STRATIGRAPHIC FRAMEWORK AND HEAVY-MINERAL RESOURCE POTENTIAL OF THE INNER CONTINENTAL SHELF, CAPE FEAR AREA, NORTH CAROLINA: FIRST INTERIM PROGRESS REPORT

NORTH CAROLINA GEOLOGICAL SURVEY

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DIVISION OF LAND RESOURCES

DEPARTMENT OF ENVIRONMENT, HEALTH,
AND NATURAL RESOURCES

STRATIGRAPHIC FRAMEWORK AND HEAVY-MINERAL RESOURCE POTENTIAL OF THE INNER CONTINENTAL SHELF, CAPE FEAR AREA, NORTH CAROLINA: FIRST INTERIM PROGRESS REPORT

by

Charles W. Hoffman, Patricia E. Gallagher, and Larry Zarra

DIVISION OF LAND RESOURCES
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WILLIAM W. COBEY, JR., SECRETARY

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Stratigraphic Framework and Heavy-Mineral Resource Potential of the Inner Continental Shelf, Cape Fear Area, North Carolina: First Interim Progress Report

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ABSTRACT

This report presents results from the first phase of a multi-year study to define the geologic framework and assess the potential for heavy-mineral resources of the inner continental shelf off southeastern North Carolina. Examination and determination of weight percent heavy minerals (S.G >2.96) has been completed for 68 samples from 19 vibracores. Upper Cretaceous through Holocene age sediments were recovered in the vibracores. Lithologies include carbonates, muddy quartz sands, and clean quartz sands typical of continental shelf depositional settings. The average weight percent heavy minerals for all samples (as a percent of the total sample) was 0.57 percent with a range from 0.00 percent to 3.69 percent and a standard deviation of 0.59 percent. Although these numbers are not encouraging in terms of the heavy-mineral resource potential, more work is needed before making a definitive assessment.

INTRODUCTION

This report presents an interim review of progress for the initial phase of a multi-year research project planned to develop an integrated geologic framework and assess the potential for heavy-mineral resources of the inner continental shelf off southeastern North Carolina (Figures 1 and 2). The overall effort is a joint project by the North Carolina Geological Survey (NCGS), the U. S. Geological Survey (USGS), and North Carolina State University. Partial funding for the work is provided through a cooperative agreement between the U. S. Department of the Interior, Minerals Management Service (MMS) and the Continental Margins Committee of the Association of American State Geologists (AASG). The North Carolina Department of Environment, Health, and Natural Resources is a participant in the program by virtue of a subagreement administered and coordinated for MMS by the University of Texas - Bureau of Economic Geology. The remaining support is being provided by the participating research organizations. The MMS-AASG cooperative agreement covering work reported herein is number 14-12-0001-30432; the subagreement number is 30432-NC.

This report presents lithologic, biostratigraphic, and heavy-mineral data derived from study of a set of vibracores (Figures 1 and 2) and compares the results

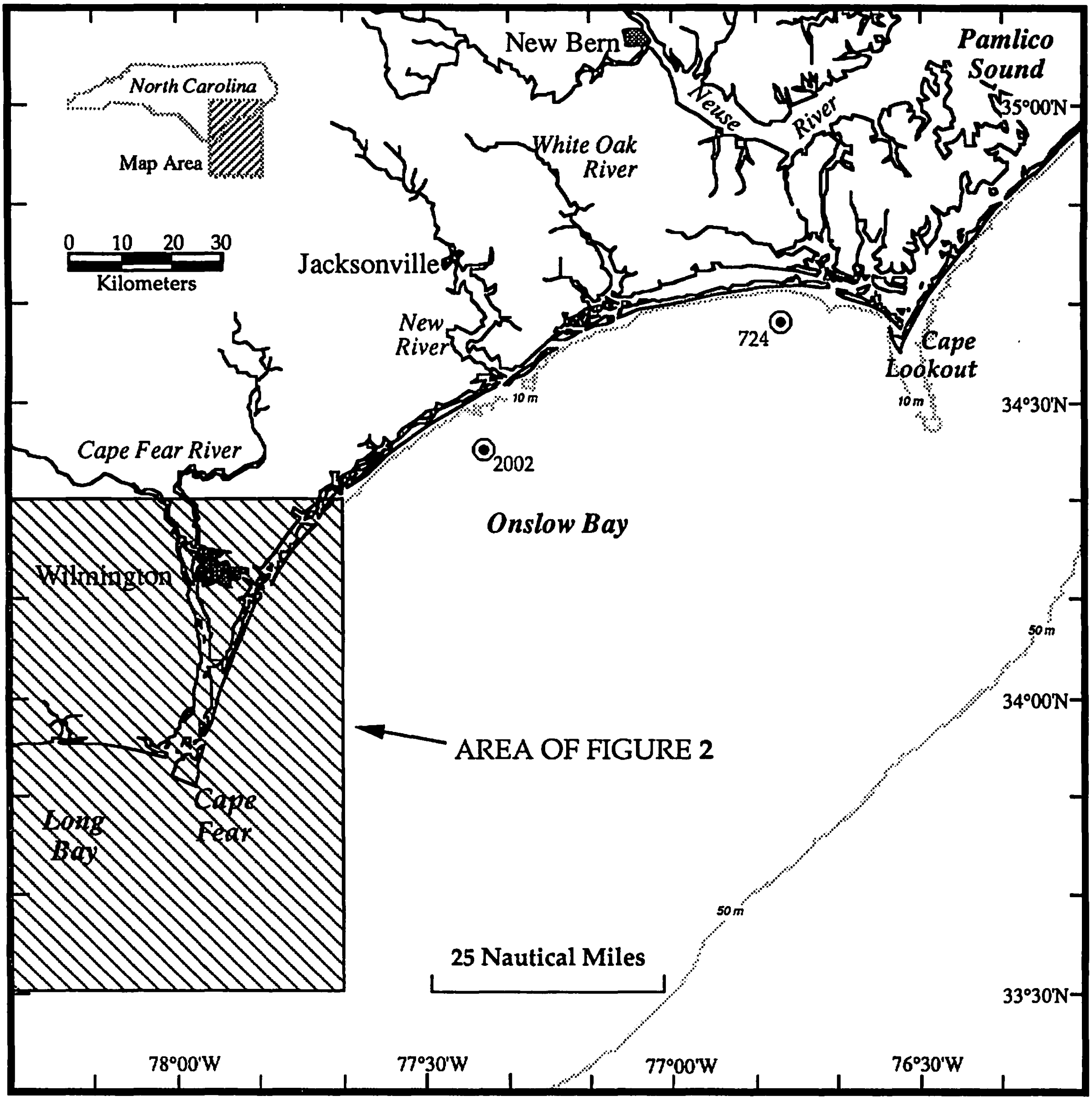

Figure 1. Map showing location and USGS core number for two vibracores in northern Onslow Bay that were used in this study.

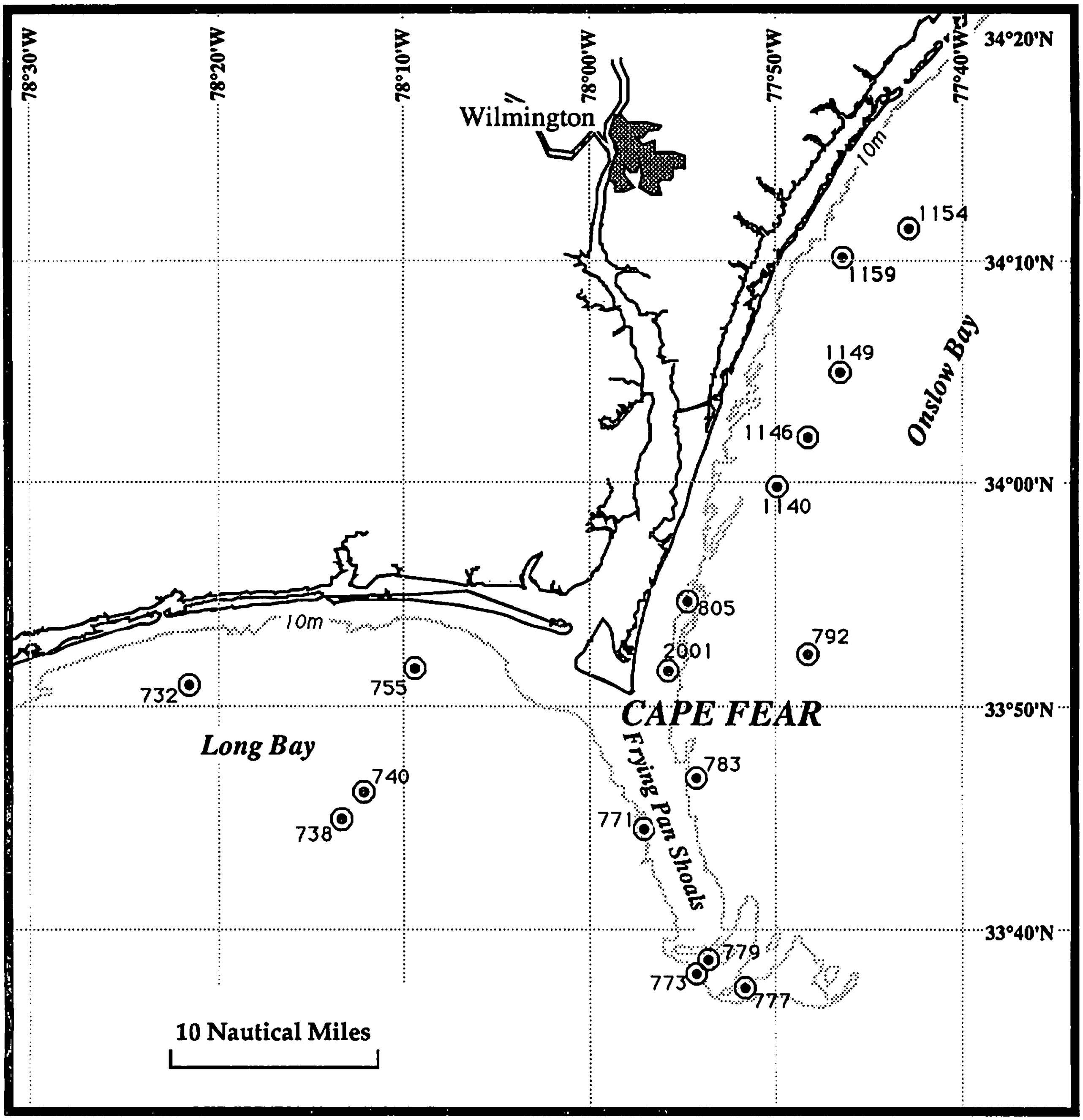

Figure 2. Map showing location and USGS core number for vibracores in the Cape Fear area that were used in this study.

to an earlier reconnaissance study in which the vibracores were collected. Subsequent phases of our research will integrate this initial data and additional vibracore data with a shallow high-resolution seismic stratigraphic model to provide a three-dimensional geologic framework of the region. Within such a framework, we expect to be able to provide a relatively definitive assessment of the potential for heavy-mineral resources.

The initial work reported here suffered setbacks due to staff turnover in mid-project (requiring additional training of new staff) and to the discovery of contamination in several heavy-mineral concentrates during microscopic and geochemical analyses. To compensate for this processing error by a subcontractor, vibracore material reserved for archiving was used to generate new heavy-mineral concentrates for determination of weight percent heavy minerals. The weight percent gravel (plus 10 mesh) determined for this second set of samples is reported herein. Core photographs and lithologic descriptions of the vibracores, made prior to any processing, were not affected by this error. Grain size distribution data generated from the spiral reject or "spiral light" fraction on the original samples was judged not to be affected by the sample handling error.

PREVIOUS WORK

The cores examined in this initial phase of study are part of a group of 114 cores taken in the Cape Fear region by the U. S. Army Corps of Engineers Coastal Engineering Research Center (CERC) as part of their Inner Continental Shelf Sediment and Structure (ICON) program. The ICON cores ultimately came into the custody of the USGS which, in turn, provided them to the NCGS for this research. The ICON program investigated sand aggregate resources of the eastern U. S. continental shelf. Two reports, Meisburger (1977) and Meisburger (1979), were produced as a result of the North Carolina portion of the ICON study. The first of these two reports assessed aggregate resource potential and identified several potential borrow areas for beach nourishment sand. The second report presented a reconnaissance description of the geology of the inner continental shelf within the survey area based on shallow high-resolution seismic data, and subsamples from the vibracores. Lithologic descriptions, textural classification, and limited biostratigraphic data were generated from the vibracore subsamples. Meisburger compiled the data set and presented the distributions of sediment textures and chronostratigraphic and seismic stratigraphic units on a series of small-scale maps (approximately 1:420,000 scale).

