HEAVY-MINERAL RESOURCE POTENTIAL OF SURFICIAL SEDIMENTS ON THE ATLANTIC CONTINENTAL SHELF OFFSHORE OF NORTH CAROLINA: A RECONNAISSANCE STUDY

BY

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Heavy-mineral resource potential of surficial sediments of the Atlantic Continental Shelf offshore of North Carolina: A reconnaissance study

by

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ABSTRACT

Textural, mineralogic, and geophysical data derived from 87 ocean floor grab samples from the Atlantic Continental Shelf offshore of North Carolina show a change in character at Cape Hatteras. Quartz-rich sediments dominate north of Hatteras, whereas carbonate-rich sediments prevail to the south. Sediments north of Cape Hatteras are finer grained, less mature (contain more feldspar), richer in heavy minerals, and more radioactive than carbonate-rich sediments to the south.

The offshore sediments north of Cape Hatteras may have potential for a number of strategic and critical heavy minerals if concentrations and compositions measured in surficial sediments persist with depth. Although sediments to the south of Hatteras contain a more mature assemblage, low overall concentrations constrain the resource potential. The observed heavy-mineral assemblages include ilmenite, rutile, zircon, monazite, sillimanite, and kyanite, as well as species of lesser economic importance such as garnet, tourmaline, and staurolite.

Concentrations of heavy minerals average 1.77 weight percent in a range of 0.04 to 7.79 weight percent. The economically valuable heavy minerals ilmenite, rutile, leucoxene (altered ilmenite), zircon, monazite, and aluminosilicates make up as much as 4.4 weight percent of some bulk samples. The highest concentrations of heavy minerals in the study area occur in approximately coast-parallel zones north of Cape Hatteras. These zones are

identified as attractive targets for heavy-mineral exploration on the United States Atlantic Continental 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 incompletely understood, many strategic and critical minerals have been shown to exist, locally in large concentrations (Goodwin and Thomas, 1973; Grosz and Escowitz, 1983; Grosz and others, 1986; Grosz, 1987; Berquist and Hobbs, 1988; Grosz and Nelson, 1989; Grosz and others, 1989).

As part of a larger effort to assess the potential for mineral resources in Atlantic Continental Shelf sediments, this report presents data on grain-size distribution and mineral components and concentrations determined for 87 surface grab samples from offshore of North Carolina. The grab samples were collected in the 1960's by the Woods Hole Oceanographic Institution and the U.S. Geological Survey as part of a joint program of study of the Atlantic continental margin of the United States.

SAMPLE ACQUISITION

The suite of surface grab samples utilized in this study consists of widely distributed samples (average spacing 20 km) from offshore of North Carolina (Figure 1). Splits of the 87 grab samples used in this study are retained in the USGS collection at Woods Hole Oceanographic Institution, MA (Hathaway, 1971). Location coordinates and lithologic descriptions for the grab samples are given in Table 1; water depth, sampling equipment type, bulk weight, and textural data are given in Table 2; and grain-size distribution, mean grain size, gamma activity and feldspar content are given in

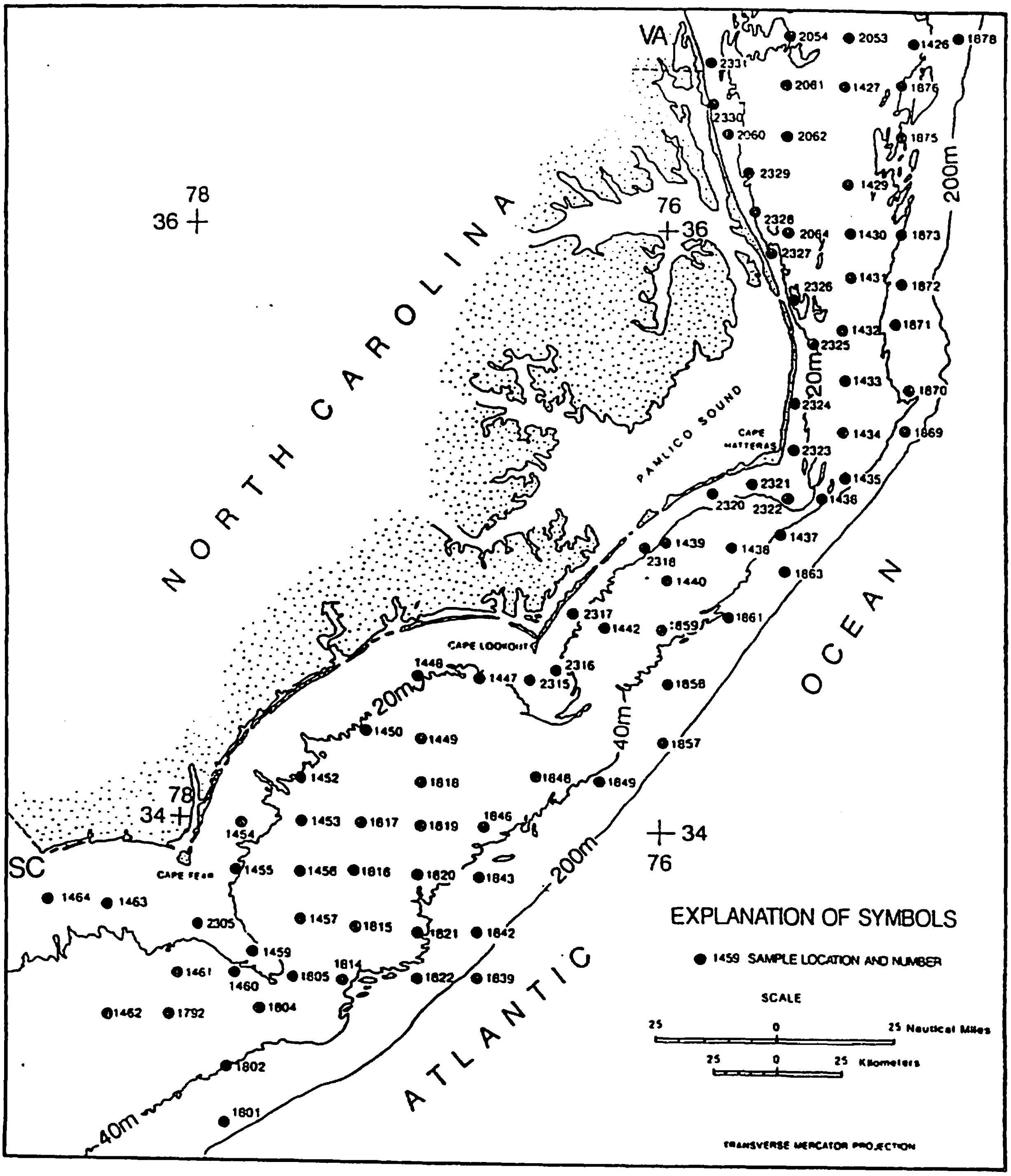


Figure 1. --Map showing locations of surface grab samples from the Atlantic Continental Shelf offshore of North Carolina. Coordinates are given in degrees of latitude (N), and longitude (W).

Table 1. --Location coordinates and lithologic descriptions of 87 surface grab samples collected from the Atlantic Continental Shelf offshore of North Carolina (modified from Hathaway, 1971).

SAMPLE NUMBER	LONGITUDE (WEST)	LATITUDE (NORTH)	LITHOLOGIC DESCRIPTION
1426	-74.95835	36.64168	GRAY-BROWN FINE TO MEDIUM SAND, CLEAN, WELL SORTED, SAND DOLLARS, SHELL
1427	-75.25334	36.50334	BROWN UNIFORM FINE SAND
1429	-75.25001	36.16000	GRAY-BROWN FINE TO MEDIUM SAND, WITH LARGE AMOUNT OF HEAVY MINERALS
1430	-75.23334	35.99335	DARK GRAY FINE SAND, HIGH PERCENTAGE OF DARK MINERALS
1431	-75.24334	35.85502	GRAY-BROWN WELL SORTED VERY FINE SAND WITH LARGE AMOUNT OF DARK MINERALS
1432	-75.24667	35.67001	GRAY-BROWN FINE-V. FINE WELL SORTED SAND WITH DK. GRAY LUMPS OF SILTY MATERIAL
1433	-75.25334	35.50834	GRAY TO DARK BROWN VERY FINE TO SILTY SAND, WITH DARK GRAY SILTY-CLAYEY LUMPS
1434	-75.25501	35.33334	DARK GRAY-BROWN VERY FINE SILTY SAND WITH HIGH PERCENTAGE OF DARK MINERALS
1435	-75.24667	35.17500	LIGHT BROWN WELL SORTED MEDIUM TO VERY COURSE SAND
1436	-75.35167	35.10834	LIGHT GRAY CLEAN WELL SORTED FINE SAND, WITH SOME BROKEN SHELLS
1437	-75.51668	34.98669	DARK BROWNISH-GRAY FINE-MEDIUM SAND WITH MANY SHELL FRGS, GRAVEL TO 1.5 CM
1438	-75.73001	34.92502	GREENISH-GRAY FINE CLEAN WELL-SORTED SAND, MUCH HEAVY MINERALS
1439	-76.00000	34.96002	BROWNISH-GRAY WELL SORTED MEDIUM SAND, OYSTER AND CLAM SHELLS, PIECE WOOD
1440	-75.99669	34.83335	GRAY-GREEN FINE TO MEDIUM WELL-WASHED SAND, SOME SHELL HASH
1442	-76.25167	34.66668	LIGHT BROWN FINE UNIFORM SAND
1447	-76.76835	34.49001	GRAY-BROWN FINE SAND WITH SHELL HASH
1448	-77.02500	34.49668	GRAY-BROWN FINE-MEDIUM WELL-WASHED SAND WITH BROKEN SAND $, OYSTER SHELLS
1449	-77.01500	34.29334	FINE SAND, WITH SHELL HASH
1450	-77.23167	34.32001	LIGHT GRAY UNIFORM WELL-SORTED SAND
1452	-77.48668	34.15000	LIGHT GRAYISH-BROWN FINE SAND WITH LUMPS OF CALCAREOUS ROCK AND CORAL TO 12 CM
1453	-77.50001	34.00000	LIGHT GRAY WELL SORTED SAND
1454	-77.73335	33.98669	GRAY-GREEN-BROWN SAND, MEDIUM TO FINE, WITH ABUNDANT SHELL HASH
1455	-77.74168	33.83168	YELLOW-BROWN COARSE TO VERY COARSE GRAVELLY SAND, SOME CALCAREOUS PARTICLES
1456	-77.50001	33.82500	GRAY TO GREENISH-BROWN GRVL WITH CSE SAND AND SHELL HASH, GRAY MUD BALLS TO 4 CM
1457	-77.50501	33.67668	BROWN MEDIUM SAND, WITH MUCH SAND-SIZE SHELL MATERIALS
1459	-77.68501	33.57334	GRAY-BROWN COARSE SAND AND SHELL HASH
1460	-77.75002	33.50001	LIGHT GRAY FINE WELL SORTED SAND, WITH A FEW SHELL FRAGMENTS
1461	-77.98502	33.50001	LIGHT GRAY CLEAN WELL SORTED FINE SAND WITH SHELL FRAGMENTS
1462	-78.25001	33.34167	GRAY-GREEN FINE SAND. SAND DOLLAR CONTAINS DARK GRAY SILTY OOZE

SAMPLE NUMBER	LONGITUDE WEST	LATITUDE NORTH	LITHOLOGIC DESCRIPTION
1463	-78.26667	33.68501	DARK GRAY-GREEN WELL SORTED SILT, WITH SOME VERY FINE SAND
1464	-78.51168	33.69501	GREEN-BROWN VERY FINE SILTY SAND, WITH SOME VERY COARSE SAND
1792	-78.02333	33.36334	V. LIGHT GRAY-CLEAN UNIFORM MEDIUM TO CSE GRAINED WITH SORTED QUARTZ SAND, 2% SHELL
1801	-77.76168	33.00833	OLIVE GREEN SAND, FINE TO VERY FINE SAND
1802	-77.76502	33.17500	GRAY SAND, 15+% SHELL
1804	-77.63168	33.39167	GRAY AND TAN SAND, 8+% SHELL
1805	-77.50334	33.48501	BROWN MOTTLED MEDIUM TO COARSE GRAINED SAND AND SHELL HASH
1814	-77.28667	33.49168	MOTTLED GRAY MEDIUM CLEAN QUARTZ SAND WITH SPECKS OF SHELL AND DARK MINERALS
1815	-77.25334	33.66001	BROWNISH GRAY MOTTLED MEDIUM CLEAN SAND, 60% QUARTZ, 40% SHELL
1816	-77.25834	33.84002	SALT AND PEPPER SAND, FINE GRAINED SHELL HASH
1817	-77.24000	34.00000	SALT AND PEPPER SAND, 85% QUARTZ, RK FRAGS AND NON-MAGNETIC DARK MINERALS
1818	-76.99669	34.15000	TAN AND GRAY SAND, SHELL
1819	-76.99502	33.99502	FINE TO MEDIUM GRAINED SAND, SHELL
1820	-77.02000	33.84335	TAN SHELL SAND
1821	-76.99002	33.65001	BROWN MOTTLED MEDIUM TO COARSE GRAINED CLEAN QUARTZ-CARBONATE SAND
1822	-76.99835	33.50001	BROWN MOTTLED MEDIUM TO COARSE GRAINED CLEAN QUARTZ-CARBONATE SAND
1839	-76.75002	33.51001	LIGHT GRAY GLOBIGERINA OOZE SAND SPECKLED WITH DARK GLAUCONITE 5% and SHELLS 3%
1842	-76.74168	33.65335	SHELL SAND, COARSE, GRAY-TAN, GREATER THAN 90% SHELL MATERIAL
1843	-76.74668	33.84002	SHELL HASH, SMALL AND MEDIUM SHELLS, ROCKS 3-4 CM
1846	-76.73835	34.00000	YELLOW-BROWN POORLY SORTED CLEAN SAND, FEW SMALL ANGULAR PEEBLES, 5% SHELL
1848	-76.51668	34.16500	FINE-MEDIUM-COARSE SAND, QUARTZ AND ROCK FRGS, LARGE % SHELL HASH, LARGE SHELLS 4-5 CM
1849	-76.23500	34.17334	DARK GRAY SAND, ABOUT 15% SHELL HASH
1857	-76.00167	34.31167	OLIVE-TAN QUARTZ AND SHELL SAND, MEDIUM TO COARSE GRAINED
1858	-75.99669	34.47668	DARK GRAY SAND QUARTZ, SHELL LESS THAN 10%, FINE TO MEDIUM GRAINED
1859	-76.01000	34.65835	GRAY WELL-SORTED CLEAN FINE QUARTZ SAND, 1-2% SHELL
1861	-75.74335	34.71001	OLIVE-GRAY, MED-CSE, MODY SRT SAND, 90% QUARTZ AND ROCK FRGS, 5% SHELL, 5% OPAQUE MIN
1863	-75.50834	34.85502	MEDIUM-FINE DARK MUDDY QUARTZ SAND
1869	-74.98502	35.34167	DARK OLIVE GRAY TO DARK GRAY SILTY MUD
1870	-74.96669	35.47834	DARK GRAY FINE QUARTZ (LESS THAN 50%) SAND, W SRT, ROCK FRAGMENTS, DARK MINERALS, MAGNETITE

SAMPLE NUMBER	LONGITUDE WEST	LATITUDE NORTH	LITHOLOGIC DESCRIPTION
1871	-75.03167	35.68501	TAN MEDIUM GRAINED FAIRLY WELL SORTED QUARTZ SAND, LESS THAN 10% SHELL
1872	-75.00000	35.83335	TAN AND GRAY MED-CSE GRAINED QUARTZ SAND, POORLY SORTED, GREATER THAT 5% SHELL
1873	-75.00000	36.00000	DARK GRAY CLEAN QUARTZ SAND, FINE GRAINED, SOME BENTHIC FORAMS, WORM TUBES
1875	-75.00167	36.33834	GRAY FINE GRAINED, UNIFORM, CLEAN QUARTZ SAND, SHELL 5%
1876	-74.99169	36.49668	DARK GRAY WITH SORTED CLEAN FINE SAND, WITH DARK MINERALS, 1-2% SHELL
1878	-74.75168	36.66668	COARSE TO MEDIUM QUARTZ SAND, MODERATE TO WELL SORTED
2053	-75.24834	36.66668	FINE GRAY-BROWN SAND
2054	-75.51168	36.65668	BROWN SAND, SHELL DEBRIS
2060	-75.75168	36.33001	GRAYISH BROWN FINE-MEDIUM SAND
2061	-75.50000	36.50834	GRAY SAND (FINE-MEDIUM)
2062	-75.50001	36.32667	OLIVE GRAY FINE SILTY SAND
2064	-75.49501	36.00000	BROWN MEDIUM SAND, NO GRAVEL, OBVIOUS BLACK OPAQUES
2305	-77.91335	33.64668	MEDIUM-COARSE LIGHT BROWN SAND
2315	-76.53668	34.49668	WELL SORTED FINE GRAINED MEDIUM OLIVE-GRAY SAND, DARK GRAY BELOW 3 CM
2316	-76.45301	34.52668	COARSE VERY SHELLY SAND, VARICOLORED, ABOUT MEDIUM OLIVE GRAY
2317	-76.38334	34.70835	VERY SHELLY COARSE SAND, APPROACHING A SHELL HASH, VARICOLORED, MD. OLIVE. GRAY.
2318	-76.10167	34.93002	MEDIUM SAND, MANY SHELL FRAGMENTS, NEARLY A SHELL HASH, VARICOLORED
2320	-75.79668	35.13000	LT OLIVE-GRAY FINE W-SORTED SAND, THIN MED GRAY STREAKS IN THIN LAYERS 3-4 CM BELOW TOP
2321	-75.63168	35.15500	DARK GREENISH GRAY VERY FINE SAND OR SILT
2322	-75.49001	35.11834	SILTY VERY FINE SAND, MEDIUM OLIVE GRAY
2323	-75.46334	35.27167	WELL SORTED VERY FINE SAND OR SILT, FEW OR NO SHELL FRAGMENTS, DARK OLIVE GRAY
2324	-75.45501	35.42501	VERY FINE WELL SORTED SAND OR SILT, MEDIUM DARK OLIVE GRAY
2325	-75.39334	35.62001	COARSE QUARTZ SAND WITH MUCH SHELL FRAGMENTS, BROWN
2326	-75.47001	35.76502	COARSE QUARTZ SAND, NUMEROUS SHELL FRAGMENTS
2327	-75.56668	35.92502	MEDIUM LIGHT BROWN SAND (BEACH SAND), SHELL FRAGMENTS LARGER THAN SAND SIZE
2328	-75.64668	36.07333	WELL SORTED VERY FINE SAND OR SILT, DARK GREENISH GRAY
2329	-75.67001	36.20000	MEDIUM GRAINED LIGHT BROWN QUARTZ SAND WITH SOME SHELL
2330	-75.81835	36.42834	DARK GREENISH GRAY FINE SOMEWHAT POORLY SORTED SAND, MANY WORM TUBES
2331	-75.83335	36.57168	MEDIUM-COARSE BROWN SAND, DARK YELLOWISH BROWN

Table 2. --Water depth, sampling equipment type, and textural data for 87 surface grab samples collected from the Atlantic Continental Shelf offshore of North Carolina.

