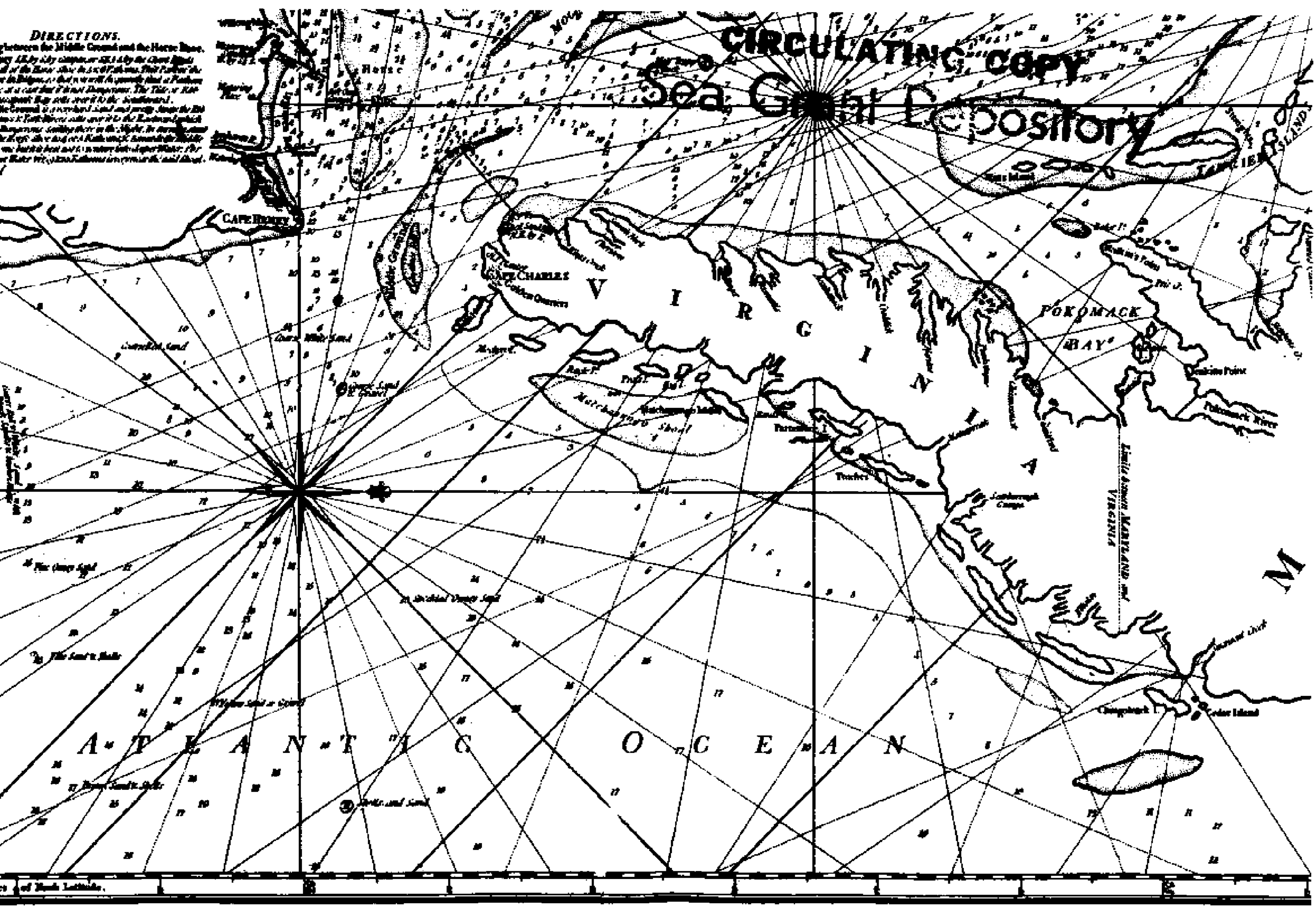
SHELF SEDIMENTS OFF CHESAPEAKE BAY

I. GENERAL LITHOLOGY AND COMPOSITION



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VIRGINIA INSTITUTE OF MARINE SCIENCE
GLOUCESTER POINT, VIRGINIA 23062

INNER SHELF SEDIMENTS OFF CHESAPEAKE BAY
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by Maynard M. Nichols

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W. J. Hargis, Jr.
Director

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Cover: Portion of an early English navigation chart dated 1776 showing bottom notations of sediment types used for navigating into the Chesapeake Entrance. This is the oldest source of information displaying sediment distributions off the Chesapeake Bay Entrance.

ABSTRACT

The sedimentary materials and bottom topography of more than 2400 square miles of the inner continental shelf floor north off the Chesapeake Bay entrance have been surveyed for potential mineral resources. Sediments consist of two principal types: (1) fine sand and (2) medium to coarse sand. The fine sand is grey-colored, subrounded, rich in quartz and relatively "clean" and well sorted. The medium-coarse sand is typically iron-stained, rich in shell and poorly sorted. The fine sand covers inner parts of the shelf floor whereas medium to coarse sand covers seaward parts. Additionally, shell-rich medium to coarse sand occurs on isolated ridges of inner parts. These preliminary geologic findings delineate several localities which contain concentrations of dark minerals, shell and gravel.

CONTENTS

INTRODUCTION

This report, the first part of several parts, presents data obtained thus far concerning the lithology and composition of bottom sediments on a portion of the inner continental shelf off Chesapeake Bay. The data were generated as part of a larger study of the shelf environment aimed to define the distribution of sediment properties. Resulting data reported here should expand our knowledge of sedimentary materials as potential mineral resources and as a substrate for bottom dwelling fish and invertebrates. Geologic interpretations and inferences are given in a separate paper.