From Meisburger (1979), Hine and Snyder (1985), and Snyder (1982) we know that the geology of the study area is relatively complex. Numerous Upper Cretaceous through Quaternary geologic units outcrop on the inner shelf of Onslow Bay, Long Bay, and the intervening Frying Pan Shoals. These units are comprised of dominantly carbonate, mixed carbonate-siliciclastic, and purely siliciclastic sediments. Most of the units that occur on the inner shelf have updip extensions that either crop out or are known within the shallow subsurface of the emerged Coastal Plain adjacent to the study area (Zarra, 1991). During relative lowstands of sea level in the Quaternary, numerous paleofluvial channels were incised into the Tertiary and Cretaceous sediments. These channels were filled by bioclastic and siliciclastic sediment.

Grosz and others (1990) analyzed a broad sampling of surficial sediments from the continental shelf off North Carolina including the region under study here. They found that samples from the southern North Carolina inner shelf region (water depth less than 20 meters (65 feet)) averaged 1.2 weight percent heavy minerals as a part of the total sample with a range of 0.1 percent to 3.3 percent. . No attempt was made to relate these samples to known geologic units.

METHODOLOGY

The vibracores analyzed for this report were opened, photographed, and described by NCGS staff. Procedures for handling the cores, numbering samples, and processing them for sedimentological and mineralogical data generally follow those set forth in Grosz, Berquist, and Fischler (1990). Core photos, lab notebooks, paleontologic slides, archive samples and other basic data from the project are currently stored at the Coastal Plain Office and Sample Repository facility of the NCGS in Raleigh. Permanent storage is expected to be under the purview of the USGS. Parties interested in these materials may contact the lead author for additional information.

A total of 20 vibracores comprising 72 samples were examined, processed, and analyzed for this portion of the study. One core, number 732R, contained numerous artifacts in the upper half and was determined not to be representative of the geology of the site; therefore it was eliminated from the study. This core was a replicate sample of core number 732 which contained a markedly different lithology from number 732R. Vibracores ranged from about 4 meters to 6 meters (13 to 20 feet) long. Cores were subdivided into two, three, or four samples about 1 to 2 meters (3 to 6 feet) long. The average sample length was 1.5 meters (5 feet). Vibracore samples are designated by the core number (for example, 725 or 1124), followed by ".1", ".2", and so on to indicate the uppermost and subsequently lower sections, respectively.

The vibracores were cut lengthwise on a static blade cutter, then were photographed, described, and subsampled. Subsamples provided a 300- to 500-gram archive sample and a sample to process for micropaleontologic analysis. The remaining vibracore material was weighed and:

- wet sieved through a U. S. Standard 10-mesh screen (2 mm, -1 Phi)
- the plus 10-mesh fraction was dried, weighed, and described.

- the minus 10-mesh fraction was passed through a 3-turn Humphreys spiral to provide an initial concentration of the heavy-mineral fraction.
- a representative subsample taken from the "spiral light" fraction was dried, weighed, and a sink/float test was performed in acetylene tetrabromide (s.g. 2.96) — the weight percent heavy minerals in the aliquot was extrapolated to determine the amount of heavy minerals that were rejected by the spiral.
- grain size distribution analysis was performed on the spiral light fraction
- a sink/float test was performed on the "spiral heavy" fraction (also in acetylene tetrabromide) to recover the main component of the heavy-mineral fraction.

Magnetic fractionation and mineralogic analysis of the heavy-mineral concentrates obtained by heavy liquid separations will be part of the next phase of this study.

RESULTS

General

Tables 1 and 2 present the primary data developed during this phase of the study. Derivative data and summaries of the Appendix data are provided in the figures and the appendix referenced below. The lithologies and stratigraphic units identified from the vibracores are consistent with what was anticipated from the previous work of Meisburger (1979). Differences can largely be attributed to the fact that the previous study of lithologies, microfauna, and seismic data was of a purely reconnaissance nature. This study is more comprehensive and involves detailed examination and processing of complete vibracore sections.

Refinement of Meisburger's stratigraphic interpretations are primarily within sediments he reported as being Pliocene to Holocene age. Several cores that Meisburger assigned to his Holo/Pleistocene unit, specifically numbers 738 (CERC 29), 740 (CERC 13), 771 (CERC 46), 773 (CERC 63), and 783 (CERC 53), are herein assigned either Pliocene or Pliocene/Pleistocene ages. In cores 1140 (CERC 79) and 1154 (CERC 106) we differentiate a Pliocene unit within the upper part of the core whereas Meisburger's reported the entire core to contain Oligocene strata.

Lithologic Descriptions and Stratigraphic Correlations

In several cores we can establish correlation to onshore lithostratigraphic units by lithologic criteria backed up with foraminiferal paleontologic data. The lower two samples from core 724 contained phosphorite sand of the Pungo River Formation (lower to middle Miocene). Core 732 contained fine to medium-grained calcareous silty sand of the Peedee Formation (Upper Cretaceous). Core 755 was comprised of bryozoan biomicrudite of the Comfort Member of the Castle Hayne Formation (middle Eocene), and core 2002 was comprised of sandy, molluscan-mold

Table 1. Lithologic and stratigraphic data for vibracore samples.

SAMP. NO.	CERC NO.	SHORT LITHOLOGIC DESCRIPTION	STRATIGRAPHIC UNIT
724.1	95	muddy, sandy shell hash	Pliocene
724.2		muddy, slightly shelly, poorly sorted, medium-grained phosphatic sand	Miocene (Pungo River Fm.)
724.3		muddy, slightly shelly, poorly sorted, medium-grained phosphatic sand	Miocene (Pungo River Fm.)
732.1	42	muddy, poorly sorted, medium sand with shelly and partially indurated zones	Cretaceous (Peedee Fm.)
732.2		muddy, moderately sorted, medium sand	Cretaceous (Peedee Fm.)
732.3		muddy, moderately well sorted, fine sand	Cretaceous (Peedee Fm.)
738.1	29	shelly, silty, medium sand	Plio/Pleistocene
738.2		slightly shelly, silty, fine sand	Plio/Pleistocene
738.3		silty fine sand	Plio/Pleistocene
738.4		silty fine sand	Plio/Pleistocene
740.1	13	muddy, moderately well sorted, shelly medium sand	Pliocene
740.2		biomicrudite	Pliocene
740.3		biomicrudite	Pliocene
755.1	19	bryozoan biomicrudite	M. Eocene (Castle Hayne Fm.)
755.2		bryozoan biomicrudite	M. Eocene (Castle Hayne Fm.)
771.1	46	slightly shelly, well sorted, fine sand	Plio/Pleistocene
771.2		slightly shelly, well sorted, fine sand	Plio/Pleistocene
771.3		slightly shelly, well sorted, fine to medium sand with clay lenses	Plio/Pleistocene
771.4		slightly shelly, well sorted, medium sand with clay lenses	Plio/Pleistocene
773.1	63	slightly shelly, well sorted, fine sand	Pliocene
773.2		shelly, well sorted, medium sand; 4-cm-thick clay lens at 248-252 cm	Pliocene
773.3		muddy, slightly shelly, moderately well sorted, fine sand	Pliocene
777.1	58	shelly, well sorted, medium sand	Holo/Pleistocene
777.2		shelly, well sorted, medium sand	Holo/Pleistocene
777.3		shelly, well sorted, medium sand	Holo/Pleistocene
777.4		shelly, well sorted, medium sand	Holo/Pleistocene

Table 1. Lithologic and stratigraphic data for vibracore samples (continued).

SAMP. NO.	CERC NO.	SHORT LITHOLOGIC DESCRIPTION	STRATIGRAPHIC UNIT
779.1	62	shelly, well sorted, medium to coarse sand	Holo/Pleistocene
779.2		shelly, well sorted, medium to coarse sand	Holo/Pleistocene
779.3		shelly, well sorted, medium to coarse sand	Holo/Pleistocene
783.1	53	slightly shelly, muddy, pebbly, poorly sorted, fine sand	Pliocene
783.2		slightly shelly, muddy, pebbly, poorly sorted, fine sand	Pliocene
783.3		muddy, shelly, poorly sorted, fine to medium sand; thin interbeds of clay & coarse sand	Pliocene
783.4		muddy, sandy, poorly sorted, shell hash	Pliocene
792.1	77	biosparudite	Plio/Pleistocene
792.2		biorudite	Plio/Pleistocene
792.3		biosparudite	Plio/Pleistocene
792.4		biorudite	Plio/Pleistocene
805.1	70	biorudite	Plio/Pleistocene
805.2		biosparudite	Plio/Pleistocene
805.3		biosparudite	Plio/Pleistocene
805.4		biosparudite	Plio/Pleistocene
1140.1	79	shelly, well sorted, fine to medium sand	Pliocene
1140.2		well sorted, carbonate-cemented, very fine to fine sand	Oligocene
1140.3		well sorted, carbonate-cemented, very fine to fine sand	Oligocene
1146.1	80	silty, shelly, well sorted, fine to medium sand	Oligocene
1146.2		silty, shelly, well sorted, fine to medium sand	Oligocene
1146.3		silty, shelly, well sorted, fine to medium sand	Oligocene
1146.4		silty, shelly, well sorted, fine sand	Oligocene
1149.1	92	shelly, moderately well sorted, medium to coarse sand	Pleistocene
1149.2		shelly, silty, well sorted, medium sand with carbonate cemented stringers	Oligocene
1149.3		shelly, silty, well sorted, fine to medium sand with carbonate cemented stringers	Oligocene
1149.4		shelly, silty, well sorted, fine to medium sand with carbonate cemented stringers	Oligocene

Table 1. Lithologic and stratigraphic data for vibracore samples (continued).

SAMP. NO.	CERC NO.	SHORT LITHOLOGIC DESCRIPTION	STRATIGRAPHIC UNIT
1154.1	106	shelly, well sorted, fine sand	Pliocene
1154.2		shelly, pebbly, poorly sorted, fine to medium sand	Pliocene
1154.3		shelly, slightly muddy, poorly sorted, fine to medium sand	Oligocene
1154.4		shelly, muddy, poorly sorted, fine to medium sand	Oligocene
1159.1	84	slightly shelly, silty well sorted, fine sand	Oligocene
1159.2		slightly shelly, silty well sorted, fine sand	Oligocene
1159.3		slightly shelly, silty well sorted, fine sand	Oligocene
1159.4		slightly shelly, silty well sorted, fine sand	Oligocene
2001R.1	73	muddy, porly sorted, shelly, fine to medium sand; whole shells	Plio/Pleistocene
2001R.2		biosparudite	Plio/Pleistocene
2001R.3		biosparudite	Plio/Pleistocene
2001R.4		biosparite	Plio/Pleistocene
2002.1	102	sandy, molluscan-mold biosparudite	Oligocene
2002.2		sandy, molluscan-mold biosparudite	Oligocene
2002.3		sandy, molluscan-mold biosparudite	Oligocene
2002.4		sandy, molluscan-mold biosparudite	Oligocene

Table 2. Sample length, water depth, bulk weight, weight percent plus 10 mesh, and weight percent heavy minerals for vibracore samples.

SAMPLE NUMBER	SAMPLE LENGTH (cm)	WATER DEPTH (ft)	BULK WT. (g)	+10 MESH (WT %)	TOTAL HM (WT % OF BULK SAMPLE)
724.1	206	51	4,422	30.5%	0.44%
724.2	177		2,596	3.9%	0.64%
724.3	157		2,155	0.8%	1.00%
732.1	154	40	4,025	48.0%	0.23%
732.2	154		2,871	5.8%	0.21%
732.3	126		1,982	17.3%	0.16%
738.1	220	58	3,933	15.3%	0.58%
738.2	105		2,309	2.5%	0.67%
738.3	156		3,099	0.0%	0.83%
738.4	130		2,523	0.0%	0.62%
740.1	141	53	3,007	3.7%	0.87%
740.2	183		3,140	62.9%	0.03%
740.3	202		5,049	58.7%	0.02%
755.1	176	46	4,634	0.4%	0.09%
755.2	185		3,821	43.7%	0.05%
771.1	140	32	2,553	0.5%	1.28%
771.2	161		3,490	0.2%	0.47%
771.3	152		3,157	0.7%	0.65%
771.4	170		3,798	3.1%	0.37%
773.1	222	41	3,477	0.5%	0.44%
773.2	99		1,297	5.3%	0.35%
773.3	123		2,165	1.2%	1.09%
777.1	153	36	2,712	0.8%	0.41%
777.2	155		2,829	1.9%	0.53%
777.3	133		1,445	0.8%	0.42%
777.4	128		2,096	1.0%	0.36%
779.1	109	23	1,549	1.0%	0.38%
779.2	112		1,943	1.3%	0.31%
779.3	142		2,292	0.6%	0.26%
783.1	162	37	3,181	5.5%	0.62%
783.2	156		2,447	3.4%	0.65%
783.3	144		2,010	6.4%	0.77%
783.4	152		2,863	23.6%	0.34%
792.1	149	57	3,573	3.6%	0.04%
792.2	100		1,763	18.0%	0.00%
792.3	145		2,936	64.9%	0.01%
792.4	136		2,730	9.2%	0.03%

Table 2. Sample length, water depth, bulk weight, weight percent plus 10 mesh, and weight percent heavy minerals for vibracore samples (continued).