Explanation of footnotes:

1 From Hathaway, 1971.

2 Sampling equipment code: 1) Campbell grab with camera, 2) Campbell grab without camera (from Hathaway, 1971).

3 N/A: data not available.

SAMPLE NUMBER	WATER DEPTH (m)	EQPT TYPE	BULK WT (g)	GRAVEL >2.00 mm %	SAND 2.00 TO 0.0625 mm %	SILT 0.0625 TO 0.0039 mm %	CLAY <0.0039 mm %	WT % >16 MESH	WT % <16->325 MESH	WT % <325 MESH
1426	32	1	385.1	0.0	100.0	0.0	0.0	0.8	99.0	0.2
1427	32	1	397.0	0.0	100.0	0.0	0.0	4.7	95.0	0.3
1429	27	1	258.7	0.0	100.0	0.0	0.0	0.9	98.9	0.2
1430	35	1	192.2	0.0	99.0	1.0	0.0	.0	99.7	0.3
1431	32	1	251.8	0.0	100.0	0.0	0.0	0.1	99.7	0.2
1432	34	1	108.1	0.0	99.0	1.0	0.0	0.6	98.2	1.2
1433	30	2	241.8	0.0	97.0	3.0	0.0	0.3	98.3	1.4
1434	25	2	206.7	0.0	100.0	0.0	0.0	0.2	99.2	0.5
1435	27	2	248.6	0.0	100.0	0.0	0.0	3.7	96.3	0.0
1436	26	2	217.3	0.0	100.0	0.0	0.0	0.6	99.4	0.0
1437	44	2	236.1	1.0	99.0	0.0	0.0	12.1	86.6	1.3
1438	27	2	222.5	0.0	100.0	0.0	0.0	1.0	98.9	0.1
1439	20	2	221.1	0.0	99.0	1.0	0.0	2.4	97.5	0.1
1440	28	2	241.5	0.0	98.5	1.5	0.0	4.2	95.7	0.1
1442	27	2	239.9	0.0	100.0	0.0	0.0	0.3	99.5	0.2
1447	22	2	217.1	0.0	100.0	0.0	0.0	0.6	99.4	0.0
1448	18	2	224.8	0.0	100.0	0.0	0.0	8.1	91.8	0.1
1449	27	2	263.5	0.0	98.0	2.0	0.0	3.5	96.3	0.1
1450	22	2	283.4	0.0	100.0	0.0	0.0	1.1	98.9	0.0
1452	20	2	212.9	0.0	100.0	0.0	0.0	11.4	88.6	0.0
1453	22	2	208.9	0.0	100.0	0.0	0.0	2.0	97.9	0.1
1454	15	2	272.5	0.0	100.0	0.0	0.0	5.4	94.6	0.0
1455	19	2	231.7	6.0	94.0	0.0	0.0	22.6	77.4	0.0
1456	27	2	260.6	1.5	98.5	0.0	0.0	44.8	55.2	0.0
1457	29	2	154.7	0.0	100.0	0.0	0.0	2.9	97.1	0.0
1459	17	2	154.0	2.0	98.0	0.0	0.0	14.9	85.1	0.0
1460	22	2	219.5	0.0	100.0	0.0	0.0	1.4	98.6	0.0
1461	23	2	304.8	0.0	100.0	0.0	0.0	0.8	99.2	0.0
1462	22	2	229.9	0.0	100.0	0.0	0.0	N/A 3/	N/A	N/A

SAMPLE NUMBER	WATER DEPTH (m)	EQPT TYPE	BULK WT (g)	GRAVEL >2.00 mm %	SAND 2.00 TO 0.0625 mm %	SILT 0.0625 TO 0.0039 mm %	CLAY <0.0039 mm %	WT % >16 MESH	WT % <16->325 MESH	WT % <325 MESH
1463	16	2	200.0	0.0	98.0	2.0	0.0	N/A	N/A	N/A
1464	16	2	244.7	0.0	100.0	0.0	0.0	N/A	N/A	N/A
1792	28	2	209.5	0.0	100.0	0.0	0.0	1.8	98.2	0.0
1801	151	2	176.6	0.0	94.0	6.0	0.0	0.2	98.9	0.9
1802	43	2	230.5	0.0	98.0	2.0	0.0	1.2	98.7	0.1
1804	22	2	153.8	0.0	100.0	0.0	0.0	1.1	98.9	0.0
1805	22	2	227.0	1.0	99.0	0.0	0.0	20.7	79.3	0.0
1814	39	2	178.8	0.0	99.0	1.0	0.0	1.9	98.0	0.1
1815	35	2	182.7	0.0	99.0	1.0	0.0	1.0	98.9	.0
1816	35	2	271.4	0.0	99.0	1.0	0.0	0.4	99.5	0.1
1817	25	2	160.9	0.0	100.0	0.0	0.0	10.7	89.3	0.0
1818	33	2	147.7	0.0	100.0	0.0	0.0	2.8	97.0	0.2
1819	33	2	175.5	0.0	98.0	2.0	0.0	0.9	98.9	0.1
1820	38	2	162.6	0.0	100.0	0.0	0.0	0.2	99.7	0.1
1821	35	2	177.6	1.0	99.0	0.0	0.0	9.1	90.9	0.0
1822	45	2	187.3	1.0	99.0	0.0	0.0	12.4	87.6	0.1
1839	259	2	94.8	0.0	98.0	2.0	0.0	1.3	98.6	0.1
1842	130	2	179.3	0.0	100.0	0.0	0.0	21.7	77.9	0.3
1843	43	2	212.6	0.0	100.0	0.0	0.0	8.4	91.6	0.0
1846	38	2	181.1	1.0	99.0	0.0	0.0	27.2	72.8	0.0
1848	35	2	148.0	0.0	100.0	0.0	0.0	20.0	80.0	0.0
1849	54	2	223.8	0.0	99.0	1.0	0.0	4.8	95.1	0.1
1857	85	2	255.7	0.0	100.0	0.0	0.0	8.9	91.1	0.0
1858	54	2	249.7	0.0	100.0	0.0	0.0	0.3	98.2	1.5
1859	33	2	238.6	0.0	100.0	0.0	0.0	0.6	99.4	0.0
1861	41	2	241.8	0.0	99.0	1.0	0.0	7.1	92.8	0.1
1863	86	2	239.7	0.0	97.0	3.0	0.0	2.3	97.0	0.7
1869	70	2	145.0	0.0	76.0	17.5	6.5	0.1	92.2	7.8
1870	42	2	146.2	0.0	98.0	2.0	0.0	1.3	98.1	0.6

SAMPLE NUMBER	WATER DEPTH (m)	EQPT TYPE	BULK WT (g)	GRAVEL >2.00 mm %	SAND 2.00 TO 0.0625 mm %	SILT 0.0625 TO 0.0039 mm %	CLAY <0.0039 mm %	WT % >16 MESH	WT % <16->325 MESH	WT % <325 MESH
1871	43	2	271.8	0.5	99.5	0.0	0.0	2.5	97.5	0.0
1872	46	2	252.0	0.0	92.0	8.0	0.0	2.2	97.7	0.1
1873	44	2	262.0	0.0	100.0	0.0	0.0	0.2	99.7	0.2
1875	38	2	188.3	0.0	100.0	0.0	0.0	1.9	98.1	0.0
1876	38	2	376.2	0.0	100.0	0.0	0.0	0.2	99.5	0.3
1878	56	2	227.0	0.0	100.0	0.0	0.0	4.2	95.8	0.0
2053	35	2	378.1	0.0	100.0	0.0	0.0	1.0	98.9	0.1
2054	20	2	283.9	0.0	100.0	0.0	0.0	2.9	97.0	0.1
2060	16	1	269.4	0.0	99.0	1.0	0.0	0.4	99.5	0.1
2061	29	1	122.1	0.0	100.0	0.0	0.0	0.2	99.5	0.3
2062	30	1	168.4	0.0	100.0	0.0	0.0	0.4	99.6	0.0
2064	23	1	181.4	0.0	100.0	0.0	0.0	0.9	99.1	0.0
2305	10	2	210.6	0.0	100.0	0.0	0.0	0.1	99.9	0.0
2315	16	1	143.9	0.0	98.0	2.0	0.0	0.1	97.5	2.3
2316	16	1	198.7	3.0	97.0	0.0	0.0	24.9	75.1	0.0
2317	16	2	187.1	0.0	100.0	0.0	0.0	16.8	83.2	0.0
2318	16	2	157.2	7.0	93.0	0.0	0.0	33.4	66.6	0.0
2320	16	2	191.6	0.0	100.0	0.0	0.0	5.9	92.3	1.8
2321	16	2	122.2	0.0	84.0	16.0	0.0	0.0	98.3	1.7
2322	16	2	184.0	0.0	92.0	8.0	0.0	0.1	98.2	1.7
2323	16	2	160.8	0.0	90.0	10.0	0.0	0.1	99.3	0.6
2324	15	2	154.2	0.0	93.0	7.0	0.0	0.1	99.3	0.6
2325	18	2	180.2	4.0	96.0	0.0	0.0	27.9	72.1	0.0
2326	17	2	207.5	9.0	91.0	0.0	0.0	28.3	71.7	0.0
2327	16	2	180.9	6.0	94.0	0.0	0.0	25.2	74.8	0.0
2328	17	2	184.0	0.0	90.0	10.0	0.0	0.2	98.9	0.9
2329	18	2	176.8	5.0	95.0	0.0	0.0	11.7	88.3	0.0
2330	9	2	202.7	0.0	94.0	6.0	0.0	2.1	97.2	0.7
2331	10	2	185.3	0.0	100.0	0.0	0.0	3.9	96.1	0.0

Table 3. The accuracy of the sample locations is estimated to be within about 1 nautical mile of the coordinates given in Table 1. The grab samples may not accurately represent the bulk ocean-floor sediments because part of the fine-grained material may have been lost from coarse-grained or gravelly sediments due to their collection with a Campbell grab-sampler.

LABORATORY PROCEDURES

An average of 213.30 grams of bulk sample (in a range of 94.83 to 396.95 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 and clay (<325 mesh). The heavy-mineral fraction 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 original 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 representative amounts of rare minerals (see for example, Clifton and others, 1969).

Heavy-mineral concentrates exceeding 1 gram in mass 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. Heavy-mineral concentrates weighing less than 1 gram were separated into two magnetic sub-fractions on a Frantz Magnetic Barrier Separator at 0.5 ampere. 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 for the visual estimation of

Table 3. --Grain-size distribution, mean size, bulk radiation activity and mineralogic data for 87 surface grab samples collected from the Atlantic Continental Shelf offshore of North Carolina.

Explanation of footnotes:

1 From Hathaway, 1971.

2 Modified from Hathaway, 1971.

SAMPLE NUMBER	NUMBER OF SIZE MODES [1]	MEAN SIZE mm [1]	GAMMA ACTIVITY CPM/g [1]	VOL % CaCO3 OF SAND [1]	POTASH FELDSPAR [1]	PLAGIOCLASE FELDSPAR [1]	TOTAL FELDSPAR [2]
					AS A PERCENTAGE OF THE NON-CARBONATE 0.125-.250 mm FRACTION		
1426	1	0.29		1	8	1	9
1427	1	0.36		2	5	3	8
1429	1	0.19		1	8	7	15
1430	1	0.19	0.64	1	10	8	18
1431	1	0.16		1	13	9	22
1432	1	0.13	1.05				
1433	1	0.12		2	9	1	10
1434	1	0.11	1.53	2	11	2	13
1435	1	0.34		7	7	2	9
1436	1	0.18	0.48	3	17	1	18
1437	1	0.42		50	3	4	7
1438	1	0.15	0.62	3	7	5	12
1439	1	0.27		3	3	3	6
1440	1	0.24	0.25	5	4	1	5
1442	2	0.19		3	6	1	7
1447	2	0.20	0.81	23	4	3	7
1448	1	0.20					
1449	1	0.21	1.10	17	3	2	5
1450	2	0.21	0.93	10	3	1	4
1452	2	0.33	1.52	20	3	1	4
1453	1	0.19		11	3	1	4
1454	1	0.27	0.61	13	3	1	4
1455	1	0.93		7	7	2	9
1456	1	0.63	0.72	15	5	1	6
1457	1	0.28		45	3	1	4
1459	1	0.71	0.34	28	1	1	2
1460	1	0.19		17	4	1	5
1461	1	0.22	0.79				
1462	1	0.23		8	3	1	4

SAMPLE NUMBER	NUMBER OF SIZE MODES	MEAN SIZE mm	GAMMA ACTIVITY CPM/g	VOL % $CaCO_3$ OF SAND	POTASH FELDSPAR	PLAGIOCLASE FELDSPAR	TOTAL FELDSPAR
					AS A PERCENTAGE OF THE NON-CARBONATE 0.125-.250 mm FRACTION		
1463	1	0.14	0.52	8			
1464	1	0.14		3	5	1	6
1792	1	0.31		3	2		
1801	1	0.10	0.75	35	15	5	20
1802	1	0.22		11	4	1	5
1804	1	0.22		21	3	1	4
1805	1	0.65	0.27	42	2	1	3
1814	1	0.22		31	3	5	8
1815	1	0.23	0.73	42	3	1	4
1816	1	0.23		42	3	4	7
1817	1	0.43	0.90	17	2	1	3
1818	1	0.27	0.47	35	2	4	6
1819	1	0.21		42	5	1	6
1820	1	0.19	1.11	78	5	6	11
1821	1	0.55		58	3	1	4
1822	1	0.55	0.45	47	3	2	5
1839	1	0.19		77	5	1	6
1842	1	0.44	0.48	75	10	5	15
1843	1	0.35	0.60	67	3	3	6
1846	1	0.38	1.12	42	3	2	5
1848	1	0.43		37	4	1	5
1849	1	0.22	0.59	31	7	2	9
1857	1	0.36	0.27	40	4	2	6
1858	2	0.12		8	13	7	20
1859	1	0.20	0.37	3	3	5	8
1861	1	0.43		4	4	7	11
1863	1	0.23	0.68	7			
1869	1	0.06		6	7	3	10
1870	1	0.14	0.93				

SAMPLE NUMBER	NUMBER OF SIZE MODES	MEAN SIZE mm	GAMMA ACTIVITY CPM/g	VOL % $CaCO_3$ OF SAND	POTASH FELDSPAR	PLAGIOCLASE FELDSPAR	TOTAL FELDSPAR
					AS A PERCENTAGE OF THE NON-CARBONATE 0.125-.250 mm FRACTION		
1871	1	0.41	0.63	1			
1872	1	0.23	0.20	1	7	10	17
1873	1	0.18		2			
1875	1	0.17		1	8	11	19
1876	1	0.18	0.27	1			
1878	1	0.35	0.92	3	10	9	19
2053	1	0.28	0.19	1			
2054	1	0.42			6	7	13
2060	1	0.22			7	4	11
2061	2	0.12			10	10	20
2062	2	0.16	0.93	1	5	6	11
2064	1	0.29	0.36		6	2	8
2305	1	0.29			1		
2315	2	0.17	0.97		9	3	12
2316	2	0.55			3	2	5
2317	2	0.42	0.26	11	3	1	4
2318	3	0.68		37	2	2	4
2320	1	0.34		8	9	5	14
2321	1	0.08	1.01	2	11	9	20
2322	2	0.11		2	13	8	21
2323	2	0.10	2.18	2	8	9	17
2324	2	0.11		2	10	7	17
2325	2	0.69	0.15	8	2	3	5
2326	3	0.65		7			
2327	3	0.75		1	5	2	7
2328	2	0.11	1.48	2	10	9	19
2329	3	0.50		6			
2330	4	0.14	0.71	1	6	10	16
2331	2	0.38		1	5	5	10

percentage composition (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. Abundances of individual mineral species in each magnetic sub-fraction were summed and calculated as percentages of the total heavy-mineral fraction without compensation for differences in densities of individual mineral species. The results of the mineralogic determinations are given in Table 4.

