UNITED STATES DEPARTMENT OF THE INTERIOR

GEOLOGICAL SURVEY

TITANIUM-ZIRCONIUM-RARE-EARTH PLACER RESOURCES POTENTIAL OF SURFICIAL SEDIMENTS ON THE ATLANTIC CONTINENTAL SHELF OFFSHORE OF NEW YORK, RHODE ISLAND, AND SOUTHERN MASSACHUSETTS

by

Andrew E. Grosz[1] and William M. Kelly[2]

Open-File Report 91-391

Prepared in cooperation with the New York State Geological Survey

[1]U.S. Geological Survey
Reston, VA, 22092

[2]N.Y. State Geological Survey
Albany, NY, 12230

TITANIUM-ZIRCONIUM-RARE-EARTH PLACER RESOURCES POTENTIAL OF SURFICIAL SEDIMENTS ON THE ATLANTIC CONTINENTAL SHELF OFFSHORE OF NEW YORK, RHODE ISLAND, AND SOUTHERN MASSACHUSETTS

by

Andrew E. Grosz and William M. Kelly

Table of Contents

FIGURES

TABLES

ABSTRACT

Textural and mineralogic data from eighty-three grab samples from the Atlantic Continental Shelf offshore of New York, Rhode Island, and southern Massachusetts are used to determine the potential for placer heavy-mineral resources in surficial sediments.

The sediments on this portion of the U.S. Atlantic Shelf were deposited largely by glacial and periglacial processes within the past 18,000 years. They are composed predominantly of quartz and rock fragments; shell fragments are only locally important constituents. In the eastern portion of the study area the sediments are finer grained than to the west, and a coast-parallel zone of coarser grained sediments approximately coincident with the 40 m isobath is evident offshore of Long Island.

The sediments average 2.58 % by weight heavy minerals with a standard deviation of 1.80. The species composing the bulk of the heavy-mineral suite, in decreasing order of abundance, are pyroboles, garnet, aluminosilicates, tourmaline, epidote, staurolite, ilmenite, magnetite, zircon, rutile, sphene, leucoxene (altered ilmenite), and monazite. Other, infrequently occurring minerals in the heavy-mineral assemblage include quartz with inclusions, rock fragments, micas, hematite (including concretions), pyrite and/or marcasite, spinels, glauconite, scheelite, shell fragments, flyash (anthropogenic), clayballs, corundum, apatite, and unidentified opaques and nonopaques.

The economically important heavy minerals ilmenite (including altered ilmenite), rutile, zircon, monazite, and aluminosilicates make up an average of 0.57 % by weight of the bulk sediments with a standard deviation of 0.46. The titanium minerals (exclusive of sphene) constitute an average 6.5 % by weight of the heavy-mineral assemblage and range 1.0 to 22.6 %. These values are far below currently mined ores onshore and are substantially below values found elsewhere on the U.S. Atlantic Shelf.

The potential for placer deposits of heavy minerals appears to be limited with respect to other portions of the U.S. Atlantic Continental Shelf by low overall concentrations of heavy minerals, and these have only small economic heavy-mineral components. Fluvial channels may also host placer mineral concentrations. However, the immature nature of the fluvial sediments coupled with lack of weathering of their heavy-mineral suite limits their potential. Although the radioactive heavy minerals zircon + monazite appear to control the radioactivity of the sediments in the study area gamma-radiation surveys would be little use in locating surface concentrations of heavy minerals. Areas of higher radioactivity are coincident with finer grained sediments devoid of (or relatively depleted in) heavy minerals.

INTRODUCTION

Background

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, critical, and industrial minerals are known to exist.

As part of a larger effort to assess the mineral resource potential of the sediments within the U.S. EEZ, grain-size distribution data were compiled and mineralogic data were generated for 83 surface grab samples that were collected from the Atlantic Continental Shelf (ACS) offshore of New York, Rhode Island, and southern Massachusetts.

Physiography

South of New York City, the shelf is approximately 190 km wide; the shelf break is in the vicinity of the 160-m isobath. The shelf surface is not a smooth plain; its physiographic features include erosional channels and terraces and depositional sand swells (Uchupi, 1968). The largest erosional feature in this area is a submerged Hudson River channel, 27 km wide at its mouth, which extends from the mouth of the Hudson River 170 km to the Hudson Canyon at the shelf edge. The channel was cut by the Hudson River during the Pleistocene Epoch when sea level was near the shelf edge (Uchupi, 1968). A series of terraces thought to be ancient beaches (Uchupi, 1968) are indicated at the 35-, 43-, 55-, 63-, 80-, 125-, 158-, and 210-m isobaths. Other features on the shelf include numerous shoals, some of which may be seaward extensions of glacial moraines.

Previous work

Schlee (1973) and Hollister (1973) showed that the surficial sediments in the study area are predominantly unimodal well-sorted sands except near the shelf edge offshore of MA, where the sediments are largely bi- or polymodal more poorly sorted silts and sandy silts. Gravel occurs in scattered discontinuous patches. Trumbull (1972) discussed the sand-size fraction of the sediments in the study area, and Schlee and Pratt (1970) discussed the composition and distribution of gravels.

Ross (1970) was among the first to report on the composition of heavy-mineral (HM) assemblages in the area of this study. In a regional study Ross addressed small-scale compositional trends; HM analyses were done in an effort to outline broad petrographic provinces. HM contents were determined as percentages of the sand-size fraction. Qualitative analyses of the HM assemblages provided mineral abundance data on non-opaque minerals only; opaque minerals such as magnetite, ilmenite, altered ilmenite (leucoxene), black rutile, cassiterite, and others were grouped into an undifferentiated "opaques" category, and highly altered minerals were reported as "altered grains." Tabulated analyses were not given; the information was presented graphically.

The first published analysis of economic HMs in the region of this study was given by Drucker (1983). Based on petrographic analyses of HMs separated from 92 surface grab samples (and use of adjunct seismic data) in the western portion of our study area, Drucker calculated 7 million dry tons of ilmenite to be present within three zones. It is not clear what procedures Drucker used to identify the opaque minerals that were mounted on slides and examined with a polarizing microscope. The data, however, appear to be internally inconsistent because it is not possible to distinguish between ilmenite, magnetite, titanomagnetite, leucoxene, and other opaque minerals with a polarizing microscope. Drucker also presents his mineralogic data graphically which does not allow for rigorous comparisons with the data of this study.

General placer HM distribution patterns in surficial sediments of the U.S. ACS were discussed by Grosz and others (1986), and an assessment of the economic HM resource potential was given by Grosz (1987). The patterns of distribution of individual HM species for ACS sediments were given by Grosz and Escowitz (1983), Grosz (1987), Grosz and others (1987), Grosz and others (1989a,b,c), Grosz and Nelson (1989), and Grosz and others (1990). These studies do not, however, provide mineralogic data for the shelf area of this study.

Thus, available literature for the area of this study provides HM data that were generated for regional studies or appear to be internally inconsistent. Analyses limited to non-opaque mineral species of narrow size fractions of small sediment samples do not provide adequate information for an assessment of detrital mineral resource potential. In addition, the use of very small samples creates a particle-sparsity-effect (Clifton and others, 1969), which makes difficult the accurate determination of scarce but highly valuable mineral species such as monazite.

PRESENT WORK

This study is based on 83 surface grab samples from the ACS offshore of NY, RI, and southern MA. The sample density (about 1 per 450 km^2), however, allows only for the definition of small-scale patterns. The 83 surface grab samples were collected on an approximate 20 km grid; coverage extends from the 9 to the 292 m isobath.

Methods

Sample acquisition

The samples in this study are part of a group of about 3600 ocean-floor sediment grab samples collected from the ACS jointly by the Woods Hole Oceanographic Institution and the U.S. Geological Survey (Hathaway, 1971). The sediment sample collection was conducted between 1955 and 1970 by using several types of bottom samplers, including Campbell, Smith-McIntyre, Van Veen, and Dietz-Lafond; the samples used in this study were collected during June 1962, October 1963, July and August 1964, and August 1965. The samples were located largely by means of a 20-km grid; the precision of the locations is estimated to be within about 1 nm (Figure 1). The grab samples may not accurately represent the bulk ocean-floor sediments, however, because part of the fine-grained material may have been lost from coarse grained or gravelly sediments during collection.

Laboratory procedures

An average of 180 g of bulk sample with a standard deviation (S.D.) of 62.54 was split and sieved in dry condition into the following textural classes: (1) gravel and very coarse sand (>16 mesh, >1.18 mm), (2) coarse- to very fine-grained sand (from <16 to >325 mesh, <1.18 - >0.045 mm), and (3) silt + clay (<325 mesh, <0.045 mm). The HM fraction of the coarse- to very fine-grained sand fraction was separated by using bromoform (SG >2.85). As large a split as could be derived from the original sample was used for the separation of HMs because some important mineral species, such as monazite, are typically present in very small quantities. Smaller samples are less likely to contain representative amounts of rare minerals.

HM concentrates exceeding about 2.0 g in mass were separated into three magnetic subfractions on a Frantz Isodynamic Magnetic Mineral Separator (0.0 - 0.5, 0.5 - 1.0, and >1.0 A) after the highly magnetic minerals were removed by using a hand-held magnet. Each of the four subfractions was weighed and studied independently by using petrographic and reflected light microscopes. The identification of some minerals was made by X-ray diffraction. Comparison charts for the visual estimation of percentage composition (Terry and Chillingar, 1955) and point-counting were utilized to estimate mineral abundances in each magnetic subfraction. The identification of zircon and monazite was aided by using long- and short-wave ultraviolet illumination. Abundances of individual mineral species in each magnetic subfraction were summed and calculated as weight percentages of the total HM fraction without compensation for differences in densities of individual mineral species. Lithologic descriptions, the results of these mineralogic determinations, and textural and limited mineralogic data compiled by Hathaway (1971) are given in Tables 1, 2, and 3. The data are given as weight percentages unless otherwise noted.

RESULTS

The sediments in the study area are predominantly unimodal quartz sands. The sand-size fraction averages 88.7 % (S.D. 17.5); gravel content averages 2.6 % (S.D. 7.9), and silt + clay content averages 3.6 % (S.D. 6.2) (Table 2). Quartz is the dominant component of the sand-size fraction accounting for an average of 78.55 % (S.D. 16.93). The mean grain size of the sediments averages 0.28 mm (medium sand) (S.D. 0.21; medium silt to very coarse sand) (Table 2). Carbonate content, principally in the form of shells, shell fragments, and foraminiferal tests averages 2.30 % (S.D. 2.64) of the sand-size fraction (Table 2).

The total feldspar content of the sand-size fraction averages 11 % (S.D. 8). Potash feldspar, averaging 6 % (S.D. 7), is more abundant than plagioclase feldspar which averages 5 % (S.D. 6) (Table 3).