SAMPLE NUMBER	SAMPLE LENGTH (cm)	WATER DEPTH (ft)	BULK WT. (g)	+10 MESH (WT %)	TOTAL HM (WT % OF BULK SAMPLE)
805.1	131	43	1,949	38.6%	0.05%
805.2	130		2,216	5.1%	0.01%
805.3	163		3,095	52.5%	0.02%
805.4	135		2,479	88.0%	0.01%
1140.1	190	44	4,135	1.3%	0.65%
1140.2	122		2,361	9.1%	0.44%
1140.3	148		2,570	10.2%	0.54%
1146.1	151	59	2,600	3.3%	0.74%
1146.2	148		2,554	5.1%	0.50%
1146.3	163		3,322	0.6%	0.77%
1146.4	152		4,065	0.0%	0.81%
1149.1	104	44	856	6.5%	0.32%
1149.2	162		3,827	8.4%	0.29%
1149.3	153		3,514	0.2%	0.32%
1149.4	156		3,803	0.0%	0.26%
1154.1	127	46	2,346	2.5%	0.38%
1154.2	140		2,738	5.5%	0.43%
1154.3	185		1,447	4.1%	2.45%
1154.4	156		2,662	0.1%	1.40%
1159.1	151	55	1,363	0.3%	3.69%
1159.2	159		3,218	0.0%	1.52%
1159.3	152		3,203	0.2%	1.52%
1159.4	93		2,065	0.1%	0.87%
2001R.1	203	40	1,586	33.9%	1.12%
2001R.2	149		3,001	58.4%	0.02%
2001R.3	145		2,695	63.7%	0.03%
2001R.4	93		1,759	83.7%	0.01%
2002.1	152	42	3,063	26.3%	0.38%
2002.2	155		3,010	13.4%	0.41%
2002.3	152		3,377	36.2%	0.39%
2002.4	146		3,956	26.0%	0.47%
			AVERAGE	15.16%	0.54%
			MINIMUM	00.03%	0.00%
			MAXIMUM	87.98%	3.69%
			STANDARD DEVIATION	22.44%	0.59%

biosparudite of the River Bend Formation (Oligocene).

Cores 1146 and 1159 and the lower parts of cores 1140, 1149, and 1154 contain a distinctive lithologic unit comprised of typically clayey, fine- to very fine-grained,well to very well sorted quartz sand of Oligocene age. Locally, the sand is lithified by carbonate cement and contains sparse, very fine-grained dolomite rhombohedrons. Based on planktic foraminifera present in core 1146, the unit is biostratigraphically correlative with the River Bend Formation. However, no similar onshore lithofacies has been recognized.

Cores 792, 805, and the lower parts of 740 and 2001R contain Pliocene or Pliocene/Pleistocene bioclastic calcareous sediments. Correlation of these units with established lithostratigraphic units onshore is not possible with the available data. Onshore, the lower to middle Pliocene Duplin Formation, the late Pliocene Bear Bluff Formation, and the lowermost Pleistocene Waccamaw Formation all have carbonate facies. We expect to be able to differentiate these units in future phases of the study by conducting more detailed paleontologic analyses and by further developing the geologic framework with seismic data and with the examination and analysis of additional vibracores. Snyder (1982) and Meisburger (1979) have recognized Pliocene and younger carbonate rocks on the inner to middle shelf of southern Onslow Bay. They report them to occur as "caps" or "highs" on the seafloor with abrupt escarpments on one or more sides or, alternatively, as channel-fill sequences. Either or both of these settings are considered likely for the late Tertiary and Quaternary bioclastic sediments obtained from these vibracores.

The Pliocene and Pliocene/Pleistocene is also represented in the vibracores of this study by muddy, typically poorly sorted, slightly to very shelly quartz sands and by relatively "clean", well sorted quartz sands. The muddy, quartz sand lithology occurs in cores 738, and 783 and the upper parts of cores 724, 740, and 2001R. The well sorted quartz sands occur in cores 773 and 771 and the upper part of core 1154. As with the Pliocene to Pleistocene age bioclastic sediments, these siliciclastic sediments are facies likely correlative with the Duplin, Bear Bluff, and Waccamaw Formations; but the specific correlations can not be resolved with the available data. Younger units (middle to late Pleistocene age) may also be equivalent to parts of these sands. Stratigraphic correlation within this part of the section, however, is quite tenuous due to poor faunal control and a less well-established lithostratigraphy onshore.

A final sediment type recovered in the vibracores was unconsolidated, well sorted, medium to coarse quartz sands of Holo/Pleistocene age. These occur in cores 777 and 779 and appear to represent an active facies of Frying Pan Shoals.

The grain size distribution of the minus 10-mesh fraction of the vibracore samples is not specifically analyzed or discussed herein. The data for non-carbonate samples are presented in the Appendix as simple histograms of weight percent for each size class. The histograms, when considered along with the weight percent gravel shown in Table 2, serve to generally characterize sedimentary textures and provide graphical comparisons of the samples. It should be noted however, that the sieving and spiraling processes do not recover the predominantly clay-sized fraction that goes into suspension. Formal textural classification of the samples remains an option for further studies, but will require processing the only remaining archive material.

Heavy Minerals

Table 2 shows the weight percent heavy minerals (S.G >2.96) for each sample expressed as a percent of the total sample. The average weight percent for all samples was 0.57 percent with a range from 0.00 percent to 3.69 percent and a standard deviation of 0.59 percent. Although the average weight percent heavy minerals value is not suggestive of a good potential for heavy-mineral resources, conclusive judgment of the potential for resources based on such a small and diverse sampling over such a large area would be premature. Determination of the quality of the heavy-mineral concentrates (that is the abundance of the various species) is yet to be done. Additionally, many more vibracores from the study area, some representing stratigraphic units or depositional settings not tested by this initial set of cores, are yet to be examined.

The weight percent heavy minerals reported for the Cape Fear area in Grosz and others (1990) are in line with the values obtained in this initial work. As a result of that earlier work, one of the chief premises of continued research in this region is that unique conditions that are favorable for the development of heavy-mineral deposits may exist locally and that the potential for heavy-mineral resources in the area can not be dismissed without more thorough testing.

The weight percent heavy minerals data for this first set of vibracores is illustrated versus several parameters in Figures 3, 4, and 5. In most cases, the number of members (n) in a given class are not sufficient to permit meaningful interpretations regarding the heavy-minerals content of that group. Classes having less than three members were not considered. These data are displayed simply for the purpose of organizing the results according to a variety of logical parameters. As additional vibracores are opened and data are added to these or similar displays, systematic patterns of heavy-minerals distribution may emerge.

As shown in Figure 3, the distribution of heavy minerals does not seem to be significantly affected by either the geographic location of or the water depth at the vibracore site. In Figure 4, part A, the distribution of heavy minerals is shown versus lithology. Not surprisingly, the heavy-mineral content of quartz sands is markedly higher than that of the carbonates. Figure 4, part B, presents the

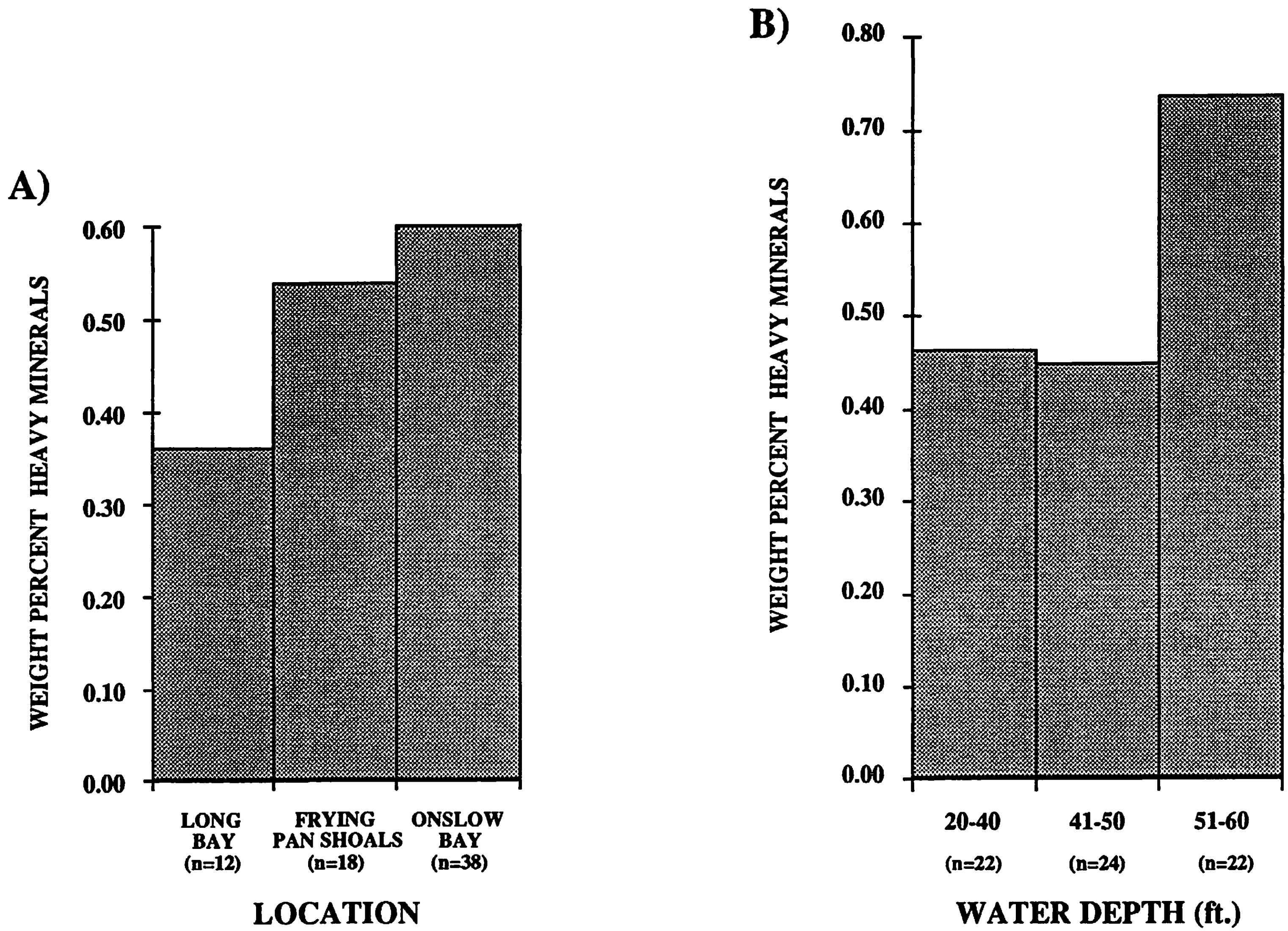

Figure 3. Average weight percent heavy minerals (as weight percent of bulk sample) by A) geographic location of vibracore site, and B) water depth at vibracore site.