RESULTS

Sketch contour plots of the percentage of heavy minerals (Figure 2), and of total feldspar content (Figure 3), show a systematic change in distribution patterns coincident with the NW-SE axis of Diamond Shoals which extend SE from Cape Hatteras. The significantly higher heavy-mineral and feldspar content and the lower carbonate content of the sediments to the north of Hatteras provide the basis for a division of the study area into northern and southern segments. Statistical parameters for all samples (N = 87), the northern group (N = 33), and the southern group (N = 54) are given on Table 5.

Within each of the two groups the samples were further sub-divided into inner-, mid-, and outer-shelf categories (<20 m, >20 m to <40 m, and >40 m water depth intervals, respectively, as per Swift and others (1973) and Stubblefield and others (1983). Carbonate-rich and carbonate-poor categories and sand and gravel categories were generated as well. These categories were generated on the basis of change in slope on cumulative frequency plots for the variables. The northern group of samples separated into carbonate-rich and carbonate-poor subgroups at 2 percent $CaCO_3$;

Table 4.--Heavy-mineral data for 87 surface grab samples collected from the Atlantic Continental Shelf offshore of North Carolina.

Explanation of footnotes:

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

2 Undifferentiated pyroxenes and amphiboles.

3 Aluminosilicates (undifferentiated sillimanite, kyanite, andalusite).

4 Others may include unidentified opaques, unidentified non-opaques, quartz, clayballs, polymineralic grains, feldspar, shell fragments, glauconite, mica, siderite(?) spinel(?), sulfides.

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

6 EHM/T; Economic heavy minerals expressed as a percentage of the bulk sample.

7 Labiles; sum of magnetite, pyroboles, garnet, and epidote expressed as a percentage of the heavy-mineral fraction.

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

9 P; <0.1 percent of the heavy-mineral fraction.

10 N; not detected.

11 NC; not calculated.

SAMPLE NUMBER	WEIGHT % HM	ILMENITE [1]	MAGNETITE	GARNET	STAUROLITE	EPIDOTE	PYROBOLES [2]	ALUMINO-SILICATES [3]	TOURMALINE	LEUCOXENE
		EXPRESSED AS WEIGHT PERCENTAGES OF THE SG >2.85 FRACTION								
1426	1.45	23.0	P [9]	13.0	6.5	3.0	28.0	6.0	3.5	3.5
1427	2.08	28.0	P	17.0	17.5	6.0	10.0	7.0	1.5	1.0
1429	3.47	47.5	P	9.0	2.6	1.7	6.0	26.7	0.5	4.3
1430	3.21	25.7	P	20.7	0.7	2.6	17.7	26.2	1.6	2.4
1431	5.34	28.7	P	15.4	2.0	3.4	23.3	16.9	2.2	1.6
1432	3.13	38.8	P	9.2	2.3	1.2	13.3	27.2	0.7	3.0
1433	5.24	45.1	P	8.2	P	0.9	8.6	28.7	0.8	2.6
1434	5.12	8.9	P	8.2	1.2	3.2	43.3	26.6	1.0	2.8
1435	0.43	19.7	N [10]	26.7	9.8	5.7	10.3	17.3	1.8	0.7
1436	0.59	26.6	N	11.7	2.6	3.9	29.5	15.5	1.1	2.2
1437	0.41	14.3	N	5.7	1.7	P	21.8	22.1	P	P
1438	2.21	37.5	N	6.2	2.4	5.3	19.9	15.4	1.1	1.8
1439	0.64	47.4	N	6.2	8.1	6.4	4.3	11.0	3.1	0.7
1440	0.62	56.9	N	3.6	4.2	5.0	2.0	14.1	1.6	0.8
1442	0.78	38.1	N	5.9	6.3	5.9	20.1	13.5	1.7	1.6
1447	1.39	15.7	N	8.0	9.5	3.5	20.8	23.1	1.7	2.6
1448	1.49	29.0	N	3.9	5.2	2.9	4.6	6.8	1.6	0.8
1449	1.56	22.9	N	3.4	11.4	1.5	2.1	12.8	0.7	1.1
1450	1.41	18.8	N	4.2	14.7	2.9	6.8	20.5	1.1	1.9
1452	3.27	22.5	N	5.8	21.8	0.6	P	8.6	0.3	P
1453	0.81	31.0	N	2.1	7.5	2.5	2.2	9.7	2.1	0.6
1454	0.52	24.8	N	3.2	14.2	2.3	6.2	12.2	2.5	1.6
1455	0.12	12.4	N	3.0	5.1	0.6	P	7.0	2.3	P
1456	0.47	20.0	N	5.7	11.9	2.1	2.9	11.4	1.3	1.3
1457	1.37	16.4	N	3.0	17.9	2.8	3.2	12.8	0.8	2.1
1459	0.14	N	N	P	1.0	N	P	P	N	N
1460	1.32	29.2	P	2.6	14.2	3.4	3.7	15.7	2.8	2.9
1461	0.72	26.1	P	3.4	12.1	6.8	8.7	14.1	7.3	5.3
1462	0.87	30.2	N	3.3	15.2	3.8	6.8	17.0	3.8	2.6

SAMPLE NUMBER	WEIGHT % HM	ILMENITE	MAGNETITE	GARNET	STAUROLITE	EPIDOTE	PYROBOLES	ALUMINO-SILICATES	TOURMALINE	LEUCOXENE
		EXPRESSED AS WEIGHT PERCENTAGES OF THE SG >2.85 FRACTION								
1871	0.94	16.5	N	27.9	5.1	2.6	18.8	16.7	3.4	1.3
1872	2.35	19.1	N	22.8	4.2	5.6	23.7	16.8	1.1	1.6
1873	4.05	47.6	4.8	4.6	7.6	11.4	6.3	12.0	3.0	0.9
1875	7.16	37.9	7.3	7.5	12.6	10.6	6.7	12.5	3.0	0.8
1876	5.12	10.0	P	12.0	7.0	5.5	42.0	7.0	4.0	2.5
1878	1.05	45.3	1.3	5.4	10.2	6.1	14.7	10.0	1.9	3.6
2053	3.22	17.0	P	13.0	17.0	P	21.5	9.0	10.0	1.5
2054	1.13	9.5	P	12.0	13.0	7.5	25.0	7.0	7.5	3.0
2060	2.11	21.1	N	6.9	2.6	6.3	29.0	19.1	1.9	3.2
2061	5.25	9.0	P	7.0	4.0	2.5	42.0	21.0	6.0	2.0
2062	2.36	14.7	P	10.1	2.3	2.1	25.7	37.4	2.6	1.4
2064	0.83	15.1	N	11.3	8.3	11.3	27.1	22.8	1.2	1.2
2305	1.24	15.8	N	14.1	34.0	2.7	1.5	4.8	3.9	2.3
2315	2.23	30.7	N	8.3	3.0	5.2	25.6	17.8	0.8	0.8
2316	0.73	12.1	N	6.2	7.8	1.6	0.9	2.0	P	N
2317	0.49	24.4	N	11.1	13.9	2.8	1.7	14.7	0.9	0.9
2318	0.32	23.2	N	12.5	9.8	6.3	9.4	4.4	2.5	0.7
2320	0.44	4.6	N	5.5	5.5	7.9	35.6	26.4	1.4	4.3
2321	2.81	5.6	P	9.8	1.3	2.5	32.9	39.5	2.6	1.7
2322	2.32	7.0	P	8.0	1.3	3.8	35.7	33.9	1.3	1.5
2323	4.60	4.5	0.1	6.7	0.2	1.5	47.0	30.2	1.7	2.5
2324	7.79	13.7	0.1	6.8	1.3	3.7	27.0	38.1	3.4	1.8
2325	0.29	30.8	N	21.5	2.4	3.6	7.5	16.0	4.1	0.8
2326	1.74	21.8	N	27.9	12.3	14.4	6.6	8.1	0.8	0.2
2327	0.47	21.5	N	20.1	11.7	4.7	5.0	9.3	6.6	2.3
2328	5.02	14.2	P	10.5	1.8	3.1	33.5	27.1	2.1	2.4
2329	0.19	10.5	N	13.9	5.8	7.3	32.7	19.3	2.1	2.1
2330	1.71	12.6	P	3.9	1.3	4.2	33.9	30.8	1.9	5.8
2331	0.73	22.1	N	17.8	3.0	7.1	16.3	11.9	4.3	2.9

SAMPLE NUMBER	WEIGHT % HM	ILMENITE	MAGNETITE	GARNET	STAUROLITE	EPIDOTE	PYROBOLES	ALUMINO-SILICATES	TOURMALINE	LEUCOXENE
		EXPRESSED AS WEIGHT PERCENTAGES OF THE SG >2.85 FRACTION								
1463	1.05	29.8	P	2.6	6.3	10.5	10.8	26.7	0.6	1.2
1464	0.85	17.3	P	1.4	3.3	13.1	24.9	29.3	0.3	0.8
1792	0.38	28.5	N	3.3	12.8	9.4	6.6	14.0	6.5	1.3
1801	1.19	23.7	N	1.5	0.6	0.2	22.0	25.4	0.4	N
1802	0.64	30.9	N	2.4	10.9	8.0	8.2	13.9	4.4	2.1
1804	0.46	16.0	N	2.7	11.4	2.7	3.3	21.6	7.0	0.6
1805	0.52	3.8	N	1.9	7.5	0.4	P	2.6	2.6	N
1814	0.49	22.6	N	2.8	10.0	5.1	3.0	16.9	2.0	1.6
1815	1.25	8.4	N	0.9	3.8	0.5	1.3	16.0	0.5	P
1816	1.64	14.7	N	2.4	11.4	3.9	0.9	8.4	0.6	P
1817	2.55	14.1	N	5.4	19.0	2.3	0.3	5.5	1.1	0.6
1818	1.63	13.8	N	5.3	12.9	1.4	1.9	16.4	1.0	0.5
1819	1.41	15.4	N	5.1	13.9	3.6	0.1	12.2	1.3	P
1820	0.55	20.0	N	2.3	6.2	3.0	2.4	14.1	0.7	0.3
1821	1.18	4.4	N	0.9	4.6	0.5	0.4	4.3	0.6	0.2
1822	1.44	2.3	N	1.9	5.2	0.9	P	2.4	0.3	P
1839	0.32	1.2	N	0.6	2.6	0.4	P	1.3	0.8	0.3
1842	0.04	31.0	N	10.0	5.0	5.0	3.0	10.0	2.0	1.0
1843	0.33	10.4	N	8.1	11.4	1.6	0.3	2.7	2.7	N
1846	0.63	6.7	N	6.4	10.9	2.5	0.3	3.0	2.0	0.7
1848	0.84	5.3	N	4.4	0.9	1.8	4.4	2.0	0.4	P
1849	0.43	14.9	N	5.2	7.7	7.7	7.7	12.8	4.0	0.5
1857	0.57	3.2	N	1.9	1.4	1.0	1.0	2.0	0.3	P
1858	1.86	22.7	N	6.2	4.2	4.0	34.4	18.9	2.2	0.9
1859	0.64	26.1	N	7.2	11.3	14.3	11.6	15.6	2.7	1.4
1861	1.26	30.6	N	11.6	11.0	7.1	2.9	6.6	4.0	1.3
1863	1.13	30.0	N	5.8	12.9	3.8	8.7	19.2	0.7	1.5
1869	3.85	9.6	0.6	4.8	0.3	0.6	41.2	35.0	0.9	1.1
1870	5.88	33.7	N	12.3	0.6	5.3	19.4	22.9	0.9	1.4

SAMPLE NUMBER	RUTILE	ZIRCON	MONAZITE	PHOSPHORITE	OTHERS [4]	WT % EHM/C [5]	WT % EHM/T [6]	WT % LABILES [7]	ZTR INDEX [8]	ILMENITE/ LEUCOXENE RATIO
	------EXPRESSED AS WEIGHT PERCENTAGES------ OF THE SG >2.85 FRACTION									
1426	2.5	3.5	0.5	P	7.0	39.0	0.57	44.0	14.3	6.6
1427	3.0	4.0	0.5	N	4.5	43.5	0.90	33.0	12.8	28.0
1429	P	1.3	P	0.1	0.3	79.9	2.77	16.6	3.8	11.0
1430	0.3	1.2	P	P	0.9	55.7	1.79	41.0	4.3	10.6
1431	0.7	5.6	P	N	0.1	53.5	2.86	42.1	12.3	17.6
1432	0.1	3.3	P	P	0.8	72.5	2.27	23.7	7.3	12.9
1433	P	3.6	P	0.1	1.4	80.0	4.19	17.7	8.7	17.3
1434	P	3.2	P	P	1.5	41.6	2.13	54.7	4.9	3.2
1435	0.3	3.9	P	2.2	1.8	41.8	0.18	42.7	7.9	30.1
1436	P	4.4	1.6	P	1.0	50.2	0.30	45.2	7.8	12.1
1437	P	10.7	P	1.1	22.5	47.1	0.19	27.5	5.8	NC
1438	P	7.1	P	0.2	3.2	61.7	1.37	31.4	14.2	21.2
1439	0.0	11.1	0.0	1.6	0.1	70.1	0.45	16.9	28.2	70.9
1440	P	9.9	P	2.0	P	81.7	0.50	10.6	28.4	67.2
1442	0.3	6.3	P	0.1	0.1	59.8	0.46	31.9	13.8	24.3
1447	0.3	6.8	P	6.5	1.5	48.6	0.67	32.2	11.9	6.0
1448	0.4	10.0	P	34.2	0.8	46.9	0.70	11.4	33.9	36.9
1449	P	3.8	P	39.1	1.1	40.6	0.63	7.0	12.8	21.0
1450	P	3.0	P	24.4	1.6	44.2	0.62	13.9	7.8	10.1
1452	P	3.5	P	36.9	P	34.5	1.13	6.4	9.4	NC
1453	0.3	7.2	P	33.9	0.9	48.9	0.40	6.8	28.7	53.4
1454	P	5.4	P	27.0	0.5	44.0	0.23	11.8	17.2	15.4
1455	N	3.5	N	66.0	P	23.0	0.03	3.6	27.0	NC
1456	P	22.7	P	20.8	P	55.4	0.26	10.6	41.4	15.1
1457	P	7.9	P	22.3	10.8	39.2	0.54	9.0	18.0	7.7
1459	1.0	P	N	5.0	93.0	1.0	.00	0.0	50.0	NC
1460	0.8	11.6	P	12.3	0.9	60.2	0.79	9.6	27.7	10.0
1461	2.6	10.9	P	1.7	1.0	59.0	0.42	18.9	31.6	4.9
1462	P	14.0	P	0.6	0.9	65.8	0.57	13.9	29.9	11.6

SAMPLE NUMBER	RUTILE	ZIRCON	MONAZITE	PHOSPHORITE	OTHERS	WT % EHM/C	WT % EHM/T	WT % LABILES	ZTR INDEX	ILMENITE/ LEUCOXENE RATIO
	------EXPRESSED AS WEIGHT PERCENTAGES------ OF THE SG >2.85 FRACTION									
1463	0.5	9.7	P	1.2	P	67.9	0.71	23.9	16.0	24.6
1464	0.8	7.3	P	1.3	0.1	55.5	0.47	39.5	10.5	20.7
1792	1.3	15.1	P	0.9	0.4	60.2	0.23	19.2	33.1	22.1
1801	N	1.8	N	1.5	23.0	50.9	0.60	23.7	4.3	NC
1802	0.6	13.8	0.2	4.1	0.7	61.4	0.39	18.5	30.3	15.0
1804	P	9.3	P	19.4	6.2	47.5	0.22	8.6	28.2	25.8
1805	P	4.4	P	5.3	71.5	10.8	0.06	2.3	35.9	NC
1814	0.5	9.3	P	23.7	2.3	51.0	0.25	10.9	23.9	14.1
1815	P	1.5	P	59.5	7.7	25.8	0.32	2.7	8.1	NC
1816	P	6.5	P	41.1	10.1	29.6	0.49	7.2	20.9	NC
1817	0.3	9.7	P	36.1	5.6	30.1	0.77	8.0	25.4	25.6
1818	P	13.4	P	22.1	11.2	44.1	0.72	8.6	27.5	25.8
1819	1.1	8.5	P	32.7	6.1	37.3	0.52	8.8	23.8	NC
1820	1.3	8.1	P	35.8	5.8	43.8	0.24	7.7	26.5	66.7
1821	N	2.6	P	13.5	68.0	11.5	0.14	1.7	23.0	25.7
1822	P	0.9	P	4.7	81.6	5.6	0.08	2.7	9.9	NC
1839	P	0.6	P	59.8	32.4	3.4	0.01	1.0	22.2	4.0
1842	N	3.0	N	15.0	15.0	45.0	0.02	18.0	13.2	31.0
1843	0.7	3.4	P	28.0	30.7	17.1	0.06	10.0	21.8	NC
1846	0.4	3.0	0.1	37.5	26.5	13.9	0.09	9.2	18.8	9.0
1848	N	2.5	0.2	P	78.3	9.9	0.08	10.6	17.2	NC
1849	P	4.8	1.0	4.0	29.6	34.1	0.15	20.6	17.4	30.9
1857	P	0.9	0.2	1.1	87.0	6.3	0.04	3.9	13.7	NC
1858	0.5	4.3	P	0.3	1.2	47.3	0.88	44.7	9.4	26.3
1859	1.4	7.1	0.7	0.6	N	52.3	0.33	33.1	15.6	18.5
1861	1.2	15.3	0.3	6.4	1.7	55.3	0.70	21.6	34.1	23.2
1863	0.5	4.9	0.3	8.2	3.4	56.4	0.64	18.3	10.7	19.4
1869	P	0.8	N	0.2	5.1	46.5	1.79	47.2	1.9	8.9
1870	0.7	1.4	P	P	1.4	60.0	3.53	37.0	4.7	24.5

