LITHOLOGICAL AND FORAMINIFERAL CHARACTERISTICS OF SHOREFACE AND SHALLOW SHELF FACIES OFF BOGUE BANKS, NC

by

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A Senior Honors Project Presented to the
Honors College
East Carolina University
In Partial Fulfillment of the
Requirements for
Graduation with Honors
by
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Greenville, NC
May 2018

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ABSTRACT

Fossil foraminiferal assemblages are used by paleontologists to determine the depositional environment of the strata in which the assemblages are found. This allows for the reconstruction of past environments and climates working under the assumption that specific foraminiferal assemblages are diagnostic to the depositional environment. However, foraminiferal assemblages of several coastal subenvironments (e.g., beach, shoreface, ebb tide delta, inner shelf) have yet to be extensively studied. In this study, Holocene sediments from vibracores taken off the coast of Bogue Banks, NC, were analyzed for their lithology and foraminiferal assemblages to study the differences before shoreface and inner shelf environments. Two 3 m vibracores from each environment were logged using a method that is independent from composition, and samples of sediment from Holocene units were taken for foraminiferal analysis. Sand and mud content were determined by sieving. The 63-710 micron fraction of the samples were floated in a sodium polytungstate solution to concentrate foraminiferal tests. Approximately 100 specimens were randomly picked from each sample and the relative percentages of three major foraminiferal taxonomic groups were recorded. In shelf sediment samples, assemblages comprised 95% to 100% Rotaliina. By comparison, in shoreface sediment samples, assemblages comprised 85% to 90% Rotaliina, with 10% to 15% Miliolina. These results suggest that a potential method for distinguishing the two subenvironments could be found in the presence of absence of genera within the suborder Miliolina.

ACKNOWLEDGEMENTS

We acknowledge the generous donors of the American Chemical Society Petroleum Research Fund for the project funding. We also acknowledge Greg “rudi” Rudolph for providing the cores, and Caroline Smith for training in lab procedures.

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FIGURE 1.. 2

(A) Map of the study area, showing the locations of Swansboro, Bogue, and Emerald Isle in relation to Bogue Inlet on the left and the area from which cores were taken (marked in red). Satellite imagery from Google Map data, 2016. (B) Inset of the area from which cores were taken, showing the location of Bogue Inlet Fishing Pier at the top. Satellite imagery from Google Map data, 2016.

FIGURE 2.. 5

(A - D) Computer-generated core logs for 3 meters of cores Y-69, Y-70, Y-91, and Y-103 alongside graphic interpretations of data for each sample. The data includes, from left to right, % fossil, number of species, calculated specimens per gram of sediment, number of species, alpha, and relative percentages of the most abundant species in each core.

FIGURE 3.. 9

Ternary diagram showing the relative abundance of the three foraminiferal suborders, Rotaliina, Miliolina, and Textulariina, with data points colored by core number for identification.

INTRODUCTION

The fossilized remains of foraminifera have long been used in paleoenvironmental reconstruction for many different environments and time frames, and are essential to many industries that depend on the understanding of ancient environments and their impacts on sediment formation and deposition. A difficult task in interpreting a coastal stratigraphic record is distinguishing between certain coastal subenvironments such as coastal dune, shoreface, shallow shelf, and ebb tide delta (Culver, 2014). Because these subenvironments have very similar lithologies and sedimentary structures, trying to interpret them becomes problematic, and other factors need to be examined. A common method of examining and reconstructing past environments is the use of foraminiferal assemblages, however sufficient research on the use of foraminiferal assemblages in distinguishing between subenvironments has not yet been done. Little foraminiferal research has been done on the seaward side of barrier islands such as those found off the coast of North Carolina, and the integration of foraminiferal and sedimentological studies in this area is also lacking. The purpose of this project was to combine sedimentological and foraminiferal studies of cores taken from off the coast of North Carolina in order to document and help define the foraminiferal assemblages found in the Shoreface and Shallow Shelf environments.

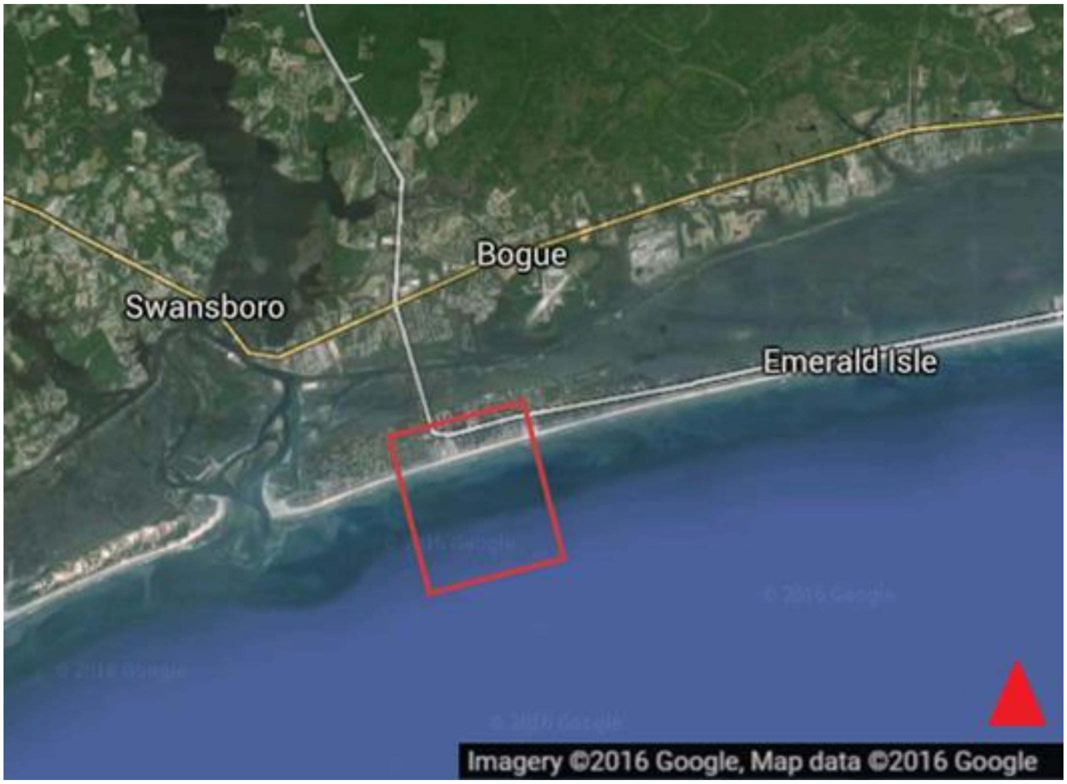

Fig. 1A: Map of the surveyed location off Bogue Banks, North Carolina. See fig. 1B for specific core locations.