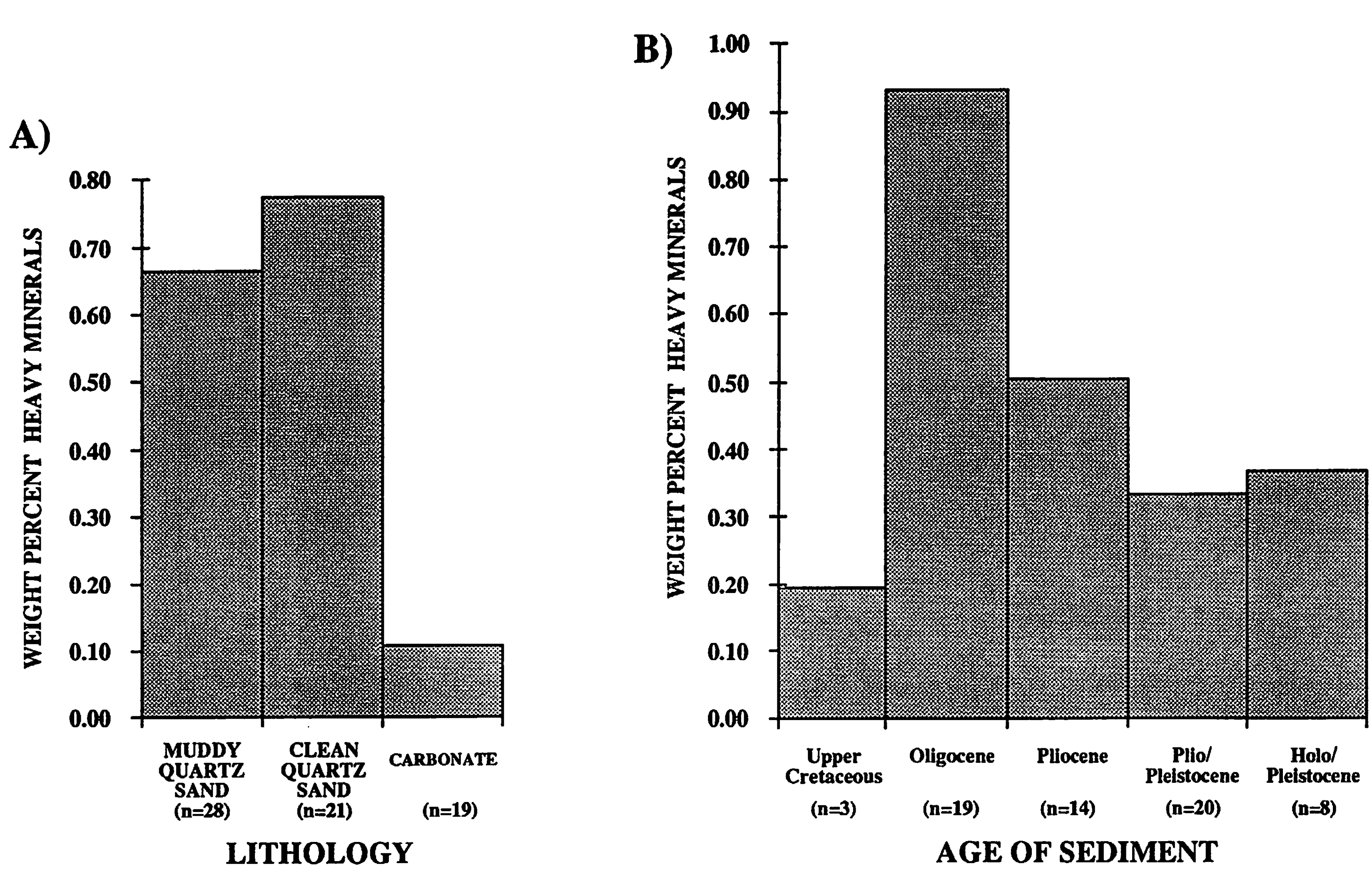

Figure 4. Distribution of heavy minerals (as weight percent of bulk sample) by A) lithology of sample, and B) age of sediment in sample – classes with less than 3 members (Middle Eocene and Miocene) not shown.

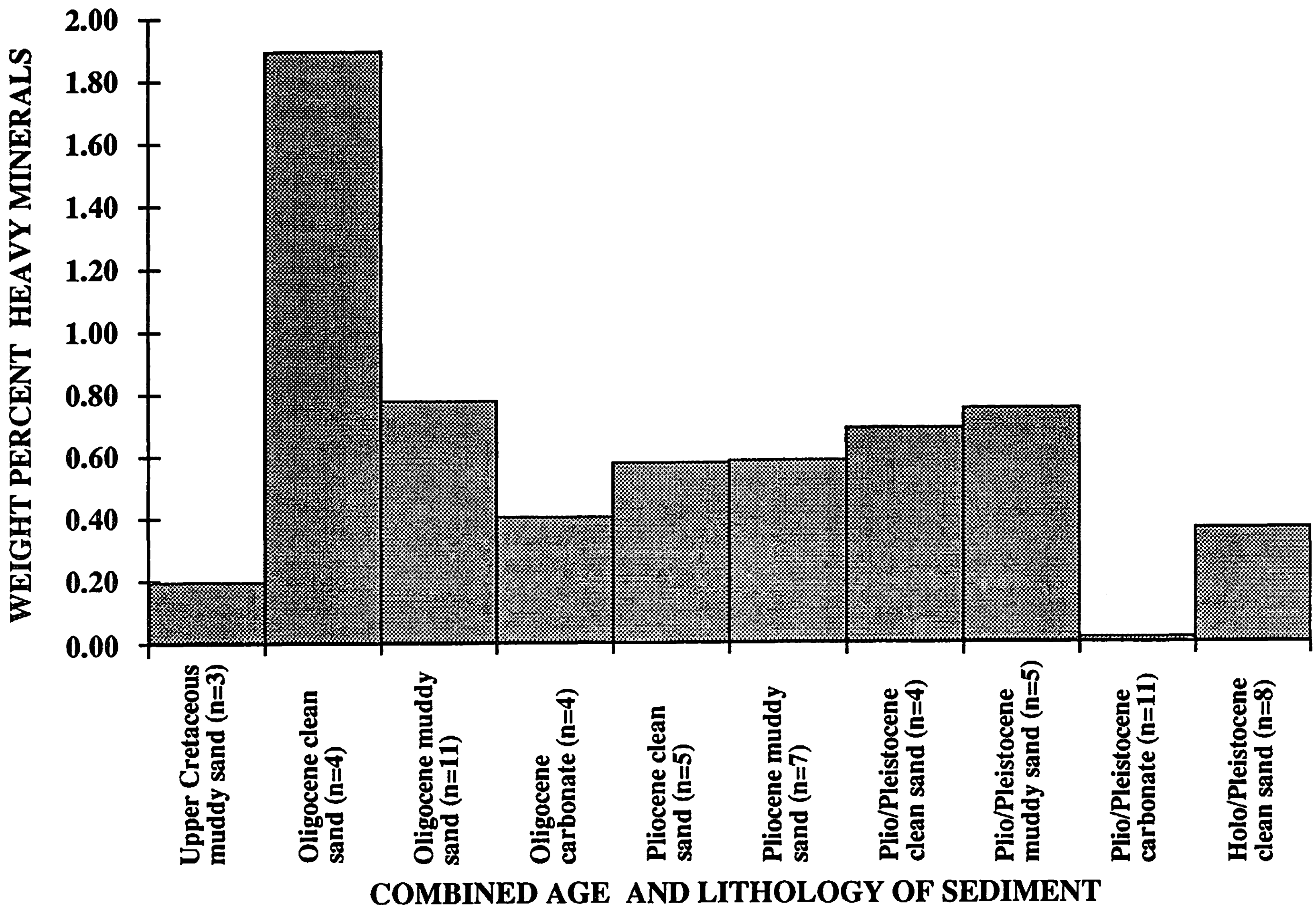

Figure 5. Distribution of heavy minerals (as weight percent of bulk sample) by combined age and lithology of sediment – classes with less than 3 members (Middle Eocene carbonate, Miocene muddy sand, and Pliocene carbonate) not shown.

distribution of heavy minerals according to the age of the sediment. Some differentiation is evident by this graph. Namely, Oligocene age material (despite four carbonate samples weighting the average down) is approximately double any other category. A combination of both age and lithology is used in Figure 5 to categorize heavy-mineral content of these samples. A single core, number 1159 which contains clean quartz sand of Oligocene age, stands out on the graph. Otherwise, no patterns emerge from this graph that are not evident from the preceding graphs of these same parameters.

SUMMARY

The 19 vibracores examined as part of this study provide an initial body of data that will be expanded and refined in ongoing and forthcoming phases of this research program. Although it is an important beginning and will be an integral part of the ultimate understanding we expect to reach regarding the geologic framework and mineral resource potential of the study area, no definitive conclusions can be drawn at this early juncture. The general conceptual framework and mineral resource models suggested by previous reconnaissance work in the region have not been appreciably altered or reinforced.

ACKNOWLEDGEMENTS

The cooperation of Andrew Grosz, who provided guidance, use of USGS laboratory facilities, and comments on the manuscript is gratefully acknowledged. Steve Snyder of N. C. State University also provided assistance and cooperation for parts of this phase of research and commented on the manuscript. Michael Dixon, geologic technician with the NCGS, performed much of the sample processing. Joel Hutwelker, N. C. State University Minerals Research Laboratory, provided grain size data on the spiral light fraction of the samples.

REFERENCES CITED

Grosz, A. E., Berquist, C. R., Jr., and Fischler, C. T., 1990, A procedure for assessing heavy-mineral resources potential of continental shelf sediments, *in* Berquist, C. R., Jr., editor, Heavy-mineral studies — Virginia inner continental shelf: Virginia Division of Mineral Resources Publication 103, p. 13-30.

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: North Carolina Geological Survey Open-File Report 90-3, 58 p.

Hine, A. C., and Snyder, S. W., 1985, Coastal Lithosome preservation: evidence from the shoreface and inner continental shelf off Bogue Banks, North Carolina: Marine Geology, v. 63, p. 307-330.

Meisburger, E. P., 1977, Sand Resources on the inner Continental Shelf of the Cape Fear region, North Carolina, U. S. Army Corps of Engineers, Coastal Engineering Research Center Technical Paper 77-11, 20 p.

Meisburger, E. P., 1979, Reconnaissance geology of the inner Continental Shelf, Cape Fear region, North Carolina, U. S. Army Corps of Engineers, Coastal Engineering Research Center Technical Paper 79-3, 135 p.

Snyder, S. W., 1982, Seismic stratigraphy within the Miocene Carolina phosphogenic province: chronostratigraphy, paleotopographic controls, sea-level cyclicity, Gulf Stream dynamics, and the resulting depositional framework [M. S. Thesis]: Chapel Hill, North Carolina, University of North Carolina at Chapel Hill, 183 p.

Zarra, Larry, 1991, Subsurface stratigraphic framework for Cenozoic strata in Brunswick and New Hanover Counties, North Carolina: North Carolina Geological Survey Information Circular 27, 1 sheet.

APPENDIX – Grain size distribution of spiral light subsample for non-carbonate vibracore samples.

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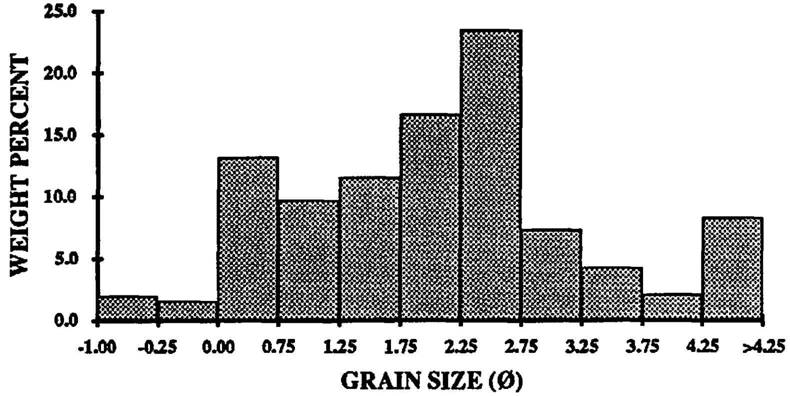

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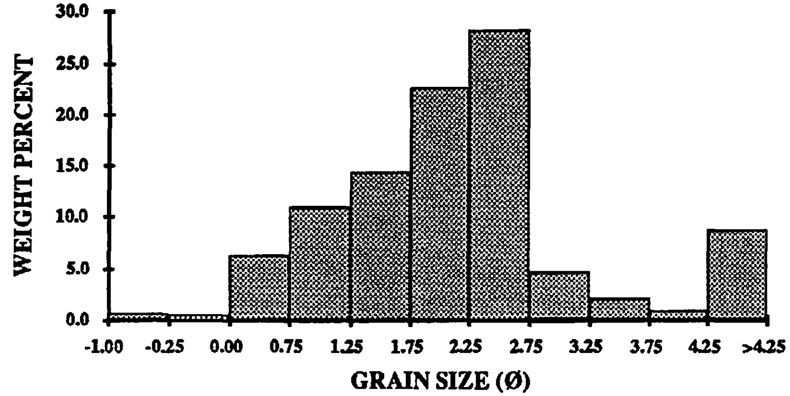