SAMPLING PLAN

Most of the samples were taken during three cruises, August 21-25, 1961; January 22-25, 1962; and July 15-18, 1963. The location of sampling stations is given in Fig. 1. In general, stations were sampled on a basic grid consisting of stations at 2 mile (3.22 km) intervals along traverses 4 miles (6.44 km) apart. Additionally, three traverses extend across the entire shelf with stations at 3- to 10-mile (4.8 to 16.1 km) intervals. Stations are designated by a number in which the first group of three digits is taken from the degrees and minutes north of 30°00' (e.g. 37°00') and the second group of two digits, following a hyphen, is taken from the distance in miles east of the 76°00'W longitude through Chesapeake Bay entrance. The samples include a range of different sediment types from various water depths and different morphologic features. Although the station density in this area is greater than previous studies (e.g. Emery, 1966) the samples may not include all local changes because the sediment properties are so variable. Future studies utilizing a higher sampling density will undoubtedly show larger variations than reported here.

FIELD PROCEDURES

Samples were collected from the R/V Pathfinder, a 16.5 m (55 ft) oceanographic research vessel. Stations were positioned mainly by Loran bearings and also by ranging on bouys wherever possible. Accuracy of the positions is estimated to be better than 0.8 km (0.5 mi). A total of 168 samples were collected in this cruise series including subsamples for macrofauna, microfauna, grain size

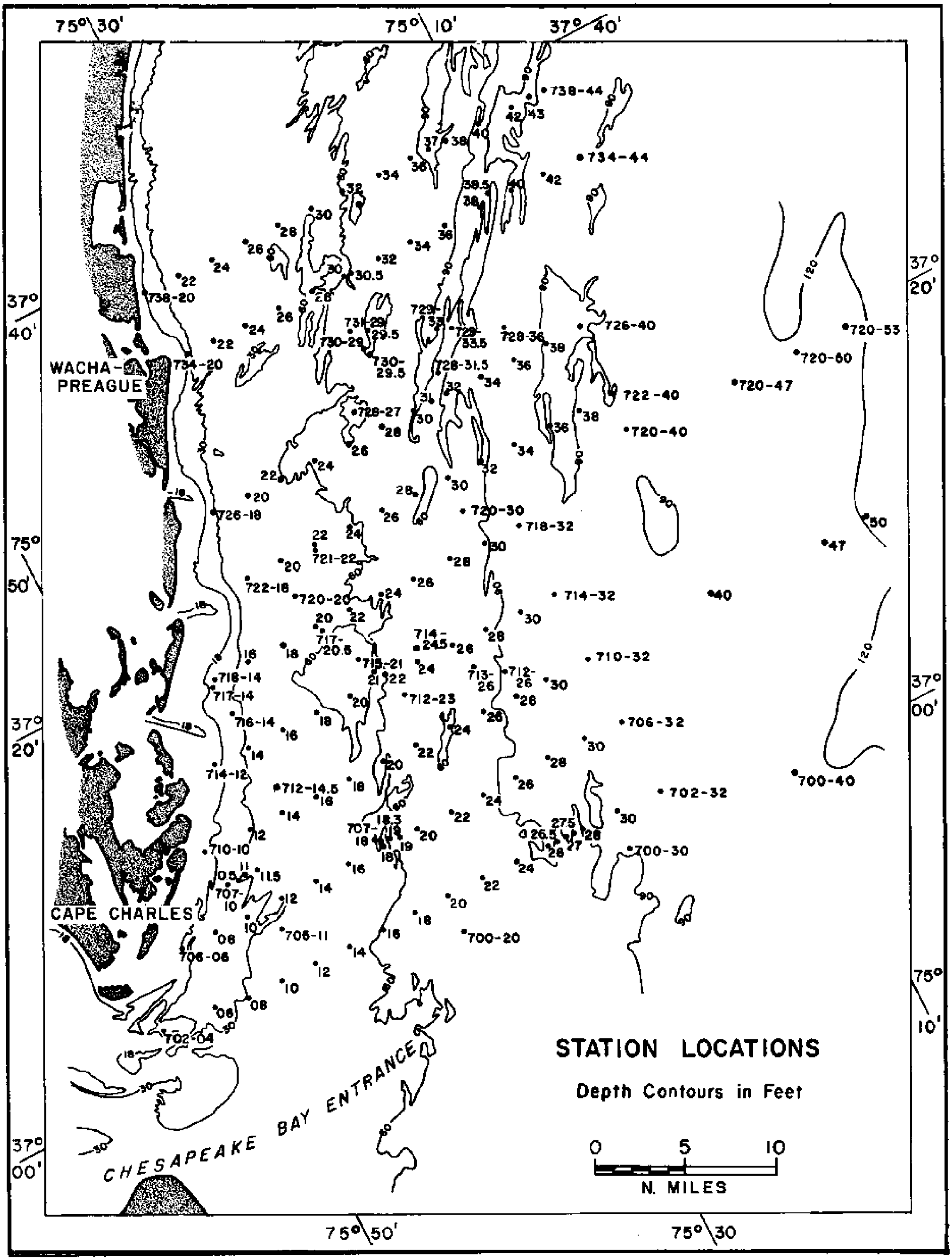

Fig. 1. Location of sampling stations and general bathymetry. For scheme of station designation, see text. Depth contours from U. S. Coast and Geodetic charts, 1109, 1221 and 1222.

and coarse fraction composition.

Most of the bottom samples were taken with a Van Veen grab which "bites" a 0.17 m^2 surface area. Penetration depth varied 2 to 16 cms. depending on the sediment type. In very coarse material and hard bottom, samples were obtained with an orange peel grab which bites about 0.10 m^2. Subsamples of about 40 ml were obtained from the grabs by punching a 5 cm diameter core tube into the surface sediment and slicing off the top 2 cm. By these procedures it was possible to obtain more or less equal area and equal volume samples, although the sediment was usually subjected to some degree of washing during retrieval from the bottom. After subsampling, the bulk of the sediment was washed through 1 and 2 mm screens to concentrate benthic organisms.