The sediments contain an average 2.58 % (S.D. 1.80) HM; labile minerals (magnetite, pyroboles, garnet, and epidote) comprise an average of 53.3 % (S.D. 13.3) of the HMs. Although there are variations apparently related to water depth and depositional environment, the frequencies of occurrence (in decreasing order of abundance) of the HMs for the sample population are pyroboles (undifferentiated pyroxenes and amphiboles), garnet, aluminosilicates (sillimanite, kyanite, and andalusite), tourmaline, epidote, staurolite, ilmenite, magnetite, zircon, rutile, sphene, leucoxene (altered ilmenite), and monazite. Other, infrequently occurring minerals in the heavy-mineral assemblage include quartz with inclusions, rock fragments, micas (chlorite, biotite, occasional muscovite), hematite (including concretions), pyrite and/or marcasite (as filling of foraminiferal tests), spinels, glauconite, scheelite, shell fragments, flyash (anthropogenic), clayballs, corundum, apatite, and unidentified opaques and nonopaques. The results of mineralogic analyses are given on Table 3.

The detrital minerals of possible commercial interest on the study area shelf consist of ilmenite, leucoxene (altered ilmenite), rutile, zircon, monazite, and aluminosilicates (sillimanite, kyanite, and andalusite). Other HM species such as sphene, staurolite, tourmaline, and garnet have industrial applications and are valuable but are not included in this analysis. The variable EHM/T (Table 3; the sum of the economic heavy minerals ilmenite + leucoxene + rutile + zircon + monazite + aluminosilicates expressed as a percentage of the bulk sample,

T) is used as a measure of the potential for commercial deposits that the surficial sediments may have.

EHM/T averages 0.57 % (S.D. 0.46) and exhibits a general decrease with increasing mean grain size of the bulk sediments. Factors that limit the potential for significant concentrations of economic HMs include the juvenile nature of the HM assemblage and the low overall abundance of HMs in the sediments of the study area. The HM assemblage deposited in the study area shelf is ubiquitously juvenile, upgrading of the assemblages by weathering does not appear to be significant or areally extensive, and textural and mineralogic data do not provide supporting evidence for significant sea-level stillstands (necessary for the formation of large placer deposits). As marine transgressions may be effective dispersing agents of beach-complex sands, the preservation potential of beach-complex-associated deposits of HMs on the study area shelf is low. Although it is possible that small remnants of basal portions of larger HM deposits may exist, their expression would be difficult to detect with broad surface grab sampling grids; sampling at depth is necessary.

Although the potential for detrital HM resources in the surficial sediments of the study area is low with respect to other portions of the U.S. ACS, concepts and data of use to their exploration are provided for future studies. Gamma radioactivity measurements for some of the samples used in this study were made by C.L. Schelske (Emery and Uchupi, 1972). The measurements were made by use of a scintillation counter capable of plotting gamma radiation in a spectrum over 0 to 3 MeV. Schelske observed that the most prominent peak in the spectrum was at 1.43 MeV for K^{40}; lesser peaks included those for Th^{232} and U^{238}. Peaks for manmade radioelements were subordinate or absent. The total counts were corrected for sample weight, volume, shape of container, and background count and are reported as counts per minute per gram (CPM/g; Table 2). Radioactive minerals in the samples include light (SG <2.85) and heavy minerals. The light minerals may include mica, feldspars, illite, and glauconite. Some glauconite may sink in bromoform, but, in our experience, most remains with the light mineral fraction. Mica, the feldspars, illite, and glauconite are radioactive because of their K^{40} content. The HMs (and their radioelements) include monazite (Th, U), zircon (U, Th), phosphate and apatite (U, Th), sphene (U, Th), and epidote group minerals (U, Th). Other sources of gamma radiation in marine sediments may include radioelements adsorbed onto iron oxides and in organic matter (Grosz, 1991).

Finer grained sediments tend to have higher radioactivity than coarser sediments (Figure 2), and the overall radioactivity of the sediments appears to be controlled by the distribution of zircon + monazite (Figure 3). A contour plot of the gamma radiation data (Figure 4) shows that higher radiation values are found associated with areas where finer grained sediments prevail (Figure 5). Because finer grained sediments contain smaller quantities of heavy minerals (Figure 6), gamma radiation highs in the area of this study, unlike elsewhere on the U.S. ACS (Grosz, 1991), are of little value in defining areas of where economic heavy minerals are preferentially concentrated.

Concentrations of HMs on the Shelf area of this study do not parallel the coastline, but rather appear to be distributed in two coast-oblique bands extending in a southeasterly direction offshore of western and central Long Island (Figure 7). The distribution of the economically important heavy minerals (EHM/T) follows this same pattern (Figure 8).

CONCLUSIONS

The placer resource potential of the surficial sediments in the study area is limited by the immature HM suite that has been provided by periglacial processes through the time interval that the sediments have accumulated. The data indicate that the surficial sediments in the study area have a low overall potential for titanium-zirconium-rare-earth-bearing placers, although higher concentrations in some samples may indicate locally greater potential. An additional constraint is the absence of extensive discernible depositional beach-complex sediments.

ACKNOWLEDGMENTS

We extend our appreciation to J.C. Hathaway of the USGS at Woods Hole, MA for supervising the heavy-liquid separation and magnetic fractionation of some of the samples. We are also indebted to J.R. Albanese, of the State University of New York, Oneonta for his assistance with the HM data reduction. W.J. Greenwood and A.R. Gadgil, Volunteers for Science at the USGS in Reston, VA drafted some of the figures. This study was funded, in part, by a grant from the Minerals Management Service through the Texas Bureau of Economic Geology under Cooperative Agreement 14-12-0001-30432 to the New York State Geological Survey.

REFERENCES

Clifton, H.E., Hunter, R.E., Swanson, F.J., and Phillips, R.L., 1969, Sample size and meaningful gold analysis: U.S. Geological Survey Professional Paper 625-C, 19 p.

Drucker, B.S., 1983, Distribution and analysis of selected economic heavy mineral species within the inner New York Bight: Proceedings of the 15th Annual Offshore Technology Conference, Houston, Texas, May 2-5, 1983, pp. 427-430.

Emery, K.O., and Uchupi, Elazar, 1972, Western North Atlantic Ocean: topography, rocks, structure, water, life, and sediments: American Association of Petroleum Geologists Memoir 17, 532 p.

Force, E.R., Grosz, A.E., Loferski, P.J., and Maybin, A.H., 1982, Aeroradioactivity maps in heavy-mineral Exploration--Charleston, South Carolina, area: U.S. Geological Survey Professional Paper 1218, 19 p.

Grosz, A.E., 1983, Application of total count aeroradiometric maps to the exploration for heavy mineral deposits in the Coastal Plain of Virginia, with a section on Field-spectrometer-data reduction by Kenneth L. Kosanke: U.S. Geological Survey Professional Paper 1263, 20 p.

------1987, Nature and distribution of potential heavy-mineral resources offshore of the Atlantic Coast of the United States: Marine Mining, v. 6, p. 339-357.

Grosz, A.E., 1991 (in press), Exploration for submarine mineral deposits by use of gamma-ray radiometric methods, in, Geyer, R.A., and Grosz, A.E., eds., Handbook of Geophysical Exploration at Sea, CRC Press, Inc., Boca Raton, Florida, 49 manuscript pages.

Grosz, A.E., Cathcart, J.B., Macke, D.L., Knapp, M.S., Schmidt, Walter, and Scott, T.M., 1989a, Geologic interpretation of the gamma-ray aeroradiometric maps of central and northern Florida: U.S. Geological Survey Professional Paper 1461, 48 p.

Grosz, A.E., and Escowitz, E.C., 1983, Economic heavy minerals of the U.S. Atlantic Continental Shelf, in Tanner, W.F., ed., Symposium on Coastal Sedimentology, 6th, Tallahassee, 1983, Proceedings: Tallahassee, Florida State University, p. 234-242.

Grosz, A.E., Hathaway, J.C., and Escowitz, E.C., 1986, Placer deposits of heavy minerals in Atlantic Continental Shelf sediments: Proceedings of the 18th Annual Offshore Technology Conference, Houston, Texas, May 5-8, OTC 5198, p. 387-394.

Grosz, A.E., Hoffman, C.W., Gallagher, P.E., Reid, J.C., and Hathaway, J.C., 1990, Heavy-mineral resource potential of surficial sediments on the Atlantic continental shelf offshore of North Carolina: A reconnaissance study: U.S. Geological Survey Open-File Report 90-0245, 58 p.

Grosz, A.E., Muller, F.E., Uptegrove, Jane, Farnsworth, John, Bell, Christy, Maharaj, S.V., Muessig, Karl, and Hathaway, J.C., 1989b, Textural, physiographic, bathymetric, and geologic factors controlling economic heavy minerals distribution in surficial sediments on the Atlantic Continental Shelf offshore of New Jersey: U.S. Geological Survey Open-File Report 89-0683, 32 p.

Grosz, A.E., and Nelson, D.D., 1989, Textural and mineralogic analyses of surficial sediments offshore of Myrtle Beach,-South Carolina: U.S. Geological Survey Open-File Report 89-0168, 23 p.

Grosz, A.E., Nocita, B.W., Kohpina, Pramuan, Olivier, M.M., and Scott, T.M., 1989c, Preliminary grain-size, and mineralogic analyses of vibracore samples from the Inner Continental Shelf offshore of Cape Canaveral, Florida: U.S. Geological Survey Open-File Report 89-0018. 22 p.

Hathaway, J.C., 1971, Data file, Continental Margin Program, Atlantic coast of the United States, v. 2, Sample collection and analytical data: Woods Hole Oceanographic Institution Reference Number 71-15, 486 p.

Hollister, C.D., 1973, Atlantic continental shelf and slope of the United States - Texture of surface sediments from New Jersey to Florida: U.S. Geological Survey Professional Paper 529-M, 23 p.

Ross, D.A., 1970, Atlantic continental shelf and slope of the United States - Heavy minerals of the continental margin from southern Nova Scotia to northern New Jersey: U.S. Geological Survey Professional Paper 529-G, 40 p.

Schlee, John, 1973, Atlantic continental shelf and slope of the United States - Sediment texture of the northeastern part: U.S. Geological Survey Professional Paper 529-L, 64 p.

Schlee, John, and Pratt, R.M., 1970, Atlantic continental shelf and slope of the United States - Gravels of the northeastern part: U.S. Geological Survey Professional Paper 529-H, 39 p.

Terry, R.D., and Chillingar, G.V., 1955, Comparison charts for visual estimation of percentage composition: Journal of Sedimentary Petrology, v. 25, p. 229-234.

Trumbull, J.V.A., 1972, Atlantic continental shelf and slope of the United States - Sand-size fraction of bottom sediments, New Jersey to Nova Scotia: U.S. Geological Survey Professional Paper 529-K, 45 p.