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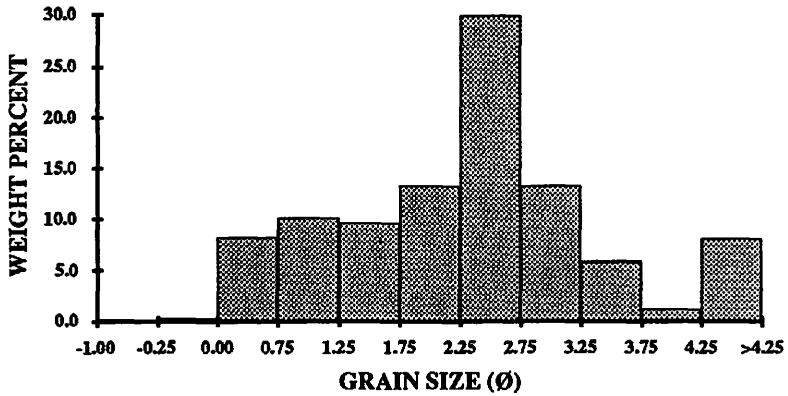

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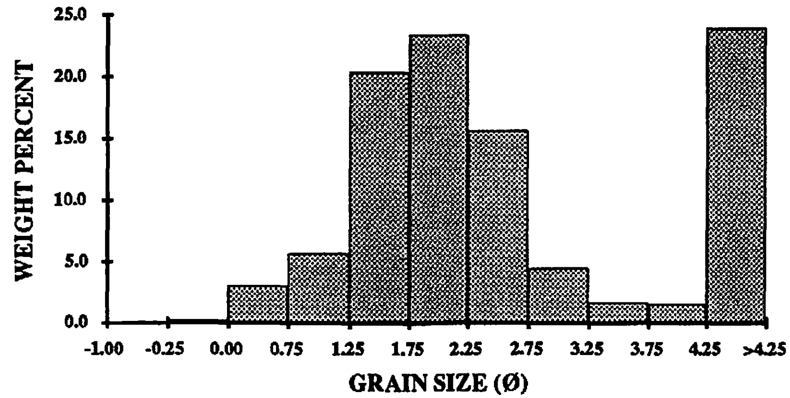
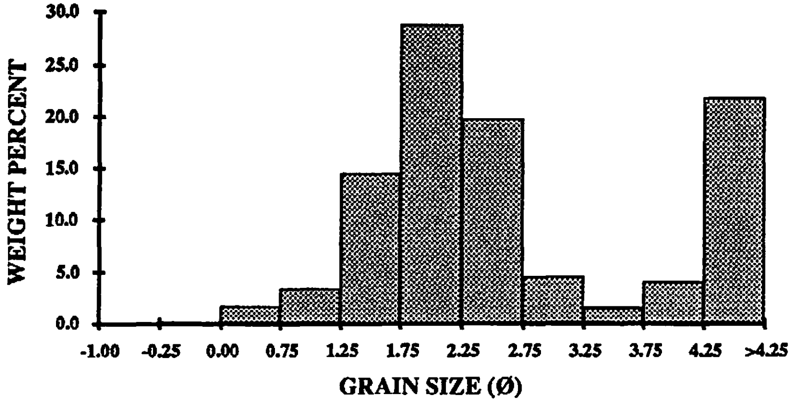


APPENDIX – Grain size distribution of spiral light subsample for non-carbonate vibracore samples (continued).

732.2



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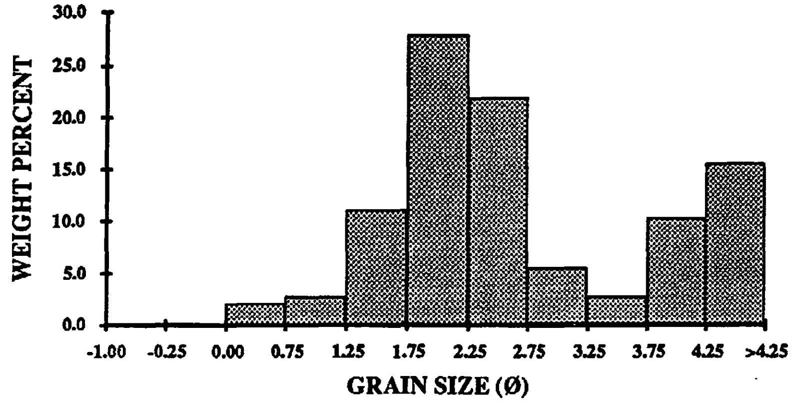

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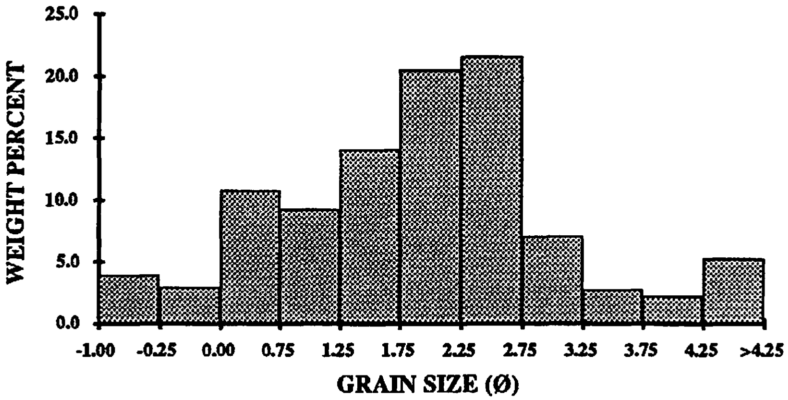

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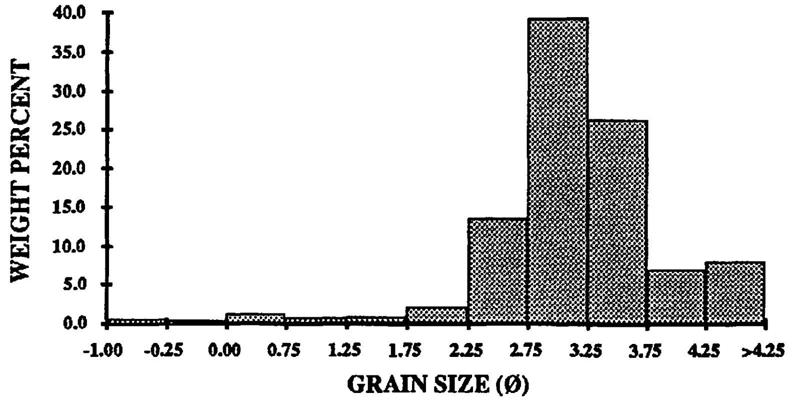
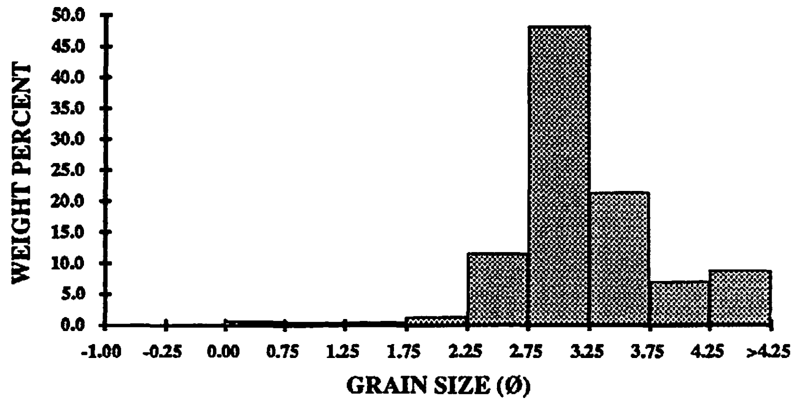


APPENDIX – Grain size distribution of spiral light subsample for non-carbonate vibracore samples (continued).

738.3



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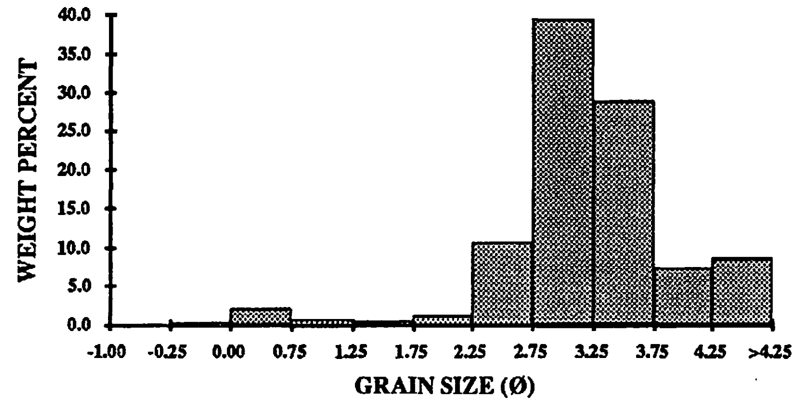

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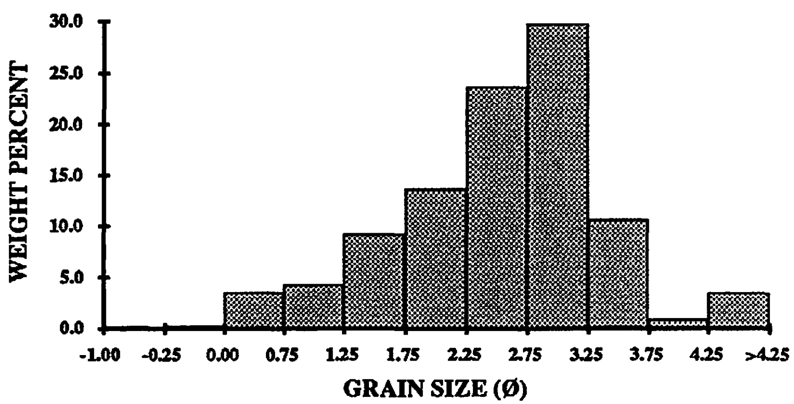

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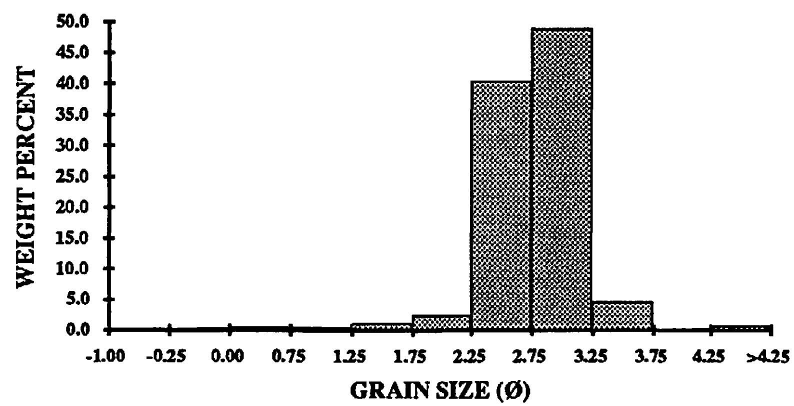
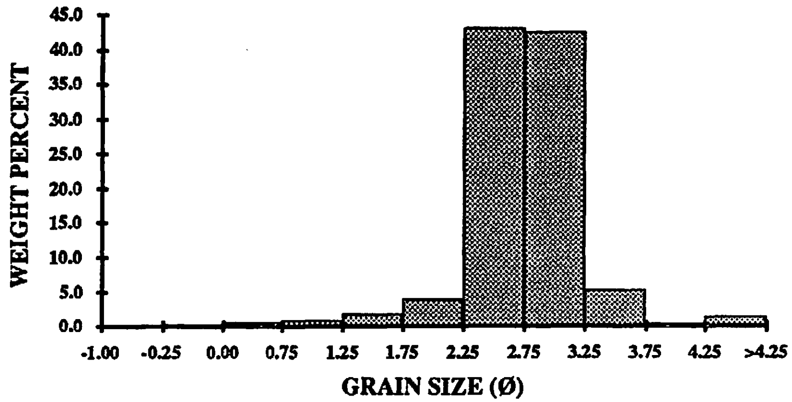


APPENDIX – Grain size distribution of spiral light subsample for non-carbonate vibracore samples (continued).