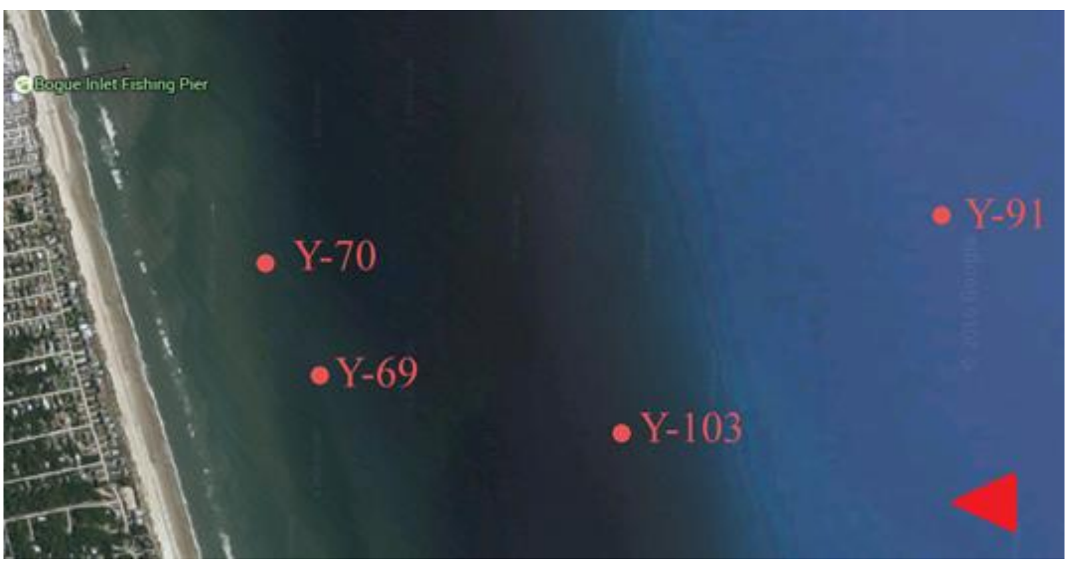

Fig. 1B: Inset with locations of individual cores studied. These cores were taken between 10-20 meters water depth.

PREVIOUS WORK

In 1971, an investigation into the foraminiferal distribution off the north Carolina coast was published by Detmar Schnitker. This study surveyed foraminifera in Near-shore, Central Shelf, and Shelf Edge environments and used the data to construct maps showing the distribution of species. The study found that there was a major boundary located at Cape Hatteras, south of which the species found are similar to those from Florida and the Gulf of Mexico (Schnitker, 1971). Because the location from which the cores were taken is south of Cape Hatteras, it was reasonable to assume that the characteristics of the assemblages found in Schnitker's study can be applied to this area. However, Schnitker's study was very limited in the samples taken near-shore, leaving it with a poorly-defined picture of the near shore foraminiferal assemblages (1971). Workman's 1981 thesis investigated benthic foraminifera living off the along the near-shore coast of North Carolina in Onslow Bay and just off Nags Head. Because of the geography of the North Carolina coast and the two distinct water masses that characterize it, two foraminiferal assemblages exist along the coast south of Cape Hatteras, where more diverse subtropical foraminifera are located, and north of Cape Hatteras, where a less diverse population of temperate foraminifera are located (Workman, 1981). The Onslow Bay samples yielded abundant species such as *Ammonia tepida, Elphidium excavatum,* and members of the genus *Quinqueloculina,* the latter of which became more common in samples farther offshore (Workman, 1981). A more recent study was done in 2009 by Smith et. al. examining foraminiferal assemblages in Holocene Flood Tide Deltas. This study characterized five biofacies using foraminiferal data, two of which were dominated by calcareous marine or estuarine foraminifera, and three of which were dominated by agglutinated marsh species (Smith et. al., 2009). Carolina Smith's 2015 thesis studied foraminiferal assemblages found in the Ocracoke Flood-Tide Delta, finding four biofacies dominated by species such as *Elphidium excavatum* and *Ammonia* parkinsoniana. These facies were predominantly fine-to-medium grained sand (Smith, 2015).

METHODS

As part of a sand resource investigation, a suite of vibracores was taken in 2011 from environments off Bogue Banks, North Carolina. These cores (fig. #) represent shoreface and shallow shelf facies between 10 and 20 meters water depth. From these cores, four were selected (fig. #), two to represent each subenvironment. These cores were logged to define lithofacies using the sedimentological characteristics of the contents and from the determined lithofacies, a probable Holocene-Pleistocene boundary could also be defined. Using this boundary as a guide, samples were taken from each unit determined to be Holocene in age to be subjected to foraminiferal analysis. Graphic logs were drawn up using the protocol established by Farrell et al. (2013).

A total of 16 samples (27cm^3 each) were taken from the four cores to represent each of the Holocene units. These samples were dried and weighed, then were disaggregated, sieved to separate sand and gravel portions, dried, and weighed again. Using the weights of the final dried samples, the sand to mud ratio of the samples was determined.

Because all samples were sand-rich, the samples were floated in sodium polytungstate to concentrate the foraminiferal tests before picking. After being floated, the samples were split with a microsplitter if needed and spread evenly onto a picking tray. A random number sheet was used to randomly select approximately 100 specimens from each sample. These specimens were identified to the species level using published and unpublished literature, and were also classified as recent or fossil based on their preservation.