Uchupi, Elazar, 1968, Atlantic continental shelf and slope of the United States--Physiography: U.S. Geological Survey Professional Paper 529-C, 30 p.

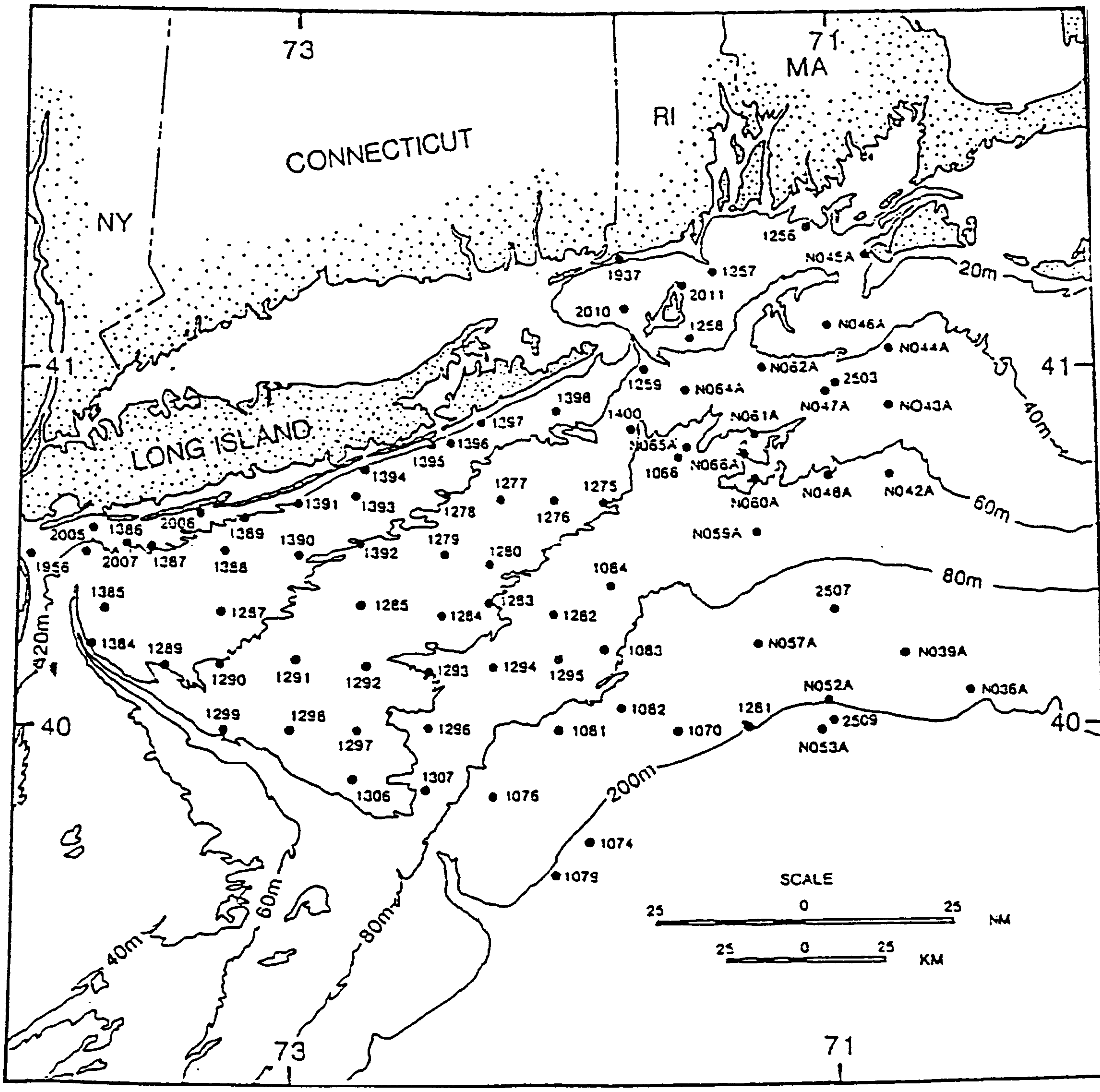

Figure 1.--Map showing the locations of the surface grab samples used in this study.

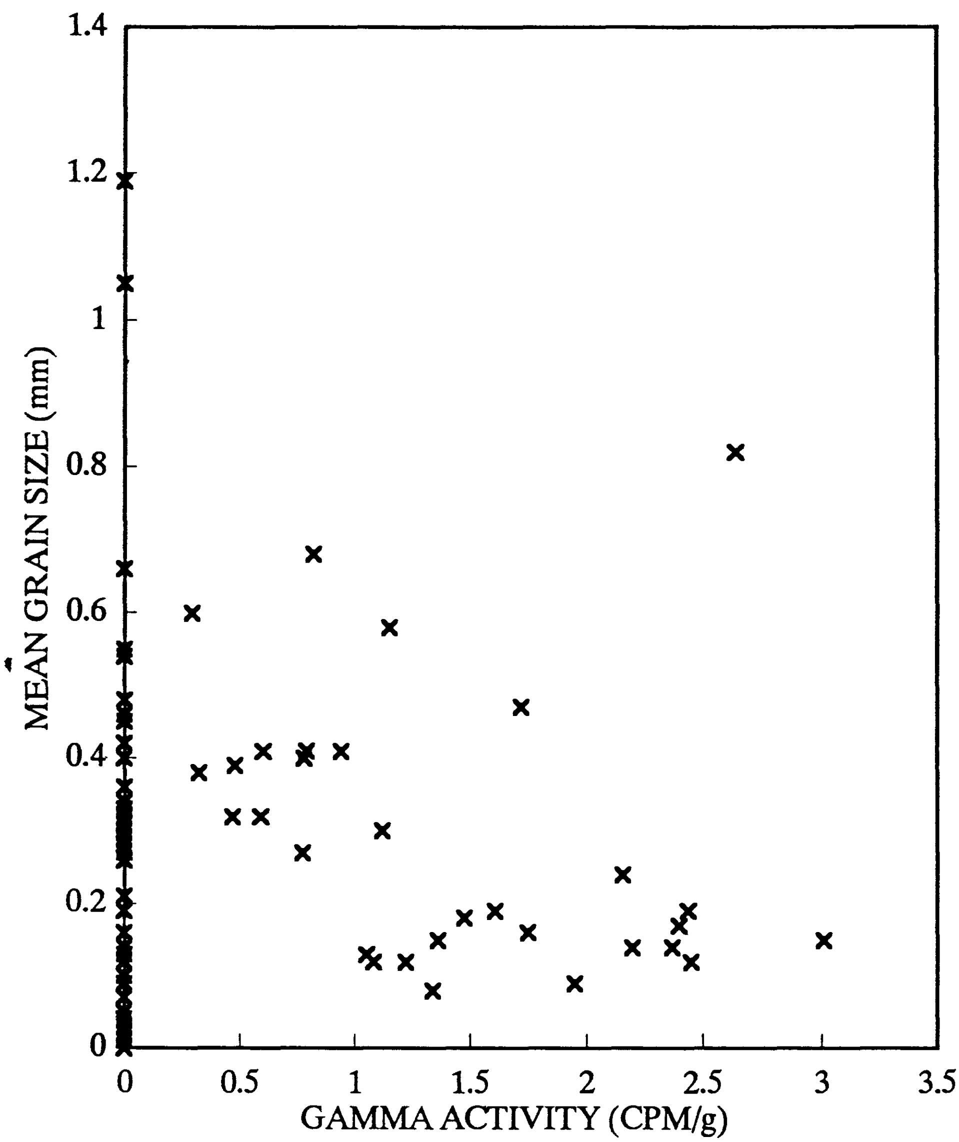

Figure 2.--Plot showing the relationship between mean grain size and gamma activity of bulk sediments.

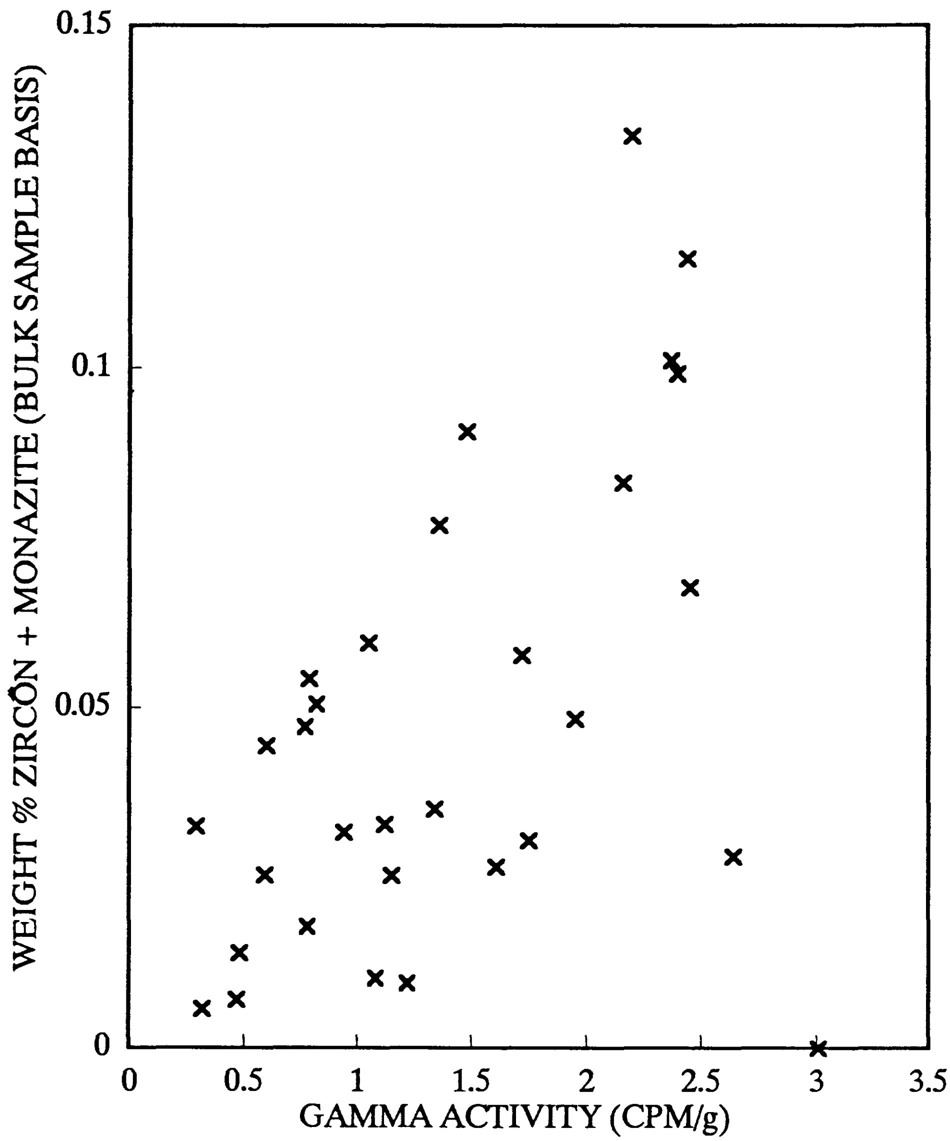

Figure 3.--Plot showing the relationship between the percentage of monazite + zircon and gamma activity of bulk sediments.

