UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

Textural, physiographic, bathymetric, and geologic factors controlling economic heavy minerals distribution in surficial sediments on the Atlantic Continental Shelf offshore of New Jersey

by

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Open-File Report 89-683

Prepared in cooperation with the New Jersey Geological Survey and Rutgers University

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ABSTRACT

Data from 76 ocean floor grab samples from the New Jersey continental shelf show patterns of heavy-mineral distribution that are controlled by texture, physiography, and bathymetry. Concentrations of heavy minerals average 3.61 in a range of 0.36 to 12.80 weight percent. The economically valuable heavy minerals ilmenite, rutile, leucoxene (altered ilmenite), zircon, monazite, and aluminosilicates reach a 5.1 weight percent on a bulk sample basis.

Coast-parallel paleobarrier deposits of the mid-shelf province (20-40 m depth interval) along with sediments of the nearshore (<20 m isobath) province contain the highest concentrations of heavy minerals, and are here identified as principal targets for exploration. Heavy-mineral values are shown to decrease consistently with water depth with a concurrent increase in the less economically important minerals magnetite, garnet, pyroboles, and epidote.

Strong correlation of total and economic heavy-mineral percentages of samples with total gamma-ray activity of bulk samples indicates that exploration for offshore deposits of heavy minerals can be conducted by use of submersible gamma-radiation detection systems. The data show that the cumulative effects of rising sea-level and later modification by shelf currents have not modified the mineralogic and textural characteristics of the mid-shelf beach-complex sediments beyond recognition, and that heavy-

mineral data can be of fundamental utility to mapping the geology and resolving the geologic evolution of the surficial sediments on the New Jersey Shelf.

INTRODUCTION

The Proclamation of the United States Exclusive Economic Zone (EEZ) in March 1983 nearly doubled the jurisdictional area of the United States. Although the location, concentration, and abundance of resources in the EEZ are poorly understood, many strategic and critical minerals are known to exist (Grosz, 1987).

As part of a larger effort to assess the mineral resource potential of the sediments within the U.S. Exclusive Economic Zone, grain-size distribution and mineralogic components and concentrations were determined for 76 surface grab samples that were collected from the Continental Shelf offshore of New Jersey. The grab samples were collected by the Woods Hole Oceanographic Institution in cooperation with the U.S. Geological Survey in a joint program of study of the Atlantic continental margin of the United States started in the 1960's.

Data presented in this report indicate that the sediments offshore of New Jersey may have potential for a number of strategic and critical heavy minerals if concentrations and compositions of heavy-mineral assemblages measured in surficial sediments are persistent with depth. The observed heavy-mineral assemblages include ilmenite, rutile, zircon, and monazite as well as species of lesser economic importance such as garnet, staurolite, sillimanite, and kyanite.

SAMPLE ACQUISITION

The suite of small-volume grab samples utilized in this study consists of spatially well distributed samples (Figure 1) from offshore of New Jersey.

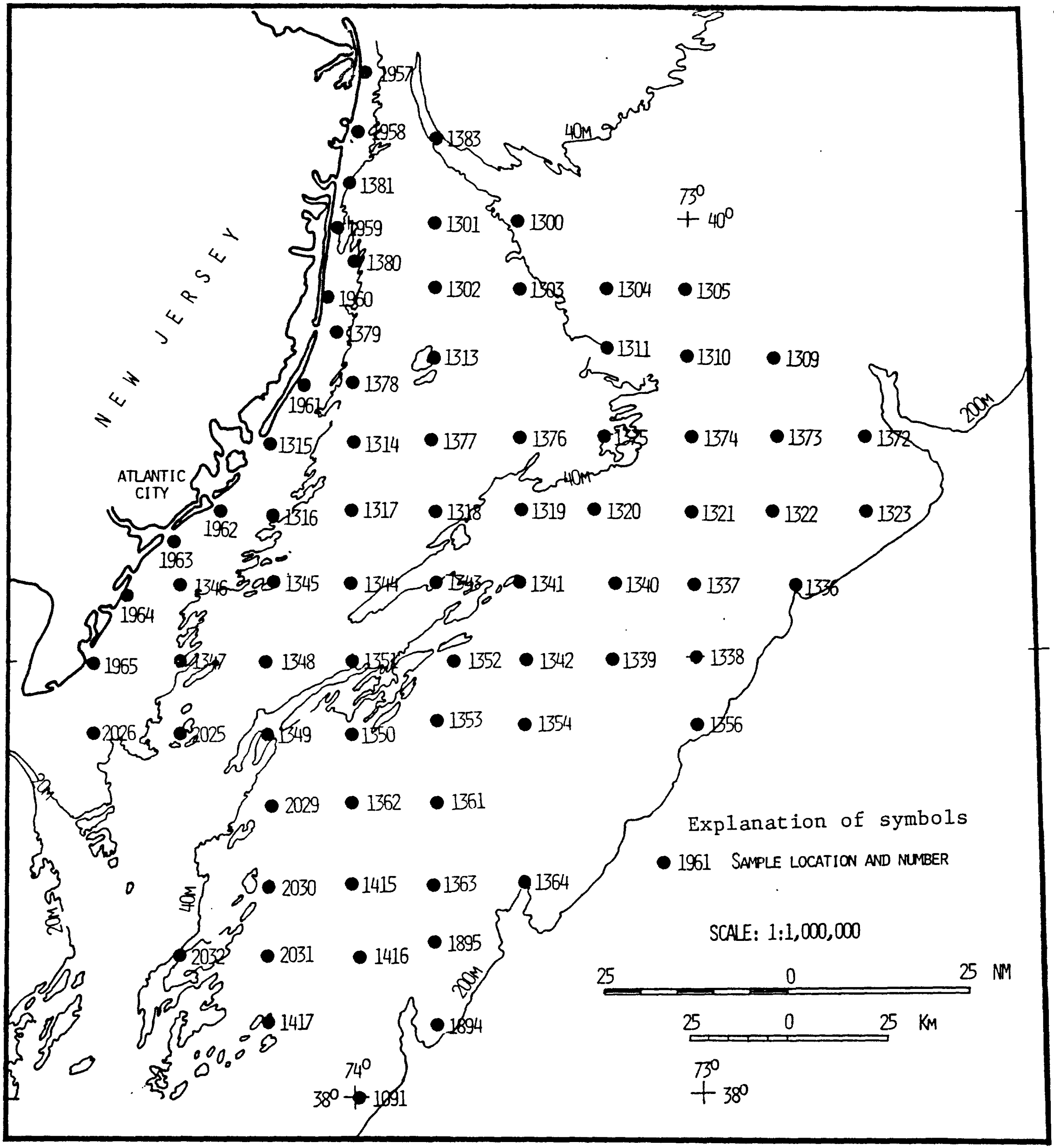

Figure 1.--Map showing the locations of surficial grab samples from the continental shelf offshore of New Jersey. Labeled lines give depth in meters.

However, the wide spacing between samples (20 km) precludes the determination of absolute relationships between them. The 76 grab samples are retained in the USGS collection at Woods Hole Oceanographic Institution, MA (Hathaway, 1971). The accuracy of the sample locations is estimated to be within about 1 nautical mile of the coordinates given in Table 1. Because the samples were collected with Campbell and Smith-McIntyre grab-samplers, part of the fine-grained material may have been lost from coarse-grained or gravelly sediments.

LABORATORY PROCEDURES

An average of 230 grams of bulk sample (in a range of 101 to 331 grams) from each location was split and sieved in dry condition into three textural classes: 1) gravel and very coarse sand (>16 mesh), 2) coarse- to very fine-grained sand (<16 to >325 mesh), and 3) silt to clay (<325 mesh). The heavy-mineral content of the coarse- to very fine-grained sand fraction was separated using bromoform (SG >2.85). As large a split as could be derived from the archived sample was used for the separation of heavy minerals because some mineral species, such as monazite are present in very small quantities. Smaller samples are less likely to contain rare minerals (see for example, Clifton and others, 1969).

The heavy minerals of each sample were separated into three magnetic sub-fractions on a Frantz Isodynamic Magnetic Mineral Separator (0.0 to 0.5 ampere, 0.5 to 1.0 ampere, and >1.0 ampere) after the highly magnetic minerals were removed by use of a hand-held magnet. Each sub-fraction was weighed and studied independently with petrographic and reflected light microscopes. The identification of some minerals was made by X-ray diffraction. Comparison charts (Terry and Chillingar, 1955) and point-counting were utilized to estimate mineral abundances in each magnetic sub-fraction.

The identification of zircon and monazite was aided by the use of long- and short-wave ultraviolet illumination. Values for individual mineral species in each magnetic sub-fraction were summed and calculated as percentages of the total heavy-mineral fraction. Densities were not compensated for by this method. The results are given in Table 1.

RESULTS

The average gravel content (>2.00 mm size fraction) for the 76 samples is 4.2 weight percent in a range of 0.0 to 50.7 percent. The particles in this size fraction are composed of carbonate (shells and shell fragments), quartz pebbles, and rock fragments. The sand-size fraction (2.00 to 0.0625 mm) constitutes an average of 94.2 weight percent in a range of 49.2 to 100.0 percent of the bulk sample. Quartz is the dominant constituent in the study area, but a significant portion of this size fraction consists of carbonate locally. The silt-size fraction (0.0625 to 0.0039 mm) averages 1.1 weight percent in a range of 0.0 to 21.4 percent. The clay-size fraction (<0.0039 mm) averages 0.6 weight percent in a 0.0 to 14.9 percent range.

The percentage of heavy minerals (calculated as a percentage of the bulk sample on a dry weight basis) ranges from 0.35 to 12.80, but averages 3.61 percent. The heavy-mineral assemblage consists of (in decreasing order of abundance) ilmenite (including leucoxene: altered ilmenite), pyroboles (undifferentiated pyroxene and amphibole), garnet, aluminosilicates (undifferentiated sillimanite, kyanite, and andalusite), epidote, staurolite, tourmaline, magnetite, monazite, zircon, and rutile. An "others" group was also estimated and includes unidentified opaques and non-opaques, quartz, clay balls, polymineralic grains, sulfides, and glauconite, among others.

DATA ANALYSIS

A cumulative-frequency histogram of percentage coarse sand and gravel

(>16 mesh fraction, Table 1) by weight plotted against the number of samples indicated that below the 10 percent interval the change in number of samples per weight percent coarse sand and gravel class-interval becomes much more gradual (Figure 2). The change in slope at the 10 percent interval was set as an arbitrary boundary for the separation of samples into "gravel" and "sand" classes. Therefore, samples having a coarse sand and gravel content greater than 10 were placed in the "gravel" category, whereas all others were classified as "sand". Statistics are given for samples sorted by this criterion in Table 2.

The inner-outer shelf boundary at the 40 m isobath (Swift and others, 1973) was used to group samples. The inner shelf is further subdivided into nearshore (<20 m isobath) and mid-shelf (20-m to 40-m isobath) provinces (Stubblefield and others, 1983). Cumulative statistics (Table 2) for samples are grouped according to these bathymetric intervals.