SAMPLE NUMBER	RUTILE	ZIRCON	MONAZITE	PHOSPHORITE	OTHERS	WT % EHM/C	WT % EHM/T	WT % LABILES	ZTR INDEX	ILMENITE/ LEUCOXENE RATIO
	------EXPRESSED AS WEIGHT PERCENTAGES------ OF THE SG >2.85 FRACTION									
1871	0.4	4.2	0.6	P	2.6	39.7	0.37	49.3	10.1	12.5
1872	0.4	3.3	P	N	1.5	41.2	0.97	52.0	6.1	11.7
1873	0.3	0.1	P	N	1.4	60.9	2.47	27.1	7.5	52.9
1875	0.3	0.6	P	0.3	N	52.1	3.73	32.0	7.2	46.0
1876	2.0	2.0	T	T	6.0	23.5	1.20	59.5	9.8	4.0
1878	P	0.2	P	1.3	N	59.1	0.62	27.5	4.4	12.6
2053	3.0	2.0	2.0	N	4.0	34.5	1.11	34.5	19.4	11.3
2054	3.0	5.0	0.5	N	7.0	28.0	0.32	44.5	19.3	3.2
2060	0.9	7.9	N	P	1.2	52.2	1.10	42.2	14.3	6.6
2061	1.5	1.5	T	N	3.5	35.0	1.84	51.5	10.5	4.5
2062	0.3	2.3	P	P	1.0	56.2	1.33	37.9	6.3	10.7
2064	0.5	1.2	P	N	N	40.8	0.34	49.7	3.5	12.2
2305	3.3	11.4	P	2.1	4.1	37.7	0.47	18.3	24.5	6.8
2315	1.1	6.5	P	0.2	0.2	56.9	1.27	39.0	12.3	38.0
2316	N	0.7	0.3	0.7	67.8	15.1	0.11	8.7	3.5	NC
2317	0.4	6.7	0.6	4.2	17.8	47.7	0.23	15.5	15.2	27.4
2318	0.4	5.6	P	2.5	22.7	34.3	0.11	28.2	16.6	31.2
2320	0.2	3.2	P	1.0	4.4	38.7	0.17	49.0	5.7	1.1
2321	0.2	1.2	N	P	2.8	48.1	1.35	45.1	4.5	3.2
2322	0.6	2.0	P	P	4.9	45.0	1.04	47.5	4.5	4.6
2323	0.3	1.7	N	N	3.6	39.2	1.80	55.3	4.1	1.8
2324	0.6	2.0	P	P	1.6	56.2	4.38	37.6	7.2	7.4
2325	0.8	4.2	0.7	0.3	7.1	53.5	0.16	32.5	15.1	36.3
2326	0.8	6.2	0.3	P	0.8	37.3	0.65	48.8	10.0	140.2
2327	1.0	6.6	P	0.7	10.6	40.7	0.19	29.8	4.6	9.3
2328	0.5	2.6	P	1.1	1.0	46.9	2.35	47.1	6.3	5.8
2329	0.3	6.1	P	N	N	38.2	0.07	53.9	9.7	4.9
2330	0.6	3.0	P	P	2.0	52.8	0.90	42.0	6.9	2.2
2331	0.3	2.0	P	1.6	10.7	39.2	0.29	41.2	10.5	7.7

Table 5. --Table showing statistical data for 87 surface grab samples collected from the Atlantic Continental Shelf offshore of North Carolina grouped into all, northern, and southern sets. Explanation of column headers is given on Tables 2 - 4; NV indicates statistics are not valid because of the small number of samples.

		GRAVEL >2.00 mm %	SAND 2.00 TO 0.0625 mm %	SILT 0.0625 TO 0.0039 mm %	CLAY <0.0039 mm %	WT % >16 MESH	WT % <16->325 MESH	WT % <325 MESH	MEAN SIZE mm	GAMMA ACTIVITY CPM/g
	COUNT	87	87	87	87	84	84	84	87	44
	MINIMUM	0.0	76.0	0.0	0.0	0.0	55.2	0.0	0.06	0.15
ALL SAMPLES	AVERAGE	0.6	98.0	1.4	0.1	6.2	93.5	0.4	0.29	0.72
	MAXIMUM	9.0	100.0	17.5	6.5	44.8	99.9	7.8	0.93	2.18
	STD DEV	1.6	3.8	3.2	0.7	9.2	9.1	0.9	0.18	0.42
	COUNT	33	33	33	33	33	33	33	33	16
	MINIMUM	0.0	76.0	0.0	0.0	.0	71.7	0.0	0.06	0.15
NORTHERN GROUP	AVERAGE	0.7	97.0	2.0	0.2	3.9	95.6	0.5	0.26	0.79
	MAXIMUM	9.0	100.0	17.5	6.5	28.3	99.7	7.8	0.75	2.18
	STD DEV	2.1	5.0	4.0	1.1	7.7	7.6	1.3	0.17	0.55
	COUNT	54	54	54	54	51	51	51	54	28
	MINIMUM	0.0	84.0	0.0	0.0	0.0	55.2	0.0	0.08	0.25
SOUTHERN GROUP	AVERAGE	0.5	98.6	1.0	0.0	7.6	92.1	0.3	0.31	0.69
	MAXIMUM	7.0	100.0	16.0	0.0	44.8	99.9	2.3	0.93	1.52
	STD DEV	1.3	2.7	2.5	0.0	9.8	9.7	0.6	0.18	0.31

		VOL % CACO3 OF SAND	POTASH FELDSPAR	PLAGIOCLASE FELDSPAR	TOTAL FELDSPAR	NUMBER OF SIZE MODES	WEIGHT % HM	ILMENITE	MAGNETITE	GARNET
			AS A PERCENTAGE OF THE NON-CARBONATE 0.125-.250 mm FRACTION					----EXPRESSED AS WEIGHT---- PERCENTAGES OF THE SG >2.85 FRACTION		
	COUNT	76	75	73	73	87	87	86	6	86
	MINIMUM	1	1	1	2	1.0	0.04	1.2	0.1	0.6
ALL SAMPLES	AVERAGE	17	6	4	10	1.3	1.77	21.1	2.4	8.0
	MAXIMUM	78	17	11	22	4.0	7.79	56.9	7.3	27.9
	STD DEV	20	3	3	6	0.6	1.69	11.9	2.7	6.2
	COUNT	27	25	25	25	33	33	33	6	33
	MINIMUM	1	2	1	5	1.0	0.19	4.5	0.1	3.9
NORTHERN GROUP	AVERAGE	2	8	6	14	1.5	2.97	22.7	2.4	12.9
	MAXIMUM	8	17	11	22	4.0	7.79	47.6	7.3	27.9
	STD DEV	2	3	3	5	0.8	2.10	12.1	2.7	6.8
	COUNT	49	50	48	48	54	54	53	0	53
	MINIMUM	2	1	1	2	1.0	0.04	1.2	NV	0.6
SOUTHERN GROUP	AVERAGE	25	5	3	7	1.2	1.04	20.1	NV	5.0
	MAXIMUM	78	15	9	21	3.0	3.27	56.9	NV	14.1
	STD DEV	21	3	2	5	0.4	0.71	11.6	NV	3.1

		STAUROLITE	EPIDOTE	PYROBOLES	ALUMINO-SILICATES	TOURMALINE	LEUCOXENE	RUTILE	ZIRCON	MONAZITE
		EXPRESSED AS WEIGHT PERCENTAGES OF THE SG > 2.85 FRACTION								
	COUNT	86	84	81	86	84	73	56	87	18
	MINIMUM	0.2	0.2	0.1	1.3	0.3	0.2	0.1	0.0	0.1
ALL SAMPLES	AVERAGE	7.7	4.3	14.6	15.7	2.3	1.7	0.9	5.3	0.6
	MAXIMUM	34.0	14.4	47.0	39.5	10.0	5.8	3.3	22.7	2.0
	STD DEV	5.9	3.2	13.0	9.2	1.9	1.1	0.8	4.2	0.5
	COUNT	32	32	33	33	33	33	27	33	8
	MINIMUM	0.2	0.6	5.0	6.0	0.5	0.2	0.1	0.1	0.3
NORTHERN GROUP	AVERAGE	5.6	5.0	22.5	19.3	2.7	2.1	0.9	3.1	0.8
	MAXIMUM	17.5	14.4	47.0	38.1	10.0	5.8	3.0	7.9	2.0
	STD DEV	4.9	3.3	12.3	9.3	2.1	1.2	0.9	1.9	0.6
	COUNT	54	52	48	53	51	40	29	53	10
	MINIMUM	0.6	0.2	0.1	1.3	0.3	0.2	0.2	0.6	0.1
SOUTHERN GROUP	AVERAGE	8.9	4.0	9.2	13.5	2.0	1.4	0.9	6.9	0.4
	MAXIMUM	34.0	14.3	35.7	39.5	7.3	5.3	3.3	22.7	1.0
	STD DEV	6.1	3.1	10.4	8.5	1.6	1.0	0.7	4.5	0.3

		PHOSPHORITE	OTHERS	WT % EHM/C	WT % EHM/T	WT % LABILES	ZTR INDEX	ILMENITE/ LEUCOXENE RATIO
		EXPRESSED AS WEIGHT PERCENTAGES OF THE SG >2.85 FRACTION						
	COUNT	61	78	87	86	87	87	73
	MINIMUM	0.1	0.0	1.0	.0	0.0	1.9	1.1
ALL SAMPLES	AVERAGE	13.4	12.3	43.9	0.9	25.9	15.5	20.6
	MAXIMUM	66.0	93.0	81.7	4.4	59.5	50.0	140.2
	STD DEV	17.1	22.2	17.2	1.0	16.7	10.1	21.0
	COUNT	10	29	33	33	33	33	33
	MINIMUM	0.1	0.1	23.5	0.1	16.6	1.9	1.8
NORTHERN GROUP	AVERAGE	0.8	3.1	48.2	1.5	40.6	8.6	17.8
	MAXIMUM	2.2	10.7	80.0	4.4	59.5	19.4	140.2
	STD DEV	0.7	2.9	12.9	1.2	10.6	4.3	24.8
	COUNT	51	48	54	53	54	54	40
	MINIMUM	0.1	0.1	1.0	.0	0.0	3.5	1.1
SOUTHERN GROUP	AVERAGE	15.9	18.1	41.3	0.5	16.9	19.7	22.9
	MAXIMUM	66.0	93.0	81.7	1.4	49.0	50.0	70.9
	STD DEV	17.7	26.6	18.8	0.3	12.8	10.3	16.9

whereas the southern group of samples separated into carbonate-rich and carbonate-poor subgroups at 40 percent $CaCO_3$. Greater or less than 10 weight percent >16 mesh (>1.18mm) defined coarser-grained (gravel) and finer-grained (sand) populations within each area.

The average gravel content (>2.00 mm size fraction) for the 87 samples is 0.6 weight percent in a range of 0.0 to 9.0 percent (Table 5). The particles in this size fraction are composed mostly of carbonate (shells and shell fragments), with minor quartz pebbles, and rock fragments. The sand-size fraction (2.00 to 0.0625 mm) constitutes an average of 98.0 weight percent in a range of 76.0 to 100.0 percent of the bulk sample. Quartz is the dominant mineral constituent of the sand-size fraction in both the northern and southern portions of the study area, however, a significant portion of this size fraction consists of carbonate in some places. The silt-size fraction (0.0625 to 0.0039 mm) averages 1.4 weight percent in a range of 0.0 to 17.5 percent. The clay-size fraction (<0.0039 mm) averages 0.1 weight percent in a 0.0 to 6.5 percent range.

The percentage of heavy minerals (calculated as a percentage of the bulk sample on a dry weight basis) ranges from 0.04 to 7.79, and averages 1.77 (Table 5). The heavy-mineral assemblage (population average percentage given in parenthesis) consists of ilmenite (21.1), aluminosilicates (undifferentiated sillimanite, kyanite, and andalusite, 15.7), pyroboles (undifferentiated pyroxene and amphibole, 14.6), phosphorite (13.4), garnet (8.0), staurolite (7.7), zircon (5.3), epidote (4.3), magnetite (2.4), tourmaline (2.4), leucoxene (altered ilmenite, 1.7), rutile (0.9), and monazite (0.6). An "others" group was also estimated and includes shell fragments (both macro- and microfossil), mica, polymineralic grains, siderite(?), spinel(?), glauconite, sulfides (of biogenic origin), unidentified opaques and non-opaques, quartz, and clay balls.

DATA ANALYSIS

Variations in mineral composition appear to be a function of sediment texture and site bathymetry. An abrupt decrease in the heavy-mineral content of the offshore sediments to the south of Cape Hatteras (Figure 2) is paralleled by a decrease in total feldspar content (Figure 3). We interpret the higher feldspar content of the sediments to the north of Hatteras as an indicator of a fluvial source of detritus. Seismic surveys showing the presence of an eastward-trending ancestral Albemarle channel, as well as fluvial channel deposits (Shideler and Swift, 1972) and bathymetric and textural data showing what may constitute the retreat path of the ancestral James River (Swift and others, 1977) provide supporting evidence for this interpretation. Within the northern group $CaCO_3$-poor sands have higher feldspar contents as do deeper-water samples (Figure 4). Within the southern group, outer- and inner-shelf $CaCO_3$-poor sands have higher feldspar contents while mid-shelf sediments have lower values.

The heavy-mineral content and distribution in the northern and southern groups also show marked differences (Figure 5). Overall, the northern group contains almost three times more heavy minerals than the southern group does. In the north, heavy-mineral values are highest in the mid-shelf region; south of Cape Hatteras the heavy-mineral content decreases steadily with increasing water depth. $CaCO_3$-poor sands in both areas have the highest heavy-mineral contents. Distribution of the economically valuable heavy minerals (EHM/T; the sum of ilmenite, leucoxene (altered ilmenite), rutile, zircon, monazite, and aluminosilicates (undif-

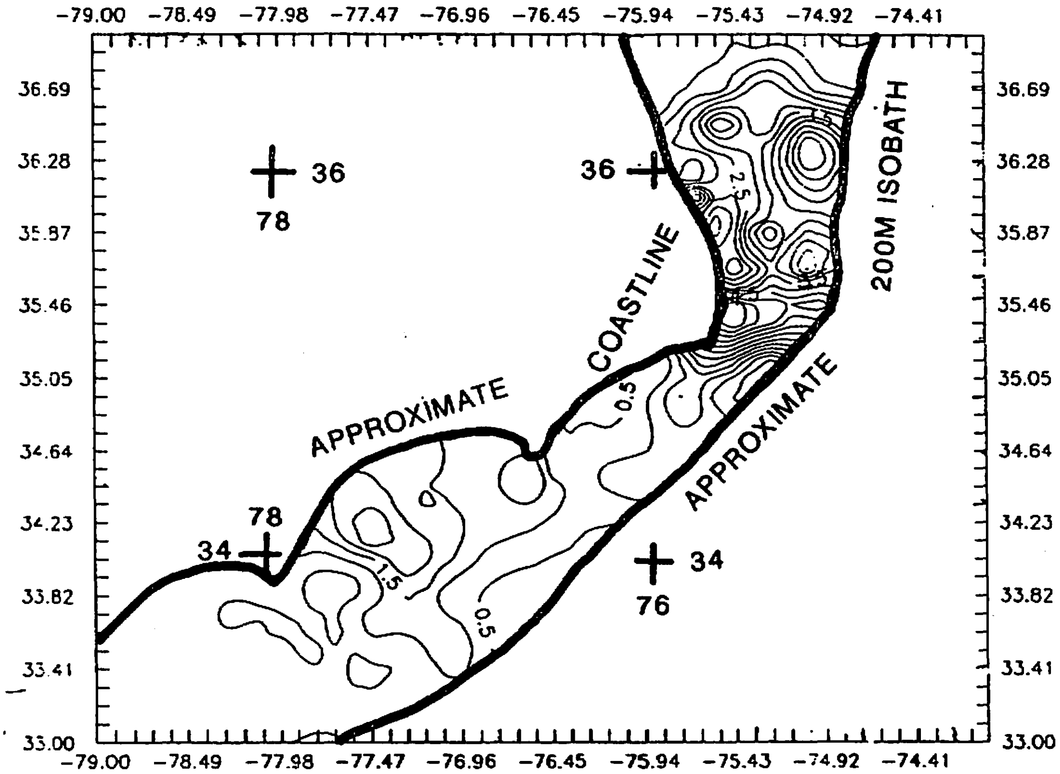


Figure 2. --Contour map of the percentage of heavy minerals in surficial sediments on the Atlantic Continental Shelf offshore of North Carolina. Contour interval is 0.5 percent.