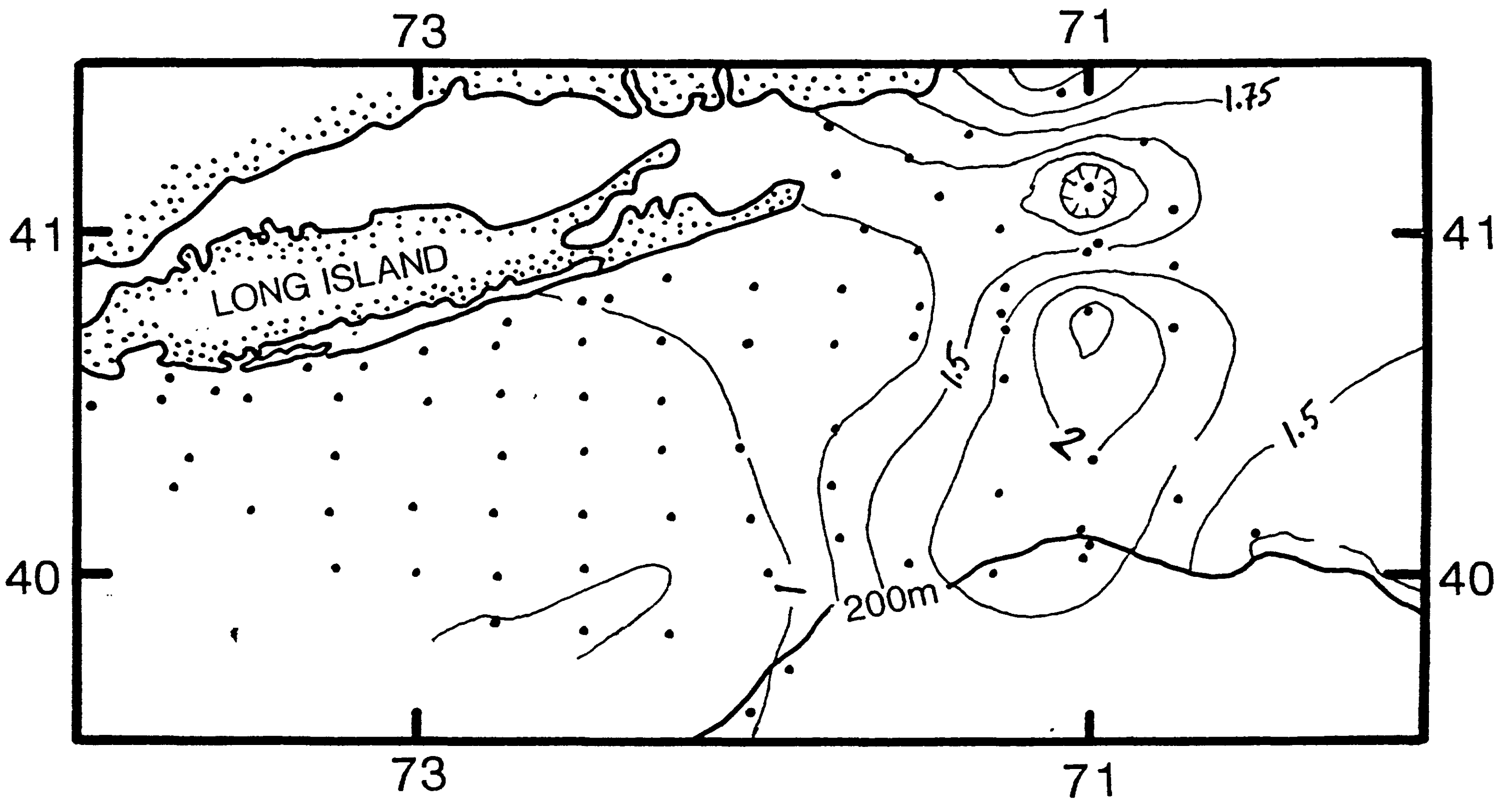

Figure 4.--Contour plot showing areas of higher radioactivity in the study area. Contour interval 0.25 CPM/g.

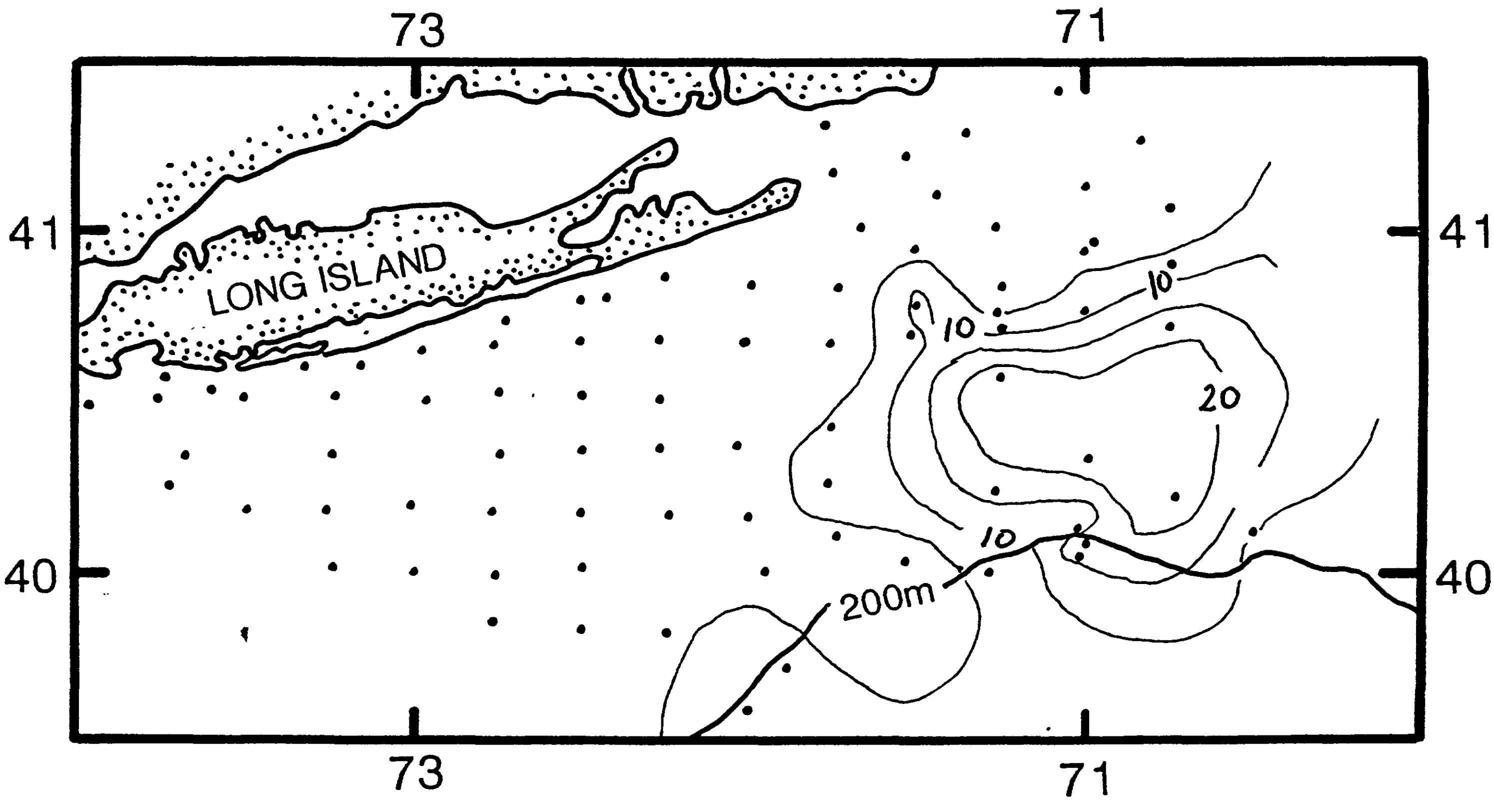

Figure 5.--Contour plot showing areas of high silt + clay content in the study area. Contour interval 5 percent.

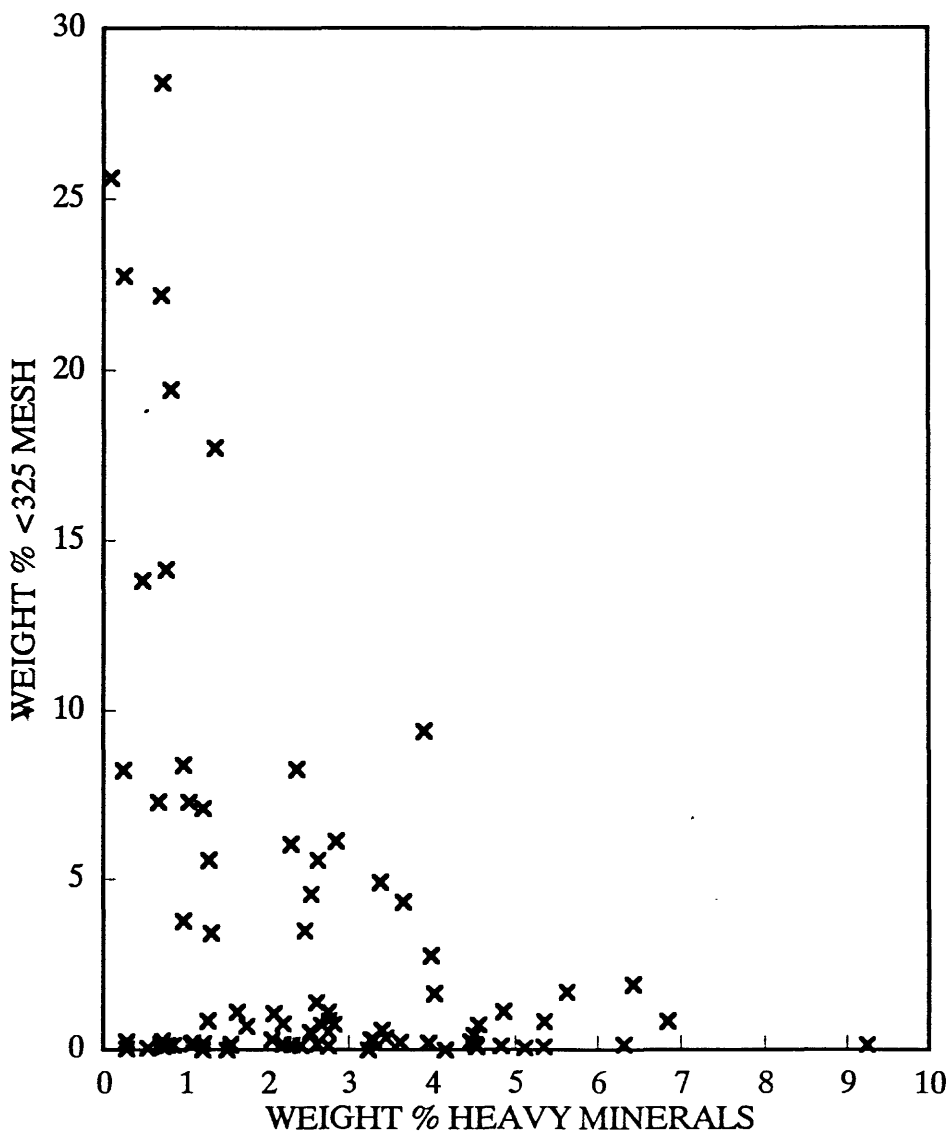

Figure 6.--Plot showing the relationship between heavy-mineral and the silt + clay contents.