Preliminary analysis of the data shows patterns of mineral distribution on the New Jersey shelf that are controlled by the bathymetric and textural criteria. The percentage of heavy minerals decreases overall with depth (Figure 3, and Table 2); higher values are associated with the 25 to 40 m depth interval (the mid-shelf), geologically the paleobarriers of Swift and others (1973), and Stubblefield and others (1983). The abundance of economic heavy minerals (EHM, defined as the sum of ilmenite + leucoxene (altered ilmenite) + rutile + zircon + monazite + aluminosilicates in the heavy-mineral suite) on a bulk sample basis (EHM/T, Table 1) also show overall decrease with depth (Table 2), with notable high values spanning the 25 to 40 m depth interval.

Gamma-ray activity (expressed as counts per minute per gram of bulk sample) is highest in inner shelf sands, averaging 0.93 CPM/g as compared

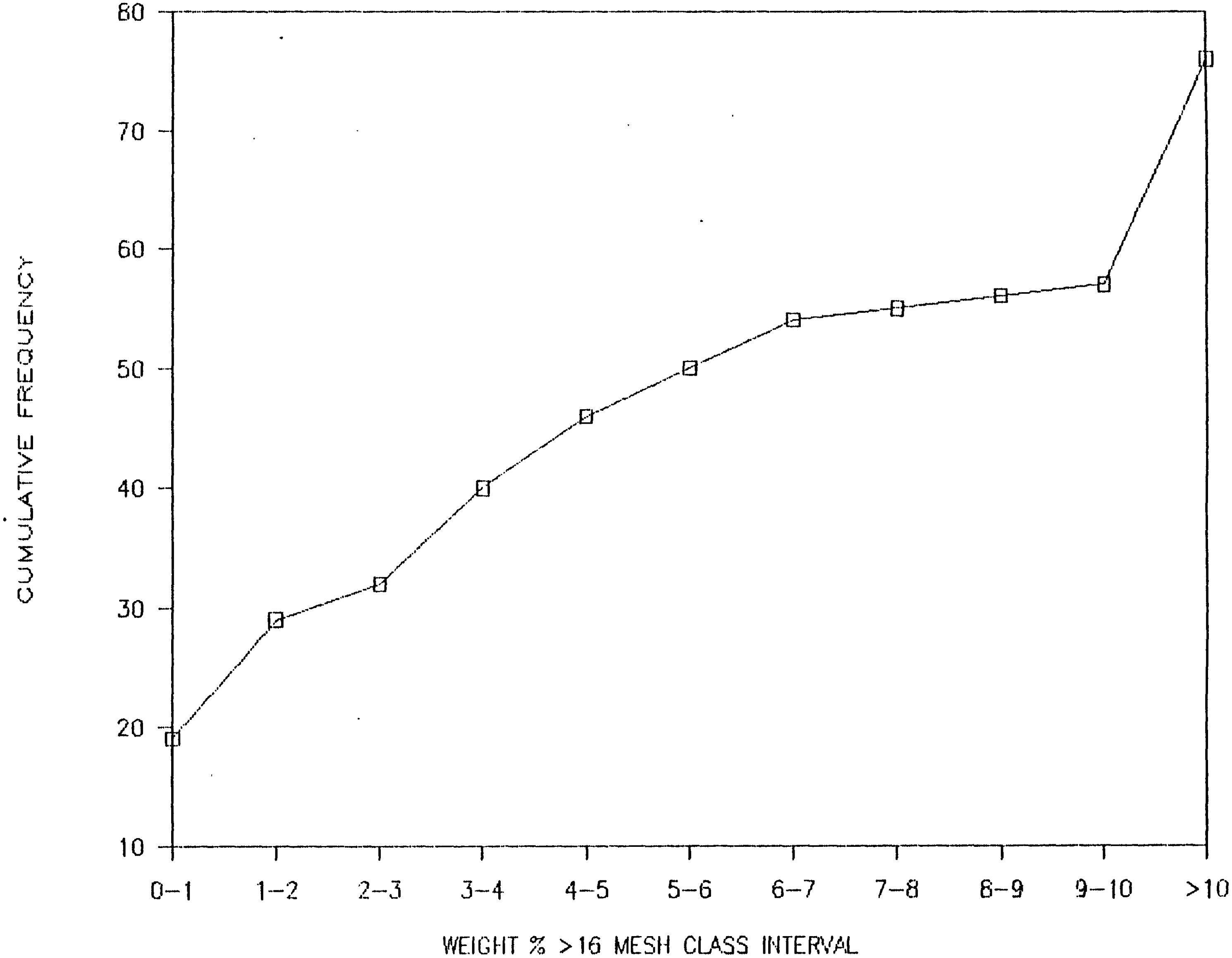

Figure 2.--Plot showing cumulative frequency of samples against weight percentage of greater than 16 mesh fraction.

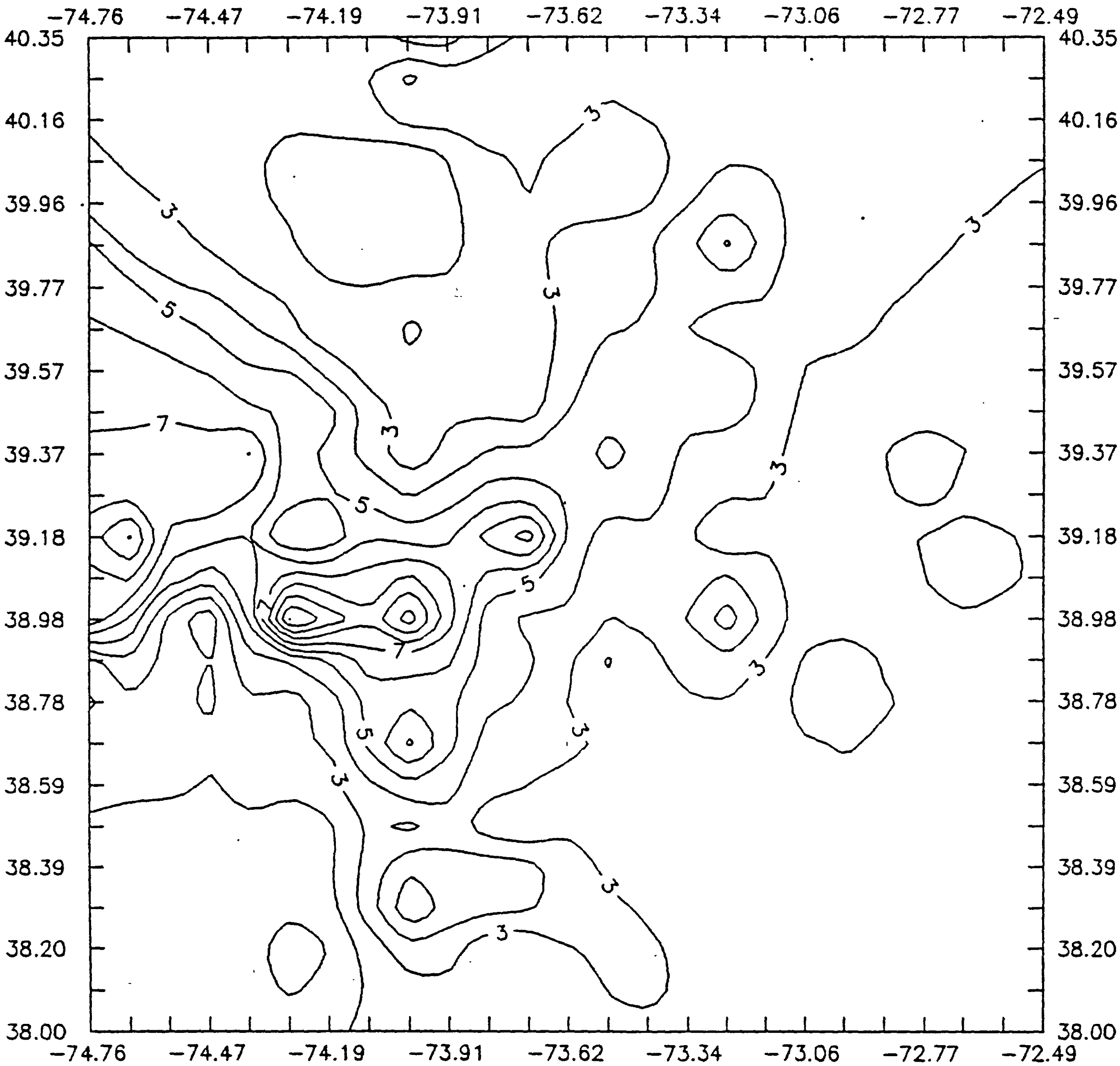

Figure 3.--Sketch contoured plot of the percentage of heavy minerals.

Contours are in weight percent heavy minerals.

to 0.35 CPM/g in gravels (Table 2). Within the inner shelf province, gamma activity tends to be higher in the nearshore sediments than in the mid-shelf sediments (Table 2). A strong linear relationship between the heavy-mineral content of a sample and its gamma activity (Figure 4) shows that the overall radioactivity of the ocean floor samples is controlled by radioactive minerals (probably monazite and zircon) in the heavy-mineral suite. Further, the data shows gamma activity to be an excellent quantitative predictor of the economic heavy-mineral component on a bulk sample basis (Figure 5). These relationships are consistent with onshore observations of coastal plain sediments (Mahdavi, 1964; Force and others, 1982; Grosz, 1983; Grosz and others, in press).

Gravel is more abundant in inner shelf sediments than in outer shelf sediments; within the inner shelf province it is more abundant in the nearshore zone where water depths are shallower than 20 m. Sands contain nearly twice the heavy minerals that gravels do. Two distinct and one less distinct coast-parallel zones of heavy-mineral concentration are evident on Figure 6. Concentrations are associated with 1) a zone of nearshore sediments extending from Ocean City to the vicinity of Cape May, 2) with a coast-parallel sand-ridge system near the 40-m isobath (the paleobarriers previously mentioned), and 3) a less distinct zone in the middle portion of the outer shelf region as indicated on Figure 6.

Gravels are enriched in ilmenite (including leucoxene), zircon, garnet, and staurolite in comparison to sands; whereas monazite and pyroboles are more abundant in sands. Inner shelf sediments contain higher concentrations of ilmenite (including altered ilmenite), zircon, and aluminosilicates than outer shelf sediments. Magnetite, garnet, epidote, and pyroboles tend to be more abundant in outer shelf sediments than in inner shelf sediments.