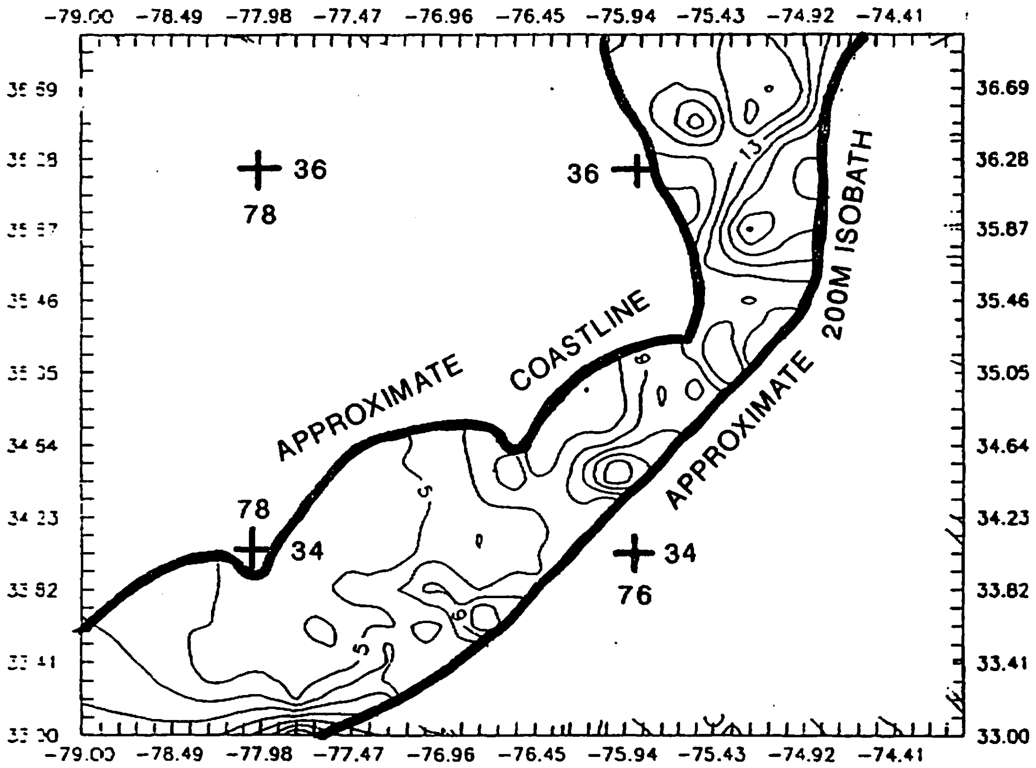


Figure 3. --Contour map of the percentage of total feldspar in surficial sediments on the Atlantic Continental Shelf offshore of North Carolina. Contour interval is 1.0 percent.

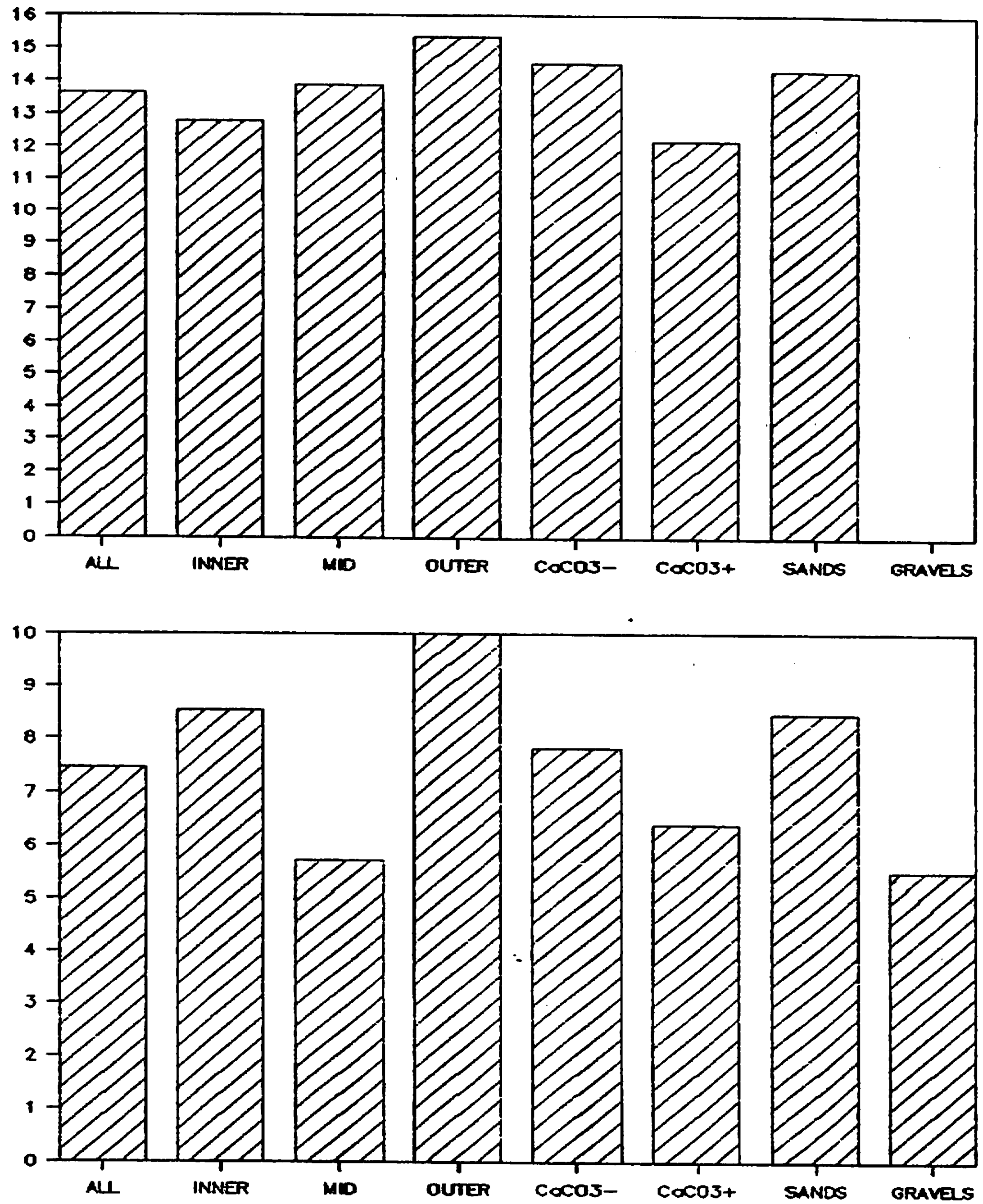


Figure 4. --Histograms showing the distribution of feldspar in samples from north of Cape Hatteras (upper histograms) and from south of Cape Hatteras (lower histograms). Class headers are ALL, all samples; INNER, inner-shelf; MID, mid-shelf; OUTER, outer shelf; CaCO-, carbonate-poor (<2 percent in the northern samples --<40 percent in the southern samples) sediments; CaCO3+, carbonate-rich samples (>2 percent in the northern samples-->40 percent in the southern samples); SANDS, <10 weight percent >16 mesh fraction; GRAVELS, >10 weight percent >16 mesh fraction.

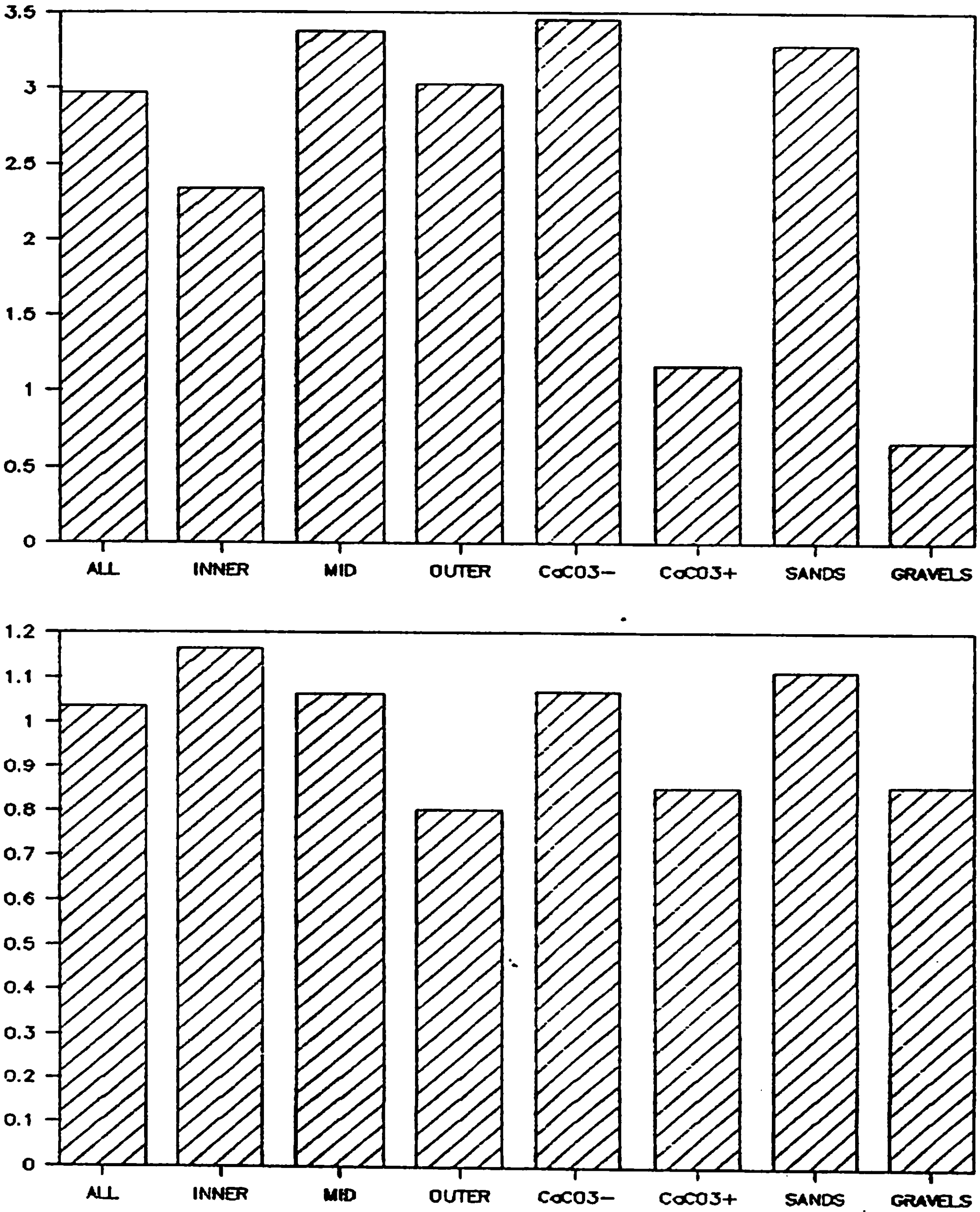
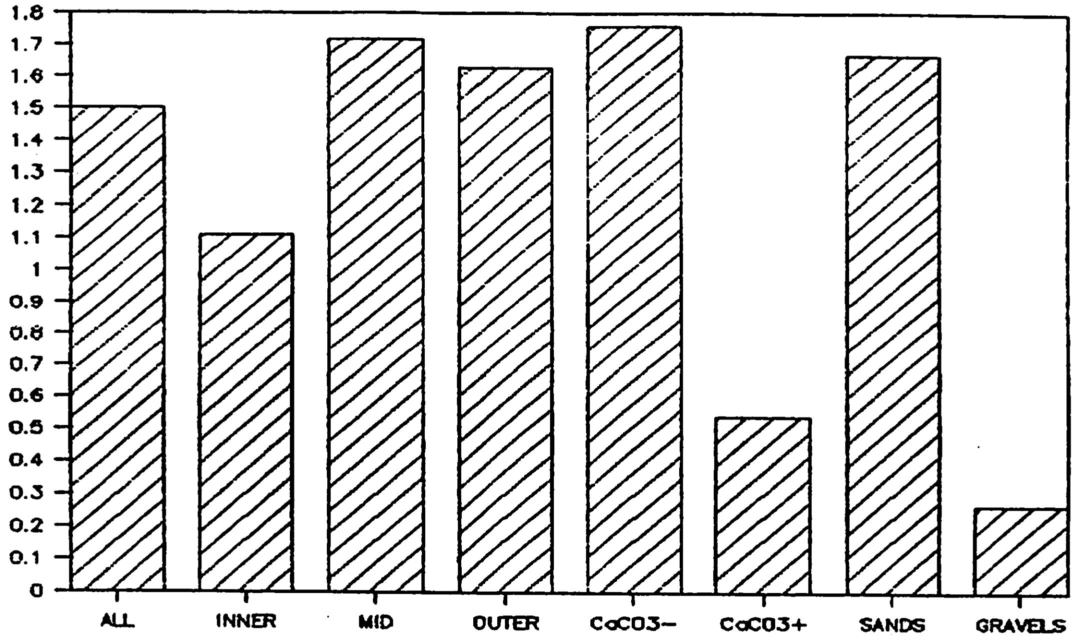


Figure 5. --Histograms showing the distribution of heavy minerals in samples from north of Cape Hatteras (upper histograms) and from south of Cape Hatteras (lower histograms). Class headers are ALL, all samples; INNER, inner-shelf; MID, mid-shelf; OUTER, outer shelf; CaCO-, carbonate-poor (<2 percent in the northern samples --<40 percent in the southern samples) sediments; CaCO3+, carbonate-rich samples (>2 percent in the northern samples-->40 percent in the southern samples); SANDS, <10 weight percent >16 mesh fraction; GRAVELS, >10 weight percent >16 mesh fraction.

ferentiated sillimanite, kyanite, andalusite) expressed as a weight percentage of the bulk sample) parallels the distribution pattern of the heavy minerals (Figure 6). On the northern segment of the North Carolina Continental Shelf economically valuable heavy minerals have their highest level of concentration in the mid-shelf region; on the southern segment, highest values are found in the inner-shelf region.

The $CaCO_3$ content of the shelf sediments south of Cape Hatteras is approximately 10 times that of the sediments to the north (Figure 7). The southern sediments show a steady increase of carbonate content with distance from shore, reaching 40 percent by weight of the sand-size fraction in the outer-shelf region. Mid-shelf sediments of the northern area have lower carbonate content than adjacent regions. The data on the $CaCO_3$ content of the sediments to the north and to the south of Cape Hatteras are consistent with Uchupi's (1963) observation that the Cape Hatteras area divides the dominantly relict fluvial or nearshore quartzose sands to the north from the dominantly calcareous organic and authigenic sediments to the south.

Sedimentary phosphorite (probably a carbonate fluorapatite) is about 20 times more abundant in sediments to the south of Cape Hatteras than to the north (Table 6, Figure 8). Outer-shelf sediments in the northern area have no detectable phosphorite in the heavy-mineral assemblage; in the southern area mid-shelf sediments have higher concentrations than the inner- or outer-shelf regions. Higher overall phosphorite contents of the sediments to the south are consistent with previously documented phosphorite resources in ocean floor sediments (for example, Riggs and others, 1982; Riggs and others, 1985).