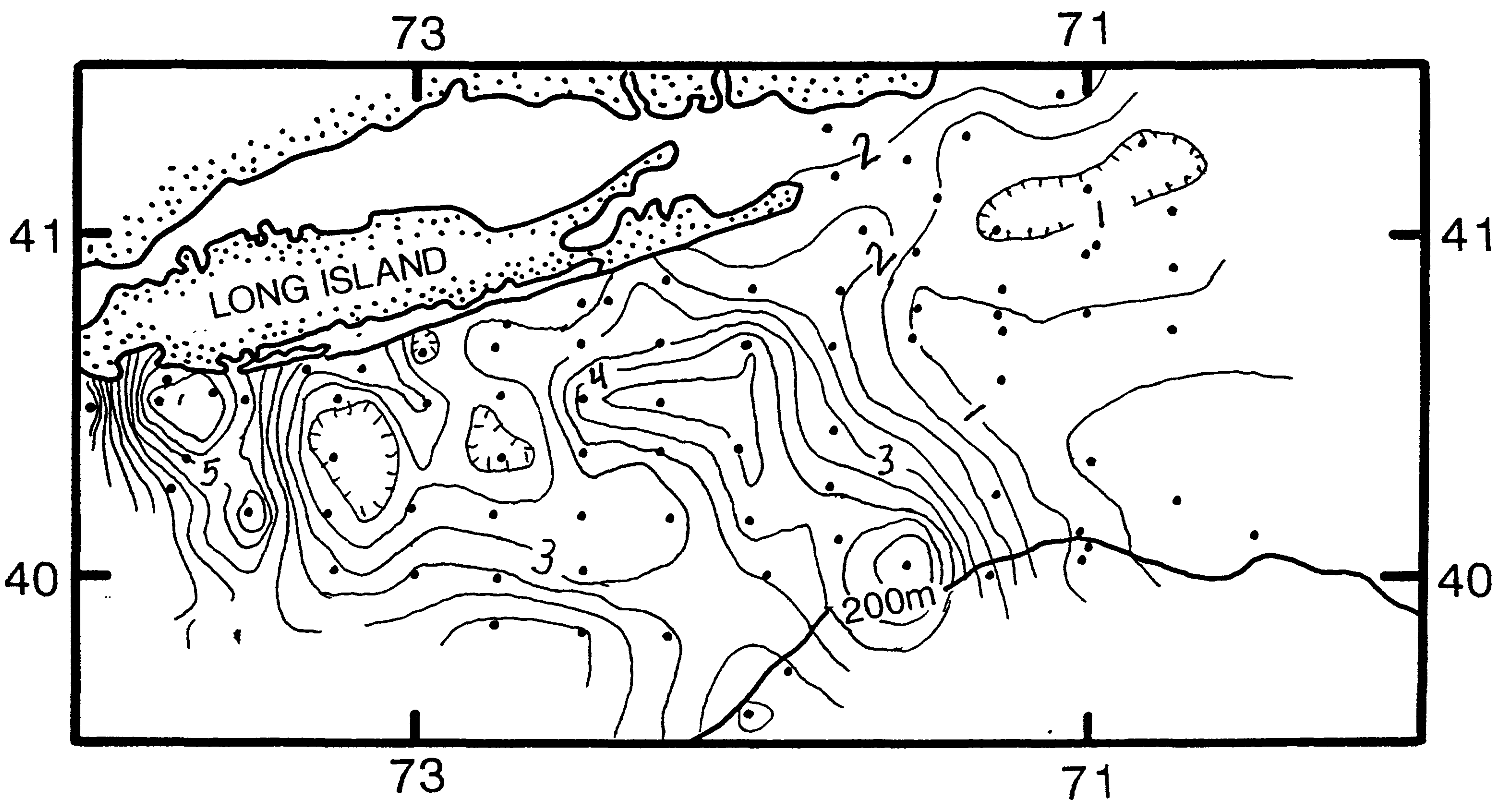

Figure 7.--Contour plot showing the percentage of heavy minerals in the study area. Contour interval 0.5 percent.

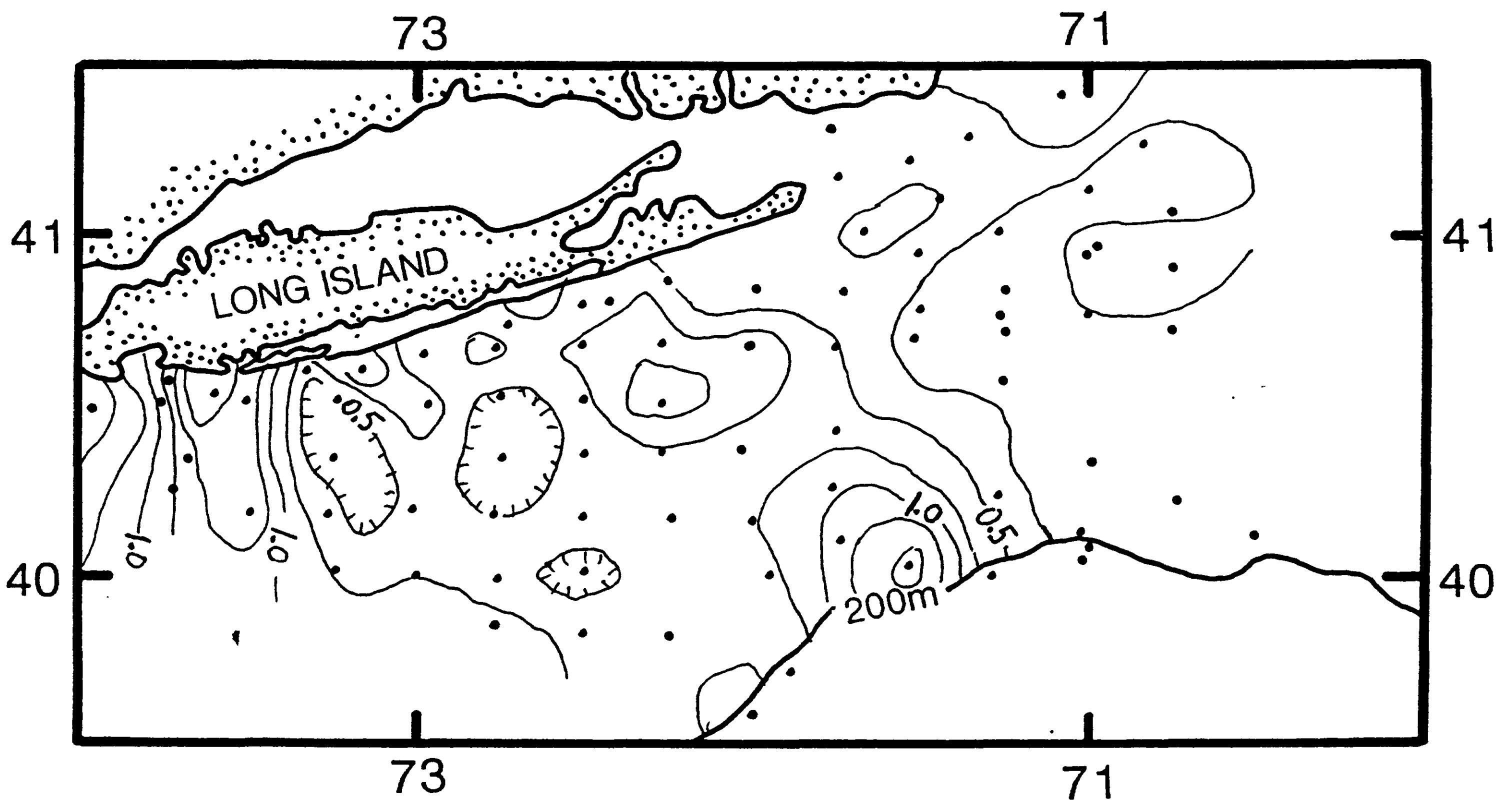

Figure 8.--Contour plot showing the percentage of economic heavy minerals (bulk sample basis) in the study area. Contour interval 0.25 percent.