RESULTS

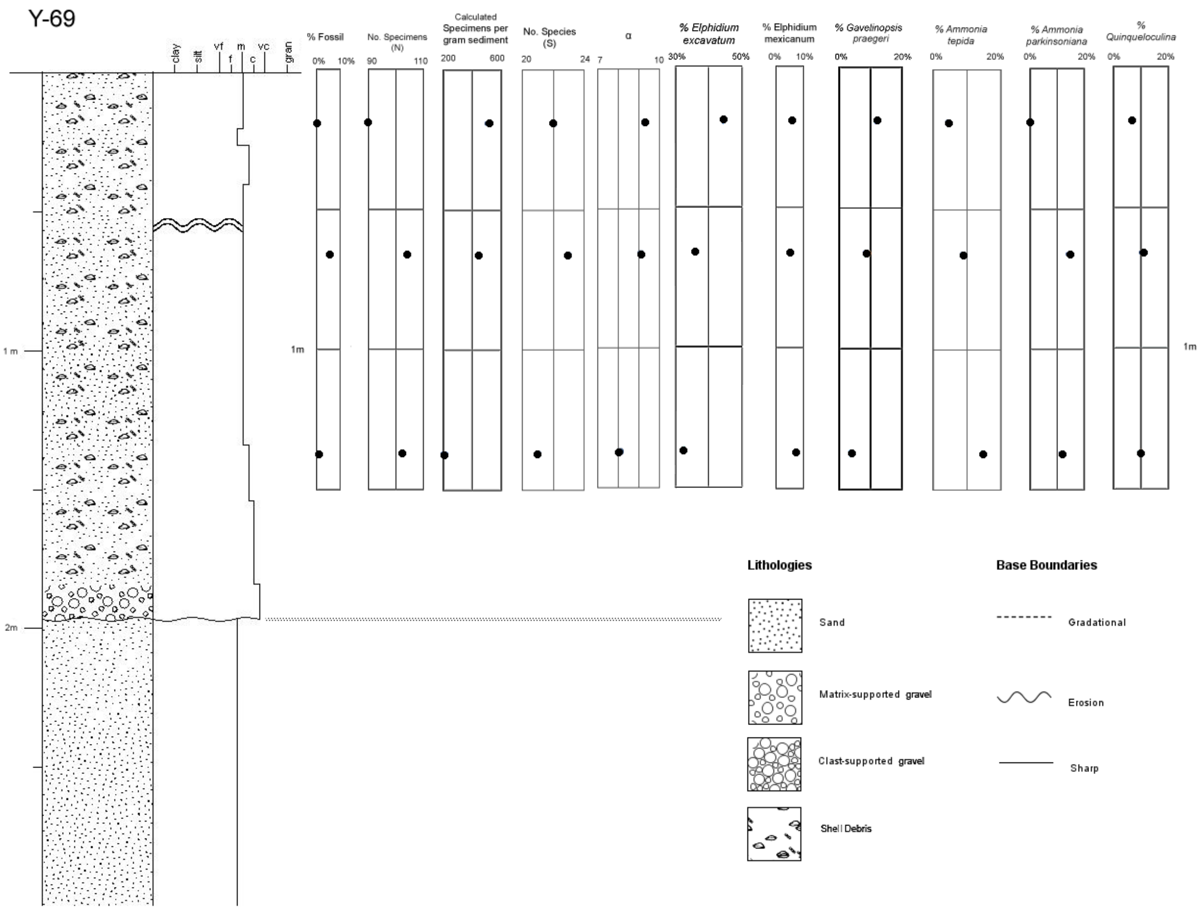

Fig. 2A: Core log and foraminiferal data for Y-69, showing lithological units alongside data for % fossil, number of species, calculated specimens per gram of sediment, number of species, alpha, and relative percentages of the most abundant species. Refer to the key for core lithologies.

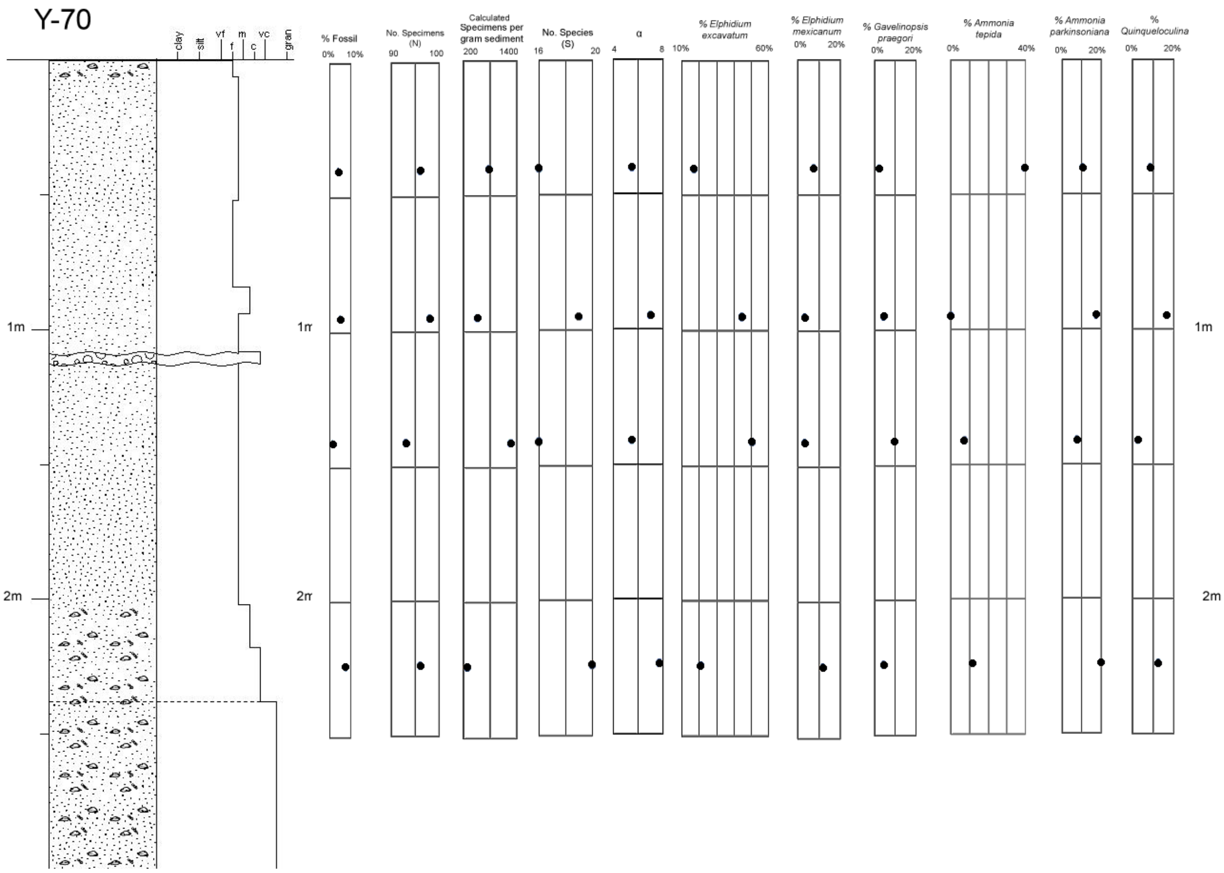

Fig. 2B: Core log and foraminiferal data for Y-70, showing lithological units alongside data for % fossil, number of species, calculated specimens per gram of sediment, number of species, alpha, and relative percentages of the most abundant species. Refer to the key in Fig. 2.1 for core lithologies.