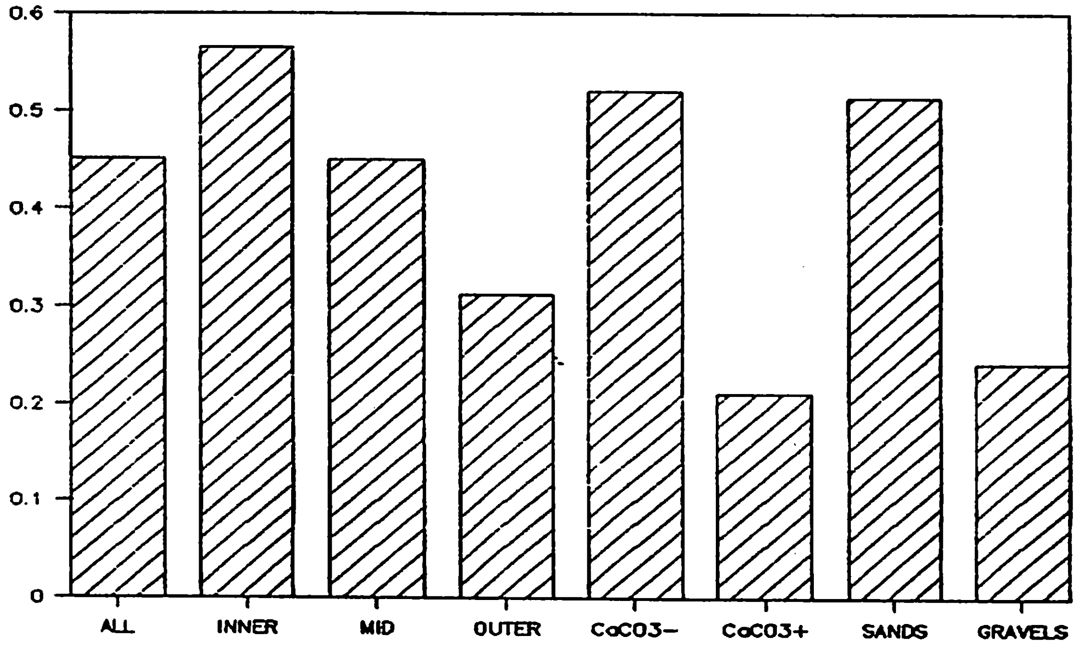


Figure 6. --Histograms showing the distribution of economic heavy minerals (expressed as weight percentages of bulk samples) in samples from north of Cape Hatteras (upper histograms) and from south of Cape Hatteras (lower histograms). Class headers are ALL, all samples; INNER, inner-shelf; MID, mid-shelf; OUTER, outer shelf; CaCO-, carbonate-poor (<2 percent in the northern samples --<40 percent in the southern samples) sediments; CaCO3+, carbonate-rich samples (>2 percent in the northern samples-->40 percent in the southern samples); SANDS, <10 weight percent >16 mesh fraction; GRAVELS, >10 weight percent >16 mesh fraction.

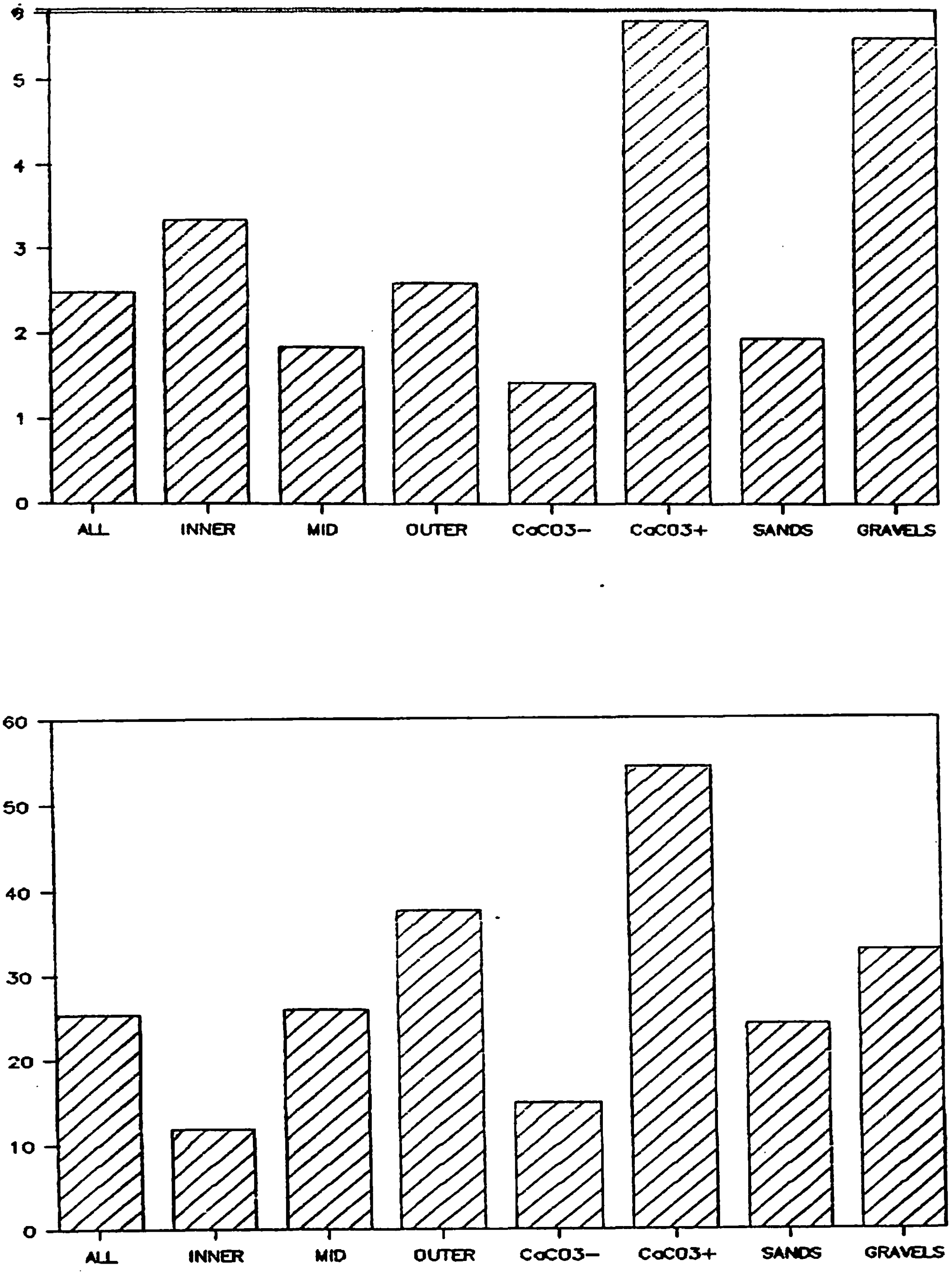


Figure 7. --Histograms showing the distribution of $CaCO_3$ (calcium carbonate) in sediments from north of Cape Hatteras (upper histograms) and from south of Cape Hatteras (lower histograms). Class headers are ALL, all samples; INNER, inner-shelf; MID, mid-shelf; OUTER, outer shelf; CaCO-, carbonate-poor (<2 percent in the northern samples --<40 percent in the southern samples) sediments; CaCO3+, carbonate-rich samples (>2 percent in the northern samples-->40 percent in the southern samples); SANDS, <10 weight percent >16 mesh fraction; GRAVELS, >10 weight percent >16 mesh fraction.

Table 6. --Table showing statistical data for 87 surface grab samples collected from the Atlantic Continental Shelf offshore of North Carolina south of Cape Hatteras grouped according to compositional, textural, and bathymetric criteria.

Explanation of column headers given on Tables 2 - 4.

		GRAVEL >2.00 mm %	SAND 2.00 TO 0.0625 mm %	SILT 0.0625 TO 0.0039 mm %	CLAY <0.0039 mm %	WT % >16 MESH	WT % <16->325 MESH	WT % <325 MESH	MEAN SIZE mm	GAMMA ACTIVITY CPM/g
	COUNT	16	16	16	16	14	14	14	16	7
SOUTHERN	MINIMUM	0.0	84.0	0.0	0.0	0.0	66.6	0.0	0.08	0.26
INNER SHELF	AVERAGE	1.1	97.1	1.8	0.0	10.4	89.0	0.5	0.35	0.75
<20m DEPTH	MAXIMUM	7.0	100.0	16.0	0.0	33.4	99.9	2.3	0.93	1.52
	STD DEV	2.2	4.2	4.2	0.0	10.3	9.9	0.8	0.24	0.41
	COUNT	26	26	26	26	25	25	25	26	14
SOUTHERN	MINIMUM	0.0	98.0	0.0	0.0	0.2	55.2	0.0	0.15	0.25
MID SHELF	AVERAGE	0.2	99.5	0.3	0.0	6.4	93.5	0.1	0.29	0.73
>20m-<40m DEPTH	MAXIMUM	1.5	100.0	2.0	0.0	44.8	99.7	0.2	0.65	1.12
	STD DEV	0.4	0.7	0.6	0.0	10.6	10.6	0.1	0.14	0.29
	COUNT	12	12	12	12	12	12	12	12	7
SOUTHERN	MINIMUM	0.0	94.0	0.0	0.0	0.2	77.9	0.0	0.10	0.27
OUTER SHELF	AVERAGE	0.2	98.6	1.3	0.0	6.7	92.8	0.4	0.30	0.55
>40m DEPTH	MAXIMUM	1.0	100.0	6.0	0.0	21.7	98.9	1.5	0.55	0.75
	STD DEV	0.4	1.7	1.7	0.0	6.2	6.1	0.5	0.14	0.15
	COUNT	36	36	36	36	33	33	33	36	19
SOUTHERN	MINIMUM	0.0	84.0	0.0	0.0	0.0	55.2	0.0	0.08	0.25
CaCO3-POOR	AVERAGE	0.5	98.3	1.2	0.0	7.1	92.6	0.3	0.30	0.67
SEDIMENTS	MAXIMUM	7.0	100.0	16.0	0.0	44.8	99.5	1.8	0.93	1.52
	STD DEV	1.5	3.2	3.0	0.0	10.1	10.0	0.5	0.18	0.32
	COUNT	13	13	13	13	13	13	13	13	7
SOUTHERN	MINIMUM	0.0	98.0	0.0	0.0	0.2	72.8	0.0	0.19	0.27
CaCO3-RICH	AVERAGE	0.4	99.2	0.5	0.0	9.1	90.7	0.2	0.36	0.68
SEDIMENTS	MAXIMUM	1.0	100.0	2.0	0.0	27.2	99.7	1.3	0.65	1.12
	STD DEV	0.5	0.7	0.7	0.0	8.9	9.0	0.3	0.15	0.30
	COUNT	37	37	37	37	37	37	37	37	18
SOUTHERN	MINIMUM	0.0	84.0	0.0	0.0	0.0	90.9	0.0	0.08	0.25
SANDS	AVERAGE	.0	98.6	1.4	0.0	2.5	97.1	0.3	0.23	0.70
	MAXIMUM	1.0	100.0	16.0	0.0	9.1	99.9	2.3	0.55	1.11
	STD DEV	0.2	3.0	3.0	0.0	2.7	2.7	0.6	0.09	0.25
	COUNT	14	14	14	14	14	14	14	14	9
SOUTHERN	MINIMUM	0.0	93.0	0.0	0.0	10.7	55.2	0.0	0.33	0.26
GRAVELS	AVERAGE	1.7	98.3	0.0	0.0	21.0	78.9	0.1	0.54	0.67
	MAXIMUM	7.0	100.0	0.0	0.0	44.8	89.3	1.3	0.93	1.52
	STD DEV	2.2	2.2	0.0	0.0	9.2	9.1	0.3	0.16	0.41

		VOL % CACO3 OF SAND	POTASH FELDSPAR	PLAGIOCLASE FELDSPAR	TOTAL FELDSPAR	NUMBER OF SIZE MODES	WEIGHT % HM	ILMENITE	MAGNETITE	GARNET
			AS A PERCENTAGE OF THE NON-CARBONATE 0.125-.250 mm FRACTION					----EXPRESSED AS WEIGHT---- PERCENTAGES OF THE SG >2.85 FRACTION		
	COUNT	12	14	13	13	16	16	15	0	15
SOUTHERN	MINIMUM	2	1	1	2	1.0	0.1	4.6	NV	1.4
INNER SHELF	AVERAGE	12	5	3	9	1.4	1.2	20.4	NV	6.8
<20m DEPTH	MAXIMUM	37	13	9	21	3.0	3.3	47.4	NV	14.1
	STD DEV	11	4	3	6	0.6	1.0	11.1	NV	3.7
	COUNT	25	25	24	24	26	26	26	0	26
SOUTHERN	MINIMUM	3	2	1	3	1.0	0.4	3.8	NV	0.9
MID SHELF	AVERAGE	26	4	2	6	1.1	1.1	20.9	NV	3.9
>20m-<40m DEPTH	MAXIMUM	78	7	6	12	2.0	2.5	56.9	NV	8.0
	STD DEV	19	1	2	2	0.3	0.6	11.8	NV	1.8
	COUNT	12	11	11	11	12	12	12	0	12
SOUTHERN	MINIMUM	4	3	1	5	1.0	.0	1.2	NV	0.6
OUTER SHELF	AVERAGE	38	6	4	10	1.1	0.8	17.9	NV	5.1
>40m DEPTH	MAXIMUM	77	15	7	20	2.0	1.9	31.0	NV	11.6
	STD DEV	25	4	2	6	0.3	0.5	11.3	NV	3.4
	COUNT	36	34	33	33	36	36	35	0	35
SOUTHERN	MINIMUM	2	1	1	2	1.0	0.1	3.2	NV	1.4
CaCO3-POOR	AVERAGE	15	5	3	8	1.3	1.1	22.9	NV	5.1
SEDIMENTS	MAXIMUM	40	15	9	21	3.0	3.3	56.9	NV	12.5
	STD DEV	12	3	2	5	0.5	0.8	11.6	NV	2.8
	COUNT	13	13	13	13	13	13	13	0	13
SOUTHERN	MINIMUM	42	2	1	3	1.0	.0	1.2	NV	0.6
CaCO3-RICH	AVERAGE	54	4	2	6	1.0	0.9	11.5	NV	3.8
SEDIMENTS	MAXIMUM	78	10	6	15	1.0	1.6	31.0	NV	10.0
	STD DEV	14	2	2	3	0.0	0.5	8.1	NV	2.9
	COUNT	33	34	32	32	37	37	37	0	37
SOUTHERN	MINIMUM	2	1	1	4	1.0	0.3	1.2	NV	0.6
SANDS	AVERAGE	24	5	3	8	1.2	1.1	21.5	NV	4.8
	MAXIMUM	78	15	9	21	2.0	2.8	56.9	NV	14.1
	STD DEV	22	3	2	5	0.4	0.6	12.2	NV	3.0
	COUNT	13	14	14	14	14	14	13	0	13
SOUTHERN	MINIMUM	7	1	1	2	1.0	.0	2.3	NV	1.9
GRAVELS	AVERAGE	33	4	2	6	1.4	0.9	14.8	NV	6.1
	MAXIMUM	75	10	5	15	3.0	3.3	31.0	NV	12.5
	STD DEV	18	2	1	3	0.6	0.9	8.6	NV	3.2

EXPRESSED AS WEIGHT PERCENTAGES OF THE SG > 2.85 FRACTION

		STAUROLITE	EPIDOTE	PYROBOLES	ALUMINO-SILICATES	TOURMALINE	LEUCOXENE	RUTILE	ZIRCON	MONAZITE
	COUNT	16	15	13	15	14	12	11	15	2
SOUTHERN	MINIMUM	1.0	0.6	0.9	2.0	0.3	0.7	0.2	0.7	NV
INNER SHELF	AVERAGE	8.8	4.6	14.9	16.3	1.7	1.5	0.8	5.8	NV
<20m DEPTH	MAXIMUM	34.0	13.1	35.7	39.5	3.9	4.3	3.3	11.4	NV
	STD DEV	8.5	3.5	13.3	11.5	1.1	1.0	0.8	3.4	NV
	COUNT	26	26	25	26	26	21	13	26	3
SOUTHERN	MINIMUM	0.9	0.4	0.1	2.0	0.4	0.2	0.3	1.5	0.1
MID SHELF	AVERAGE	10.2	3.7	5.4	12.8	2.1	1.5	1.0	8.2	0.3
>20m-<40m DEPTH	MAXIMUM	19.0	14.3	20.8	23.1	7.3	5.3	2.6	22.7	0.7
	STD DEV	4.6	2.9	6.1	5.6	1.9	1.1	0.7	4.6	0.3
	COUNT	12	11	10	12	11	7	5	12	5
SOUTHERN	MINIMUM	0.6	0.2	0.3	1.3	0.3	0.3	0.5	0.6	0.2
OUTER SHELF	AVERAGE	6.2	3.6	11.0	11.4	2.0	1.1	0.7	5.4	0.4
>40m DEPTH	MAXIMUM	12.9	8.0	34.4	25.4	4.4	2.1	1.2	15.3	1.0
	STD DEV	4.2	2.9	10.7	8.2	1.5	0.6	0.2	4.9	0.3
	COUNT	36	35	33	35	35	30	21	35	8
SOUTHERN	MINIMUM	0.6	0.2	0.3	2.0	0.3	0.5	0.2	0.9	0.2
CaCO3-POOR	AVERAGE	8.8	4.6	11.1	15.9	2.1	1.4	0.7	7.5	0.4
SEDIMENTS	MAXIMUM	21.8	14.3	35.7	39.5	7.0	4.3	1.9	22.7	1.0
	STD DEV	5.4	3.4	10.9	8.4	1.6	0.8	0.4	4.8	0.3
	COUNT	13	12	10	13	12	6	4	13	1
SOUTHERN	MINIMUM	1.7	0.4	0.1	1.3	0.3	0.2	0.4	0.6	NV
CaCO3-RICH	AVERAGE	7.9	2.1	3.4	8.6	1.2	0.8	0.9	4.7	NV
SEDIMENTS	MAXIMUM	17.9	5.0	21.8	22.1	2.7	2.1	1.3	10.7	NV
	STD DEV	4.7	1.5	6.2	6.3	0.8	0.7	0.4	3.1	NV
	COUNT	37	37	36	37	37	31	21	37	6
SOUTHERN	MINIMUM	0.6	0.2	0.1	1.3	0.3	0.2	0.2	0.6	0.2
SANDS	AVERAGE	9.0	4.1	9.8	14.8	2.2	1.5	0.9	6.9	0.5
	MAXIMUM	34.0	14.3	35.7	39.5	7.3	5.3	3.3	15.3	1.0
	STD DEV	6.2	2.9	11.0	8.0	1.8	1.1	0.8	4.1	0.3
	COUNT	14	12	9	13	11	6	5	13	4
SOUTHERN	MINIMUM	0.9	0.4	0.3	2.0	0.3	0.6	0.3	0.7	0.1
GRAVELS	AVERAGE	8.7	2.2	5.0	7.4	1.4	0.9	0.5	5.9	0.3
	MAXIMUM	21.8	6.3	21.8	22.1	2.6	1.3	1.0	22.7	0.6
	STD DEV	6.2	1.7	6.5	5.8	0.9	0.2	0.3	5.6	0.2