SAMPLE NUMBER	LONGITUDE (WEST)	LATITUDE (NORTH)	LITHOLOGIC DESCRIPTION
N036A	-70.50001	40.11667	OLIVE SANDY SILT
N039A	-70.73335	40.21667	OLIVE SILT CLAY
N042A	-70.75002	40.71668	OLIVE SAND,SILT,CLAY
N043A	-70.75002	40.90002	OLIVE SAND SILT CLAY
N044A	-70.75002	41.06667	REDDISH BROWN MEDIUM SAND
N045A	-70.83335	41.26667	RUSSET SAND
N046A	-71.00000	41.13334	TAN MEDIUM-FINE SAND
N047A	-71.00000	40.95002	OLIVE SAND, SILT, CLAY
N048A	-71.00000	40.76668	OLIVE SAND, SILT, CLAY
N052A	-71.01667	40.11667	OLIVE SAND, SILT, CLAY
N053A	-71.01667	40.05000	OLIVE SILT, CLAY
N057A	-71.26667	40.23334	OLIVE SAND, SILT, CLAY
N059A	-71.25001	40.56668	OLIVE SILT, CLAY
N060A	-71.25001	40.71668	OLIVE SAND, SILT, CLAY
N061A	-71.25001	40.83335	
N062A	-71.26667	41.01667	RUSTY BROWN MD-FINE SAND
N064A	-71.50001	40.95002	OLIVE BROWN SAND, SILT, CLAY
N065A	-71.50001	40.78335	OLIVE SILT, CLAY
N066A	-71.26667	40.76668	YELLOW TAN SANDY GRAVEL
1066	-71.51668	40.70335	GREEN SANDY SILT
1070	-71.53334	40.03333	GREEN SHELL FRAGMENTS AND MEDIUM SAND
1074	-71.88668	39.71668	GREEN SILTY FORAM SAND
1076	-72.24167	39.81668	GREEN SILTY SAND AND SHELL DEBRIS
1079	-72.00000	39.58668	GREEN SILTY FORAM SAND
1081	-71.95335	40.00000	GREEN SILTY SAND AND SHELLS
1082	-71.73335	40.09167	GREEN SILTY SAND AND SHELLS
1083	-71.76668	40.25334	GREEN SILT AND SHELL FRAGMENTS
1084	-71.75002	40.42334	GREEN SILTY SAND AND SHELLS
1256	-71.08667	41.41167	MEDIUM SAND
1257	-71.35501	41.29667	BROWN MEDIUM SAND
1258	-71.44168	41.10834	BROWN MEDIUM GRAINED WELL SORTED SAND AND BROKEN SHELLS
1259	-71.67001	41.01333	BROWN POORLY SORTED SAND, GRAVEL AND SHELLS
1261	-71.28001	40.00000	GREEN SANDY MUD
1275	-71.75835	40.67001	GRAVELLY MEDIUM GRAINED BROWN SAND
1276	-72.01000	40.68001	MEDIUM OLIVE-BROWN SAND, WITH SOME GRAVEL
1277	-72.26667	40.67835	GREENISH-BROWN SAND
1278	-72.50501	40.67501	GREENISH-GREY MEDIUM GRAINED SAND
1279	-72.50001	40.51168	MEDIUM TO COARSE BROWN SAND
1280	-72.26834	40.50001	MEDIUM GRAINED GREENISH SAND, WITH SCATTERED PEBBLES

Table 1.--Location coordinates and lithologic descriptions of the surface grab samples.

SAMPLE NUMBER	LONGITUDE (WEST)	LATITUDE (NORTH)	LITHOLOGIC DESCRIPTION
1282	-72.02667	40.35834	BROWN TO GREYISH MEDIUM TO COARSE WELL SORTED SAND
1283	-72.26167	40.35834	COARSE BROWN SAND
1284	-72.50501	40.34834	MEDIUM TO COARSE BROWN SAND
1285	-72.74668	40.34834	COARSE BROWN SAND
1287	-73.25001	40.33334	LIGHT BROWN MEDIUM GRAINED SAND
1289	-73.49668	40.17667	FINE BROWN SAND, WELL SORTED
1290	-73.27001	40.17667	OLIVE-BROWN MEDIUM SAND
1291	-73.02167	40.19167	BROWN MEDIUM GRAINED SAND
1292	-72.76668	40.17667	BROWN MEDIUM GRAINED SAND
1293	-72.50501	40.17167	BROWN MEDIUM-GRAINED SAND WITH GRAVEL TO 5MM
1294	-72.23500	40.17000	BROWNISH-GREEN VERY SANDY CLAY
1295	-72.00667	40.16500	COARSE BROWN WELL SORTED SAND WITH CLAM SHELLS
1296	-72.50001	40.01667	BROWN AND GREEN SAND
1297	-72.75668	39.99002	BROWN MEDIUM TO COARSE SAND WITH MINOR AMOUNT OF GRAVEL
1298	-73.00667	40.00000	COARSE BROWN WELL-SORTED SAND
1299	-73.24334	40.01000	COARSE BROWN SAND WITH MUCH SHELL DEBRIS
1306	-72.76668	39.85502	BROWN COARSE-GRAINED SAND
1307	-72.50001	39.83335	BROWN COARSE-GRAINED SAND
1384	-73.73001	40.24167	VERY FINE GRAINED SAND; BROWN AT SURFACE, GREENISH-GREY BELOW
1385	-73.68335	40.32834	BROWN VERY FINE SILTY SAND. MOTTLED GREY AND BLACK BENEATH
1386	-73.60335	40.52334	MEDIUM TO COARSE WELL-SORTED SAND; BROWNISH-GREY, WITH ROUNDED BLACK GRAINS
1387	-73.51334	40.50501	YELLOW-BROWN TO GREY MEDIUM SAND, WELL SORTED
1388	-73.24000	40.50834	MEDIUM TO FINE SAND, WELL SORTED; BROWN ON TOP, GREY BELOW
1389	-73.16667	40.59835	MEDIUM TO FINE SAND, BROWN ON TOP, GREY BELOW
1390	-72.97335	40.49334	BROWN SILTY VERY FINE GRAINED WELL SORTED SAND
1391	-72.98502	40.64335	VERY COARSE BROWN SAND, SOME GRAVEL
1392	-72.75668	40.52168	BROWNISH-GREY FINE GRAINED SAND WITH SHELL FRAGMENTS
1393	-72.76502	40.66335	BROWN FINE GRAINED SAND
1394	-72.73501	40.73168	SANDY GRAVEL; CLEAN, QUARTZOSE, SOME SHELL FRAGMENTS
1395	-72.50334	40.80002	MOTTLED BROWN-GREY FINE TO MEDIUM WELL SORTED SAND
1396	-72.43334	40.80335	DARK YELLOW-BROWN FINE TO MEDIUM WELL SORTED SAND
1397	-72.25001	40.86002	BROWN MEDIUM SAND, WELL SORTED
1398	-72.00167	40.84168	BROWN MEDIUM SAND, WELL SORTED
1400	-71.73335	40.83502	DARK GREENISH-GREY MEDIUM SAND, POSSIBLY GLAUCONITIC
1937	-71.77668	41.31001	BRN MD.W.SRT.SD W GRV.TO 4CM,GRV ENCRUSTED,SLY WASHED
1956	-73.97052	40.48468	MEDIUM SAND AND ROUND QTZ PEBBLES,70% PEBBLES,30% SAND
2005	-73.74501	40.56668	BRN,SLTY,V FN GRN SD,FEW SM MASSES GY CL,GRV,(MANY W RNDD PEBS)
2006	-73.33667	40.60001	GREYISH-BROWN FINE + V FINE SAND, WITH SOME SILT
2007	-73.76502	40.50168	BROWN, FINE TO MEDIUM GRAINED SAND
2010	-71.75168	41.17000	BROWN, MEDIUM TO COARSE SAND
2011	-71.52501	41.23000	BROWN, SILTY, VERY FINE SAND
2503	-70.98335	40.96669	SAND
2507	-70.99169	40.33333	SANDY-SILT
2509	-70.00000	40.08334	SANDY SILT

Table 1.--Continued.

SAMPLE NUMBER	WATER DEPTH (m)	GRAVEL >2.00 mm %	WT % >16 MESH	WT % <16->32 MESH	WT % <325 MESH	WT % HM	MEAN SIZE mm	GAMMA ACTIVITY CPM/g	Wt. % CaCO3 OF SAND
N036A	129	0.0	3.7	88.1	8.2	0.24	0.12	1.22	8.03
N039A	129	0.0	0.6	73.8	25.6	0.09	0.02	ND	8.84
N042A	60	0.0	0.0	77.8	22.2	0.70	0.04	ND	0.51
N043A	53	0.0	0.1	94.4	5.6	1.28	0.13	ND	0.88
N044A	46	0.0	1.4	98.4	0.2	1.09	0.36	ND	0.21
N045A	33	0.0	2.9	97.0	0.1	0.73	0.48	ND	0.21
N046A	46	0.0	1.3	98.6	0.1	0.85	0.32	0.59	0.42
N047A	59	0.0	3.9	92.3	3.8	0.97	0.10	ND	ND
N048A	60	0.0	0.0	91.6	8.4	0.97	0.12	2.45	0.56
N052A	165	1.0	4.0	88.9	7.1	1.21	0.09	1.95	9.81
N053A	190	0.0	0.3	85.8	13.8	0.48	0.01	ND	12.07
N057A	98	0.0	0.5	81.8	17.7	1.35	0.07	ND	2.30
N059A	69	0.0	0.0	71.6	28.4	0.72	0.07	ND	0.69
N060A	62	0.0	0.5	92.2	7.3	0.67	0.10	ND	0.72
N061A	62	0.0	52.6	47.2	0.2	2.19	0.09	ND	0.36
N062A	47	0.0	54.1	45.9	0.1	0.54	0.31	ND	6.55
N064A	57	0.0	0.7	95.9	3.4	1.31	0.14	ND	0.65
N065A	62	0.0	0.2	85.7	14.1	0.76	0.05	ND	0.83
N066A	60	26.0	49.6	50.3	0.0	0.29	1.19	ND	0.13
1066	68	0.0	1.4	91.3	7.3	1.04	0.12	1.08	1.12
1070	94	0.0	5.3	92.8	1.9	6.43	0.47	1.72	2.37
1074	225	0.0	0.4	93.5	6.1	2.84	0.13	1.05	8.68
1076	89	13.4	3.2	92.5	4.3	3.66	0.34	ND	1.92
1079	292	0.0	1.1	90.6	8.3	2.35	0.09	ND	7.53
1081	88	0.0	3.4	91.6	4.9	3.38	0.27	0.77	2.54
1082	86	0.0	5.7	91.5	2.8	3.99	0.32	ND	1.94
1083	82	0.0	2.4	88.2	9.4	3.91	0.08	1.34	1.56
1084	76	0.0	4.8	89.6	5.6	2.62	0.13	ND	1.87
1256	23	0.0	0.1	99.4	0.5	2.52	0.19	2.44	0.34
1257	35	0.0	1.9	97.9	0.2	1.07	0.30	ND	0.78
1258	38	0.0	1.4	97.9	0.7	1.75	0.15	1.36	1.15
1259	45	0.0	11.9	86.8	1.4	2.60	0.16	ND	2.92
1261	235	0.0	0.5	93.5	6.0	2.28	0.10	ND	8.62
1275	59	29.5	30.3	68.9	0.8	2.19	1.05	ND	1.21
1276	51	0.0	3.1	96.2	0.7	4.57	0.27	ND	1.07
1277	53	0.0	0.7	98.2	1.1	2.75	0.16	ND	1.41
1278	38	0.0	0.2	99.0	0.9	2.76	0.19	ND	1.04
1279	44	0.0	4.5	95.3	0.2	4.53	0.41	0.79	1.26
1280	49	0.0	3.9	94.5	1.7	5.62	0.21	ND	1.38

Table 2.--Water depth, textural, carbonate content, and gamma radiation activity data for the surface grab samples.