LABORATORY PROCEDURES

Particle Size Analyses

Particle size was determined by a combination of sieving, settling and pipette analysis. Samples were initially washed through 0.062, 1 and 2 mm size sieves. The fraction finer than 0.062 mm was collected in a large evaporating dish and run by pipette analysis following procedures of Folk (1961). The fractions coarser than 1 and 2 mm were dried, weighed and their weight percentage (of the total sample) determined. The sand fraction of 0.062-1.00 mm size was run in a Woods Hole rapid sediment analyser according to procedures of Zeigler, Whitney and Hayes (1960). Measured settling velocities were converted to nominal diameters by using the tables of Zeigler and Gill (1959) and a shape factor of 0.7. Results of the analyses from sieving, settling and pipette, were combined and plotted as cumulative curves on probability paper using a logarithmic phi (Ø) scale for grain diameter where Ø is $-\log_2$ of the diameter in millimeters. The particle diameters at the 20, 50 and 80 percentiles were obtained from the curves and used to derive the following statistical measures:*

$$\text{Median diameter } (Md\emptyset) = \emptyset 50$$

$$\text{Mean diameter } (Mz\emptyset) = \frac{(\emptyset 20 + \emptyset 50 + \emptyset 80)}{3}$$

$$\text{Deviation measure (sorting) } (So\emptyset) = \frac{(\emptyset 80 - \emptyset 20)}{2}$$

The primary and secondary modes were determined from the size frequency curves to the nearest 0.02 mm. Results of the size analyses are tabulated in Appendix I.

Coarse Fraction Analyses

The composition of the sand fraction (0.062-1.00 mm) was determined under a binocular microscope following the technique of Shepard and Moore (1954). A split of sample material obtained by sieving in the initial size analyses, was spread out on a gridded petri dish and at least 300 grains were counted along the grid lines. Major constituents identified in this study were light-colored minerals (mainly quartz, but including some feldspar), dark-colored minerals including both pyroxene-hornblende and magnetite-ilmenite groups plus others undifferentiated and shell fragments. Among the minor constituents were mica, fragments of wood and plants, benthic diatoms, foraminifera and ostracods. Spines, coal, cinder and glauconite are present in trace amounts. Each grain type has a characteristic color, luster, morphology, microstructure and optical properties

* Ø20, Ø50, Ø80 are the diameters in phi units corresponding to the 20th, 50th and 80th percentiles respectively of the cumulative weight-percent coarser curves.

by which it is recognized. Descriptions of diagnostic features are given in Appendix II. Frequency counts by number were reduced to percent of the whole coarse fraction and results are listed in Appendix III.

RESULTS

Most of the bottom sediments consist of two textural types: (1) fine sand and (2) medium and coarse sand. The medium and coarse sand type is often rich in shell and typically iron-stained as distinguished by its orange-brown color. Mud (silt and clay), gravel and pure shell are subordinate types that occur locally. The distribution of sediment types is shown in Fig. 2. This chart is compiled mainly from general visual observation of sediment size and compositio and supplemented by bottom notations on U. S. Coast and Geodetic Survey charts dated 1934-1938. Sediment containing more than 2% shell in the total sample is called "shelly," and greater than 2% gravel is called "gravelly." A sample with more than 80% shell is taken as "pure shell." In general, fine sand is distributed over a wide area of the inner shelf mainly off the Chesapeake Bay entrance whereas medium to coarse sand occurs farther seaward. Additionally, shell-rich medium to coarse sand occurs as patches in the fine sand type, often on ridge crests.

Mean diameters, Appendix I, range from 0.15 to 2.2 mm with low values in the fine sand type and high values in the shelly, coarse-sands type farther seaward. Most shelf sediments are well sorted and have one mode, but locally, along the boundary between principal types especially in zones of relief, shell and coarse sand are mixed with fine sand, producing a poorly sorted sediment with two or more modes.