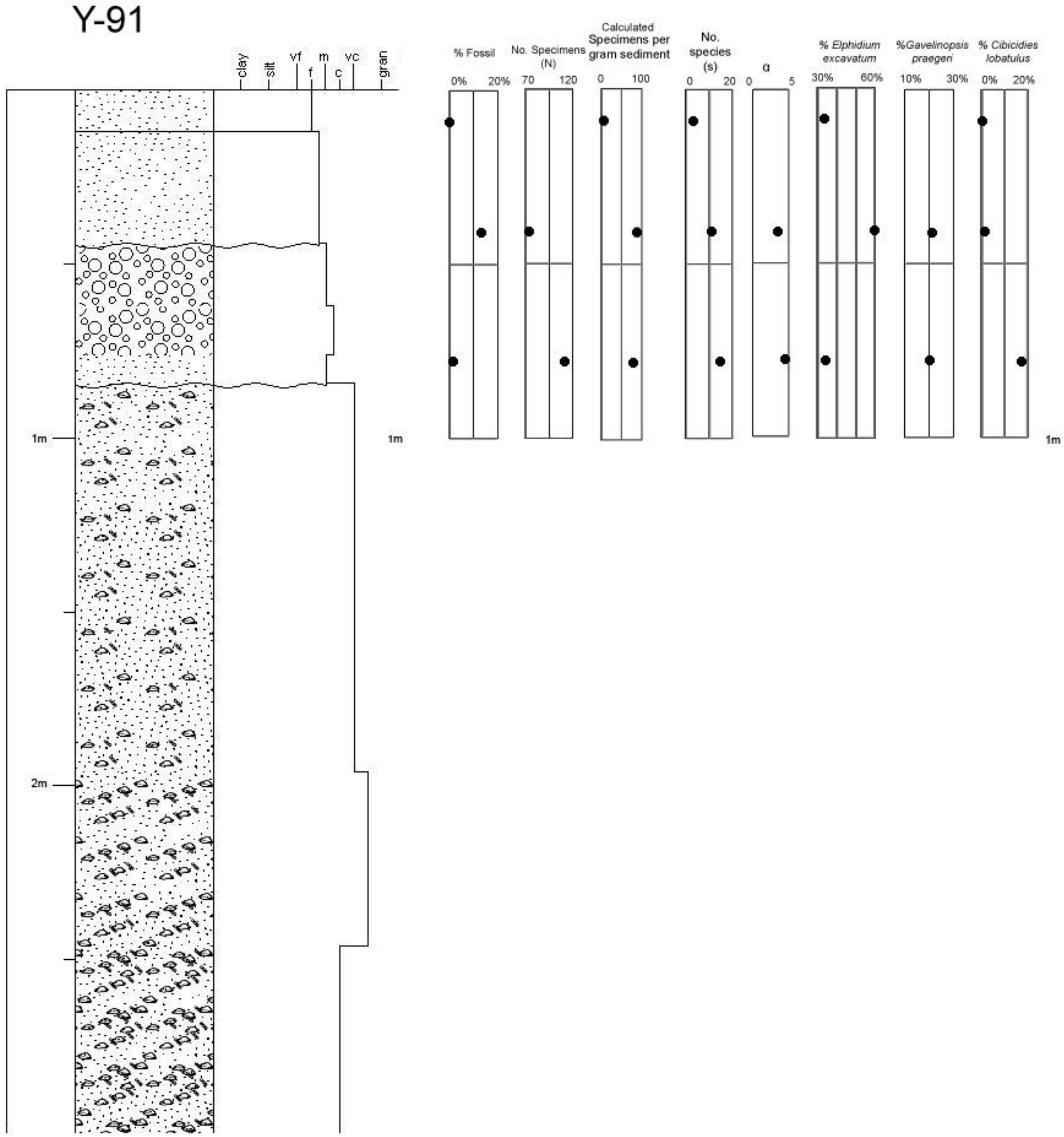

Fig. 2C: Core log and foraminiferal data for Y-91, showing lithological units alongside data for % fossil, number of species, calculated specimens per gram of sediment, number of species, alpha, and relative percentages of the most abundant species. Refer to the key in Fig. 2.1 for core lithologies.