SAMPLE NUMBER	WATER DEPTH (m)	GRAVEL >2.00 mm %	WT % >16 MESH	WT % <16->32 MESH	WT % <325 MESH	WT % HM	MEAN SIZE mm	GAMMA ACTIVITY CPM/g	Wt. % CaCO3 OF SAND
1282	57	5.0	9.2	89.7	1.1	4.87	0.54	ND	2.26
1283	61	22.3	8.8	90.7	0.5	2.75	0.66	ND	0.44
1284	52	0.0	4.8	94.9	0.3	3.30	0.42	ND	3.06
1285	52	0.0	12.8	87.0	0.2	1.22	0.31	ND	6.62
1287	36	0.0	2.1	97.8	0.1	0.78	0.27	ND	1.75
1289	38	0.0	0.2	99.7	0.2	6.32	0.14	2.37	0.80
1290	40	0.0	2.9	96.9	0.2	1.55	0.36	ND	1.58
1291	47	0.0	4.2	95.6	0.2	2.61	0.41	0.60	2.24
1292	55	0.0	7.6	92.3	0.1	2.75	0.45	ND	3.78
1293	64	17.3	16.8	82.5	0.8	2.82	0.58	1.15	7.27
1294	70	0.0	5.6	89.8	4.6	2.53	0.29	ND	4.98
1295	67	0.0	3.3	96.4	0.2	4.47	0.40	0.78	1.78
1296	69	0.0	0.7	95.8	3.5	2.45	0.26	ND	0.98
1297	56	0.0	12.9	86.8	0.4	3.45	0.55	ND	5.04
1298	51	0.0	7.1	92.7	0.2	3.62	0.46	ND	1.21
1299	50	0.0	12.9	86.3	0.7	2.66	0.30	ND	6.92
1306	55	0.0	5.3	94.6	0.1	4.84	0.40	ND	2.52
1307	64	0.0	4.2	95.7	0.1	4.54	0.41	0.94	1.04
1384	37	0.0	0.1	99.6	0.3	3.27	0.12	ND	0.72
1385	28	0.0	0.7	98.5	0.8	5.35	0.14	2.20	1.10
1386	21	0.0	0.1	99.8	0.1	5.34	0.19	1.61	0.95
1387	20	0.0	0.5	99.4	0.1	5.12	0.21	ND	0.90
1388	30	0.0	0.4	99.5	0.2	0.70	0.39	0.48	1.68
1389	22	0.0	0.2	99.8	0.0	4.16	0.21	ND	1.10
1390	40	0.0	0.2	99.2	0.6	3.40	0.16	1.75	1.04
1391	21	10.0	17.7	82.3	0.0	1.21	0.60	0.29	1.47
1392	40	0.0	4.6	95.2	0.1	1.55	0.33	ND	1.39
1393	31	0.0	0.2	99.6	0.2	3.96	0.16	ND	0.86
1394	23	45.4	48.5	51.4	0.1	2.41	0.68	0.82	0.88
1395	23	0.0	0.7	99.3	0.0	1.51	0.46	ND	1.65
1396	28	0.0	0.3	99.3	0.4	4.51	0.17	2.40	0.72
1397	30	0.0	0.7	99.2	0.2	2.30	0.28	ND	0.73
1398	39	0.0	0.9	98.9	0.3	2.06	0.30	1.12	2.11
1400	54	3.0	9.3	89.6	1.1	2.08	0.24	2.16	1.47
1937	16	29.2	46.6	51.8	1.7	4.03	0.82	2.64	0.62
1956	9	5.0	76.3	23.5	0.2	0.29	0.38	0.32	2.10
2005	13	0.0	2.7	96.5	0.9	6.84	0.15	3.01	0.62
2006	14	0.0	0.1	99.9	0.0	3.24	0.18	1.48	0.21
2007	24	0.0	0.3	99.6	0.1	9.24	0.21	ND	0.16
2010	23	0.0	0.1	99.6	0.3	0.72	0.32	0.47	0.20
2011	34	0.0	0.0	98.9	1.1	1.63	0.13	ND	0.21
2503	49	ND	1.6	97.6	0.8	1.27	ND	ND	ND
2507	93	0.0	0.8	76.4	22.8	0.25	0.03	ND	ND
2509	188	ND	0.8	79.8	19.4	0.82	ND	ND	ND
COUNT	83	81	83	83	83	83	81	31	79
MINIMUM	9	0.0	0.0	23.5	0.0	0.09	0.01	0.29	0.13
AVERAGE	63	2.6	7.2	89.2	3.6	2.58	0.28	1.40	2.30
MAXIMUM	292	45.4	76.3	99.9	28.4	9.24	1.19	3.01	12.07
S.D.	50	7.9	14.4	14.4	6.2	1.80	0.21	0.75	2.64

Table 2.--Continued.

SAMPLE NUMBER	POTASH FELDSPAR	PLAGIOCLASE FELDSPAR	TOTAL FELDSPAR	ILMENITE	MAGNETITE	GARNET	STAUROLITE	EPIDOTE	PYROBOLES
	AS A PERCENTAGE OF THE NON-CARBONATE 0.125-.250 mm FRACTION								
N036A	6	3	9	1.0	N	25.0	7.0	20.0	15.0
N039A	16	4	20	5.0	N	30.0	15.0	15.0	10.0
N042A	7	17	24	N	N	18.0	5.0	5.0	16.0
N043A	24	0	24	1.0	N	23.0	10.0	10.0	8.0
N044A	0	4	4	N	N	15.0	7.0	7.0	10.0
N045A	3	0	3	2.0	1.0	10.0	6.0	6.0	10.0
N046A	5	0	5	4.0	N	5.0	5.0	5.0	5.0
N047A	3	0	3	2.0	N	20.0	5.0	5.0	17.0
N048A	0	0	0	1.0	N	10.0	6.0	6.0	20.0
N052A	0	8	8	1.0	1.0	18.0	3.0	3.0	36.0
N053A	31	0	31	1.0	N	5.0	4.0	4.0	23.0
N057A	8	0	8	1.0	1.0	20.0	3.0	3.0	30.0
N059A	0	9	9	5.0	1.0	15.0	4.0	4.0	30.0
N060A	0	12	12	3.0	N	7.0	4.0	4.0	25.0
N061A	0	7	7	1.0	0.1	4.9	0.8	0.8	2.5
N062A	0	5	5	5.0	5.0	2.0	1.0	1.0	27.0
N064A	6	5	11	5.0	5.0	25.0	6.0	6.0	20.0
N065A	8	0	8	5.0	N	10.0	6.0	6.0	25.0
N066A	0	4	4	3.0	N	20.0	6.0	6.0	25.0
1066	40	0	40	1.0	N	9.0	5.0	5.0	60.0
1070	3	10	13	21.7	7.2	28.8	5.7	5.7	15.1
1074	5	2	7	4.2	5.1	22.9	5.2	5.2	28.8
1076	8	4	12	7.1	4.4	33.2	11.1	11.1	19.5
1079	3	4	7	5.0	10.0	10.0	5.0	5.0	41.0
1081	11	16	27	4.7	1.8	38.3	6.3	6.3	20.7
1082	0	7	7	4.5	0.7	38.0	4.4	4.4	15.9
1083	0	15	15	5.6	1.6	23.1	4.2	4.2	31.9
1084	5	8	13	4.2	1.7	23.7	3.4	3.4	33.8
1256	3	0	3	10.5	3.6	10.2	3.0	3.0	22.7
1257	2	2	4	4.7	3.3	3.8	3.2	3.2	21.4
1258	4	9	13	5.1	2.7	6.5	1.8	1.8	22.9
1259	18	1	19	7.0	7.7	12.4	6.6	6.6	26.8
1261	13	0	13	6.7	3.0	22.1	3.7	3.7	35.0
1275	6	2	8	3.4	3.6	32.1	7.3	7.3	18.6
1276	5	16	21	5.2	2.8	34.5	10.9	10.9	19.1
1277	16	0	16	3.3	0.6	10.9	3.3	3.3	35.3
1278	6	0	6	5.2	1.3	11.3	8.2	8.2	29.2
1279	8	0	8	4.5	0.8	35.3	11.9	11.9	16.0
1280	0	26	26	3.1	2.3	17.3	5.3	5.3	32.0

Table 3.--Feldspar and heavy-mineral data for the surface grab samples.

SAMPLE NUMBER	POTASH FELDSPAR	PLAGIOCLASE FELDSPAR	TOTAL FELDSPAR	ILMENITE	MAGNETITE	GARNET	STAUROLITE	EPIDOTE	PYROBOLES
	AS A PERCENTAGE OF THE NON-CARBONATE 0.125-.250 mm FRACTION								
1282	3	14	17	4.3	0.6	37.8	7.3	7.3	26.7
1283	5	0	5	2.1	0.7	26.3	11.1	11.1	22.3
1284	3	5	8	3.2	0.5	34.0	9.6	9.6	17.4
1285	3	0	3	1.0	1.0	15.0	6.0	6.0	22.0
1287	0	0	0	0.0	1.0	16.0	10.0	10.0	19.0
1289	8	12	20	3.2	0.8	13.5	2.4	2.4	38.5
1290	2	5	7	5.4	1.2	27.1	6.6	6.6	21.6
1291	7	0	7	11.2	3.2	32.7	8.5	8.5	17.9
1292	6	0	6	9.4	5.7	29.4	5.6	5.6	21.3
1293	16	0	16	8.4	3.4	20.5	4.2	4.2	32.0
1294	0	21	21	2.6	1.7	12.5	1.6	1.6	37.5
1295	3	6	9	4.0	0.4	43.5	4.2	4.2	18.2
1296	6	7	13	5.1	6.7	24.5	4.5	4.5	26.9
1297	5	10	15	7.0	9.2	26.6	10.3	10.3	26.8
1298	10	0	10	8.3	11.6	19.1	8.0	8.0	26.2
1299	13	0	13	4.5	9.0	18.1	7.3	7.3	29.9
1306	9	13	22	6.1	15.7	14.2	10.3	10.3	21.6
1307	8	3	11	6.8	8.8	19.7	7.2	7.2	23.1
1384	4	6	10	1.4	4.7	17.0	3.5	3.5	24.3
1385	10	0	10	5.0	5.2	15.6	4.2	4.2	23.2
1386	0	4	4	5.8	5.4	4.4	1.7	1.7	25.1
1387	0	0	0	4.6	1.1	20.2	10.8	10.8	19.9
1388	0	0	0	5.0	5.0	25.0	7.0	7.0	28.0
1389	5	7	12	3.2	1.1	16.9	8.2	8.2	20.0
1390	0	6	6	3.0	2.2	17.0	4.7	4.7	26.4
1391	0	0	0	1.0	0.5	17.5	14.7	14.7	12.5
1392	0	8	8	2.7	0.4	27.2	12.9	12.9	15.0
1393	7	0	7	2.7	0.9	14.9	5.1	5.1	28.5
1394	0	0	0	4.1	0.3	31.4	12.5	12.5	17.9
1395	0	0	0	3.9	0.6	16.8	12.2	12.2	18.8
1396	5	19	24	1.6	3.2	17.1	3.9	3.9	25.9
1397	4	16	20	5.9	4.9	27.5	2.8	2.8	22.0
1398	2	8	10	3.0	1.9	23.9	3.8	3.8	28.2
1400	6	1	7	1.0	10.0	8.0	3.0	3.0	41.0
1937	21	21	42	9.6	10.2	7.1	1.0	1.0	46.1
1956	0	11	11	2.0	10.0	5.0	2.0	2.0	40.0
2005	2	13	15	3.4	1.5	15.9	2.3	2.3	35.3
2006	10	0	10	1.1	1.7	24.9	6.9	6.9	24.8
2007	11	0	11	2.9	5.9	8.0	1.2	1.2	27.9
2010	0	15	15	2.0	8.0	35.0	2.0	2.0	30.0
2011	19	0	19	8.9	12.7	13.0	1.4	1.4	20.8
2503	ND	ND	ND	8.6	1.7	14.0	4.8	4.8	11.9
2507	ND	ND	ND	7.0	N	38.0	5.0	5.0	10.0
2509	ND	ND	ND	2.0	1.0	30.0	4.0	4.0	15.0
COUNT	80	80	80	81	69	83	83	83	83
MINIMUM	0	0	0	0.0	0.1	2.0	0.8	0.8	2.5
AVERAGE	6	5	11	4.4	3.8	19.6	5.9	6.0	23.9
MAXIMUM	40	26	42	21.7	15.7	43.5	15.0	20.0	60.0
S.D.	7	6	8	3.1	3.5	9.8	3.3	3.6	9.3

Table 3.--Continued.