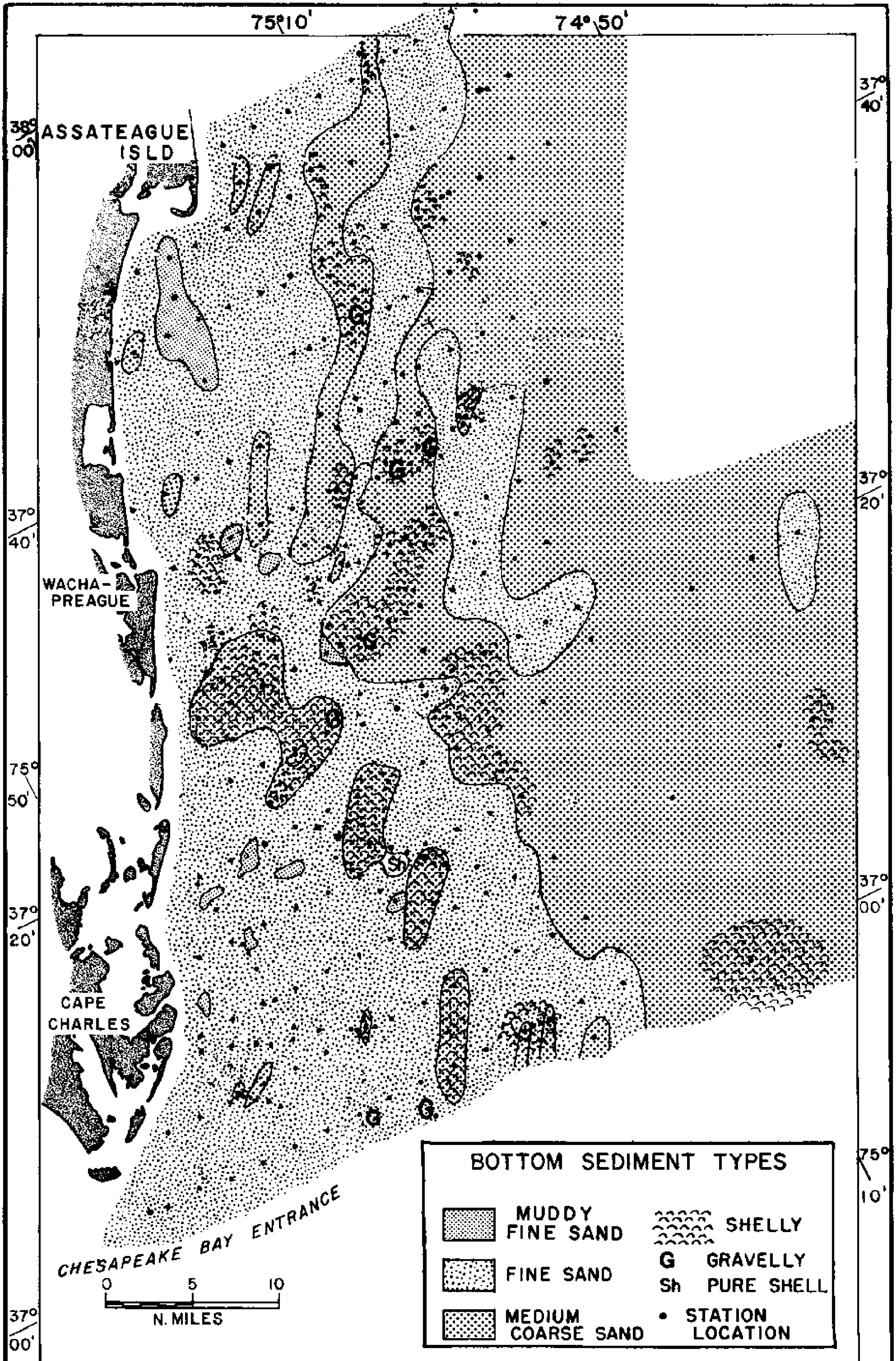

Fig. 2. General distribution of bottom sediment types.

Frequency counts of different sand components indicate that the sediment mainly consists of light minerals, chiefly quartz, which makes up more than 90% of the sand at most stations. The iron-stained particles are believed to be older sediment deposited during the Pleistocene stages of lower sea level. Dark minerals are relatively scarce, less than 8% and biologic constituents are rare, less than 2%. The distribution of foraminifera is presented in a separate study (Delaney, 1968). Sediments found on the shelf off Chesapeake Bay are comparable to those reported by Shepard and Cohee (1936) in the New York Bight. However, unlike the northern region, sediments off the Chesapeake have only trace amounts of the mineral glauconite, and are generally finer grained.

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APPENDIX I

Particle Size Analyses Data

Station	Median, Md, mm	Mean, Mz, mm	Sorting, So,	Mode, Mo,* mm
700-30	0.287	0.27	0.52	0.29
700-40	0.395	0.40	0.54	0.35
700-47	0.170	0.15	0.70	0.15
700-50	0.185	0.19	0.61	0.16
706-06	0.168	0.18	0.64	0.13, 0.31
706-08	0.128	0.12	0.74	0.12
706-10	0.153	0.16	0.76	0.14
706-12	0.182	0.19	0.75	0.17
706-14	0.129	0.13	0.77	0.12
706-16	0.127	0.13	0.83	0.12
706-18	0.154	0.17	0.63	0.12
706-20	0.197	0.19	0.73	0.13
710-10	0.149	0.15	0.76	0.13, 0.25
710-12	0.153	0.15	0.76	0.14
710-14	0.127	0.12	0.74	0.125
710-20	0.280	0.18	0.74	0.25, 0.29
710-30	0.165	0.16	0.80	0.15
710-40	0.370	0.36	0.66	0.24
710-47	0.313	0.38	0.78	0.31, 0.25
710-50	0.552	0.54	0.80	
710-53	0.372	0.36	0.71	0.25, 0.28, 0.32
710-56	0.290	0.28	0.74	0.20
714-12	0.162	0.16	0.74	0.12, 0.17
714-14	0.143	0.14	0.76	0.12
714-16	0.198	0.21	0.78	0.19
714-18	0.196	0.20	0.76	-
714-20	0.175	0.18	0.69	0.12
714-22	0.135	0.14	0.81	0.12
714-24	2.2	----	----	0.65, 2.0
714-26	0.198	0.22	0.70	0.16
714-28	0.167	0.17	0.80	0.16
714-30	0.170	0.18	0.72	0.15
714-32	0.432	0.43	0.73	0.35, o.45, 0.59
718-14	0.149	0.15	0.85	0.14
718-16	0.137	0.14	0.80	0.14
718-18	0.188	0.15	0.73	-
718-20	0.149	0.15	0.80	0.15
718-22	0.193	0.20	0.72	0.16
718-24	0.829	0.81	0.67	0.45, 2.0
718-26	0.243	0.24	0.76	0.23

* Primary mode underlined

APPENDIX I, cont'd.