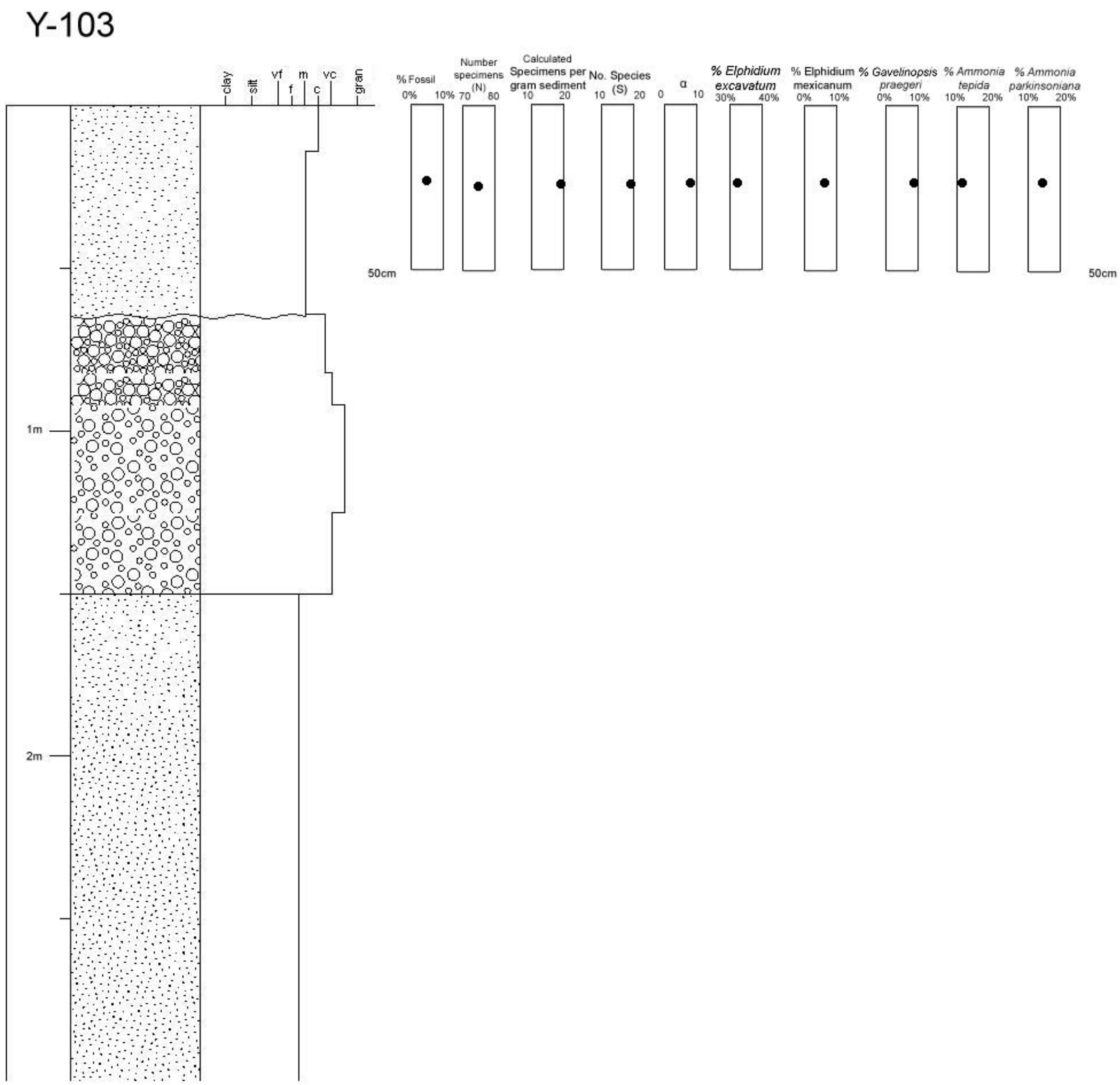

Fig. 2D: Core log and foraminiferal data for Y-103, showing lithological units alongside data for % fossil, number of species, calculated specimens per gram of sediment, number of species, alpha, and relative percentages of the most abundant species. Refer to the key in Fig. 2.1 for core lithologies.

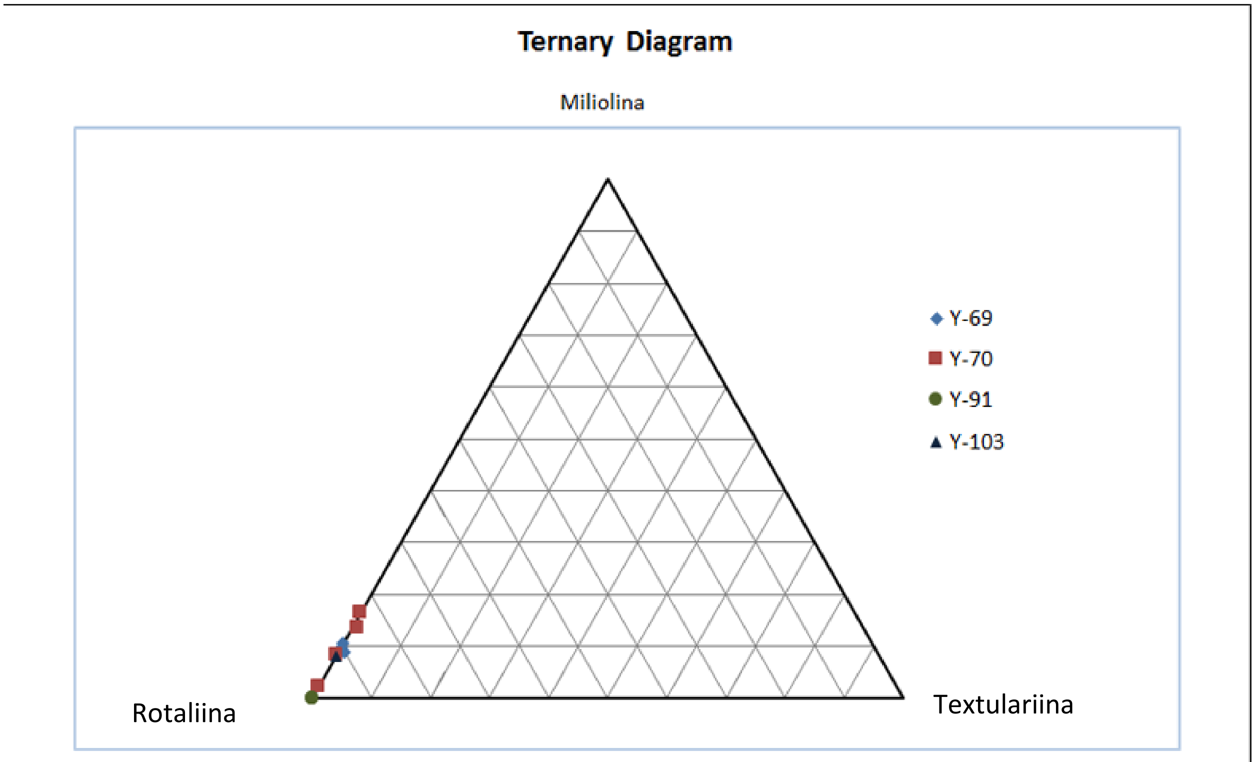

Fig. 3: Ternary diagram showing relative percentages of foraminiferal suborders in each sample, separated by core.