771.2



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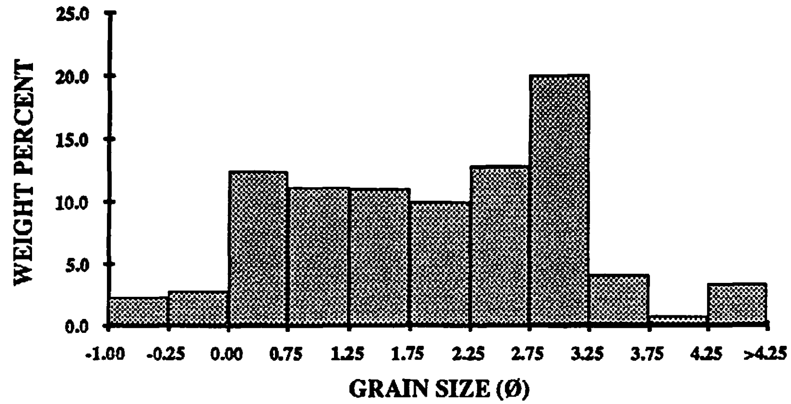

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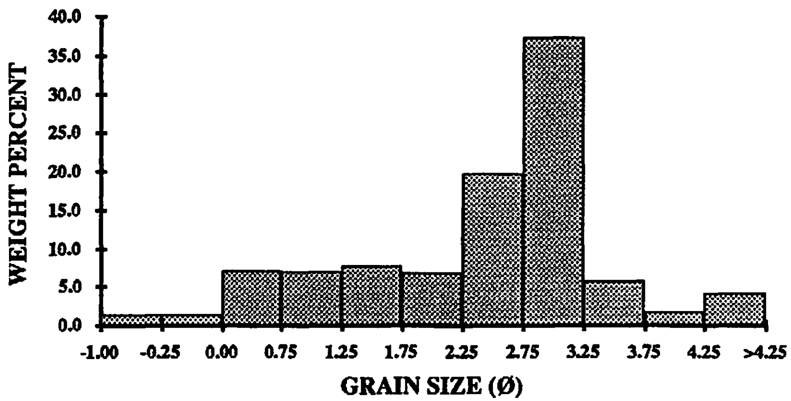

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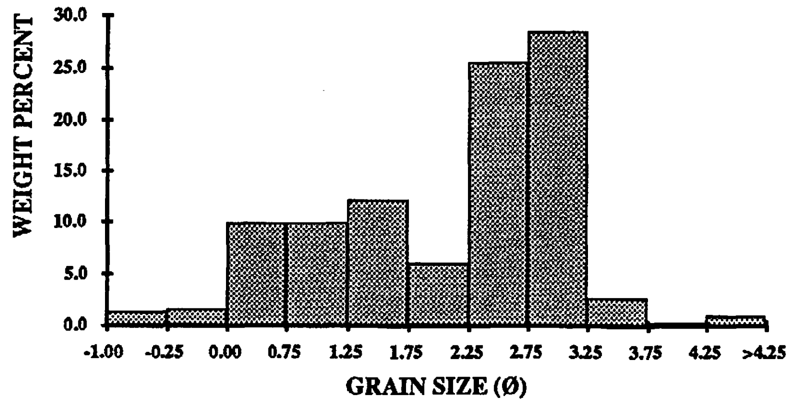
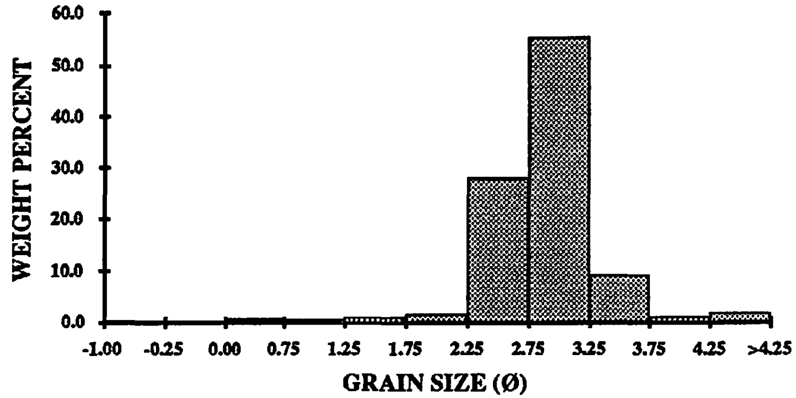


APPENDIX – Grain size distribution of spiral light subsample for non-carbonate vibracore samples (continued).

773.2



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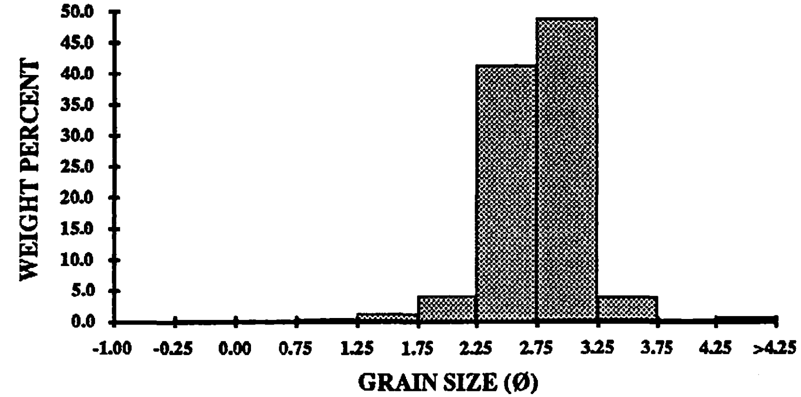

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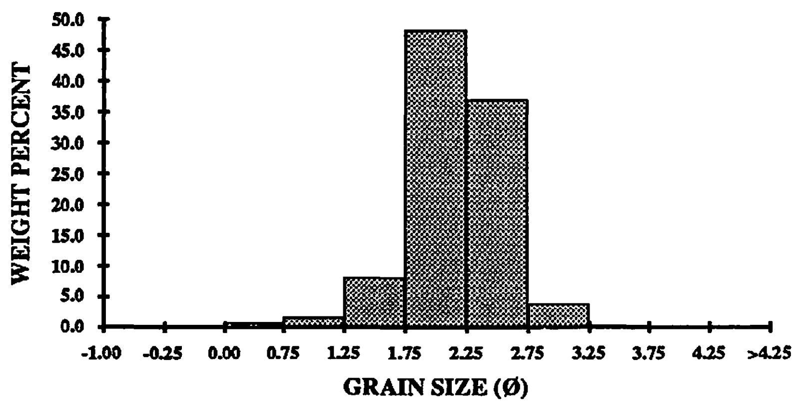

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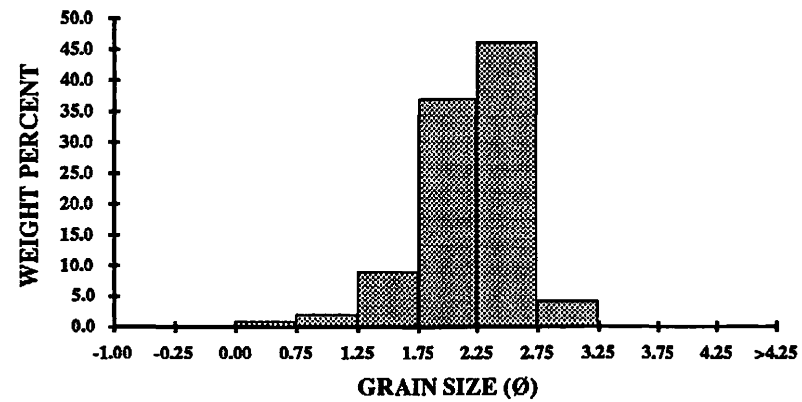
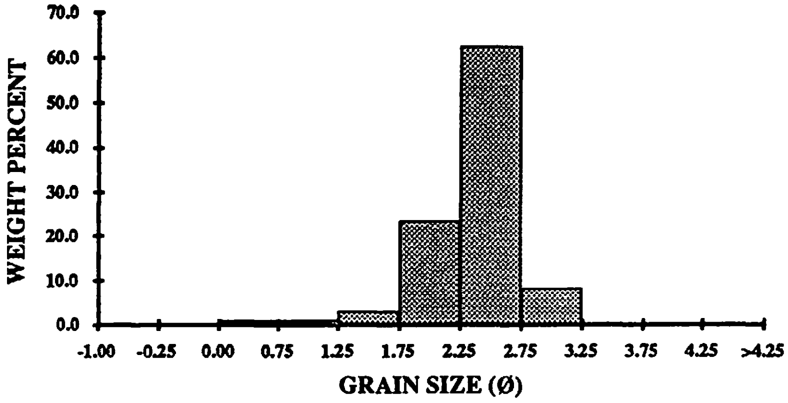


APPENDIX – Grain size distribution of spiral light subsample for non-carbonate vibracore samples (continued).

777.3



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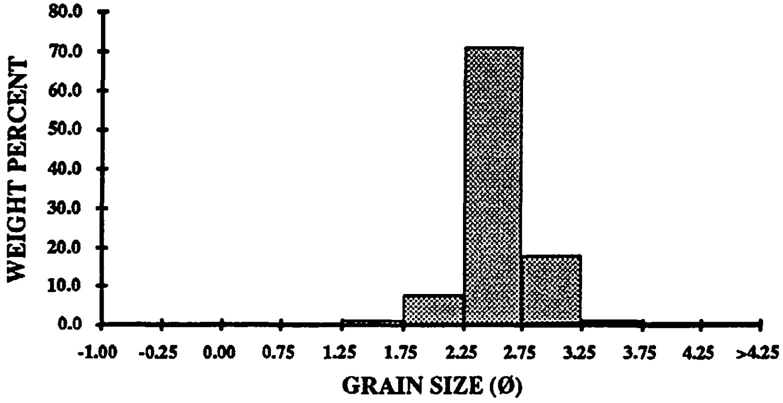

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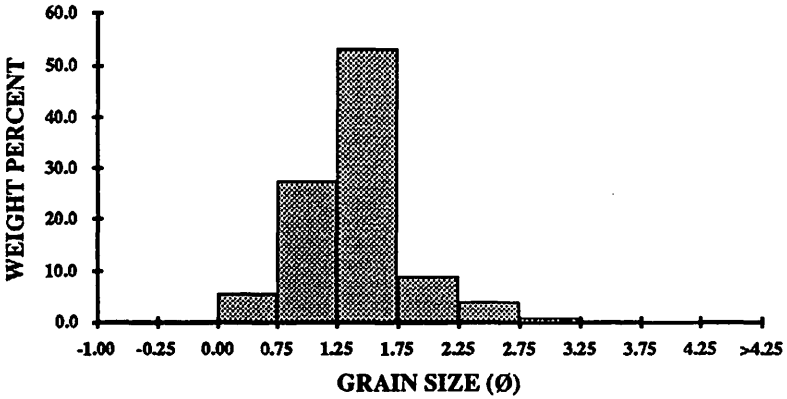

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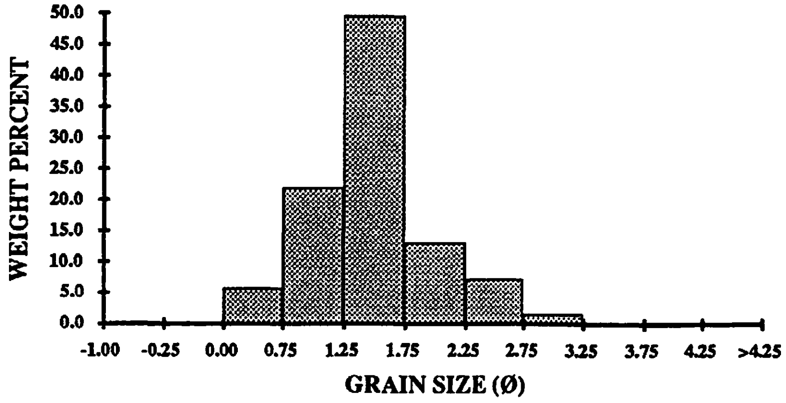
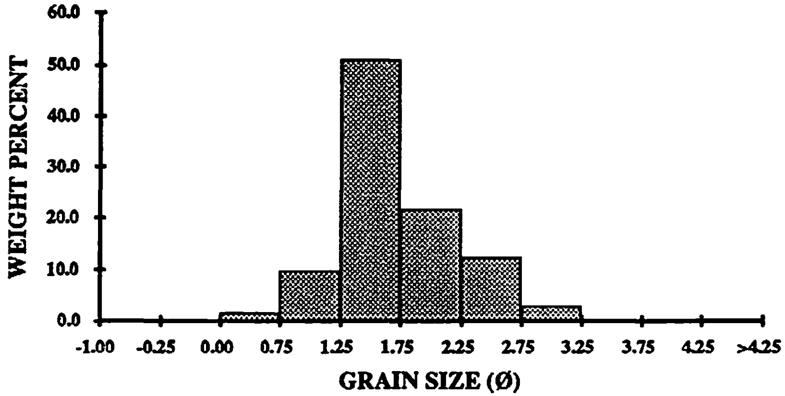


APPENDIX – Grain size distribution of spiral light subsample for non-carbonate vibracore samples (continued).

