 5	41. 2	30. 1	26. 2	37. 3	43. 3
Total grains counted	302	300	305	291	309	317	300	300

APPENDIX 6. CORE DESCRIPTIONS

Sample number

70 — Core Length: 12.4 cm

Depth Intervals	Sediment Types
0 to 3.8 cm	Light brown, fine to very fine sand. Contains two pods or burrow fillings at a depth of 3.3 cm.
3.8 to 12.4 cm	Brownish-gray silty sand. Contains two pods or burrows filled with very fine sand at depths of 7.1 and 8.4 cm.

82 — Core Length: 22.6 cm

Depth Intervals	Sediment Types
0 to 2.5 cm	Dark gray to black glauconitic silty sand with scattered rocks and pebbles. Has a 2.5 cm siltstone pebble on the surface.
2.5 to 8.9 cm	Grayish-brown, glauconitic, sandy silt with a small lens of glauconitic sand at a depth of 5.8 cm.
8.9 to 11.2 cm	Silty glauconitic sand.
11.2 to 22.6 cm	Stiff gray clayey silt containing occasional borings filled with fine glauconitic sand and sandy silt.

86 — Core Length: 32.0 cm

Depth Intervals	Sediment Types
0 to 32.0 cm	Homogenous brown clayey silt with shell fragments at depths of 21.8 and 25.4 cm.

Sample number	Depth Interval	Sediment Types
87	Core Length: 28. 0 cm	
	0 to 28. 0 cm	Brownish silty sand interspersed with burrows filled with light brown clayey silt.
99	Core Length: 29. 0 cm	
	0 to 29. 0 cm	Homogenous brownish-gray clayey silt with scattered shell fragments in the bottom 23 cm.
102	Core Length: 41. 4 cm	
	0 to 8. 7 cm	Brownish-gray glauconitic silty sand.
	8. 7 to 41. 4 cm	Stiff gray clayey silty containing shell fragments and borings filled with silt.
103	Core Length: 12. 2 cm	
	0 to 12. 2 cm	Homogenous grayish-brown glauconitic clayey silt.
104	Core Length: 28. 9 cm	
	0 to 17. 8 cm	Dark brownish-gray, fine to very fine, glauconitic, silty clay. Pebbles and burrow fillings in the bottom 12. 7 to 17. 8 cm. A worm tube is present at a depth of 15. 2 cm.

Sample number		
104 (Cont.)		
	17. 8 to 28. 9 cm	Stiff gray clayey silt.
105		Core Length: 27. 0 cm
	Depth Intervals	Sediment Types
	0 to 16. 8 cm	Dark brown to black, glauconitic silty sand. Some clay-filled burrows at a depth of 2. 5 to 3. 8 cm.
	16. 8 to 27. 0 cm	Stiff gray clayey silt. Contact between the clay and silt is greatly disturbed by burrowing.
106		Core Length: 28. 4 cm
	Depth Intervals	Sediment Types
	0 to 15. 2 cm	Grayish-brown silty sand with lenses of glauconite at depths of 2. 5, 3. 8, 12. 7, and 14. 0 cm. Several filled burrows and pebbles present.
	15. 2 to 28. 4 cm	Stiff gray clayey silt. Glauconitic, silt-filled burrows present at depths of 15. 2 to 19. 0 cm.