DISCUSSION

The ternary diagram (fig. 3) showed that all samples were dominated by small rotaliina, with few miliolina and almost no textulariina. Examination of the trends in the overall core data reveals that miliolina are more abundant closer to the shore, and decrease in abundance farther from shore until they are completely absent. The studies done by Culver, Abbene, and Vance showed that the source of the miliolina is likely the brackish water on the other side of the barrier islands, and those present in the shoreface and shelf facies have been carried there through inlets. Michael Twarog's work, done at the same time as this study, showed large percentages of miliolina in inlet throat and ebb tide delta environments. However, the discovery of miliolina, particularly *Quinqueloculina* appearing more abundantly near-shore than farther off-shore is the opposite of what was found in Onslow Bay in the Workman (1981) thesis. This discrepancy provides a topic for further study, as the species of

Quinqueloculina were the only specimens that allowed for differentiation between the shoreface and the shelf samples.

The two shoreface cores showed very similar lithologies and foraminiferal assemblages. In core Y-69, species diversity steadily increased up-core, while the diversity values in Y-70 did not display the same pattern. Similarly, the calculated number of specimens per gram of sediment increased up-core in Y-69, but did not show a steady pattern in Y-70. In both cores, examination of species data showed an inverse relationship between the genera *Elphidium* and *Gavelinopsis* and the genus *Ammonia.* This suggests fluctuations in water salinity, with *Ammonia* preferring higher-salinity environments than *Elphidium and Gavelinopsis*. In both shoreface cores, higher values of species richness and specimens per gram of sediment are usually found in samples that have higher relative percentages of *Elphidium* and lower relative percentages of *Ammonia*.

Lithologically, the two shelf cores were extremely different from one another, with Holocene-Pleistocene boundaries determined to be much closer to the surface than those of the shoreface cores. Much of the sediment in core Y-103, in fact, showed terrestrial depositional environments rather than marine. Because core Y-103 yielded only one sample of foraminiferal species, it is difficult to properly compare the patterns found in the shelf cores. However, the relationship between the species mentioned above were the same, with higher relative percentages of *Elphidium* correlated with lower relative percentages of foraminifera such as Cibicides.

In the end, the most abundant foraminifera found in both shoreface and shelf cores were the same: the assemblages were dominated by *Elphidium excavatum, Elphidium mexicanum, Gavelinopsis praegeri, Ammonia parkinsoniana,* and *Ammonia tepida.* Comparing the most abundant species in each sample did not produce a discernable difference between samples of different subenvironments. However, a difference was found in the abundance of genera *Quniqueloculina* and *Triloculina*, which were present in shoreface cores, but were either rare or absent in shelf cores. This difference suggests a potential method for distinguishing between shoreface and shallow shelf facies which must be investigated further to determine reliability.

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APPENDIX A: Table of foraminiferal data used to create figures 2 A-D

Core/Depth	Depth (cm)	Percent Fossil	Percent Planktonic	Alpha	Species	N	E. excavatum	E. mexicanum	A. tepida	A. parkinsoniana	G. praegori	R. floridana	C. lobatulus	Quinqueloculina	forams per gram
Y-60 17-20cm	19	0.0%	0.0%	9.3	22	90	44.4%	5.6%	4.4%	0.0%	12.2%	4.4%		6.6%	510.46
Y-60 65-68cm	66	5.5%	1.0%	9.1	23	104	35.9%	4.9%	8.7%	14.6%	8.7%	2.9%		10.7%	442.60
Y-60 136-139cm	137	1.0%	0.0%	8.1	21	102	32.4%	6.9%	14.7%	11.8%	3.9%	3.9%		9.80%	205.50
Y-70 39-42cm	40	4.0%	0.0%	5.5	16	96	16.7%	7.3%	39.6%	10.4%	2.1%	1.0%		8.3%	777.90
Y-70 94-97cm	95	4.9%	0.0%	7	19	98	44.9%	3.1%	0.0%	17.3%	4.1%	2.0%		16.3%	521.76
Y-70 140-143cm	141	1.1%	0.0%	5.5	16	93	50.5%	3.2%	7.5%	7.5%	9.7%	3.2%		2.2%	1278.74
Y-70 223-226cm	224	7.7%	1.1%	7.7	20	96	20.8%	11.6%	11.6%	20.0%	4.2%	3.2%		12.6%	283.25
Y-91 8-11cm	9	0.0%	0.0%		3	3	33.3%	0.0%	0.0%	0.0%	0.0%	0.0%	0.0%		1.02
Y-91 40-43cm	41	13.1%	2.8%	3.6	73	11	59.2%	0.0%	0.0%	1.4%	21.1%	5.6%	2.8%		86.89
Y-91 77-80cm	78	0.9%	0.9%	4.6	112	15	34.2%	1.8%	0.0%	0.9%	19.8%	5.4%	34.2%		79.88
Y-103 25-28cm	26	5.1%	1.4%	8.2	19	75	32.4%	6.8%	12.2%	14.9%	8.1%	4.1%			19.40