779.3



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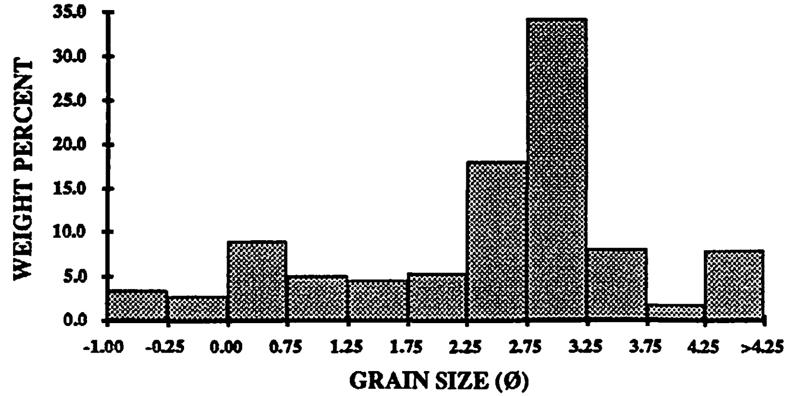

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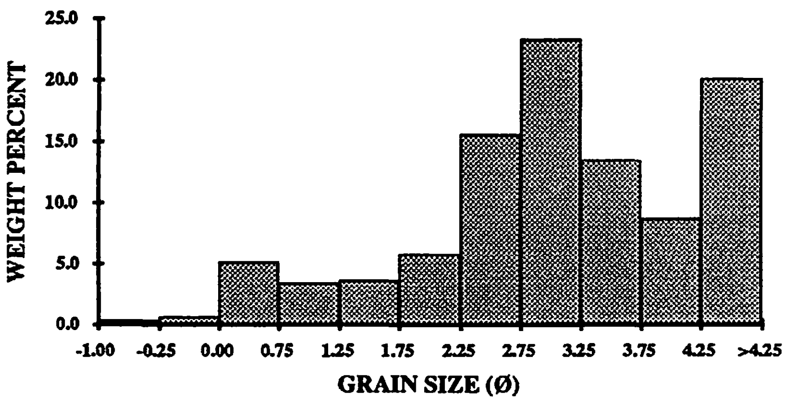

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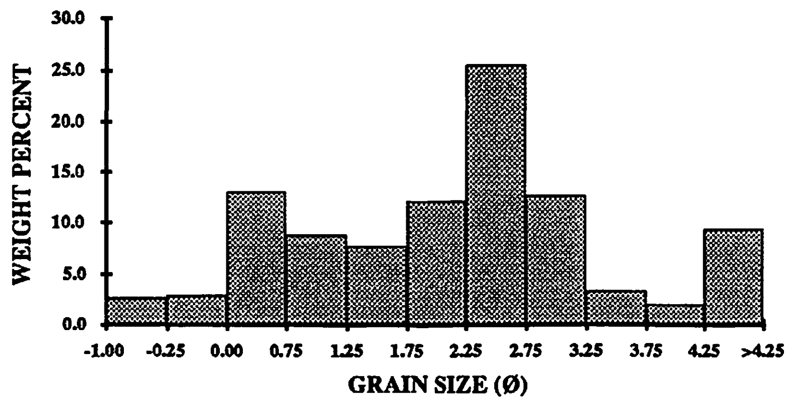
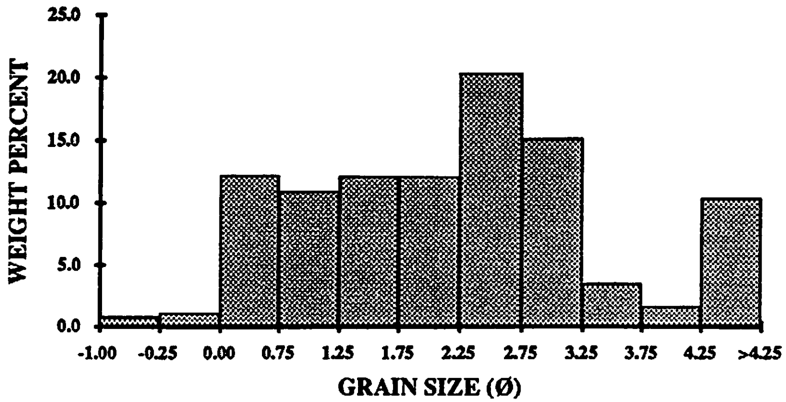


APPENDIX – Grain size distribution of spiral light subsample for non-carbonate vibracore samples (continued).

783.4



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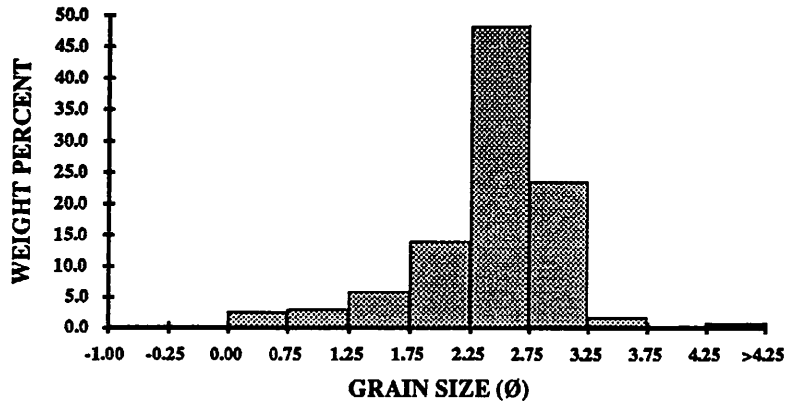

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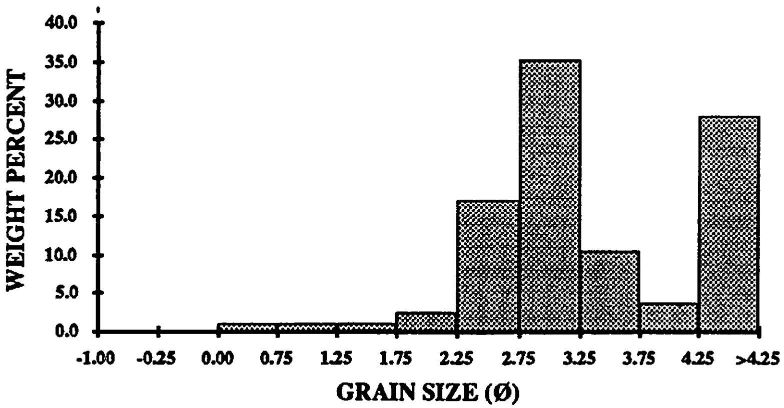

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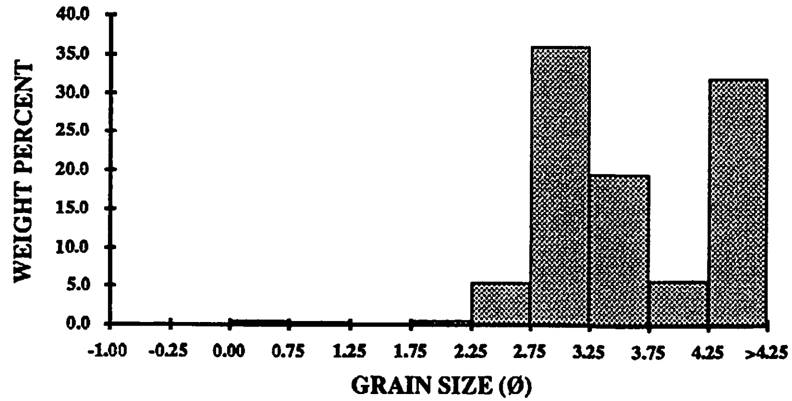
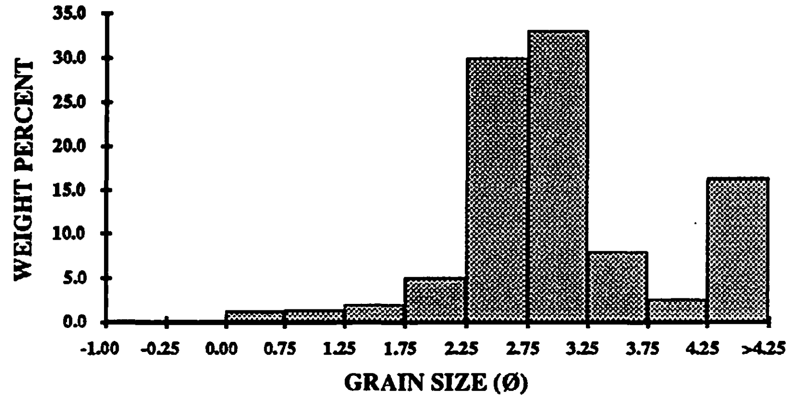


APPENDIX – Grain size distribution of spiral light subsample for non-carbonate vibracore samples (continued).

1146.1



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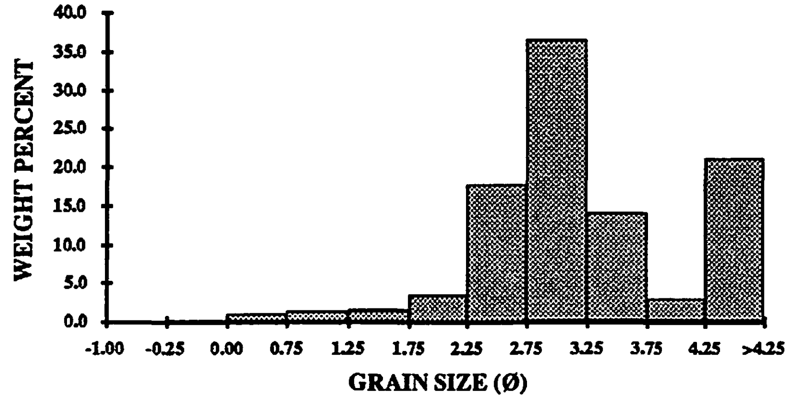

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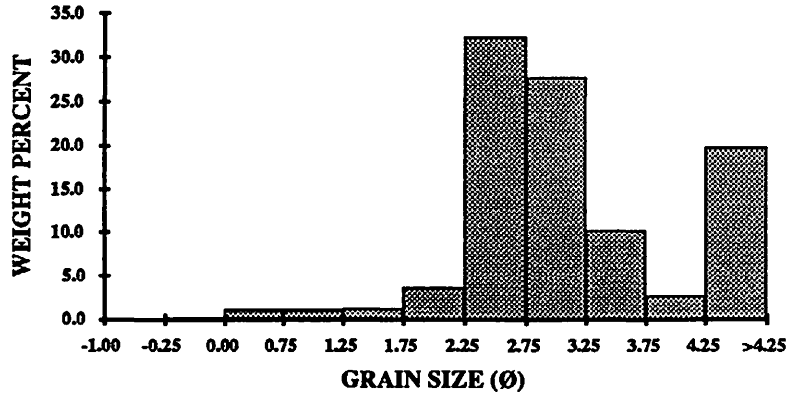

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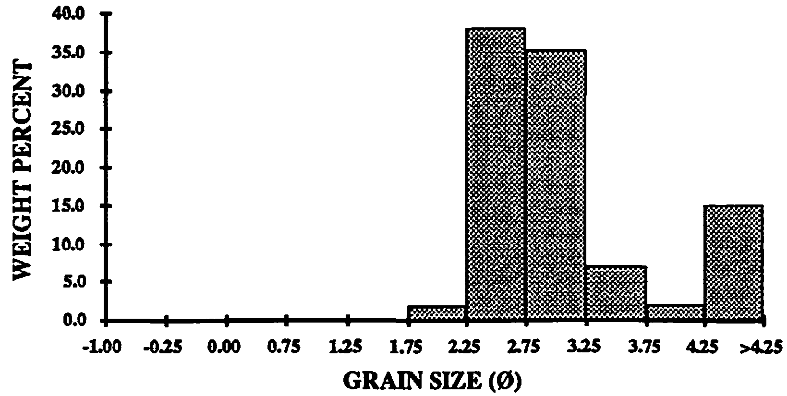
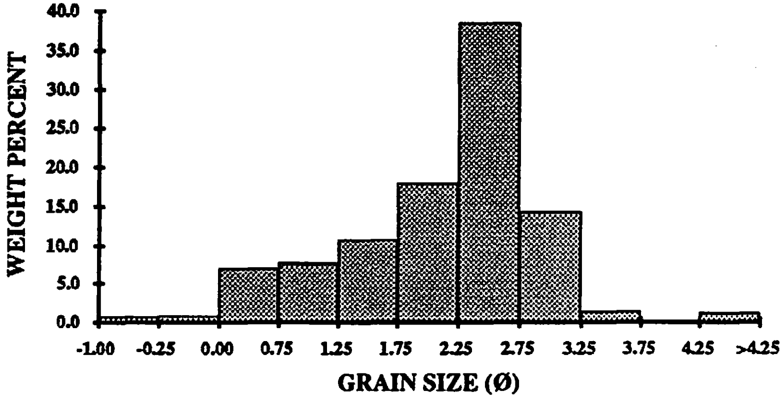


APPENDIX – Grain size distribution of spiral light subsample for non-carbonate vibracore samples (continued).