		PHOSPHORITE	OTHERS	WT % EHM/C	WT % EHM/T	WT % LABILES	ZTR INDEX	ILMENITE/ LEUCOXENE RATIO
		EXPRESSED AS WEIGHT PERCENTAGES OF THE SG >2.85 FRACTION						
	COUNT	14	13	16	15	16	16	12
SOUTHERN	MINIMUM	0.2	0.1	1.0	.0	0.0	3.5	1.1
INNER SHELF	AVERAGE	13.1	16.9	41.7	0.6	22.8	17.4	23.4
<20m DEPTH	MAXIMUM	66.0	93.0	70.1	1.4	49.0	50.0	70.9
	STD DEV	19.4	28.3	17.5	0.4	16.0	12.3	19.0
	COUNT	25	23	26	26	26	26	21
SOUTHERN	MINIMUM	0.1	0.1	9.9	0.1	1.7	7.8	4.9
MID SHELF	AVERAGE	19.7	14.0	43.6	0.5	12.9	22.8	23.1
>20m-<40m DEPTH	MAXIMUM	59.5	78.3	81.7	1.4	33.1	41.4	67.2
	STD DEV	16.3	23.4	18.1	0.3	9.1	8.5	17.6
	COUNT	12	12	12	12	12	12	7
SOUTHERN	MINIMUM	0.3	0.7	3.4	.0	1.0	4.3	4.0
OUTER SHELF	AVERAGE	11.2	27.4	35.8	0.3	17.5	16.1	21.4
>40m DEPTH	MAXIMUM	59.8	87.0	61.4	0.9	44.7	34.1	31.0
	STD DEV	16.5	27.9	20.9	0.3	11.7	9.0	8.9
	COUNT	33	30	36	35	36	36	30
SOUTHERN	MINIMUM	0.1	0.1	1.0	.0	0.0	4.3	1.1
$CaCO_3$-POOR	AVERAGE	12.6	13.6	46.8	0.5	19.6	19.8	22.8
SEDIMENTS	MAXIMUM	66.0	93.0	81.7	1.4	49.0	50.0	70.9
	STD DEV	15.6	25.4	17.1	0.3	13.3	10.8	16.0
	COUNT	13	13	13	13	13	13	6
SOUTHERN	MINIMUM	1.1	5.8	3.4	.0	1.0	5.8	4.0
$CaCO_3$-RICH	AVERAGE	27.4	29.9	25.4	0.2	8.3	19.1	24.0
SEDIMENTS	MAXIMUM	59.8	81.6	47.1	0.5	27.5	35.9	66.7
	STD DEV	18.7	25.6	15.3	0.2	7.1	7.9	21.5
	COUNT	35	35	37	37	37	37	31
SOUTHERN	MINIMUM	0.1	0.1	3.4	.0	1.0	4.3	1.1
SANDS	AVERAGE	16.3	10.5	45.0	0.5	18.4	19.5	23.2
	MAXIMUM	59.8	87.0	81.7	1.4	49.0	34.1	70.9
	STD DEV	17.1	18.8	16.5	0.3	13.5	9.1	18.7
	COUNT	13	11	14	13	14	14	6
SOUTHERN	MINIMUM	0.7	5.6	1.0	.0	0.0	3.5	9.0
GRAVELS	AVERAGE	18.1	45.7	26.7	0.2	10.8	20.7	23.2
	MAXIMUM	66.0	93.0	55.4	1.1	28.2	50.0	31.2
	STD DEV	19.4	30.9	17.1	0.3	8.4	13.3	8.3

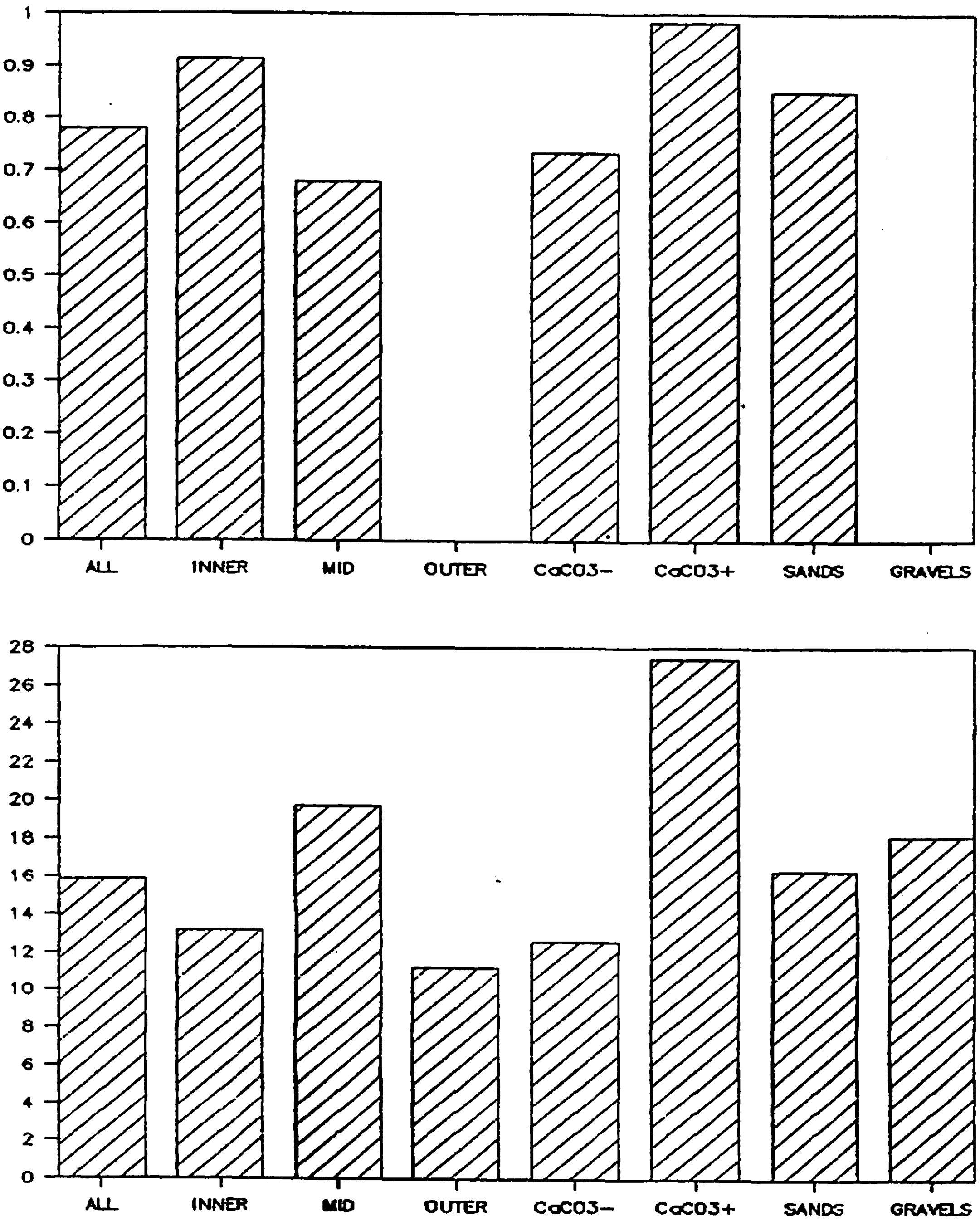


Figure 8. --Histograms showing the distribution of phosphorite in samples from north of Cape Hatteras (upper histograms) and from south of Cape Hatteras (lower histograms). Class headers are ALL, all samples; INNER, inner-shelf; MID, mid-shelf; OUTER, outer shelf; CaCO-, carbonate-poor (<2 percent in the northern samples --<40 percent in the southern samples) sediments; CaCO3+, carbonate-rich samples (>2 percent in the northern samples-->40 percent in the southern samples); SANDS, <10 weight percent >16 mesh fraction; GRAVELS, >10 weight percent >16 mesh fraction.

Gamma-ray activity (expressed as counts per minute per gram of bulk sample) is higher overall in sediments to the north of Cape Hatteras than to the south (Tables 3, 6, 7, 8, and Figure 9); inner-shelf $CaCO_3$-poor sediments have the higher gamma-radiation signature--southern sediments have uniformly low gamma radiation activity. A general linear relationship between the heavy-mineral content of a sample and its gamma activity (Figure 10) implies that the radioactivity of the ocean floor samples is controlled by the abundance of radioactive minerals (probably monazite because of its thorium and uranium, zircon because of its uranium and thorium, and phosphorite because of its uranium) in the heavy-mineral suite. However, potash feldspar (because of its potassium) in the sediments also should affect the radioactivity of the samples. Because feldspar (Table 3) was determined only for non-carbonate 0.125 - 0.250 mm fractions, and phosphorite is reported as a percentage recovered by heavy liquid (Table 4) from the <16 - >325 mesh (1.18 - 0.045 mm) size fraction of the bulk samples, their effect on the gamma-ray radiation signature can not be fully evaluated with the existing data. These relationships are consistent with onshore observations of Coastal Plain sediments (Mahdavi, 1964; Force and others, 1982; Grosz, 1983; Grosz and others, in press) as well as with findings on the Continental Shelf offshore of New Jersey (Grosz and others, 1989).

Table 7.--Table showing statistical data for 87 surface grab samples collected from the Atlantic Continental Shelf offshore of North Carolina north of Cape Hatteras grouped according to compositional, textural, and bathymetric criteria. Explanation of column headers given on Tables 2 - 4.

		GRAVEL >2.00 mm %	SAND 2.00 TO 0.0625 mm %	SILT 0.0625 TO 0.0039 mm %	CLAY <0.0039 mm %	WT % >16 MESH	WT % <16->325 MESH	WT % <325 MESH	MEAN SIZE mm	GAMMA ACTIVITY CPM/g
	COUNT	11	11	11	11	11	11	11	11	4
NORTHERN	MINIMUM	0.0	90.0	0.0	0.0	0.1	71.7	0.0	0.10	0.15
INNER SHELF	AVERAGE	2.2	94.7	3.1	0.0	9.3	90.4	0.3	0.37	1.13
<20m DEPTH	MAXIMUM	9.0	100.0	10.0	0.0	28.3	99.5	0.9	0.75	2.18
	STD DEV	3.1	3.5	4.1	0.0	11.3	11.2	0.3	0.24	0.77
	COUNT	16	16	16	16	16	16	16	16	8
NORTHERN	MINIMUM	0.0	97.0	0.0	0.0	.0	95.0	0.0	0.11	0.19
MID SHELF	AVERAGE	0.0	99.7	0.3	0.0	1.0	98.7	0.3	0.20	0.68
>20m-<40m DEPTH	MAXIMUM	0.0	100.0	3.0	0.0	4.7	99.7	1.4	0.36	1.53
	STD DEV	0.0	0.8	0.8	0.0	1.3	1.3	0.4	0.08	0.43
	COUNT	6	6	6	6	6	6	6	6	4
NORTHERN	MINIMUM	0.0	76.0	0.0	0.0	0.1	92.2	0.0	0.06	0.20
OUTER SHELF	AVERAGE	0.1	94.3	4.6	1.1	1.7	96.8	1.4	0.23	0.67
>40m DEPTH	MAXIMUM	0.5	100.0	17.5	6.5	4.2	99.7	7.8	0.41	0.93
	STD DEV	0.2	8.6	6.4	2.4	1.4	2.4	2.8	0.12	0.30
	COUNT	21	21	21	21	21	21	21	21	11
NORTHERN	MINIMUM	0.0	90.0	0.0	0.0	.0	74.8	0.0	0.10	0.19
CaCO3-POOR	AVERAGE	0.3	97.5	2.1	0.0	2.4	97.3	0.3	0.24	0.88
SEDIMENTS	MAXIMUM	6.0	100.0	10.0	0.0	25.2	99.7	1.4	0.75	2.18
	STD DEV	1.3	3.6	3.5	0.0	5.3	5.2	0.4	0.15	0.60
	COUNT	7	7	7	7	7	7	7	7	3
NORTHERN	MINIMUM	0.0	76.0	0.0	0.0	0.1	71.7	0.0	0.06	0.15
CaCO3-RICH	AVERAGE	2.6	94.0	2.5	0.9	10.9	88.0	1.1	0.40	0.52
SEDIMENTS	MAXIMUM	9.0	100.0	17.5	6.5	28.3	99.4	7.8	0.69	0.92
	STD DEV	3.3	8.0	6.1	2.3	11.4	10.7	2.7	0.22	0.32
	COUNT	29	29	29	29	29	29	29	29	15
NORTHERN	MINIMUM	0.0	76.0	0.0	0.0	.0	92.2	0.0	0.06	0.19
SANDS	AVERAGE	.0	97.5	2.3	0.2	1.3	98.2	0.6	0.21	0.83
	MAXIMUM	0.5	100.0	17.5	6.5	4.7	99.7	7.8	0.42	2.18
	STD DEV	0.1	5.1	4.2	1.2	1.4	1.7	1.4	0.10	0.54
	COUNT	4	4	4	4	4	4	4	4	1
NORTHERN	MINIMUM	4.0	91.0	0.0	0.0	11.7	71.7	0.0	0.50	NV
GRAVELS	AVERAGE	6.0	94.0	0.0	0.0	23.3	76.7	0.0	0.65	NV
	MAXIMUM	9.0	96.0	0.0	0.0	28.3	88.3	0.0	0.75	NV
	STD DEV	1.9	1.9	0.0	0.0	6.8	6.8	0.0	0.09	NV

		VOL % CaCO3 OF SAND	POTASH FELDSPAR	PLAGIOCLASE FELDSPAR	TOTAL FELDSPAR	NUMBER OF SIZE MODES	WEIGHT % HM	ILMENITE	MAGNETITE	GARNET
			AS A PERCENTAGE OF THE NON-CARBONATE 0.125-.250 mm FRACTION					----EXPRESSED AS WEIGHT---- PERCENTAGES OF THE SG >2.85 FRACTION		
NORTHERN INNER SHELF <20m DEPTH	COUNT	9	9	9	9	11	11	11	2	11
	MINIMUM	1	2	2	5	1.0	0.2	4.5	NV	3.9
	AVERAGE	3	7	6	13	2.3	2.3	16.6	NV	13.5
	MAXIMUM	8	10	10	19	4.0	7.8	30.8	NV	27.9
	STD DEV	3	2	3	5	0.9	2.3	7.2	NV	7.2
NORTHERN MID SHELF >20m-<40m DEPTH	COUNT	13	13	13	13	16	16	16	1	16
	MINIMUM	1	5	1	8	1.0	0.4	8.9	NV	7.0
	AVERAGE	2	9	5	14	1.1	3.4	24.7	NV	12.5
	MAXIMUM	7	17	11	22	2.0	7.2	47.5	NV	26.7
	STD DEV	2	3	4	5	0.3	1.9	12.1	NV	5.1
NORTHERN OUTER SHELF >40m DEPTH	COUNT	5	3	3	3	6	6	6	3	6
	MINIMUM	1	7	3	10	1.0	0.9	9.6	0.6	4.6
	AVERAGE	3	8	7	15	1.0	3.0	28.6	2.2	13.0
	MAXIMUM	6	10	10	19	1.0	5.9	47.6	4.8	27.9
	STD DEV	2	1	3	4	0.0	1.8	14.5	1.8	9.2
NORTHERN CaCO3-POOR SEDIMENTS	COUNT	21	17	17	17	21	21	21	5	21
	MINIMUM	1	5	1	7	1.0	0.5	4.5	0.1	3.9
	AVERAGE	1	8	6	15	1.5	3.5	24.0	2.7	12.4
	MAXIMUM	3	13	11	22	4.0	7.8	47.6	7.3	27.9
	STD DEV	1	2	3	4	0.8	2.1	13.1	2.9	6.4
NORTHERN CaCO3-RICH SEDIMENTS	COUNT	7	5	5	5	7	7	7	2	7
	MINIMUM	3	2	1	5	1.0	0.2	9.6	NV	4.8
	AVERAGE	6	9	4	12	1.7	1.2	23.5	NV	16.0
	MAXIMUM	8	17	9	19	3.0	3.9	45.3	NV	27.9
	STD DEV	2	5	3	5	0.9	1.2	11.5	NV	8.8
NORTHERN SANDS	COUNT	23	23	23	23	29	29	29	6	29
	MINIMUM	1	5	1	8	1.0	0.4	4.5	0.1	3.9
	AVERAGE	2	8	6	14	1.3	3.3	22.9	2.4	11.8
	MAXIMUM	7	17	11	22	4.0	7.8	47.6	7.3	27.9
	STD DEV	2	3	3	4	0.6	2.0	12.6	2.7	6.2
NORTHERN GRAVELS	COUNT	4	2	2	2	4	4	4	0	4
	MINIMUM	1	2	NV	NV	2.0	0.2	10.5	NV	13.9
	AVERAGE	6	4	NV	NV	2.8	0.7	21.1	NV	20.9
	MAXIMUM	8	5	NV	NV	3.0	1.7	30.8	NV	27.9
	STD DEV	3	2	NV	NV	0.4	0.6	7.2	NV	5.0