Station	Median, Md., mm	Mean, Mz, mm	Sorting, So,	Mode, Mo,* mm
718-28	0.198	0.19	0.81	0.16, 0.21
718-30	0.570	0.52	0.67	
718-32	0.377	0.39	0.70	0.29, 0.39, 0.53, 0.59
720-20	0.170	0.24	0.46	0.14
720-30	0.245	0.26	0.60	-
720-40	0.258	0.26	0.75	0.22
720-47	0.335	0.27	0.76	0.29, 0.39
720-50	0.697	0.69	0.81	0.69
720-53	0.210	0.22	0.70	0.19
720-59	0.338	0.34	0.42	0.36
702-04	0.256	0.26	0.80	0.230
702-05	0.181	0.18	0.81	0.170
704-05	0.195	0.20	0.75	0.190
708-00	0.138	0.14	0.91	0.125
710-16	0.183	0.19	0.69	0.150
710-18	0.168	0.17	0.72	0.140
710-20	0.176	0.18	0.74	0.180
710-22	0.137	0.14	0.76	0.120
722-18	0.166	0.17	0.76	0.145
722-20	0.164	0.16	0.75	0.130
722-22	0.240	0.25	0.68	0.190
722-28	0.229	0.24	0.73	0.190
722-32	0.264	0.25	0.81	0.230, 0.270
722-32N	0.340	0.34	0.71	0.260, 0.350
722-34	0.415	0.42	0.66	0.250, 0.350
722-38	0.173	0.18	0.78	0.170
722-40	0.184	0.19	0.67	0.195
726-18	0.260	0.25	0.72	0.190
726-20	1.870	1.73	2.95	0.290, 0.390, 0.490 0.130
726-22	0.820	1.01	0.49	0.750
726-24	0.227	0.12	0.72	0.190
726-26	0.219	0.12	0.65	0.190
726-28	1.650	2.93	0.24	0.800
726-30	0.640	0.61	0.84	0.650
726-31	0.263	0.24	0.72	0.210, 0.330
726-32	0.555	0.54	0.52	0.390, 0.450, 0.550
726-34	0.217	0.22	0.69	0.150
726-36	0.152	0.15	0.82	0.110, 0.150
726-38	0.265	2.93	0.24	0.230

APPENDIX I, cont'd.

Station	Median, Md, mm	Mean, Mz, mm	Sorting, So,	Mode, Mo,* mm
726-40	0.341	0.35	0.76	0.250, 0.310
728-36	0.161	0.17	0.78	0.145
729-33.5	0.375	0.38	0.76	0.370
731-29	0.180	0.18	0.75	0.150
731-29.5	0.168	0.17	0.81	0.170
734-20	0.158	0.16	0.70	-
734-22	0.150	0.20	0.49	0.170, 0.230
734-24	0.161	0.16	0.79	0.150
734-26	0.241	0.24	0.69	0.180
734-28	0.194	0.20	0.66	0.170
734-30	0.771	0.76	0.62	0.650
734-32	0.213	0.21	0.74	0.130, 0.290
734-34	0.775	0.72	0.58	0.750
734-36	1.150	1.17	0.49	0.750
734-38	0.149	0.15	0.83	0.170
734-38.5	0.369	0.34	0.64	0.345
734-39	0.293	0.31	0.78	0.290, 0.250
734-40	0.222	0.22	0.74	0.180
734-42	0.186	0.20	0.66	0.165
734-44	0.413	0.38	0.77	0.375
738-20	0.158	0.17	0.70	0.130
738-22	0.292	0.28	0.80	0.240, 0.290
738-24	0.235	0.24	0.74	0.190, 0.230
738-26	0.224	0.23	0.74	0.190, 0.250
738-28	0.243	0.26	0.74	0.210, 0.310
738-30	0.775	0.23	0.76	0.750
738-32	0.189	0.27	0.76	0.165
738-34	0.201	0.78	0.80	0.170
738-36	0.167	0.17	0.84	0.160
738-37	0.378	0.27	0.60	0.280
738-38	0.378	0.21	0.75	0.390, 0.330
738-40	0.282	0.18	0.74	0.200
738-42	o.163	0.38	0.74	0.150
738-44	0.232	0.38	0.80	0.190

APPENDIX II

CHARACTERISTICS OF SAND COMPONENTS

Light Minerals

This group consists mainly of quartz and small proportions of feldspar. Quartz is mainly colorless but also honey-colored, pink or light green and is largely angular or subangular but often subrounded. It is transparent or translucent and has a vitreous luster. Subconchoidal or conchoidal fracture distinguishes quartz from feldspar which displays a basal cleavage with cleavage planes at nearly right angles. Feldspar from the shelf floor is commonly opaque and light grey to greyish white. Often both quartz and feldspar are stained with iron oxide as distinguished by brownish orange to dark brown color.

Dark Minerals

Included in this group are dark colored grains of pyroxenes, amphiboles, and rock fragments, iron oxides such as magnetite and ilmenite, glauconite and garnet. They are commonly green and translucent, angular and prismatic or elongate and tabular. Others are black, opaque and subrounded. The rock fragments, though rare, often consist of grey micaceous schist and are usually subrounded to rounded. Glauconite occurs as infillings in foraminiferal tests and as dark green to black ovoid grains with cracked surfaces having white infillings. Glauconite is very rare.

Mica

This group includes forms of mica, muscovite and biotite. They are subtranslucent to opaque, colorless and green or dark greenish grey and have a vitreous or pearly luster. It is distinguished by strong basal cleavage and thin cleavage sheets.

Shell

This consists of fragments and small whole specimens of pelecypods, a few gastropods and echinoderms. Shell is calcareous, opaque and commonly white in color or occasionally light grey or purple. Iron-stained grains are brownish orange to dark brown. Broken fragments are conchoidal, laminar or slightly fibrous on broken edges. Fragments are often rounded on edges and display numerous solution cavities. Echinoderms exhibit basal plates of spine attachment whereas pelecypods display growth lines.

Wood and Plant Fragments

This group consists of fibrous "leafy" and "woody" fragments that are usually brown in color but often "charred" black on exterior surfaces due to aging. They are either straight, slightly curved or ribbon-shaped and often "blocky" along broken edges.

Foraminifera

This group mainly consists of calcareous benthic forms but also includes a few benthic arenaceous specimens. Tests consist of aggregations of chambers in various arrangements coiled planispiral or trochospiral. The most dominant species are Elphidium clavatum, Elphidium incertum, Eggerella advena and Discorbis sp. Most specimens are white with a dull or pearly luster. They are subtranslucent to opaque. Species found on the shelf are illustrated by Delaney (1968).

Ostracod

These are a class of Crustacea consisting of small lentil-shaped, thin-walled calcareous shells. Living specimens have hinged pairs with overlapping valves but dead specimens consist of single detached valves often broken. The valves are white in color, subtranslucent to opaque, and often ornamented with slight depressions and ridges. Species for the shelf are described by Hulings (1966).