1149.1



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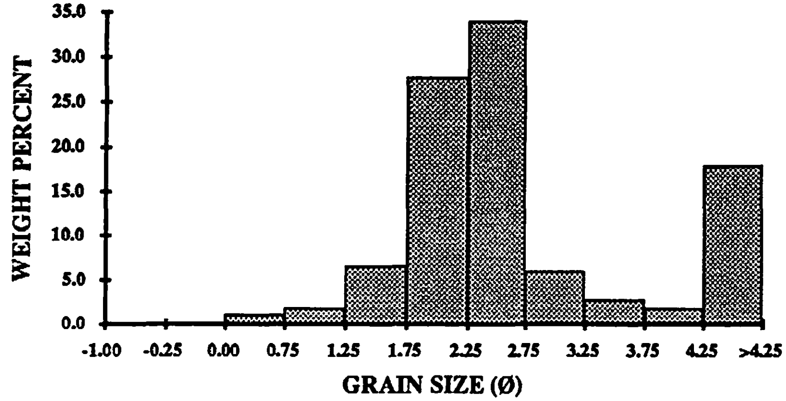

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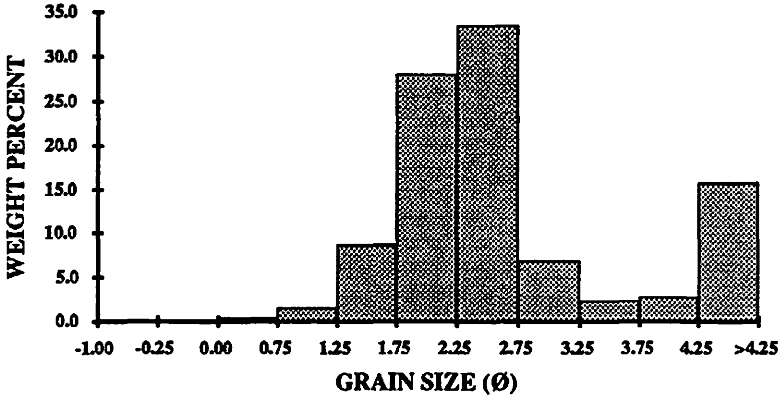

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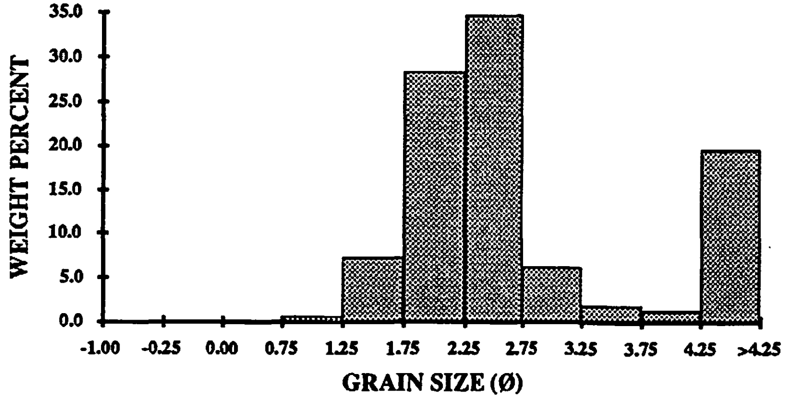
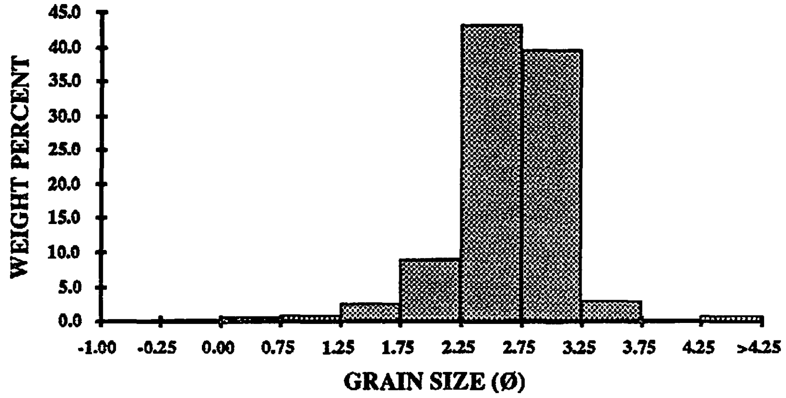


APPENDIX – Grain size distribution of spiral light subsample for non-carbonate vibracore samples (continued).

1154.1



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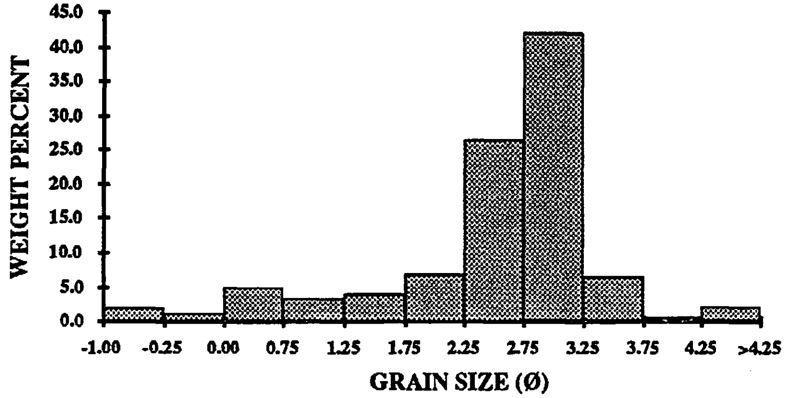

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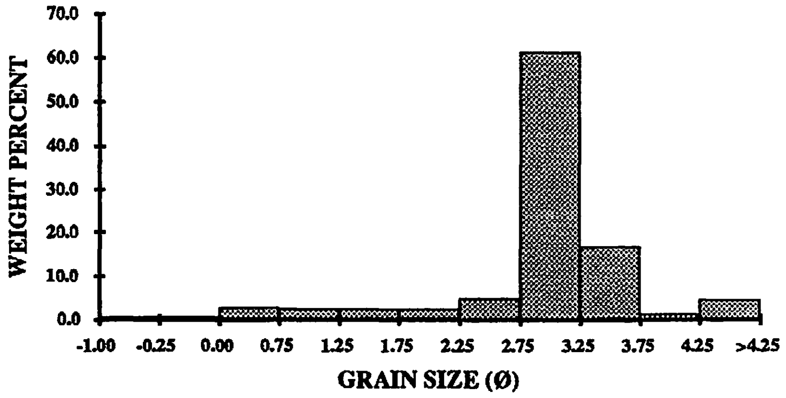

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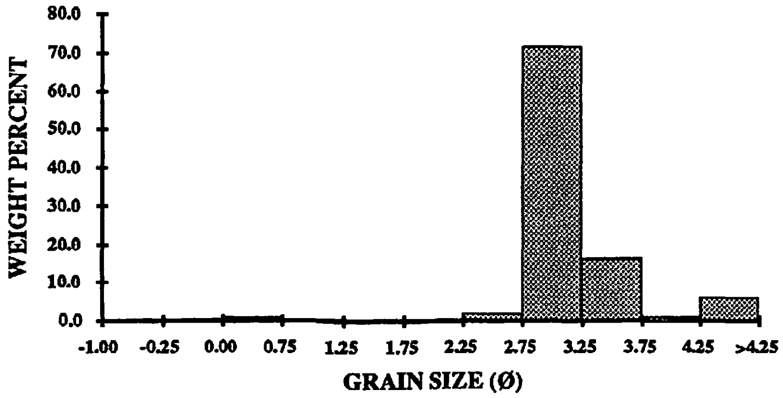
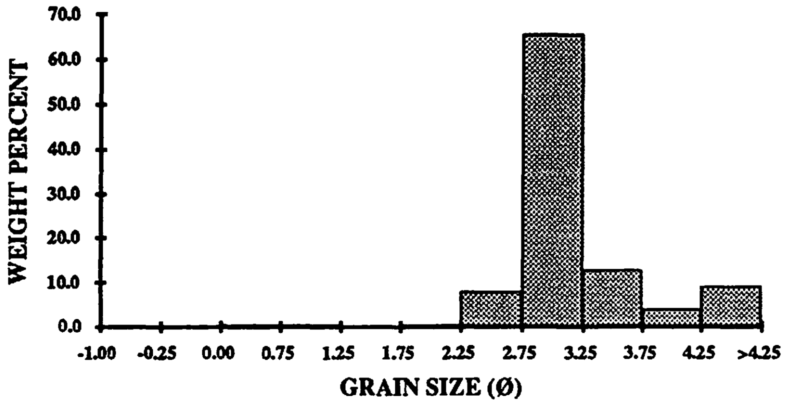


APPENDIX – Grain size distribution of spiral light subsample for non-carbonate vibracore samples (continued).

1159.1



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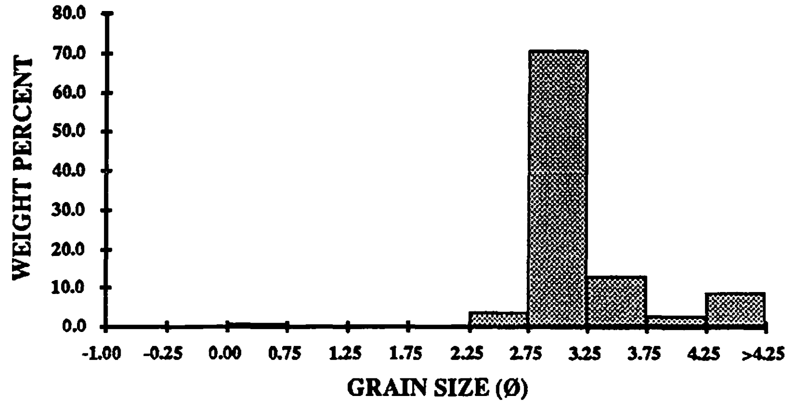

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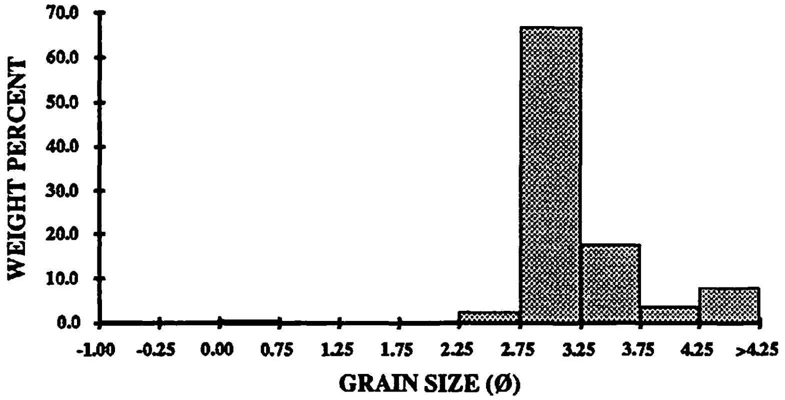

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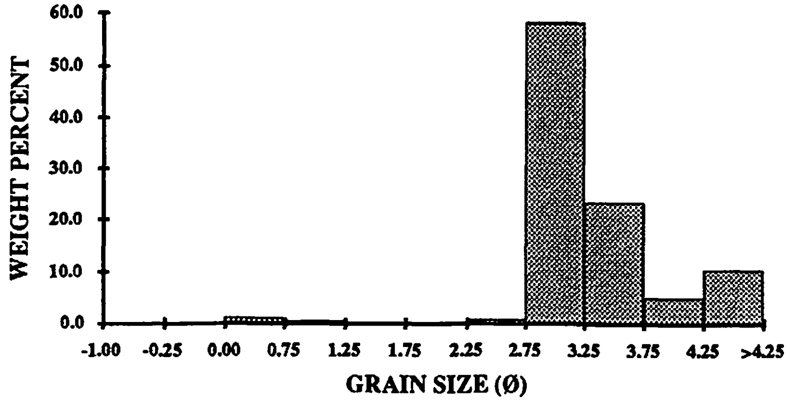

APPENDIX – Grain size distribution of spiral light subsample for non-carbonate vibracore samples (continued).

2001R.1