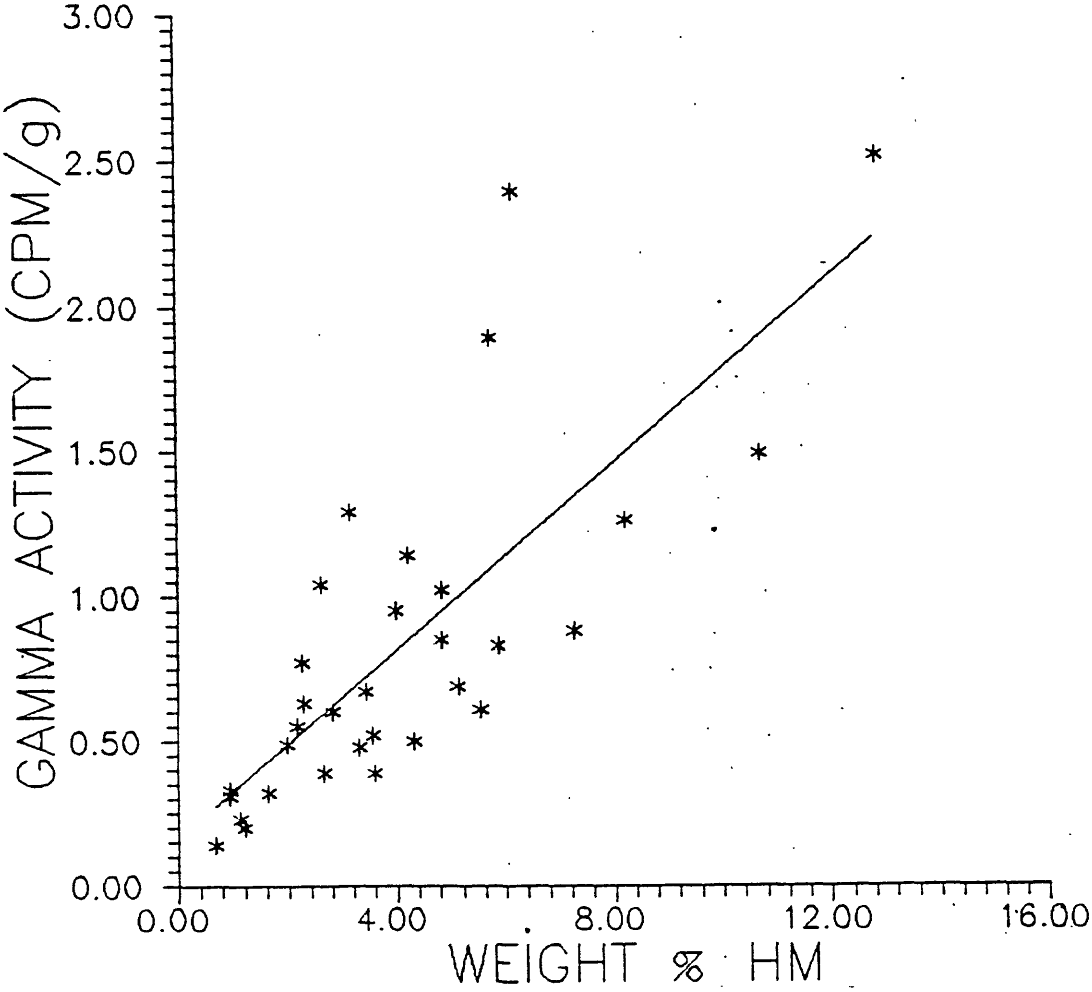

Figure 4.--Plot of gamma activity and total heavy-mineral content of bulk sediments. Line is linear best fit curve.

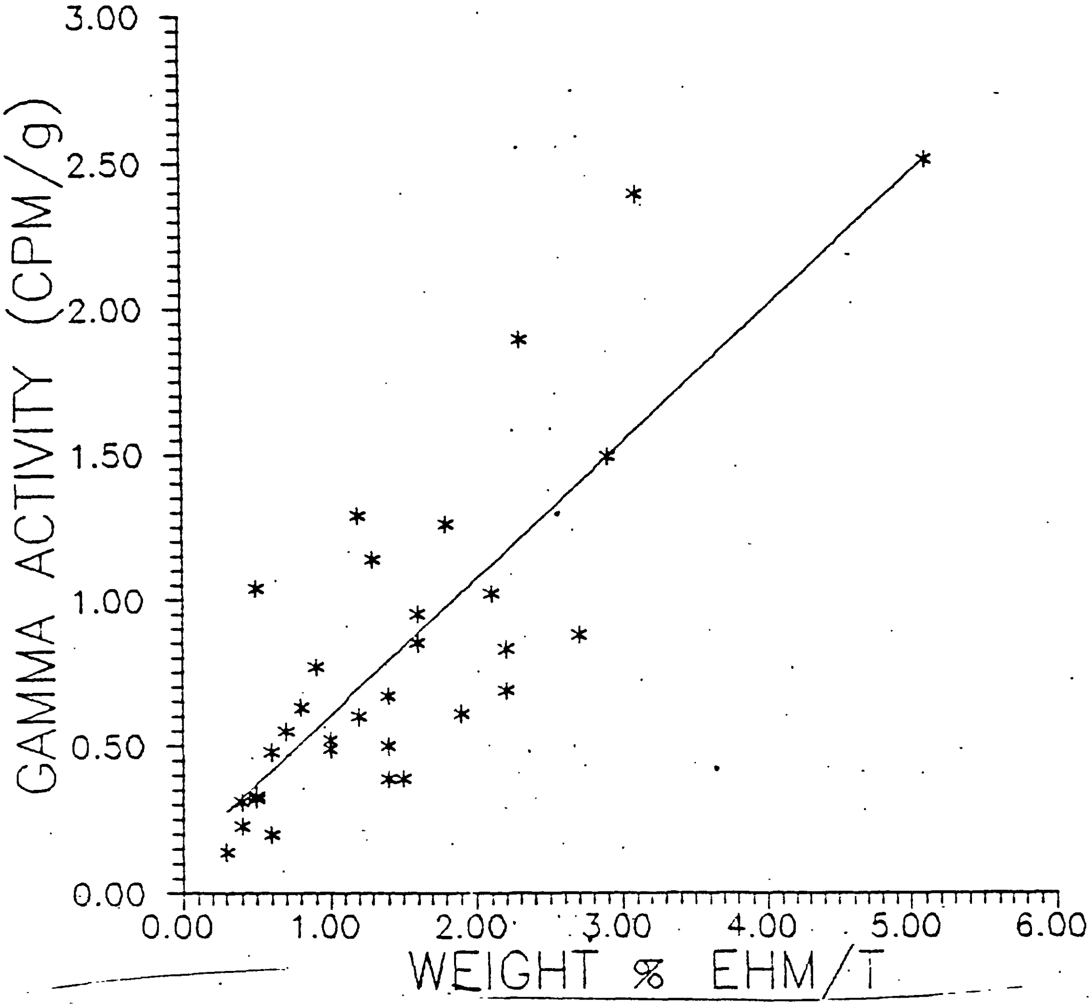

Figure 5.--Plot of gamma activity and economic heavy-mineral content of bulk samples. Line is linear best fit curve.

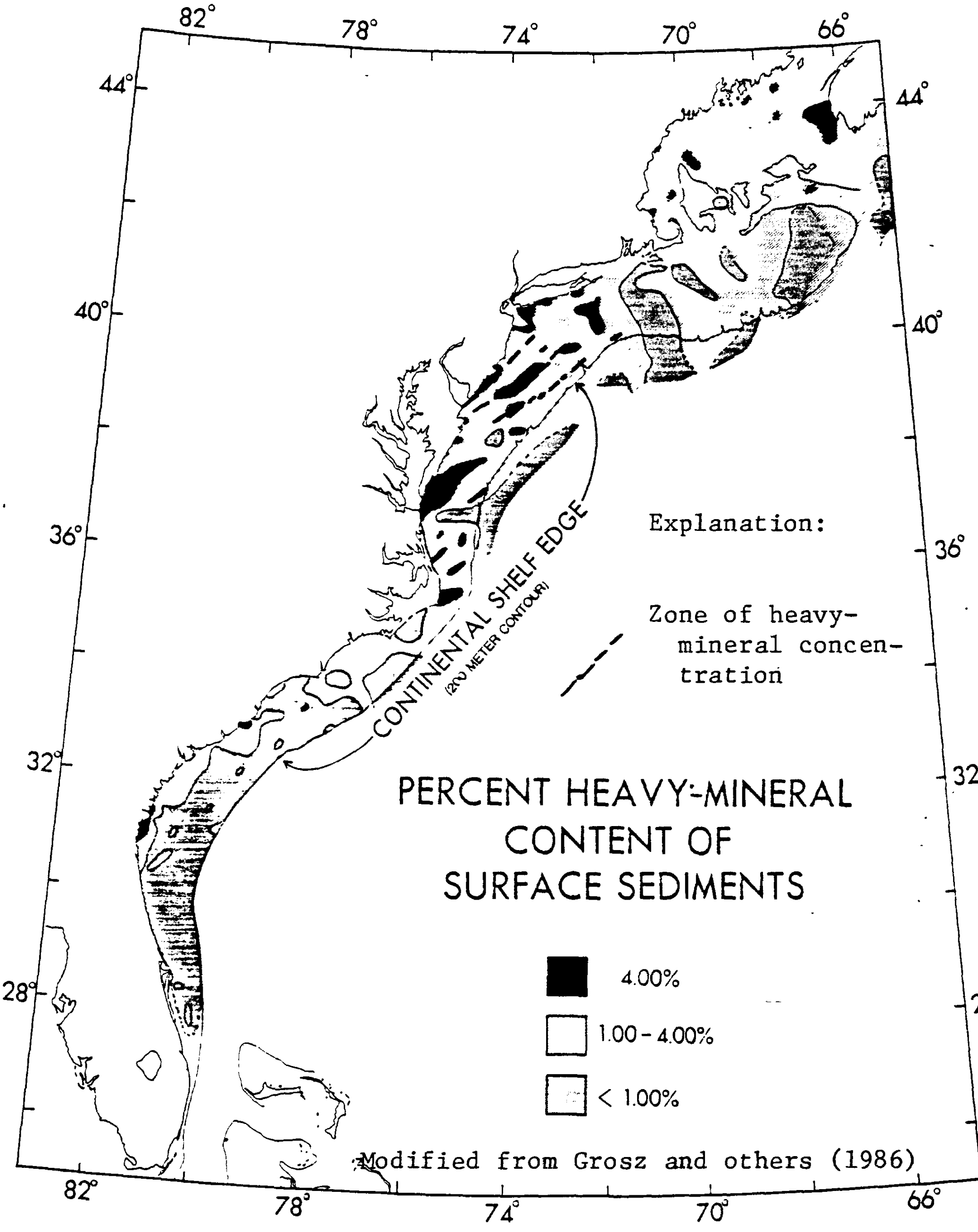

Figure 6.--Map showing the distribution of total heavy minerals in surficial sediments of the Atlantic Continental Shelf.

Although gravels have the highest absolute values of EHM/C the distribution of economic heavy minerals calculated on the basis of their percentage of the bulk sample shows sands (averaging 1.7 weight percent EHM/T) and inner shelf sediments (averaging 1.6 weight percent EHM/T) to hold the highest potential for placer resources on the New Jersey Shelf.

ZTR indices calculated for these samples show that gravels (as a group) and inner shelf (specifically nearshore) sediments are texturally most mature in the study area. High textural maturity is associated with extensive reworking, a process known to be an effective concentrator of heavy minerals. The ZTR index shows an overall decrease with depth (Figure 7); higher values associated with inner shelf depth intervals are consistent with this province being referred to as hosting high energy paleobarrier deposits.

As nearshore marine deposits may be subject to extended periods of subaerial weathering (a process that removes the labile heavy minerals magnetite, garnet, epidote and pyroboles), inner shelf sediments should have the smallest labile mineral component, followed by mid-shelf sediments. Deep water sediments, on the other hand, should have considerably higher labile mineral components as they would have been least weathered. Figure 9 is supports these contentions.