EXPRESSED AS WEIGHT PERCENTAGES OF THE SG > 2.85 FRACTION

		STAUROLITE	EPIDOTE	PYROBOLES	ALUMINO- SILICATES	TOURMALINE	LEUCOXENE	RUTILE	ZIRCON	MONAZITE
	COUNT	11	11	11	11	11	11	11	11	3
NORTHERN	MINIMUM	0.2	1.5	5.0	7.0	0.8	0.2	0.3	1.7	0.3
INNER SHELF	AVERAGE	5.0	5.8	23.9	19.7	3.3	2.5	0.8	4.3	0.5
<20m DEPTH	MAXIMUM	13.0	14.4	47.0	38.1	7.5	5.8	3.0	7.9	0.7
	STD DEV	4.7	3.3	12.9	10.0	2.0	1.4	0.7	2.1	0.2
	COUNT	15	15	16	16	16	16	12	16	4
NORTHERN	MINIMUM	0.7	0.9	6.0	6.0	0.5	0.7	0.1	0.6	0.5
MID SHELF	AVERAGE	6.4	4.2	22.2	19.2	2.6	2.1	1.2	2.7	1.1
>20m-<40m DEPTH	MAXIMUM	17.5	11.3	43.3	37.4	10.0	4.3	3.0	5.6	2.0
	STD DEV	5.4	3.0	12.3	9.0	2.4	1.0	1.1	1.4	0.7
	COUNT	6	6	6	6	6	6	4	6	1
NORTHERN	MINIMUM	0.3	0.6	6.3	10.0	0.9	0.9	0.3	0.1	NV
OUTER SHELF	AVERAGE	4.7	5.3	20.7	18.9	1.9	1.6	0.4	1.7	NV
>40m DEPTH	MAXIMUM	10.2	11.4	41.2	35.0	3.4	3.6	0.7	4.2	NV
	STD DEV	3.5	3.4	10.6	8.3	1.0	0.9	0.1	1.6	NV
	COUNT	20	20	21	21	21	21	17	21	4
NORTHERN	MINIMUM	0.2	0.9	5.0	6.0	0.5	0.8	0.3	0.1	0.5
CaCO3-POOR	AVERAGE	5.8	4.5	21.9	19.4	2.9	2.4	1.0	2.6	0.9
SEDIMENTS	MAXIMUM	17.5	11.4	47.0	38.1	10.0	5.8	3.0	6.6	2.0
	STD DEV	5.2	2.7	12.5	10.2	2.1	1.2	1.0	1.6	0.6
	COUNT	7	7	7	7	7	7	4	7	3
NORTHERN	MINIMUM	0.3	0.6	6.6	8.1	0.8	0.2	0.3	0.2	0.3
CaCO3-RICH	AVERAGE	6.2	5.9	20.3	17.3	1.8	1.5	0.5	3.7	0.9
SEDIMENTS	MAXIMUM	12.3	14.4	41.2	35.0	4.1	3.6	0.8	6.2	1.6
	STD DEV	4.3	4.0	12.9	8.1	1.1	1.1	0.3	2.2	0.5
	COUNT	28	28	29	29	29	29	23	29	6
NORTHERN	MINIMUM	0.2	0.6	6.0	6.0	0.5	0.7	0.1	0.1	0.5
SANDS	AVERAGE	5.3	4.6	23.8	20.2	2.6	2.2	1.0	2.7	0.9
	MAXIMUM	17.5	11.4	47.0	38.1	10.0	5.8	3.0	7.9	2.0
	STD DEV	4.9	2.9	11.8	9.4	2.1	1.1	1.0	1.7	0.6
	COUNT	4	4	4	4	4	4	4	4	2
NORTHERN	MINIMUM	2.4	3.6	5.0	8.1	0.8	0.2	0.3	4.2	NV
GRAVELS	AVERAGE	8.1	7.5	12.9	13.2	3.4	1.4	0.7	5.8	NV
	MAXIMUM	12.3	14.4	32.7	19.3	6.6	2.3	1.0	6.6	NV
	STD DEV	4.1	4.2	11.4	4.6	2.2	0.9	0.3	0.9	NV

		PHOSPHORITE	OTHERS	WT % EHM/C	WT % EHM/T	WT % LABILES	ZTR INDEX	ILMENITE/ LEUCOXENE RATIO
		EXPRESSED AS WEIGHT PERCENTAGES OF THE SG >2.85 FRACTION						
	COUNT	4	10	11	11	11	11	11
NORTHERN	MINIMUM	0.3	0.8	28.0	0.1	29.8	4.1	1.8
INNER SHELF	AVERAGE	0.9	4.6	44.0	1.1	43.2	9.8	20.5
<20m DEPTH	MAXIMUM	1.6	10.7	56.2	4.4	55.3	19.3	140.2
	STD DEV	0.5	3.8	8.4	1.2	7.6	4.5	38.9
	COUNT	4	14	16	16	16	16	16
NORTHERN	MINIMUM	0.1	0.1	23.5	0.2	16.6	3.5	3.2
MID SHELF	AVERAGE	0.7	2.4	50.0	1.7	39.1	8.8	14.9
>20m-<40m DEPTH	MAXIMUM	2.2	7.0	80.0	4.2	59.5	19.4	46.0
	STD DEV	0.9	2.1	15.7	1.2	12.0	4.1	10.9
	COUNT	2	5	6	6	6	6	6
NORTHERN	MINIMUM	NV	1.4	39.7	0.4	27.1	1.9	8.9
OUTER SHELF	AVERAGE	NV	2.4	51.2	1.6	40.0	5.8	20.5
>40m DEPTH	MAXIMUM	NV	5.1	60.9	3.5	52.0	10.1	52.9
	STD DEV	NV	1.4	9.0	1.1	10.1	2.6	15.3
	COUNT	7	19	21	21	21	21	21
NORTHERN	MINIMUM	0.1	0.1	23.5	0.2	16.6	3.8	1.8
CaCO3-POOR	AVERAGE	0.7	3.3	49.3	1.8	39.1	8.2	13.8
SEDIMENTS	MAXIMUM	1.6	10.7	80.0	4.4	59.5	19.4	52.9
	STD DEV	0.6	3.1	13.5	1.2	11.4	3.9	13.0
	COUNT	4	5	7	7	7	7	7
NORTHERN	MINIMUM	0.2	0.8	37.3	0.1	27.5	1.9	4.9
CaCO3-RICH	AVERAGE	1.0	3.1	46.7	0.5	42.5	8.1	35.0
SEDIMENTS	MAXIMUM	2.2	7.1	59.1	1.8	53.9	15.1	140.2
	STD DEV	0.8	2.5	7.5	0.6	8.6	3.9	44.3
	COUNT	8	26	29	29	29	29	29
NORTHERN	MINIMUM	0.1	0.1	23.5	0.2	16.6	1.9	1.8
SANDS	AVERAGE	0.9	2.8	49.0	1.7	40.5	8.4	13.7
	MAXIMUM	2.2	10.7	80.0	4.4	59.5	19.4	52.9
	STD DEV	0.8	2.5	13.4	1.2	10.6	4.3	12.0
	COUNT	2	3	4	4	4	4	4
NORTHERN	MINIMUM	NV	0.8	37.3	0.1	29.8	4.6	4.9
GRAVELS	AVERAGE	NV	6.2	42.4	0.3	41.3	9.9	47.7
	MAXIMUM	NV	10.6	53.5	0.6	53.9	15.1	140.2
	STD DEV	NV	4.1	6.5	0.2	10.3	3.7	54.8

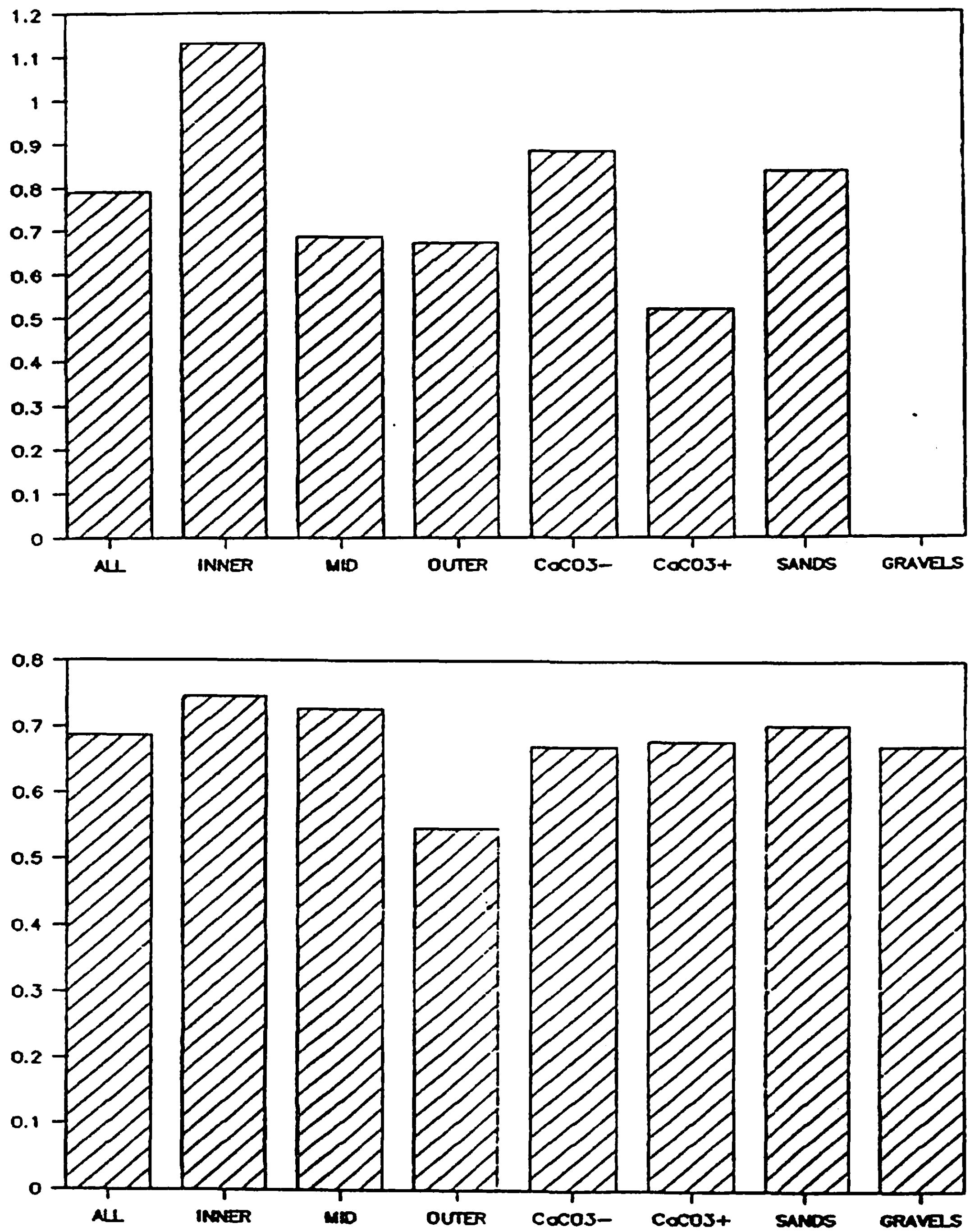


Figure 9. --Histograms showing the gamma-radiation signature of sediments from north of Cape Hatteras (upper histograms) and from south of Cape Hatteras (lower histograms). Class headers are ALL, all samples; INNER, inner-shelf; MID, mid-shelf; OUTER, outer shelf; CaCO-, carbonate-poor (<2 percent in the northern samples --<40 percent in the southern samples) sediments; CaCO3+, carbonate-rich samples (>2 percent in the northern samples-->40 percent in the southern samples); SANDS, <10 weight percent >16 mesh fraction; GRAVELS, >10 weight percent >16 mesh fraction.

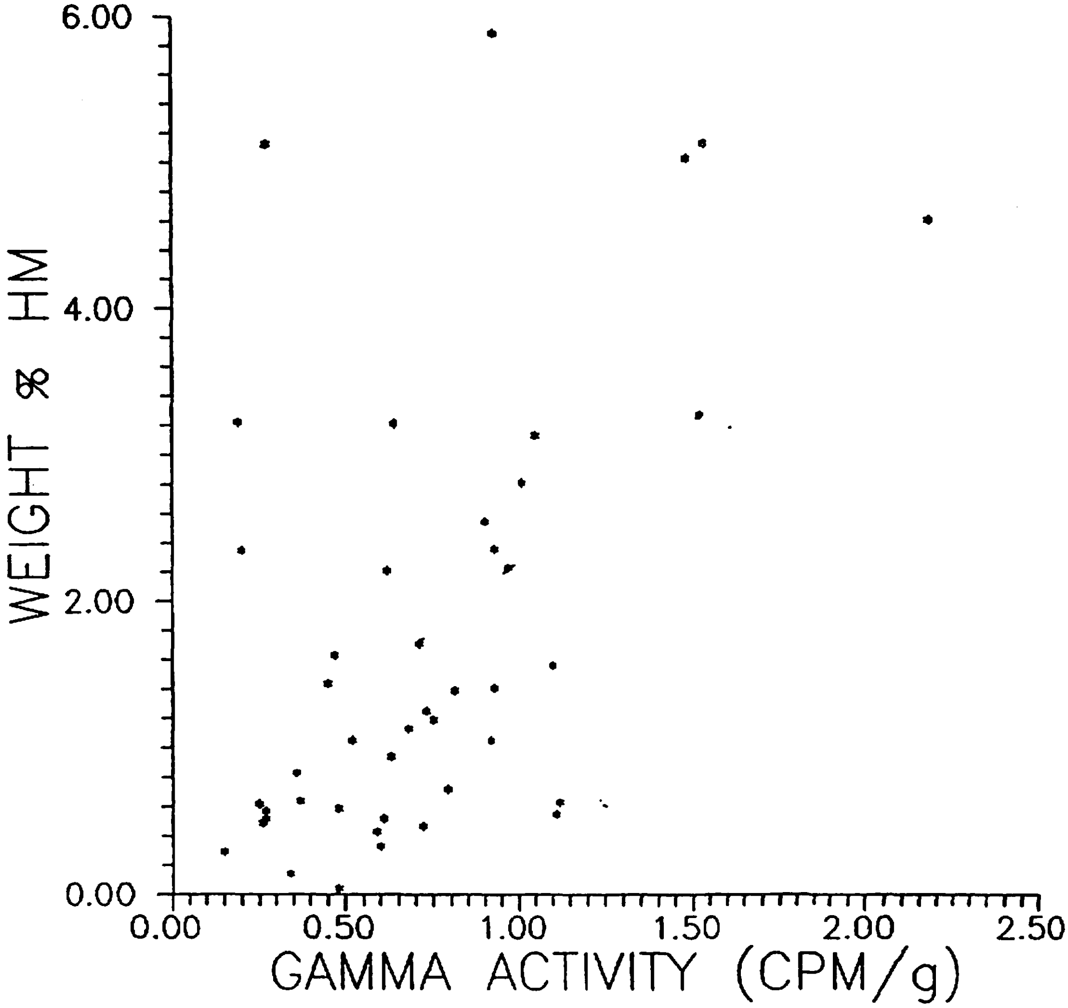


Figure 10. --Plot of gamma activity and heavy-mineral content of bulk samples for the study area.

CONCLUSIONS

Data generated for the North Carolina Continental Shelf show patterns of heavy-mineral distribution that are related to sample texture, and to site physiography and bathymetry. High concentrations of heavy minerals are associated with sediments north of Cape Hatteras where glacial-fluvial sedimentation was dominant during the Pleistocene (Hathaway, 1987). Little fluvial sedimentation takes place today north of Hatteras (Hathaway, 1972). South of Hatteras a mid-Tertiary carbonate- and phosphate-rich substrate (Popenoe, 1985) is associated with heavy-mineral concentrations that are about 30 percent of those of the northern area. The data indicate that fluvial sedimentation south of Hatteras is minimal.

North of Cape Hatteras, sediments of the inner- and mid-shelf provinces contain comparatively high concentrations of heavy minerals with notable concentrations of economically valuable heavy minerals in sediments of the mid-shelf region. Mid-shelf ridges on the Atlantic Continental Shelf offshore of New Jersey were interpreted as submerged paleobarriers that 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). Studies of heavy-mineral assemblages supported that interpretation (Grosz and others, 1989).

Similar data from this study only partially support that interpretation for the North Carolina Continental Shelf. In North Carolina the characteristic mineralogic and textural fingerprints of mid-shelf beach-complex sediments are apparently dispersed by the cumulative effects of sea-level transgression and shelf currents. The overall fluvial character of the sediments, however, is not changed by these processes. Thus, heavy-mineral studies, in conjunction with other data can be of utility in mapping the geology and resolving the geologic evolution of the surficial sediments on the North Carolina Continental Shelf.

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

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