Spines

These consist mainly of echinoid spines that are rod shaped with cell-like markings along the spine length. Spines are often broken and fibrous on broken ends. They are white in color, translucent to opaque and calcareous.

Diatoms

These are unicellular plants recognized by siliceous cell walls or frustules. They are triangular shaped, rod-or ribbon-like, or pillbox shaped, subtransparent to transparent and colorless. Many specimens display an internal or external iridescence or series of spectral colors.

APPENDIX III, Sediment type and percentage sand composition (by number) of 0.062 - 1.00 mm size.

STATION	SEDIMENT TYPE	SAND COMPOSITION IN PERCENT								
		Light Minerals	Dark Minerals	Mica	Shell	Wood-Plant Fragments	Forams	Ostracods	Diatoms	Spines
700-20	Fine Sand	86.7	3.0	7.0	1.0	0.7	1.0	Tr	0.6	
700-30	Medium Sand	90.1	8.5	Tr	1.0		0.3	Tr		
700-40	Shelly Medium Sand	91.4	6.1	0.3	1.2		0.7	0.3		
700-47	Fine Sand	89.0	9.6		0.7	Tr	0.7	Tr		
700-50	Shelly Fine Sand	90.4	10.0		2.2	Tr	Tr	Tr		
702-04	Medium Sand	94.9	5.1	Tr	Tr					
702-06	Fine Sand	89.2	9.1	0.5	1.2	Tr	Tr			
702-08	Fine Sand	91.6	7.4	1.1	Tr	Tr	Tr			Tr
702-10	Fine Sand	89.8	7.6	2.0	0.1	0.5	Tr			
702-12	Fine Sand	90.4	8.2	1.1	0.3	Tr	Tr			Tr
702-14	Fine Sand	92.0	6.9	0.9	0.1	Tr	Tr			Tr
702-16	Fine Sand, Gravel	95.9	3.1	0.5	0.2	0.2	0.2			
702-18	Fine Sand	91.6	7.7	0.7	Tr	Tr	Tr			
702-20	Fine Sand	84.4	14.9	0.2	0.4		Tr			Tr
702-22	Shelly Medium Sand	86.0	7.7	0.3	6.1					
702-24	Fine Sand	85.7	12.6	0.5	1.2	Tr	Tr	Tr		
702-26	Shelly Fine Sand	86.3	8.4	0.4	4.9		Tr	Tr		Tr
702-26.5	Shelly Medium Sand	90.5	4.3		5.2		Tr			
702-27	Shelly Fine Sand	89.9	7.9	0.7	1.5	Tr	Tr			Tr
702-27.5	Fine Sand	92.4	6.9		0.7		Tr			
702-28	Shelly Medium Sand	83.5	2.8	Tr	13.4		0.4			Tr
702-30	Fine Sand	93.4	5.7	0.9	Tr		Tr			Tr
702-32	Shelly Fine Sand	93.6	5.0	0.6	0.8		Tr	Tr		
705-11	Fine Sand	89.8	9.3	0.6	0.3			Tr	Tr	
706-06	Fine Sand	95.1	4.0	0.3	0.3	Tr	0.3	Tr		
706-08	Fine Sand	97.9	1.3		0.7		0.1			
706-10	Fine Sand	90.1	9.3	0.3	Tr		0.3			
706-12	Fine Sand	98.1	1.2		0.3	Tr	0.4			
706-14	Fine Sand	92.6	6.0	0.8	0.3	Tr	0.3		Tr	
706-16	Fine Sand	92.3	8.0		Tr	Tr	0.7	Tr		

APPENDIX III, cont'd.

STATION	SEDIMENT TYPE	SAND COMPOSITION IN PERCENT								
		Light Minerals	Dark Minerals	Mica	Shell	Wood-Plant Fragments	Forams	Ostracods	Diatoms	Spines
706-18	Fine Sand	94.6	4.0		0.7	Tr	0.6	Tr		
706-19	Shelly Fine Sand	91.6	7.1	Tr	1.3		Tr			Tr
706-20	Fine Sand	89.6	10.1	Tr	Tr		0.3			
706-22	Fine Sand	88.8	10.2	0.2	0.1	0.2	0.5	Tr		
706-24	Shelly Medium Sand	83.9	3.8	11.3	Tr	1.0				
706-26	Fine Sand	92.4	7.3	0.3	Tr		Tr			
706-28	Fine Sand	92.8	7.1	Tr	0.1		Tr			
706-30	Fine Sand	91.4	7.5	Tr	1.5		Tr		Tr	
706-32	Shelly Medium Sand	90.3	8.6	Tr	1.2		Tr			Tr
707-10	Shelly Coarse Sand	81.8	8.5	1.1	8.0	0.7				
707-10.5	Shelly Fine Sand	76.4	20.5	Tr	3.1					
707-11	Shelly Coarse Sand	82.5	3.0	0.2	13.7		Tr			Tr
707-11.5	Fine Sand	91.9	6.8	Tr	1.3					
707-18	Fine Sand	89.5	9.1	0.5	0.9		Tr	Tr		Tr
707-18.3	Fine Sand	90.9	8.6	Tr	0.3	Tr	Tr			
707-18.5	Shelly Fine Sand	86.1	5.9	0.5	7.2		0.3			Tr
710-10	Fine Sand	98.5	1.0	0.3	Tr		0.3	Tr		
710-12	Fine Sand	93.8	5.0	0.7	0.3		0.2			
710-14	Fine Sand	94.7	4.0	0.3	0.7	Tr	0.3			
710-16	Fine Sand	94.4	4.3	0.7	0.2		0.2		0.2	Tr
710-18	Fine Sand	94.1	5.0	0.7	0.2		Tr		Tr	
710-20	Medium Sand	92.4	7.0		0.3			0.3		
710-22	Fine Sand	88.2	7.7	1.3	Tr					0.1
710-24	Fine Sand	86.1	7.7	0.4	5.8		Tr	Tr		
710-26	Fine Sand	90.4	9.1	Tr	0.5		Tr	Tr	Tr	Tr
710-28	Fine Sand	92.1	6.7	0.8	0.3	Tr	Tr			Tr
710-30	Fine Sand	89.8	9.4	0.6	0.2		Tr			Tr
710-32	Fine Sand	91.0	8.7	0.3	Tr	Tr	Tr			Tr
710-40	Medium Sand	95.9	3.0	0.3	0.7	Tr		Tr		
710-47	Medium Sand	92.3	7.0		0.3			0.3		

APPENDIX III, cont'd.