PRELIMINARY CONCLUSIONS

Data generated for the New Jersey continental shelf show patterns of heavy-mineral distribution closely controlled by texture, physiography, and bathymetry. High concentrations of heavy minerals are associated with texturally and chemically mature (as shown by high ZTR index and low labile mineral component) sediments of the nearshore and mid-shelf provinces. The mid-shelf ridges have been interpreted as submerged paleobarriers that

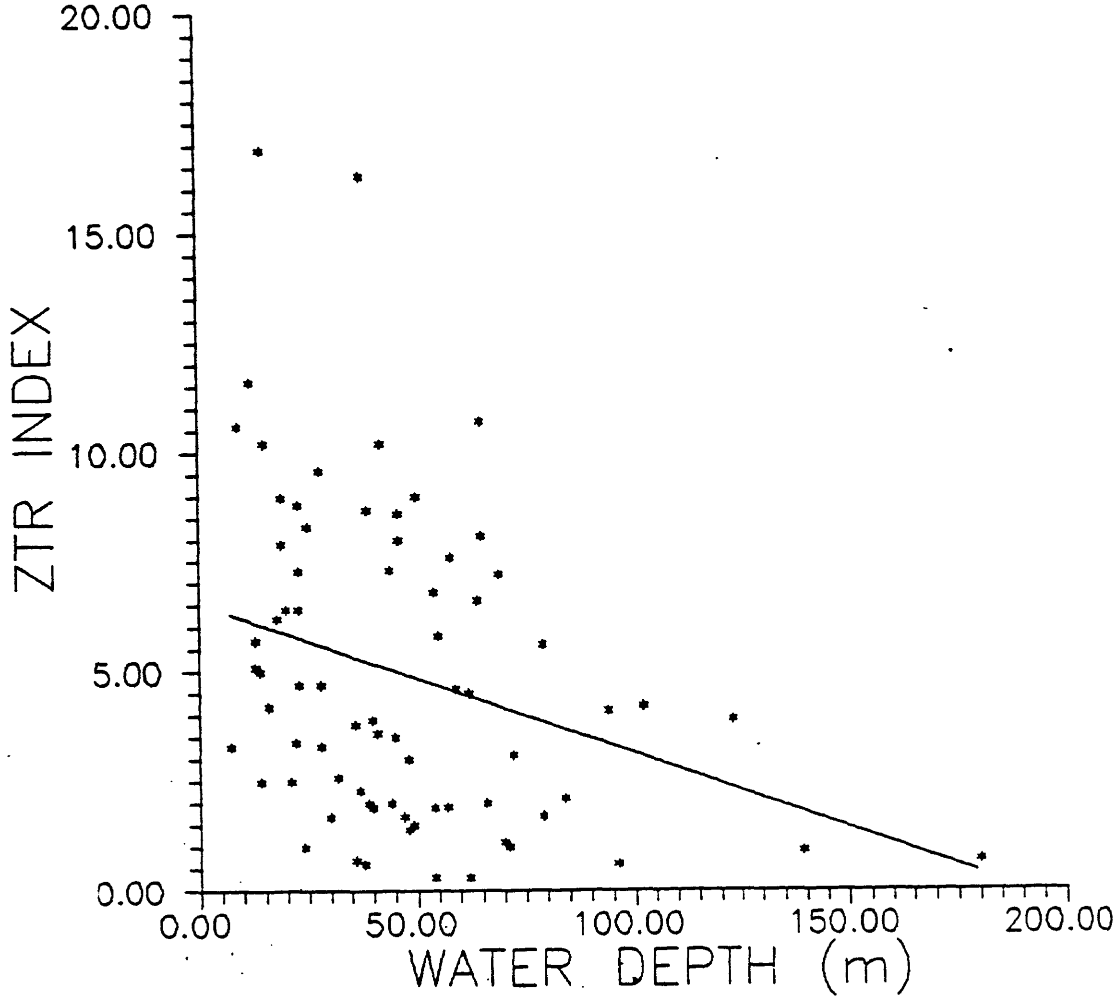

Figure 7.--Plot of the ZTR index as a function of water depth.
Line is linear best fit curve.

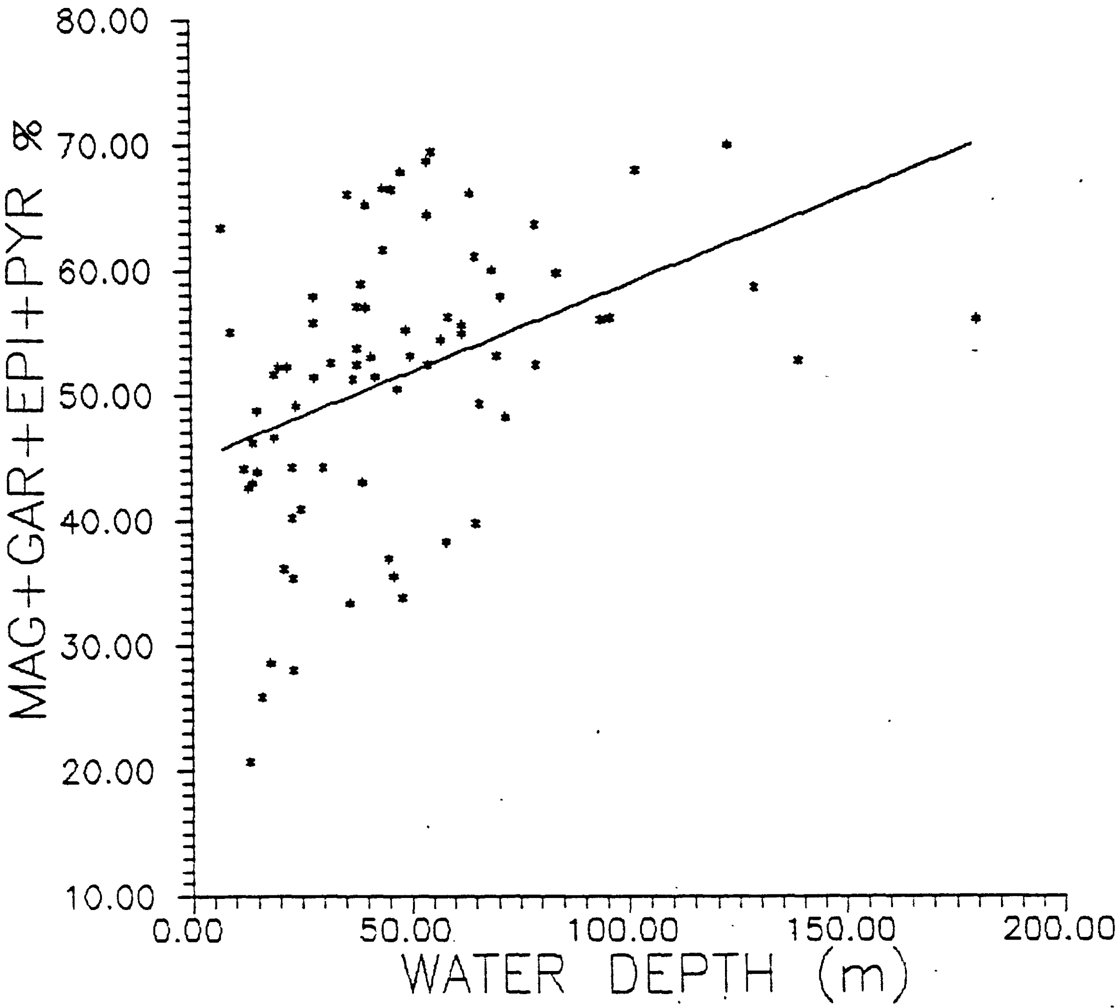

Figure 8.--Plot of labile heavy-mineral content of surficial sediments as a function of water depth. Line is linear best fit curve.

developed between 8,000 and 14,000 years B.P and were subsequently modified by shelf currents (Swift and others, 1973; Stubblefield and others, 1983). The data shows that the cumulative effects of sea-level transgression and subsequent modification by shelf currents have not eradicated (or dispersed beyond recognition) the characteristic mineralogic and textural fingerprints of the mid-shelf beach-complex sediments. These features, subjects of intensive studies and speculation in the published literature, appear to be relict. Thus, the use of heavy-mineral data is shown to be of fundamental utility in mapping the geology and resolving the geologic evolution of the surficial sediments on the New Jersey Continental Shelf.

Comparison to results from study areas offshore of Virginia, South Carolina, and northeastern Florida (Grosz and Escowitz, 1983; Grosz and Nelson, 1989), the data from the New Jersey shelf show higher overall concentrations of economic heavy minerals. Inasmuch as these data were derived from surficial grab samples, their application to resource assessment is limited. They do, however, provide effective guides for selection of heavy-mineral exploration targets in the study area. Vibracore samples should be collected and analyzed from nearshore and mid-shelf locations where geologic, mineralogic, textural, and bathymetric criteria suggest potential for placer deposits of heavy minerals.

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ACKNOWLEDGMENTS

We are indebted to J. Santos and M. Costello of the USGS at Woods Hole, MA for processing the samples for their heavy-mineral content; and to E. Escowitz of the USGS, Reston, VA for his assistance in retrieving some information from the computerized data file at Woods Hole. We are also indebted to Curt Larsen and Klaus Schulz of the USGS, Reston, VA for their careful review of the manuscript.

This study was funded in part by a grant from the Minerals Management Service through the Texas Bureau of Economic Geology under Cooperative Agreement 14-12-0001-30387 to the New Jersey Geological Survey.

Table 1.--Textural and mineralogic data for 76 surface grab samples collected from the New Jersey Continental Shelf.

Explanation of footnotes in Table 1

1 Latitude and longitude are given in degrees and fractions of degrees. Modified from Hathaway (1971).

2 Sampling equipment code: 1) Campbell grab with camera, 2) Campbell grab without camera, and 3) Smith-McIntyre grab with camera From Hathaway (1971).

3, 4, 5, 6, 7, 8, 9 from Hathaway (1971).

10, 11, 12 Size classes generated during processing of samples for their heavy-mineral content.

13 SG >2.85 expressed as a percentage of the bulk sample weight.

14 Undifferentiated pyroxenes and amphiboles.

15 Aluminosilicates (may include sillimanite, kyanite, and andalusite.

16 Others may include unidentified opaques, unidentified non-opaques, quartz, clayballs, polymineralic aggregates, anatase, brookite, feldspar, shell fragments, glauconite, etc.

17 EHM; Economic heavy minerals (ilmenite + leucoxene + rutile + zircon + monazite + aluminosilicates) expressed as a percentage of the heavy-mineral assemblage.

18 EHM; expressed as a percentage of the bulk sample.

19 ZTR index; zircon + tourmaline + rutile expressed as a percentage of the sum of the non-opaque heavy minerals

20 P; present in quantity less than the lowest value displayed in the column.

21 Sample with 0.0 to 0.5 Ampere magnetic fraction missing, therefore, ilmenite, pyrobole, and garnet values given for the sample are underestimates.