Appendix B: Table of ALL foraminiferal data for core Y-69

	17-20cm			65-68cm			136-139cm	
Elphidium excavatum	40	44.4%	Elphidium excavatum	37	35.9%	Elphidium excavatum	33	32.4%
Gavelinopsis praegori	11	12.2%	Ammonia parkinsoniana	15	14.6%	Ammonia tepida	15	14.7%
Elphidium mexicanum	5	5.6%	Ammonia tepida	9	8.7%	Ammonia parkinsoniana	12	11.8%
Ammonia tepida	4	4.4%	Gavelinopsis praegori	9	8.7%	Elphidium mexicanum	7	6.9%
Bolivina lowmani	4	4.4%	Elphidium mexicanum	5	4.9%	Gavelinopsis praegori	4	3.9%
Rosalina floridana	4	4.4%	Quinqueloculina lamarkiana	3	2.9%	Quinqueloculina lamarkiana	4	3.9%
Quinqueloculina lamarkiana	3	3.3%	Rosalina floridana	3	2.9%	Rosalina floridana	4	3.9%
Buliminella elegantissima	2	2.2%	Elphidium gunteri	2	1.9%	Bucella inusitata	3	2.9%
Cibicides lobatulus	2	2.2%	Elphidium translucens	2	1.9%	Quinqueloculina seminula	3	2.9%
Hanzawaia Strattoni	2	2.2%	Haynesina germanica	2	1.9%	Buliminella elegantissima	2	2.0%
Triloculina triganula	2	2.2%	Quinqueloculina jugosa	2	1.9%	Cibicides fletcheri	2	2.0%
Cibicides fletcheri	1	1.1%	Quinqueloculina seminula	2	1.9%	Elphidium translucens	2	2.0%
Cibicides sp.	1	1.1%	Quinqueloculina sm.	2	1.9%	Haynesina germanica	2	2.0%
Deuteramina ochracea	1	1.1%	Asteriginata pulchella	1	1.0%	Quinqueloculina poeyana	2	2.0%
Discorbinella berthelori	1	1.1%	Bolivina lowmani	1	1.0%	Cibicides lobatulus	1	1.0%
Elphidium gunteri	1	1.1%	Buliminella elegantissima	1	1.0%	Elphidium advenum	1	1.0%
Elphidium sp.	1	1.1%	Cassidulina sp.	1	1.0%	Elphidium sp.	1	1.0%
Elphidium translucens	1	1.1%	Elphidium advenum	1	1.0%	Nonionella sp.	1	1.0%
Nonionella sp.	1	1.1%	Hanzawaia Strattoni	1	1.0%	Quinqueloculina bosciana	1	1.0%
Quinqueloculina frigida	1	1.1%	Quinqueloculina bosciana	1	1.0%	Triloculina sp.	1	1.0%
Quinqueloculina poeyana	1	1.1%	Quinqueloculina poeyana	1	1.0%	Uvigerina auberiana	1	1.0%
Quinqueloculina sp.	1	1.1%	Stetsonia minuta	1	1.0%			
			Triloculina triganula	1	1.0%			
Planktonic	0	0.0%		1	1.0%		0	0.0%
No. specimens (modern)	90			104			102	
No. species (modern)	22			23			21	
Alpha	9.3			9.1			8.1	
FOSSIL			Ind. Rotalid	4		Hanzawaia sp.	1	
			Elphidium sp.F1	1				
			Elphidium sp.F2	1				
No. specimens (fossil)	0			6			1	
No. species (fossil)	0			3			1	
Percent fossil	0			5.5%			1.0%	

Appendix C: Table of ALL foraminiferal data for core Y-70

	39-42cm			94-97cm			140-143cm			223-226cm	
Ammonia tepida	38	39.6%	Elphidium excavatum	44	44.9%	Elphidium excavatum	47	50.5%	Elphidium excavatum	20	20.8%
Elphidium excavatum	16	16.7%	Ammonia parkinsoniana	17	17.3%	Gavelinopsis praegori	9	9.7%	Ammonia parkinsoniana	19	20.0%
Ammonia parkinsoniana	10	10.4%	Quinqueloculina seminula	7	7.1%	Ammonia parkinsoniana	7	7.5%	Ammonia tepida	11	11.6%
Elphidium mexicanum	7	7.3%	Quinqueloculina lamarkiana	5	5.1%	Ammonia tepida	7	7.5%	Elphidium mexicanum	11	11.6%
Bolivina lowmani	5	5.2%	Gavelinopsis praegori	4	4.1%	Asteriginata pulchella	3	3.2%	Elphidium translucens	6	6.3%
Quinqueloculina sp.	4	4.2%	Bucella inusitata	3	3.1%	Elphidium mexicanum	3	3.2%	Quinqueloculina jugosa	5	5.3%
Hanzawaia Strattoni	3	3.1%	Elphidium mexicanum	3	3.1%	Elphidium translucens	3	3.2%	Gavelinopsis praegori	4	4.2%
Asteriginata pulchella	2	2.1%	Cibicides fletcheri	2	2.0%	Rosalina floridana	3	3.2%	Rosalina floridana	3	3.2%
Gavelinopsis praegori	2	2.1%	Quinqueloculina sm.	2	2.0%	Cibicides lobatulus	2	2.2%	Cibicides fletcheri	2	2.1%
Quinqueloculina lamarkiana	2	2.1%	Rosalina floridana	2	2.0%	Hanzawaia Strattoni	2	2.2%	Cibicides lobatulus	2	2.1%
Quinqueloculina poeyana	2	2.1%	Bolivina lowmani	1	1.0%	Quinqueloculina sm.	2	2.2%	Quinqueloculina lamarkiana	2	2.1%
Buliminella elegantissima	1	1.0%	Cibicides lobatulus	1	1.0%	Bolivina lowmani	1	1.1%	Quinqueloculina sp.	2	2.1%
Elphidium translucens	1	1.0%	Elphidium advenum	1	1.0%	Buliminella elegantissima	1	1.1%	Bolivina lowmani	1	1.1%
Rosalina floridana	1	1.0%	Elphidium sp.	1	1.0%	Haynesina germanica	1	1.1%	Bucella inusitata	1	1.1%
Sagrina pulchella	1	1.0%	Quinqueloculina jugosa	1	1.0%	Stetsonia minuta	1	1.1%	Deuteramina ochracea	1	1.1%
Bolivina striatula	1	1.0%	Quinqueloculina poeyana	1	1.0%	Triloculina triganula	1	1.1%	Quinqueloculina frigida	1	1.1%
			Triloculina sp.	1	1.0%				Quinqueloculina seminula	1	1.1%
			Triloculina triganula	1	1.0%				Quinqueloculina sm.	1	1.1%
			Nonionella atlantica	1	1.0%				Triloculina sp.	1	1.1%
									Lenticulina Americana	1	1.1%
Planktonic		0.0%			0.0%			0.0%		1	1.1%
No. Specimens(modern)	96			98			93			96	
No. Species(modern)	16			19			16			20	
Alpha	5.5			7			5.5			7.7	
FOSSILS											
Ind. Rotalid	3		Planktonic	3		Ind. Rotalid	1		Cibicides sp.	4	
Cibicides sp.	1		Cibicides sp.	1					Bolivina sp.	2	
			Bolivina sp.	1					Ind. Rotalid	1	
									Planktonic	1	
No. specimens (fossil)	4			5			1			8	
No. species (fossil)	2			3			1			4	
Percent fossil	4.0%			4.9%			1.1%			7.7%	