SAMPLE NUMBER	ALUMINO-SILICATES	TOURMALINE	LEUCOXENE	RUTILE	ZIRCON	MONAZITE	SPHENE	OTHERS	WT % EHM/C	WT % EHM/T
N036A	10.0	12.0	N	1.0	4.0	N	1.0	4.0	16.0	0.04
N039A	5.0	20.0	N	1.0	1.0	N	1.0	7.0	12.0	0.01
N042A	15.0	20.0	N	3.0	6.0	N	N	2.0	24.0	0.17
N043A	15.0	20.0	N	2.0	10.0	N	1.0	3.0	28.0	0.36
N044A	8.0	22.0	4.0	3.0	7.0	1.0	2.0	16.0	23.0	0.25
N045A	5.0	38.0	1.0	1.0	3.0	N	2.0	20.0	12.0	0.09
N046A	10.0	38.0	2.0	1.0	3.0	N	5.0	19.0	20.0	0.17
N047A	20.0	15.0	1.0	N	13.0	N	N	2.0	36.0	0.35
N048A	15.0	20.0	N	1.0	7.0	N	2.0	3.0	24.0	0.23
N052A	15.0	12.0	N	1.0	4.0	N	1.0	1.0	21.0	0.25
N053A	38.0	18.0	N	N	5.0	N	N	2.0	44.0	0.21
N057A	17.0	15.0	N	1.0	4.0	N	1.0	2.0	23.0	0.31
N059A	28.0	7.0	N	1.0	3.0	N	1.0	2.0	37.0	0.27
N060A	29.0	15.0	1.0	1.0	9.0	N	1.0	2.0	43.0	0.29
N061A	1.7	1.7	N	0.3	0.2	N	0.2	86.5	3.2	0.07
N062A	10.0	5.0	N	1.0	2.0	N	1.0	40.0	18.0	0.10
N064A	15.0	15.0	N	1.0	1.0	N	1.0	2.0	22.0	0.29
N065A	24.0	17.0	N	1.0	3.0	N	1.0	2.0	33.0	0.25
N066A	15.0	5.0	N	N	N	N	N	25.0	18.0	0.05
1066	7.0	4.0	N	N	1.0	N	3.0	5.0	9.0	0.09
1070	5.4	2.3	0.4	0.5	0.9	N	0.6	3.9	28.9	1.86
1074	12.7	1.5	0.6	0.8	2.1	N	0.4	2.7	20.5	0.58
1076	7.0	3.9	0.3	0.6	0.6	N	0.3	4.8	15.7	0.57
1079	10.0	5.0	N	1.0	2.0	N	1.0	5.0	18.0	0.42
1081	10.3	3.6	0.9	0.8	1.4	N	0.4	4.4	18.1	0.61
1082	21.0	4.6	0.1	0.8	0.5	N	0.3	2.3	27.0	1.08
1083	19.3	1.6	0.3	1.2	0.9	N	0.4	2.6	27.4	1.07
1084	13.3	3.6	0.3	2.1	1.1	N	0.6	5.1	21.1	0.55
1256	19.8	7.9	N	2.5	4.6	N	0.8	8.8	37.4	0.94
1257	16.3	6.2	0.7	1.0	2.8	0.1	1.0	29.0	25.6	0.27
1258	25.6	7.5	1.8	3.1	4.4	N	2.2	13.3	40.0	0.70
1259	15.8	3.1	N	1.9	3.4	N	1.9	8.4	28.1	0.73
1261	12.2	3.3	N	2.5	2.5	N	0.9	3.1	23.9	0.54
1275	18.3	4.5	2.6	1.3	1.0	N	1.7	3.7	26.6	0.58
1276	13.2	3.4	1.0	0.6	1.5	N	0.7	4.7	21.5	0.98
1277	19.3	5.6	1.6	1.7	2.4	N	2.2	7.2	28.4	0.78
1278	17.7	9.5	1.3	2.0	2.8	N	1.4	5.3	28.9	0.80
1279	7.6	11.1	N	2.0	1.2	N	1.5	1.6	15.2	0.69
1280	19.5	7.5	0.5	0.7	0.8	N	2.2	4.2	24.4	1.37

Table 3.--Continued.

SAMPLE NUMBER	ALUMINO-SILICATES	TOURMALINE	LEUCOXENE	RUTILE	ZIRCON	MONAZITE	SPHENE	OTHERS	WT % EHM/C	WT % EHM/T
1282	5.8	8.2	0.3	1.0	0.5	N	0.5	1.9	11.9	0.58
1283	13.7	9.0	N	2.4	0.9	N	1.5	2.6	19.0	0.52
1284	12.4	10.1	N	1.3	1.5	N	1.0	1.7	18.3	0.60
1285	10.0	15.0	1.0	2.0	4.0	N	3.0	5.0	18.0	0.22
1287	15.0	15.0	1.0	4.0	3.0	N	5.0	7.0	23.0	0.18
1289	16.9	6.1	1.5	1.6	1.6	N	1.5	3.0	24.8	1.57
1290	16.6	7.3	0.6	0.8	2.3	0.4	2.2	3.2	26.1	0.40
1291	7.0	8.1	1.0	0.9	1.7	N	1.3	2.8	21.8	0.57
1292	6.6	5.8	1.2	0.4	0.8	N	1.5	3.4	18.4	0.51
1293	11.7	5.5	3.5	1.3	0.9	N	0.7	1.9	25.8	0.73
1294	18.5	6.5	0.8	2.8	1.8	N	0.1	2.1	26.4	0.67
1295	10.4	6.3	1.4	0.6	0.4	N	2.1	2.2	16.8	0.75
1296	6.8	4.6	0.1	1.2	1.5	N	0.7	4.8	14.7	0.36
1297	4.7	3.1	1.5	0.3	0.7	N	3.4	3.6	14.2	0.49
1298	8.6	1.7	1.3	1.1	1.4	N	3.0	5.4	20.6	0.75
1299	15.4	1.8	1.1	0.5	2.0	N	1.5	5.7	23.5	0.63
1306	10.9	6.8	1.3	0.3	0.8	N	1.9	9.4	19.5	0.94
1307	6.4	1.7	N	0.4	0.7	N	1.0	24.0	14.3	0.65
1384	22.1	5.3	2.4	1.3	3.3	N	0.8	9.1	30.5	1.00
1385	13.6	3.5	1.3	1.0	2.5	N	0.8	21.5	23.4	1.25
1386	34.1	3.4	1.6	4.7	0.5	N	N	9.8	46.6	2.49
1387	15.7	7.7	1.4	1.7	2.6	N	1.7	7.2	25.9	1.33
1388	7.0	13.0	N	2.0	2.0	N	1.0	4.0	16.0	0.11
1389	23.5	6.1	3.0	2.5	1.8	N	1.1	6.2	33.9	1.41
1390	24.5	4.0	1.6	0.9	0.9	N	0.2	8.0	30.9	1.05
1391	19.8	13.1	1.4	2.7	2.7	N	0.7	5.8	27.5	0.33
1392	8.3	13.4	0.7	2.2	1.8	N	1.0	3.3	15.8	0.24
1393	21.7	6.2	2.4	1.5	2.7	N	0.8	5.6	31.2	1.24
1394	10.6	9.4	0.7	1.8	2.1	N	N	3.6	19.4	0.47
1395	16.3	14.9	2.6	2.5	2.5	N	0.6	3.3	27.7	0.42
1396	22.4	6.5	3.4	1.4	2.2	N	0.1	7.5	31.1	1.40
1397	2.4	12.0	0.4	1.5	N	N	0.8	8.0	10.3	0.24
1398	7.3	6.6	1.6	1.8	1.6	N	1.2	4.3	15.4	0.32
1400	5.0	5.0	N	3.0	4.0	N	2.0	15.0	13.0	0.27
1937	3.0	1.2	0.5	0.2	0.5	0.2	0.7	7.8	14.1	0.57
1956	5.0	5.0	2.0	2.0	2.0	N	2.0	20.0	13.0	0.04
2005	12.5	2.1	0.9	0.8	N	N	0.9	9.0	17.5	1.20
2006	10.0	6.8	0.3	2.2	2.8	N	0.4	5.2	16.4	0.53
2007	2.3	0.7	N	0.1	0.6	N	0.2	50.2	5.9	0.55
2010	3.0	5.0	N	N	1.0	N	3.0	5.0	6.0	0.04
2011	9.4	3.7	0.2	0.9	2.2	N	N	11.0	21.7	0.35
2503	10.0	8.7	0.7	2.3	2.8	N	1.2	10.3	24.5	0.31
2507	5.0	20.0	N	N	4.0	N	1.0	3.0	16.0	0.04
2509	8.0	15.0	1.0	1.0	5.0	N	1.0	2.0	17.0	0.14
COUNT	83	83	55	77	80	4	76	83	83	83
MINIMU	1.7	0.7	0.1	0.1	0.2	0.1	0.1	1.0	3.2	0.01
AVERAG	13.3	8.9	1.3	1.5	2.5	0.4	1.3	8.4	22.3	0.57
MAXIMU	38.0	38.0	4.0	4.7	13.0	1.0	5.0	86.5	46.6	2.49
S.D.	7.3	7.1	0.9	0.9	2.2	0.3	1.0	12.0	8.5	0.46

Table 3.--Continued.