SAMPLE NUMBER	LONGITUDE [1] WEST	LATITUDE [1] NORTH	EQP COD [2]	LITHOLOGIC TYPE [3]
1300	-73.50334	40.01333	1	SAND AND GRAVEL
1301	-73.75002	40.02000	1	BROWN MEDIUM GRAINED SAND
1302	-73.75002	39.85002	1	BROWN COARSE SAND AND GRAVEL
1303	-73.49501	39.85168	1	BROWN MEDIUM TO COARSE VARICOLORED SAND WITH SHELL FRAGMENTS
1304	-73.24500	39.83668	1	BROWN COARSE SAND AND GRAVEL
1305	-73.01000	39.84168	1	GREENISH GRAY SANDY SILT WITH SHELL FRAGMENTS
1309	-72.75002	39.66001	1	GREENISH GRAY FINE GRAINED SILTY SAND
1310	-73.01500	39.68335	1	MEDIUM TO COARSE GRAINED SAND FAIRLY WELL SORTED
1311	-73.25001	39.69668	1	COARSE BROWN SAND AND SHELL
1313	-73.75002	39.67668	1	BROWN COARSE SAND AND GRAVEL
1314	-73.98835	39.51334	1	COARSE BROWN SAND
1315	-74.24000	39.49668	1	GREENISH BLACKISH GREY VERY FINE GRAINED SILTY SAND
1316	-74.23000	39.34667	1	GREY BROWN FINE SAND
1317	-74.00667	39.34667	1	BROWN MEDIUM GRAINED WELL SORTED SAND
1318	-73.75335	39.34501	1	MEDIUM TO COARSE BROWN GRAVELLY SAND
1319	-73.51001	39.34001	1	GREENISH GRAY MEDIUM TO FINE SILTY SAND
1320	-73.25834	39.34001	1	GREENISH GRAY MEDIUM TO FINE SAND
1321	-73.01000	39.33834	1	GREENISH BROWN MEDIUM GRAINED SAND
1322	-72.76335	39.33501	1	BROWNISH GREEN CLAYEY AND SILTY FINE GRAINED SAND
1323	-72.49168	39.33834	1	GREENISH GRAY FINE GRAINED POORLY SORTED SAND, WITH SOME MUD
1336	-72.69835	39.15834	1	BROWN COARSE SAND AND GRAVEL WITH ROUNDED CLAY PEBBLES
1337	-73.00500	39.17000	1	BROWN MEDIUM GRAINED SAND, WITH A GOOD MANY SHELLS
1338	-73.01667	39.01667	1	BROWN MEDIUM GRAINED SAND, UNIFORM AND WELL SORTED
1339	-73.25001	39.01333	1	GREENISH GRAY MEDIUM SAND, WITH SHELL DEBRIS AND SCATTERED PEBBLES
1340	-73.25001	39.16667	1	BROWN MEDIUM TO COARSE WELL-SORTED SAND, WITH SHELLS
1341	-73.51668	39.17334	1	MEDIUM GRAINED BROWN SAND WITH SHELL HASH
1342	-73.50001	39.02000	1	BROWN MEDIUM TO COARSE SAND WITH GREY MUD
1343	-73.75002	39.18167	1	OLIVE MEDIUM SAND, WELL SORTED
1344	-74.00167	39.17167	1	BROWN MEDIUM TO COARSE SAND
1345	-74.24334	39.16500	1	LIGHT BROWN MEDIUM GRAINED SAND, WELL SORTED
1346	-74.51834	39.15500	1	GRAYISH GREEN TO DARK GREEN FINE GRAINED SAND, H2S ODOR
1347	-74.50501	39.00000	1	LIGHT BROWN FINE GRAINED GRAVEL TO 3 CM
1348	-74.25167	39.00000	1	DARK GRAY AND OLIVE GRAY MEDIUM SAND, WELL SORTED
1349	-74.25501	38.82502	1	BROWN COARSE SAND, SMALL AMOUNT OF GRAVEL
1350	-74.00000	38.83168	1	GRAYISH BROWN FINE GRAINED SAND, WELL SORTED
1351	-74.00667	39.00833	1	BROWNISH GRAY FINE GRAINED SAND, WELL SORTED
1352	-73.75168	38.99669	1	OLIVE BROWN SAND, MEDIUM TO COARSE, FAIRLY WELL SORTED
1353	-73.75668	38.87335	1	BROWN MEDIUM SAND

SAMPLE NUMBER	LONGITUDE[1] WEST	LATITUDE[1] NORTH	EQP[2] COD	LITHOLOGIC[3] TYPE
1354	-73.52668	38.85335	1	BROWN MEDIUM TO COARSE SAND
1356	-73.00000	38.83502	1	GRAYISH BROWN MEDIUM TO COARSE SAND
1361	-73.76835	38.67501	1	BROWN MEDIUM TO COARSE SAND
1362	-74.00000	38.67168	1	GRAYISH BROWN TO GREEN FINE SAND, WELL SORTED
1363	-73.76335	38.50334	1	BROWN WELL SORTED MEDIUM SAND
1364	-73.50834	38.51334	1	MEDIUM SAND, WELL SORTED, WITH SHELL FRAGMENTS
1372	-72.51834	39.51334	1	GRAYISH GREEN CLAYEY AND SILTY FINE-GRAINED SAND, WITH SOME GRAVEL
1373	-72.76335	39.51001	1	COARSE BROWN SAND
1374	-73.02000	39.50834	1	GREENISH-GRAY MEDIUM SAND WITH SHELL FRAGMENTS
1375	-73.26334	39.52001	1	BROWN MEDIUM TO COARSE SAND
1376	-73.50834	39.52001	1	BROWN MEDIUM SAND, WELL SORTED
1377	-73.75502	39.51668	1	BROWN COARSE SAND AND GRAVEL
1378	-73.98335	39.63168	1	COARSE BROWN SAND WITH GRAVEL TO 5 CM
1379	-74.04000	39.74668	1	BROWN MEDIUM TO COARSE SAND
1380	-73.99335	39.91669	1	COARSE BROWN SAND WITH GRAVEL
1381	-73.99169	40.09167	1	BROWN MEDIUM SAND, WELL SORTED
1383	-73.74501	40.20000	1	DARK GRAY CLAYEY SILT, ORGANIC ODOR
1415	-74.00000	38.50000	1	BROWN UNIFORM MEDIUM SAND, SHELL FRAGMENTS
1416	-73.99169	38.32834	1	GRAY-BROWN MEDIUM SAND, WITH SHELL FRAGMENTS
1417	-74.24834	38.16667	1	BROWN VERY COARSE SAND WITH GRAVEL TO 2 CM MANY SHELL FRAGMENTS
1891	-73.99002	38.00000	2	DARK GRAY SILTY POORLY SORTED FINE-MEDIUM SAND
1894	-73.76668	38.17167	2	POORLY SORTED MED-FINE SAND, GREENISH TAN, QTZ, RK FRGS, SOME FORAMS
1895	-73.77168	38.35501	2	MUDDY GREEN BROWN QTZ SAND WITH ABOUT 5% SHELL HASH
1957	-73.95285	40.35334	3	BROWN, MEDIUM GRAINED SAND, LARGE % HEAVY MINERALS
1958	-73.97202	40.20500	3	BROWN, MEDIUM GRAINED SAND, HIGH % HEAVY MINERALS, CLAY BALLS
1959	-74.03967	39.99385	3	BROWN COARSE-VERY COARSE SAND
1960	-74.06750	39.83585	3	LIGHT BROWN FINE TO MEDIUM SAND, WELL SORTED
1961	-74.13717	39.63168	3	LIGHT BROWN COARSE SAND, SPARSE GRAVEL TO 1 CM, SPARSE SHELL FRAGMENTS
1962	-74.38884	39.35467	3	GRAYISH BROWN VERY FINE GRAINED SAND, WELL SORTED
1963	-74.51634	39.28284	3	BROWN, VERY FINE GRAINED, WELL SORTED SAND
1964	-74.67218	39.14800	3	GRAY SILT, WELL SORTED, HIGH % DARK MINERALS
1965	-74.75002	39.00000	3	DARK GRAY CLAYEY SILT
2025	-74.50001	38.83335	1	MED TO CRS GRAINED BROWN SAND, SHELL FRAGS, GRANULES, LIMONITE STAINED
2026	-74.75668	38.83002	1	MEDIUM TO FINE GRAY AND BROWN SAND
2029	-74.23834	38.66668	1	BROWN, FINE SILTY SAND
2030	-74.25001	38.49334	1	BROWN SAND AND GRAVEL, LITTLE DARK GRAY MUD
2031	-74.25001	38.33334	1	SANDY GRAVEL, 32-16 MM
2032	-74.50001	38.33001	1	BROWN, COARSE GRAINED GRAVELLY, LIMONITE STAINED SAND

SAMPLE NUMBER	WATER DEPTH (m) [4]	BULK WT (g)	GAMMA ACTIVITY CPM/g [5]	GRAVEL >2.00 mm % [6]	SAND 2.00 TO 0.0625 mm [7]	SILT 0.0625 TO 0.0039 mm [8]	CLAY <0.0039 mm % [9]	WT % >16 MESH	WT % <16->325 MESH	WT % <325 MESH
1300	45	236.55		45.4	54.5	0.0	0.0	30.68	68.52	0.80
1301	36	220.69		0.0	100.0	0.0	0.0	1.19	98.70	0.11
1302	37	231.85		36.0	64.8	0.0	0.0	31.87	68.06	0.07
1303	40	204.35	0.95	0.0	99.0	0.0	0.0	3.16	96.84	0.00
1304	46	220.16		44.0	56.0	0.0	0.0	19.85	80.03	0.12
1305	79	154.94	1.29	0.0	86.0	6.1	8.1	4.52	90.29	5.19
1309	72	188.97		0.0	92.7	7.3	0.0	5.38	90.77	3.85
1310	54	193.88		0.0	100.0	0.0	0.0	6.79	93.21	0.00
1311	44	227.00		2.2	97.8	0.0	0.0	16.32	83.28	0.40
1313	23	228.78		7.2	92.6	0.0	0.0	17.03	82.97	0.00
1314	22	242.55		30.8	69.9	0.0	0.0	25.81	74.19	0.00
1315	14	207.30		0.0	96.0	4.0	0.0	1.88	97.99	0.13
1316	20	263.53	1.02	0.0	100.0	0.0	0.0	0.61	99.35	0.03
1317	30	256.17		0.0	100.0	0.0	0.0	1.56	98.44	0.00
1318	32	194.10	0.50	0.0	100.0	0.0	0.0	34.79	65.21	0.00
1319	48	176.67		0.0	100.0	0.0	0.0	1.27	97.92	0.81
1320	55	206.91		0.0	100.0	0.0	0.0	1.09	98.73	0.18
1321	71	198.39		0.0	100.0	0.0	0.0	0.55	99.45	0.00
1322	84	180.97	1.14	0.0	99.0	0.0	0.0	4.25	92.11	3.64
1323	139	166.25		0.0	68.0	21.4	10.6	2.19	85.56	12.25
1336	180	191.68		0.0	100.0	0.0	0.0	5.62	93.70	0.67
1337	70	234.44	0.63	2.0	98.0	0.0	0.0	5.14	94.12	0.74
1338	50	194.27		0.0	100.0	0.0	0.0	4.42	95.46	0.12
1339	69	282.96	0.83	0.0	100.0	0.0	0.0	6.98	92.69	0.33
1340	62	256.51		0.0	100.0	0.0	0.0	6.92	92.23	0.86
1341	47	258.86	0.67	0.0	100.0	0.0	0.0	0.79	99.21	0.00
1342	54	268.61		0.0	100.0	0.0	0.0	14.08	85.14	0.78
1343	38	244.53		0.0	100.0	0.0	0.0	0.43	99.46	0.11
1344	28	272.20	0.61	0.0	100.0	0.0	0.0	4.85	95.09	0.06
1345	21	276.41		0.0	100.0	0.0	0.0	0.52	99.48	0.00
1346	23	192.59	2.39	0.0	95.0	5.0	0.0	1.82	93.75	4.42
1347	25	258.40		50.7	49.2	0.0	0.0	59.47	40.32	0.22
1348	28	246.89	2.51	0.0	100.0	0.0	0.0	0.05	99.85	0.10
1349	40	277.68		10.5	89.4	0.0	0.0	18.61	81.30	0.10
1350	46	224.40		0.0	100.0	0.0	0.0	1.04	98.76	0.20
1351	38	267.58		0.0	100.0	0.0	0.0	0.32	99.59	0.09
1352	42	218.54	0.52	0.0	100.0	0.0	0.0	4.12	95.85	0.03
1353	44	296.18		0.0	100.0	0.0	0.0	3.89	96.11	0.00