STATION	SEDIMENT TYPE	SAND COMPOSITION IN PERCENT								
		Light Minerals	Dark Minerals	Mica	Shell	Wood-Plant Fragments	Forams	Ostracods	Diatoms	Spines
710-50	Shelly Coarse Sand	90.8	0.7		8.5			Tr		
710-53	Medium Sand	96.7	3.0		0.3			Tr		
710-56	Medium Sand	95.4	4.0		0.3	Tr		0.3		
712-14.5	Fine Sand	87.0	10.9	0.2	1.8			Tr		
712-23	Fine Sand	89.8	10.2	Tr	Tr		Tr	Tr	Tr	
712-26	Shelly Coarse Sand	70.4	3.1		26.3		Tr			0.2
713-26	Shelly Medium Sand	49.5	1.8		48.7			Tr	Tr	
714-12	Fine Sand	93.7	5.0	1.0	Tr	Tr	0.3	Tr		
714-14	Fine Sand	98.1	1.0	0.3	Tr	Tr	0.6	Tr		
714-16	Fine Sand	92.7	7.0		Tr	Tr	0.3	Tr		
714-18	Fine Sand	94.7	4.0	1.0	Tr		0.3			
714-20	Fine Sand	96.1	3.0	0.3	Tr		0.6	Tr		
714-21	Shelly Medium Sand	56.5	3.9	Tr	39.0	0.7	Tr			Tr
714-22	Fine Sand	94.1	4.5	0.7	Tr		0.7	Tr		
714-24	Shell	9.7	0.3		90.0					
714-24.5	Fine Sand	90.2	8.0	1.0	0.8		Tr			Tr
714-26	Fine Sand	94.5	5.0	0.3	Tr		0.3	Tr		
714-28	Fine Sand	98.5	1.0		0.3		0.2	Tr		
714-30	Fine Sand	97.0	2.0	0.7	0.3					
714-32	Shelly Medium Sand	71.0	0.7	0.3	28.0					
715-21	Fine Sand	90.1	8.7	0.4	0.4		0.5			Tr
716-14	Shelly Fine Sand	85.3	11.7	0.6	2.4			Tr		
717-14	Fine Sand	91.9	7.6	0.3	0.2		Tr			
717-20.5	Fine Sand	91.1	8.4	Tr	0.5		Tr			Tr
718-14	Fine Sand	95.0	4.0	0.4	Tr		0.6			
718-16	Fine Sand	88.0	11.0	0.7	0.3		Tr			
718-18	Fine Sand	90.1	9.2		Tr	Tr	0.7	Tr		
718-20	Fine Sand	90.1	8.0	0.7	0.3		0.6	0.3		
718-22	Fine Sand	95.3	4.0		Tr		0.7	Tr		
718-24	Shelly Coarse Sand	59.0	1.0		40.0					

APPENDIX III, cont'd

STATION	SEDIMENT TYPE	SAND COMPOSITION IN PERCENT								
		Light Minerals	Dark Minerals	Mica	Shell	Wood-Plant Fragments	Forams	Ostracods	Diatoms	Spines
718-26	Medium Sand	96.7	3.0		Tr	Tr	0.3	Tr	Tr	
718-28	Fine Sand	96.8	3.0		Tr		0.2		Tr	
718-30	Shelly Coarse Sand	67.5	2.0		30.5					
718-32	Shelly Medium Sand	98.7	1.0		Tr		0.3	Tr		
720-20	Medium Sand	90.7	7.0	1.0	0.3	Tr	1.0	Tr		
720-30	Medium Sand	86.6	11.0	0.7	1.0		0.7	Tr		
720-40	Medium Sand	95.4	4.0		0.3		0.3	Tr		
720-47	Medium Sand	96.7	3.0		Tr	Tr	0.3	Tr		
720-50	Coarse Sand	98.0	1.0		0.3	Tr	0.1	Tr		
720-53	Fine Sand	94.3	5.0		Tr		0.7	Tr		
720-59	Medium Sand	94.7	5.0		Tr	Tr	0.3	Tr		
721-22	Fine Sand	85.4	14.3	0.3	Tr		Tr			
722-18	Fine Sand	88.4	10.0	0.3	0.7	Tr	0.6		Tr	
722-20	Fine Sand	92.4	6.0	0.3	0.6		0.7	Tr		
722-22	Shelly Medium Sand	88.1	11.0	0.7	0.2		Tr	Tr		
722-24	Shell									
722-26	Fine Sand, Mud	93.9	4.7		100	0.1	0.6		Tr	Tr
722-28	Fine Sand	93.0	6.3	0.7	Tr	Tr	Tr	Tr		Tr
722-30	Fine Sand, Mud	93.1	4.0	1.0	0.6	Tr	1.0	Tr		0.3
722-32	Shelly Medium Sand	94.6	3.7	0.7	0.7		0.3			Tr
722-32.5	Medium Sand	95.4	3.8	0.3	0.2		0.3			Tr
722-34	Shelly Medium Sand	95.4	2.8	1.0	0.6	0.2	Tr	Tr		Tr
722-36	Fine Sand	93.5	3.7	1.3	0.3	0.2	1.0	Tr	Tr	Tr
722-38	Fine Sand	93.3	6.0	0.7	Tr	Tr	Tr	Tr		Tr
722-40	Fine Sand	93.5	4.3	0.3	0.6	Tr	1.1	0.2	Tr	Tr
726-18	Shelly Medium Sand	94.8	4.0	1.0	Tr		0.2	Tr		
726-20	Shelly Coarse Sand	89.3	7.0	2.7	0.7	Tr	0.3	Tr	Tr	Tr
726-22	Shelly Coarse Sand	96.5	2.3	0.3	0.9	Tr	Tr	Tr	Tr	Tr
726-24	Fine Sand	94.4	4.3	0.7	Tr		0.6	Tr	Tr	Tr
726-26	Fine Sand	93.1	6.3	0.3	0.3	Tr	Tr		Tr	

APPENDIX III, cont'd.