SAMPLE NUMBER	WATER DEPTH (m) 4/	BULK WT (g)	GAMMA ACTIVITY CPM/g 5/	GRAVEL >2.00 mm % 6/	SAND 2.00 TO 0.0625 mm 7/	SILT 0.0625 TO 0.0039 mm 8/	CLAY <0.0039 mm % 9/	WT % >16 MESH	WT % <16->325 MESH	WT % <325 MESH
1354	62	248.84		0.0	100.0	0.0	0.0	6.17	93.55	0.28
1356	102	272.94		0.0	100.0	0.0	0.0	3.69	96.26	0.05
1361	54	240.91	0.48	0.0	100.0	0.0	0.0	2.00	98.00	0.00
1362	49	290.68	0.88	0.0	100.0	0.0	0.0	0.39	99.46	0.14
1363	64	207.76	0.32	0.0	100.0	0.0	0.0	7.99	91.75	0.26
1364	79	277.65	0.55	0.0	100.0	0.0	0.0	0.81	99.06	0.13
1372	96	220.75	0.77	0.0	96.0	4.0	0.0	9.09	86.18	4.72
1373	65	230.72	0.49	0.0	100.0	0.0	0.0	11.25	88.61	0.14
1374	65	175.98	1.04	0.0	100.0	0.0	0.0	1.70	97.86	0.43
1375	38	149.71	0.69	0.0	100.0	0.0	0.0	8.38	91.62	0.00
1376	39	249.95	0.85	0.0	100.0	0.0	0.0	0.60	99.26	0.14
1377	28	309.05		4.0	96.0	0.0	0.0	14.09	85.91	0.00
1378	24	331.17	0.39	20.0	80.0	0.0	0.0	19.02	80.98	0.00
1379	13	257.86		4.4	95.6	0.0	0.0	2.63	97.37	0.00
1380	19	325.52	0.14	31.4	68.6	0.0	8.0	50.98	49.02	0.00
1381	23	226.89		0.0	100.0	0.0	0.0	1.56	98.44	0.00
1383	59	101.87		0.0	66.0	19.1	14.9	0.03	93.56	6.41
1415	57	255.74	0.60	0.0	98.0	2.0	0.0	3.76	95.98	0.26
1416	66	243.45		0.0	100.0	0.0	0.0	0.92	98.91	0.16
1417	41	203.07		2.0	98.0	0.0	0.0	53.60	46.40	0.00
1891	129	178.42		0.0	97.0	3.0	0.0	3.47	95.80	0.73
1894	123	218.96		0.0	100.0	0.0	0.0	3.50	96.33	0.17
1895	94	193.94		0.0	84.0	9.0	7.0	5.83	91.61	2.56
1957	14	108.38		0.0	100.0	0.0	0.0	0.33	99.67	0.00
1958	16	153.77	1.89	0.0	97.0	3.0	0.0	4.60	94.76	0.63
1959	19	194.94	0.23	0.0	100.0	0.0	0.0	13.66	86.34	0.00
1960	12	239.65	0.31	0.0	100.0	0.0	0.0	0.94	99.06	0.00
1961	15	276.74		16.0	84.0	0.0	0.0	20.58	79.42	0.00
1962	7	208.91	1.26	0.0	100.0	0.0	0.0	0.20	99.41	0.39
1963	13	265.69		0.0	100.0	0.0	0.0	0.26	98.87	0.87
1964	9	208.08	1.49	0.0	100.0	0.0	0.0	0.00	99.65	0.35
1965	15	241.44		0.0	100.0	0.0	0.0	0.39	94.93	4.68
2025	23	239.48	0.20	0.0	100.0	0.0	0.0	3.61	96.39	0.00
2026	18	236.48		0.0	100.0	0.0	0.0	0.00	100.00	0.00
2029	39	259.73	0.39	0.0	100.0	0.0	0.0	1.07	98.93	0.00
2030	48	307.99		0.0	100.0	0.0	0.0	3.56	96.37	0.07
2031	58	264.69	0.33	4.0	96.0	0.0	0.0	34.95	64.83	0.22
2032	36	205.66		5.0	95.0	0.0	0.0	25.73	74.27	0.00

Wt. % of S.G. >2.85

SAMPLE NUMBER	WT % HM [13]	WT % MAGNETITE	WT % ILMENITE	WT % LEUCOXENE	WT % RUTILE	WT % ZIRCON	WT % MONAZITE	WT % GARNET
1300	1.67	1.2	32.7	1.3	0.4	0.6	1.4	17.1
1301	3.18	1.7	8.8	4.2	0.1	1.8	0.7	11.9
1302	2.90	1.7	26.7	0.6	0.5	1.1	2.9	17.4
1303	3.98	2.9	18.5	9.3	0.4	0.9	0.6	20.2
1304	6.34	3.3	40.2	7.8	0.1	1.2	1.3	23.6
1305	3.14	1.7	21.3	1.4	0.5	0.7	2.7	12.2
1309	2.95	3.3	22.0	0.3	0.2	1.0	P	12.7
1310	3.14	4.3	14.7	1.4	P	1.4	0.6	25.3
1311	3.19	2.6	14.9	2.7	0.8	0.7	0.3	19.6
1313	2.55	3.9	29.9	2.0	P	2.1	P	20.8
1314	2.28	0.3	31.3	2.0	0.3	1.5	0.6	26.6
1315	6.26	0.6	30.1	1.7	0.1	2.0	P	15.5
1316	4.84	0.4	21.4	1.4	0.8	3.9	2.1	17.2
1317	2.23	0.9	26.4	10.8	0.5	0.5	2.8	14.7
1318	4.31	1.3	24.2	1.7	0.8	0.8	0.5	26.7
1319	5.43	5.8	12.7	1.3	0.6	0.4	3.0	17.0
1320	3.13	3.8	15.8	0.5	2.3	0.9	1.4	25.2
1321	2.60	1.3	25.6	0.9	P	0.7	1.6	19.5
1322	4.21	2.1	21.3	0.9	0.1	1.3	1.3	16.2
1323	1.98	2.1	23.0	1.7	0.2	0.3	2.2	13.5
1336	1.30	1.0	20.2	3.2	0.1	0.4	2.2	19.6
1337	2.28	2.0	26.9	1.2 [20]	P	0.3	0.8	26.1
1338	2.31	2.0	20.0	P	5.1	0.4	3.6	10.0
1339	5.86	2.3	17.8	0.8	4.0	1.3	0.2	32.7
1340	2.16	2.3	24.0	2.8	P	0.2	2.9	20.8
1341	3.43	2.4	29.8	3.7	0.1	0.5	1.1	21.9
1342	2.74	1.8	28.7	2.7	0.2	P	1.5	23.0
1343	8.98	1.3	14.9	0.2	0.2	0.8	P	26.2
1344	5.52	0.2	30.1	0.4	0.1	1.2	P	33.3
1345 [21]	2.98	0.3	41.8	3.1	0.8	0.5	2.2	20.3
1346	6.15	0.5	19.1	0.2	P	3.9	P	9.2
1347	0.35	1.0	30.0	P	P	5.0	P	25.0
1348	12.80	1.4	30.4	0.7	0.5	1.2	P	24.1
1349	1.85	1.0	15.5	4.5	1.0	0.5	1.4	30.0
1350	5.60	1.7	6.1	0.1	0.7	0.8	P	19.8
1351	11.08	4.0	30.3	0.8	0.2	0.2	2.7	23.3
1352	3.56	1.4	23.1	P	0.2	0.5	0.3	25.3
1353	4.11	1.8	24.5	0.9	3.9	0.9	0.5	38.1

Wt. % of S.G. >2.85

SAMPLE NUMBER	WT % HM	WT % MAGNETITE	WT % ILMENITE	WT % LEUCOXENE	WT % RUTILE	WT % ZIRCON	WT % MONAZITE	WT % GARNET
1354	1.72	1.2	26.3	2.5	0.2	1.4	0.9	19.1
1356	1.30	5.8	16.2	2.3	2.0	1.1	P	26.3
1361	3.30	1.0	8.3	0.1	0.1	0.4	2.4	33.0
1362	7.25	2.1	27.1	0.5	0.3	0.7	1.6	21.2
1363	1.64	2.1	17.5	1.0	2.5	1.0	1.7	21.3
1364	2.16	2.7	21.4	3.6	1.8	1.0	0.8	31.7
1372	2.24	2.4	25.1	1.2	0.2	0.2	1.3	23.6
1373	1.97	0.2	35.0	7.4	0.3	1.6	3.4	31.2
1374	2.60	4.3	5.9	0.5	0.1	0.5	P	19.7
1375	5.12	3.5	29.8	5.7	0.2	0.2	0.4	20.8
1376	4.82	6.6	22.8	1.5	2.7	0.8	2.4	23.5
1377	1.71	2.4	8.1	6.3	1.0	1.5	0.3	20.0
1378	3.59	1.5	34.1	0.5	0.3	0.2	1.2	35.9
1379	2.60	0.3	44.4	10.6	1.5	0.4	1.6	12.2
1380	0.66	0.8	20.5	11.1	3.0	2.0	0.5	19.8
1381	0.88	2.0	35.0	P	P	2.0	P	10.0
1383	4.27	1.4	9.6	8.1	0.7	P	P	9.4
1415	2.81	2.7	30.6	0.2	0.9	0.3	1.5	20.7
1416	6.26	2.2	34.7	0.8	0.5	0.7	1.0	19.8
1417	0.39	P	45.0	P	P	2.0	P	33.0
1891	2.31	2.2	14.1	2.5	0.5	1.3	0.3	16.0
1894	1.81	4.3	7.6	5.3	0.4	0.8	P	25.1
1895	5.38	2.8	14.7	6.5	0.2	1.6	P	15.3
1957	1.24	10.0	20.0	25.0	P	1.0	1.0	5.0
1958	5.74	0.7	24.9	2.0	0.5	0.9	3.0	21.0
1959	1.12	1.6	15.0	11.2	P	1.7	0.3	15.0
1960	0.93	P	27.1	P	3.5	2.7	0.7	12.6
1961	1.55	3.0	27.7	3.6	2.1	2.7	0.9	15.0
1962	8.19	0.7	4.9	2.1	0.7	0.7	1.7	14.4
1963	8.08	0.2	18.4	1.0	0.7	2.2	0.6	10.5
1964	10.67	0.5	13.9	P	1.1	4.4	1.4	11.8
1965	7.87	0.5	26.1	0.6	0.6	1.2	0.8	11.7
2025	1.20	1.0	36.3	3.7	1.2	0.9	1.3	17.7
2026	1.40	0.5	43.9	3.3	1.4	1.6	3.9	13.3
2029	2.65	0.4	38.6	1.6	0.7	0.5	3.8	19.7
2030	1.28	1.2	39.1	1.5	0.8	0.8	2.3	14.8
2031	0.94	1.5	37.6	1.5	P	2.3	1.1	18.6
2032	1.07	1.3	40.2	0.6	P	P	1.2	19.1

WT. % OF S.G. >2.85

SAMPLE NUMBER	WT % STAUROLITE	WT % EPIDOTE	WT % PYROBOLES 14/	WT % TOURMALINE	WT % ALSIL 15/	WT % OTHERS 16/	WT % EHM/C 17/	WT % EHM/T 18/	ZTR INDEX 19/
1300	9.0	10.9	7.8	0.8	1.0	16.0	37.3	0.6	3.5
1301	1.5	7.6	44.8	1.1	10.0	5.8	25.6	0.8	3.8
1302	0.8	2.8	29.3	P	13.7	2.4	45.6	1.3	2.3
1303	1.5	2.7	31.1	P	9.8	2.0	39.5	1.6	1.9
1304	1.1	1.6	7.1	2.3	3.0	7.4	53.5	3.4	8.6
1305	3.2	3.0	35.5	P	10.3	7.6	36.8	1.2	1.7
1309	1.6	0.4	31.8	0.7	12.4	13.6	35.8	1.1	3.1
1310	0.3	2.8	32.1	P	11.5	5.7	29.6	0.9	1.9
1311	1.0	5.1	39.1	P	7.4	5.8	26.8	0.9	2.0
1313	4.9	3.8	15.7	2.9	6.1	8.0	40.1	1.0	8.8
1314	1.5	4.5	20.9	0.3	4.9	5.5	40.4	0.9	3.4
1315	P	6.4	23.6	0.9	13.4	5.5	47.4	3.0	5.0
1316	2.5	3.6	31.0	P	13.0	2.6	42.6	2.1	6.4
1317	0.2	7.0	21.5	P	7.5	7.2	48.4	1.1	1.7
1318	1.4	3.8	20.6	P	4.8	13.3	32.8	1.4	2.6
1319	1.4	1.7	43.2	P	5.7	7.1	23.6	1.3	1.4
1320	2.3	6.4	34.0	1.4	6.0	P	26.9	0.8	5.8
1321	2.0	7.6	29.5	P	6.2	5.1	35.0	0.9	1.0
1322	1.1	4.0	37.5	P	4.9	9.4	29.8	1.3	2.1
1323	0.1	7.5	29.7	P	13.2	6.3	40.7	0.8	0.9
1336	5.0	5.9	29.6	P	9.1	3.8	35.1	0.5	0.7
1337	4.2	6.6	18.5	0.4	7.0	6.1	36.1	0.8	1.1
1338	4.4	7.6	33.5	1.4	11.1	0.8	40.2	0.9	9.0
1339	0.9	4.7	20.4	0.2	12.7	2.0	36.9	2.2	7.2
1340	6.7	9.3	22.5	P	4.2	4.3	34.0	0.7	0.3
1341	3.2	5.2	21.0	0.5	5.4	5.2	40.6	1.4	1.7
1342	3.9	7.3	20.4	P	5.8	4.8	38.8	1.1	0.3
1343	2.1	4.4	25.3	11.6	6.7	6.4	22.8	2.0	16.3
1344	0.5	0.3	21.9	0.7	2.4	8.8	34.2	1.9	3.3
1345	5.5	5.9	9.8	P	7.6	2.3	56.0	1.7	2.5
1346	P	1.2	24.6	0.9	26.6	13.8	49.9	3.1	7.3
1347	5.0	P	15.0	P	10.0	9.0	45.0	0.2	8.3
1348	0.7	7.4	18.5	1.1	7.1	6.9	39.9	5.1	4.7
1349	4.3	3.8	30.4	1.6	6.0	P	28.9	0.5	3.9
1350	1.8	1.8	43.0	5.4	13.3	5.3	21.1	1.2	8.0
1351	0.6	0.4	24.8	P	7.0	5.9	41.0	4.5	0.6
1352	3.2	P	24.6	5.9	4.6	11.0	28.5	1.0	10.2
1353	1.9	5.5	16.1	0.4	3.8	1.5	34.6	1.4	7.3

WT. % of S.G. >2.85

SAMPLE NUMBER	WT % STAUROLITE	WT % EPIDOTE	14/ WT % PYROBOLES	WT % TOURMALINE	15/ WT % ALSIL	16/ WT % OTHERS	17/ WT % EHM/C	18/ WT % EHM/T	19/ ZTR INDEX
1354	3.6	10.2	25.1	1.6	8.0	P	39.3	0.7	4.5
1356	2.5	7.1	28.8	P	5.3	2.5	27.0	0.4	4.2
1361	0.4	5.0	29.8	5.1	7.2	7.2	18.5	0.6	6.8
1362	1.2	1.5	30.5	P	7.6	5.9	37.7	2.7	1.5
1363	1.0	5.8	36.9	1.5	4.4	3.3	28.1	0.5	6.6
1364	1.3	7.6	21.7	1.3	4.7	0.5	33.1	0.7	5.6
1372	1.7	2.5	27.7	P	10.2	4.0	38.1	0.9	0.6
1373	3.0	3.1	5.3	2.3	2.2	5.2	49.9	1.0	8.1
1374	7.2	7.2	29.9	8.4	10.8	5.7	17.7	0.5	10.7
1375	0.1	2.2	27.2	P	7.6	2.3	44.0	2.2	0.6
1376	1.8	3.7	25.1	2.2	3.8	3.2	34.0	1.6	8.7
1377	1.5	12.9	22.6	5.3	17.0	1.0	34.2	0.6	9.6
1378	1.3	0.7	11.0	P	4.4	8.8	40.7	1.5	1.0
1379	1.6	P	8.2	P	12.4	6.8	70.9	1.8	5.1
1380	7.9	P	26.1	0.9	6.1	1.3	43.2	0.3	9.0
1381	P	1.0	15.0	P	15.0	20.0	52.0	0.5	4.7
1383	2.0	8.8	36.7	2.7	13.1	7.5	31.5	1.3	4.6
1415	0.5	0.8	30.3	P	8.6	3.0	42.1	1.2	1.9
1416	0.7	1.6	25.8	P	8.1	4.3	45.7	2.9	2.0
1417	P	15.0	5.0	P	P	P	47.0	0.2	3.6
1891	2.9	13.3	27.2	3.4	11.2	5.1	30.0	0.7	6.8
1894	2.3	14.9	25.7	1.8	6.7	5.1	20.8	0.4	3.9
1895	2.6	5.9	32.0	1.0	10.0	7.4	33.1	1.8	4.1
1957	3.0	4.0	24.0	P	2.0	5.0	49.0	0.6	2.5
1958	0.5	1.4	2.7	0.3	9.6	32.5	40.8	2.3	4.2
1959	5.9	5.2	29.9	3.8	8.5	2.2	36.7	0.4	7.9
1960	9.3	2.4	29.2	2.2	10.0	0.2	44.2	0.4	11.6
1961	4.7	5.8	20.0	6.0	7.0	1.4	44.0	0.7	16.9
1962	4.3	5.4	42.9	1.4	12.3	8.4	22.5	1.8	3.3
1963	0.6	2.7	29.2	1.0	20.2	12.8	43.1	3.5	5.7
1964	1.3	14.2	28.5	1.9	5.9	15.0	26.8	2.9	10.6
1965	0.6	13.8	22.8	5.2	11.9	4.2	41.3	3.2	10.2
2025	2.4	2.9	18.6	1.4	7.8	4.7	51.3	0.6	6.4
2026	2.7	1.2	13.7	P	10.2	4.3	64.3	0.9	6.2
2029	1.3	4.1	18.9	P	8.8	1.8	53.9	1.4	2.0
2030	2.8	3.3	14.6	P	14.3	4.7	58.7	0.8	3.0
2031	2.5	4.7	13.5	1.6	7.3	7.8	49.8	0.5	7.6
2032	3.2	1.7	11.3	0.4	19.5	1.4	61.6	0.7	0.7

Table 2.--Table showing statistical data for 76 surface grab samples from the New Jersey continental shelf grouped according to textural and bathymetric criteria. Explanation of column headers from Table 1 apply here as well.

	H2O DPT (m)	BULK WT (g)	GAMMA ACTIVITY CPM/g	GRAVEL >2.00 mm %	SAND 2.00 TO 0.0625 mm	SILT 0.0625 TO 0.0039 mm	CLAY <0.0039 mm %
STATISTICS FOR ALL SAMPLES							
NUMBER OF SAMPLES	76	76	32	76	76	76	76
MINIMUM	7	101.87	0.14	0.0	49.2	0.0	0.0
AVERAGE	48	230.08	0.82	4.2	94.2	1.1	0.6
MAXIMUM	180	331.17	2.51	50.7	100.0	21.4	14.9
STANDARD DEVIATION	32	44.43	0.57	11.1	11.9	3.6	2.5
STATISTICS FOR SANDS							
NUMBER OF SAMPLES	57	57	26	57	57	57	57
MINIMUM	7	101.87	0.20	0.0	66.0	0.0	0.0
AVERAGE	52	223.84	0.93	0.1	97.7	1.5	0.7
MAXIMUM	180	307.99	2.51	4.4	100.0	21.4	14.9
STANDARD DEVIATION	35	43.96	0.58		6.6	4.1	2.7
STATISTICS FOR GRAVELS							
NUMBER OF SAMPLES	19	19	6	19	19	19	19
MINIMUM	15	194.10	0.14	0.0	49.2	0.0	0.0
AVERAGE	35	248.80	0.35	16.3	83.8	0.0	0.4
MAXIMUM	65	331.17	0.50	50.7	100.0	0.0	8.0
STANDARD DEVIATION	14	40.39	0.13	17.2	17.2	0.0	1.8
STATISTICS FOR SAMPLES FROM 0 TO 20 M DEPTH INTERVAL							
NUMBER OF SAMPLES	14	14	7	14	14	14	14
MINIMUM	7	108.38	0.14	0.0	68.6	0.0	0.0
AVERAGE	15	227.74	0.91	3.7	95.8	0.5	0.6
MAXIMUM	20	325.52	1.89	31.4	100.0	4.0	8.0
STANDARD DEVIATION	4	52.06	0.64	8.7	8.6	1.2	2.1
STATISTICS FOR SAMPLES FROM 20 TO 40 M DEPTH INTERVAL							
NUMBER OF SAMPLES	23	23	10	23	23	23	23
MINIMUM	21	149.71	0.20	0.0	49.2	0.0	0.0
AVERAGE	31	242.89	0.95	7.1	92.6	0.2	0.0
MAXIMUM	40	331.17	2.51	50.7	100.0	5.0	0.0
STANDARD DEVIATION	7	38.61	0.78	13.6	13.4	1.0	0.0
STATISTICS FOR SAMPLES FROM THE 0 TO 40 M DEPTH INTERVAL							
NUMBER OF SAMPLES	37	37	17	37	37	37	37
MINIMUM	7	108.38	0.14	0.0	49.2	0.0	0.0
AVERAGE	25	237.15	0.93	5.8	93.8	0.3	0.2
MAXIMUM	40	331.17	2.51	50.7	100.0	5.0	8.0
STANDARD DEVIATION	10	44.79	0.73	12.1	11.9	1.1	1.3
STATISTICS FOR SAMPLES FROM >40 M DEPTH							
NUMBER OF SAMPLES	39	39	15	39	39	39	39
MINIMUM	41	101.87	0.32	0.0	54.5	0.0	0.0
AVERAGE	70	223.37	0.70	2.6	94.5	1.8	1.0
MAXIMUM	180	307.99	1.29	45.4	100.0	21.4	14.9
STANDARD DEVIATION	30	43.02	0.28	9.8	12.0	4.8	3.2