STATION	SEDIMENT TYPE	SAND COMPOSITION IN PERCENT								
		Light Minerals	Dark Minerals	Mica	Shell	Wood-Plant Fragments	Forams	Ostracods	Diatoms	Spines
726-28	Gravelly Shell	97.2	0.7	0.3	1.3	Tr	0.2	Tr	0.3	Tr
726-30	Coarse Sand	97.0	1.0		Tr	Tr	Tr	Tr	Tr	Tr
726-31	Fine Sand	96.1	3.3	0.3	0.3		Tr	Tr		Tr
726-32	Coarse Sand	94.6	4.7	0.7	Tr		Tr	Tr	Tr	Tr
726-34	Fine Sand	94.3	4.7	1.0	Tr		Tr	Tr		Tr
726-36	Fine Sand	93.4	6.3	1.3	Tr		Tr	Tr	Tr	Tr
726-38	Medium Sand	92.7	6.0	1.3	Tr		Tr	Tr		Tr
726-40	Medium Sand	95.3	3.7	1.0						
728-27	Shelly Fine Sand	85.2	6.1	0.3	8.4		Tr			
728-31.5	Shelly Coarse Sand	88.5	6.3	Tr	6.2		Tr			
728-36	Fine Sand	91.2	9.0	0.3	0.2	0.3	Tr		Tr	Tr
729-33	Shelly Fine Sand	83.0	11.7	1.0	3.3		0.5	Tr	0.2	Tr
729-33.5	Medium Sand	95.3	4.0	0.7	Tr		Tr	Tr		Tr
730-29	Medium Sand	95.9	3.5	0.6	Tr					Tr
730-29.5	Fine Sand	88.4	11.2	0.4	Tr					Tr
731-29	Fine Sand	92.3	7.0	0.7	Tr	Tr	Tr	Tr	Tr	Tr
731-29.5	Fine Sand	90.5	8.3	1.0	0.2		Tr	Tr		Tr
734-20	Fine Sand	93.7	4.7	0.3	0.5	0.2	0.4	Tr	0.2	Tr
734-22	Shelly Fine Sand	92.5	4.0	1.0	2.0	Tr	0.2	0.3		Tr
734-24	Muddy Fine Sand	89.3	10.0	1.7	0.2	0.2	0.3	Tr	0.2	0.1
734-26	Medium Sand	95.3	3.7	0.7	0.3		Tr	Tr	Tr	Tr
734-28	Fine Sand	89.5	9.7	0.3	0.2	Tr	0.3	Tr		Tr
734-30	Coarse Sand	98.4	1.0	0.3	0.3					
734-30.5	Shelly Medium Sand	95.0	3.8		1.2		Tr			
734-32	Fine Sand	91.1	8.0	0.7	Tr	Tr	0.2	Tr	Tr	Tr
734-34	Coarse Sand, Gravel	99.0	0.7		0.3	Tr	Tr		Tr	
734-36	Shelly Coarse Sand, Gravel	98.0	1.7	0.3	Tr		Tr		Tr	Tr
734-38	Fine Sand	91.0	7.0	1.0	0.2	Tr	0.6	Tr	Tr	0.2
734-38.5	Medium Sand	92.2	6.0	0.7	0.4	Tr	0.5	0.1		0.1
734-39	Medium Sand	94.8	4.3	0.3	0.6		Tr	Tr	Tr	Tr

APPENDIX III, cont'd

STATION	SEDIMENT TYPE	SAND COMPOSITION IN PERCENT								
		Light Minerals	Dark Minerals	Mica	Shell	Wood-Plant Fragments	Forams	Ostracods	Diatoms	Spines
734-40	Fine Sand	90.0	9.0	1.0	Tr	Tr	Tr			Tr
734-42	Fine Sand	91.7	7.0	1.3	Tr	Tr	Tr	Tr		Tr
734-44	Medium Sand	97.9	1.3	0.3	0.6		Tr	Tr		Tr
738-20	Fine Sand	91.7	8.0	0.3	Tr		Tr	Tr		
738-22	Medium Sand	93.5	5.3	0.7	0.5	Tr	Tr	Tr	Tr	
738-24	Fine Sand	94.3	5.0	0.3	0.3		Tr	Tr	0.1	Tr
738-26	Fine Sand	88.8	11.0		0.2		Tr	Tr	Tr	Tr
738-28	Medium Sand	94.3	5.7		Tr		Tr			Tr
738-30	Fine Sand	92.7	7.0	0.3	Tr					Tr
738-32	Medium Sand	94.2	5.7		0.1			Tr		
738-34	Coarse Sand	99.4	0.3	Tr	0.1	Tr			Tr	Tr
738-36	Fine Sand	89.7	9.3	0.3	Tr		0.6			0.1
738-37	Medium Sand	91.3	8.0	0.7	0.3	Tr	0.5	Tr	Tr	0.2
738-38	Fine Sand	92.4	6.3	0.3	0.2	Tr	0.6	0.2		Tr
738-40	Fine Sand	92.0	5.7	1.0	0.6	Tr	0.5	0.2	Tr	Tr
738-42	Medium Sand	96.5	4.0	Tr	0.5			Tr	Tr	Tr
738-44	Medium Sand	98.1	1.3		0.6		Tr	Tr		