	WT % >16M MESH	WT % <16->325 MESH	WT % <325 MESH	WT % HM	WT % MAGNETITE	WT % ILMENITE	WT % LEUCOXENE	WT % RUTILE	WT % ZIRCON	WT % MONAZITE
STATISTICS FOR ALL SAMPLES										
NUMBER OF SAMPLES	76	76	76	76	74	76	69	63	73	60
MINIMUM	0.00	40.32	0.00	0.35	0.2	4.9	0.1	0.1	0.2	0.2
AVERAGE	8.83	90.38	0.79	3.61	2.0	24.2	3.1	0.9	1.2	1.5
MAXIMUM	59.47	100.00	12.25	12.80	10.0	45.0	25.0	5.1	5.0	3.9
STANDARD DEVIATION	12.76	12.62	1.90	2.57	1.7	9.8	3.9	1.1	1.0	1.0
STATISTICS FOR SANDS										
NUMBER OF SAMPLES	57	57	57	57	56	57	52	50	56	44
MINIMUM	0.00	85.56	0.00	0.88	0.2	4.9	0.1	0.1	0.2	0.2
AVERAGE	2.79	96.21	1.01	4.09	2.2	22.9	2.8	0.9	1.1	1.6
MAXIMUM	9.09	100.00	12.25	12.80	10.0	44.4	25.0	5.1	4.4	3.9
STANDARD DEVIATION	2.44	3.39	2.15	2.68	1.8	9.5	4.0	1.1	0.9	1.0
STATISTICS FOR GRAVELS										
NUMBER OF SAMPLES	19	19	19	19	18	19	17	13	17	16
MINIMUM	11.25	40.32	0.00	0.35	0.2	8.1	0.5	0.1	0.2	0.3
AVERAGE	26.97	72.88	0.15	2.17	1.7	28.3	4.0	0.8	1.6	1.2
MAXIMUM	59.47	88.61	0.80	6.34	3.9	45.0	11.2	3.0	5.0	3.4
STANDARD DEVIATION	13.96	13.93	0.24	1.44	1.0	9.6	3.4	0.8	1.1	0.9
STATISTICS FOR SAMPLES FROM 0 TO 20 M DEPTH INTERVAL										
NUMBER OF SAMPLES	14	14	14	14	13	14	12	12	14	13
MINIMUM	0.00	49.02	0.00	0.66	0.2	4.9	0.6	0.1	0.4	0.3
AVERAGE	6.93	92.56	0.51	4.37	1.5	24.2	6.1	1.3	2.0	1.4
MAXIMUM	50.98	100.00	4.68	10.67	10.0	44.4	25.0	3.5	4.4	3.9
STANDARD DEVIATION	13.55	13.37	1.19	3.29	2.5	10.3	6.9	1.0	1.1	1.0
STATISTICS FOR SAMPLES FROM 20 TO 40 M DEPTH INTERVAL										
NUMBER OF SAMPLES	23	23	23	23	23	23	21	18	22	16
MINIMUM	0.05	40.32	0.00	0.35	0.2	8.1	0.2	0.1	0.2	0.3
AVERAGE	11.98	87.78	0.24	4.01	1.8	27.1	2.9	0.6	1.3	1.6
MAXIMUM	59.47	99.85	4.42	12.80	6.6	41.8	10.8	2.7	5.0	3.8
STANDARD DEVIATION	14.91	14.82	0.89	3.12	1.5	9.2	2.9	0.6	1.2	1.1
STATISTICS FOR SAMPLES FROM THE 0 TO 40 M DEPTH INTERVAL										
NUMBER OF SAMPLES	37	37	37	37	36	37	33	30	36	29
MINIMUM	0.00	40.32	0.00	0.35	0.2	4.9	0.2	0.1	0.2	0.3
AVERAGE	10.07	89.59	0.34	4.14	1.7	26.0	4.1	0.9	1.5	1.5
MAXIMUM	59.47	100.00	4.68	12.80	10.0	44.4	25.0	3.5	5.0	3.9
STANDARD DEVIATION	14.62	14.48	1.02	3.19	1.9	9.7	5.0	0.9	1.2	1.0
STATISTICS FOR SAMPLES FROM >40 M DEPTH										
NUMBER OF SAMPLES	39	39	39	39	38	39	36	33	37	31
MINIMUM	0.03	46.40	0.00	0.39	0.2	5.9	0.1	0.1	0.2	0.2
AVERAGE	7.66	91.12	1.22	3.10	2.4	22.6	2.2	0.9	0.9	1.5
MAXIMUM	53.60	99.46	12.25	7.25	5.8	45.0	8.1	5.1	2.3	3.6
STANDARD DEVIATION	10.57	10.50	2.38	1.63	1.2	9.6	2.2	1.3	0.5	0.9

	WT % GARNET	WT % STAUROLITE	WT % EPIDOTE	WT % PYROBOLES	WT % TOURMALINE	WT % ALSIL	WT % OTHERS	WT % EHM/C	WT % EHM/T	ZTR INDEX
STATISTICS FOR ALL SAMPLES										
NUMBER OF SAMPLES	76	72	72	76	44	75	72	76	76	76
MINIMUM	5.0	0.1	0.3	2.7	0.2	1.0	0.2	17.7	0.2	0.3
AVERAGE	20.1	2.5	5.2	24.5	2.3	8.7	6.3	38.8	1.3	4.9
MAXIMUM	38.1	9.3	15.0	44.8	11.6	26.6	32.5	70.9	5.1	16.9
STANDARD DEVIATION	6.8	2.1	3.6	9.4	2.3	4.4	4.9	10.6	1.0	3.6
STATISTICS FOR SANDS										
NUMBER OF SAMPLES	57	54	55	57	32	57	55	57	57	57
MINIMUM	5.0	0.1	0.3	2.7	0.2	2.0	0.2	17.7	0.4	0.3
AVERAGE	19.2	2.2	5.1	26.5	2.3	9.1	6.4	37.8	1.5	4.7
MAXIMUM	38.1	9.3	14.9	44.8	11.6	26.6	32.5	70.9	5.1	16.3
STANDARD DEVIATION	6.8	1.9	3.5	8.5	2.5	4.2	5.2	11.1	1.0	3.4
STATISTICS FOR GRAVELS										
NUMBER OF SAMPLES	19	18	17	19	12	18	17	19	19	19
MINIMUM	15.0	0.8	0.7	5.0	0.3	1.0	1.0	26.8	0.2	0.3
AVERAGE	23.0	3.5	5.5	18.5	2.4	7.5	6.0	41.9	0.9	5.7
MAXIMUM	35.9	9.0	15.0	39.1	6.0	19.5	16.0	61.6	3.4	16.9
STANDARD DEVIATION	6.0	2.4	3.9	9.3	1.8	4.7	4.2	8.3	0.7	4.1
STATISTICS FOR SAMPLES FROM 0 TO 20 M DEPTH INTERVAL										
NUMBER OF SAMPLES	14	13	12	14	10	14	14	14	14	14
MINIMUM	5.0	0.5	1.2	2.7	0.3	2.0	0.2	22.5	0.3	2.5
AVERAGE	13.9	3.5	5.5	23.7	2.4	10.2	7.3	44.1	1.7	7.5
MAXIMUM	21.0	9.3	14.2	42.9	6.0	20.2	32.5	70.9	3.5	16.9
STANDARD DEVIATION	3.8	2.7	4.1	9.8	1.9	4.2	8.1	12.0	1.1	3.7
STATISTICS FOR SAMPLES FROM 20 TO 40 M DEPTH INTERVAL										
NUMBER OF SAMPLES	23	21	22	23	12	23	22	23	23	23
MINIMUM	9.2	0.1	0.3	9.8	0.3	2.4	1.0	22.8	0.2	0.6
AVERAGE	21.6	2.0	3.9	21.9	2.4	9.3	6.4	41.8	1.6	4.6
MAXIMUM	35.9	5.5	12.9	44.8	11.6	26.6	20.0	61.6	5.1	16.3
STANDARD DEVIATION	6.6	1.6	2.9	7.7	3.1	5.5	4.6	9.6	1.2	3.7
STATISTICS FOR SAMPLES FROM THE 0 TO 40 M DEPTH INTERVAL										
NUMBER OF SAMPLES	37	34	34	37	22	37	36	37	37	37
MINIMUM	5.0	0.1	0.3	2.7	0.3	2.0	0.2	22.5	0.2	0.6
AVERAGE	18.7	2.6	4.4	22.6	2.4	9.6	6.8	42.7	1.6	5.7
MAXIMUM	35.9	9.3	14.2	44.8	11.6	26.6	32.5	70.9	5.1	16.9
STANDARD DEVIATION	6.8	2.2	3.5	8.6	2.6	5.1	6.2	10.6	1.2	4.0
STATISTICS FOR SAMPLES FROM >40 M DEPTH										
NUMBER OF SAMPLES	39	38	38	39	22	38	36	39	39	39
MINIMUM	9.4	0.1	0.4	5.0	0.2	1.0	0.5	17.7	0.2	0.3
AVERAGE	21.5	2.5	5.9	26.2	2.3	7.9	5.8	35.1	1.1	4.2
MAXIMUM	38.1	9.0	15.0	43.2	8.4	14.3	16.0	58.7	3.4	10.7
STANDARD DEVIATION	6.6	1.9	3.6	9.7	2.1	3.4	3.1	9.2	0.7	3.0