Appendix D: Table of ALL foraminiferal data for cores Y-91 and Y-103

	Y-91 8-11cm			Y-91 40-43cm			Y-91 77-80cm			Y-103 25-28cm	
Elphidium excavatum	1	33.3%	Elphidium excavatum	42	59.2%	Cibicides lobatulus	38	34.2%	Elphidium excavatum	24	32.4%
Haynesina germanica	1	33.3%	Gavelinopsis praegori	15	21.1%	Elphidium excavatum	27	24.3%	Ammonia parkinsoniana	11	14.9%
Rosalina floridensis	1	33.3%	Rosalina floridana	4	5.6%	Gavelinopsis praegori	22	19.8%	Ammonia tepida	9	12.2%
			Cibicides lobatulus	2	2.8%	Hanzawaia Strattoni	6	5.4%	Gavelinopsis praegori	6	8.1%
			Hanzawaia Strattoni	2	2.8%	Rosalina floridana	6	5.4%	Elphidium mexicanum	5	6.8%
			Ammonia parkinsoniana	1	1.4%	Elphidium mexicanum	2	1.8%	Rosalina floridana	3	4.1%
			Bolivina lowmani	1	1.4%	Fursenkoina fusiformis	2	1.8%	Hanzawaia Strattoni	2	2.7%
			Elphidium gunteri	1	1.4%	Ammonia parkinsoniana	1	0.9%	Quinqueloculina lamarkiana	2	2.7%
			Sagrina pulchella	1	1.4%	Bolivina lowmani	1	0.9%	Quinqueloculina sm.	2	2.7%
			Guttulina lactea	1	1.4%	Buliminella elegantissima	1	0.9%	Asteriginata pulchella	1	1.4%
			Vasiglobulina reticulata	1	1.4%	Elphidium gunteri	1	0.9%	Bolivina lowmani	1	1.4%
						Elphidium sp.	1	0.9%	Bucella inusitata	1	1.4%
						Elphidium translucens	1	0.9%	Buliminella elegantissima	1	1.4%
						Haynesina germanica	1	0.9%	Cibicides sp.	1	1.4%
						Bolivina sp.A	1	0.9%	Elphidium advenum	1	1.4%
									Quinqueloculina seminula	1	1.4%
									Quinqueloculina sp.	1	1.4%
									Valvulineria laevigata	1	1.4%
									Bolivina sp.	1	1.4%
Planktonic	0			2	2.8%		1	0.9%		1	1.4%
No. specimens (modern)	3			73			112			75	
No. species (modern)	3			11			15			19	
Alpha				3.6			4.6			8.2	
FOSSIL											
			Cibicides lobatulus	5							
			ind. Rotalid	3		ind. Rotalid	1		ind. Rotalid	2	
			Hanzawaia strattoni	1					Uvigerina auberiana	2	
			Bucella inusitata	1							
			Guttulina austriaca	1							
No. specimens (fossil)	0			11			1			4	
No. species (fossil)	0			5			1			2	
Percent fossil	0%			13.1%			0.9%			5.1%	

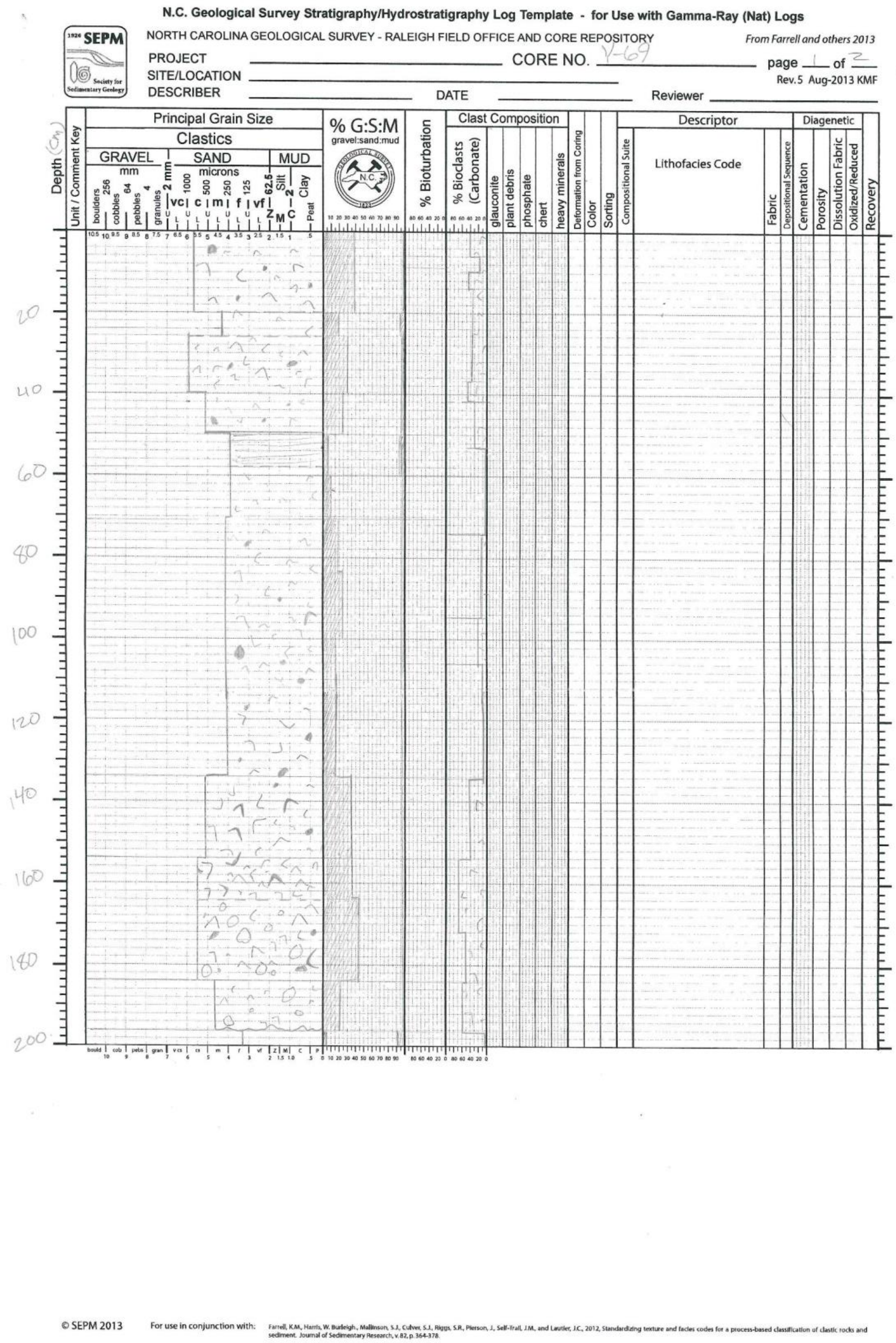
Appendix E: Table of ALL foraminiferal data for core Y-91

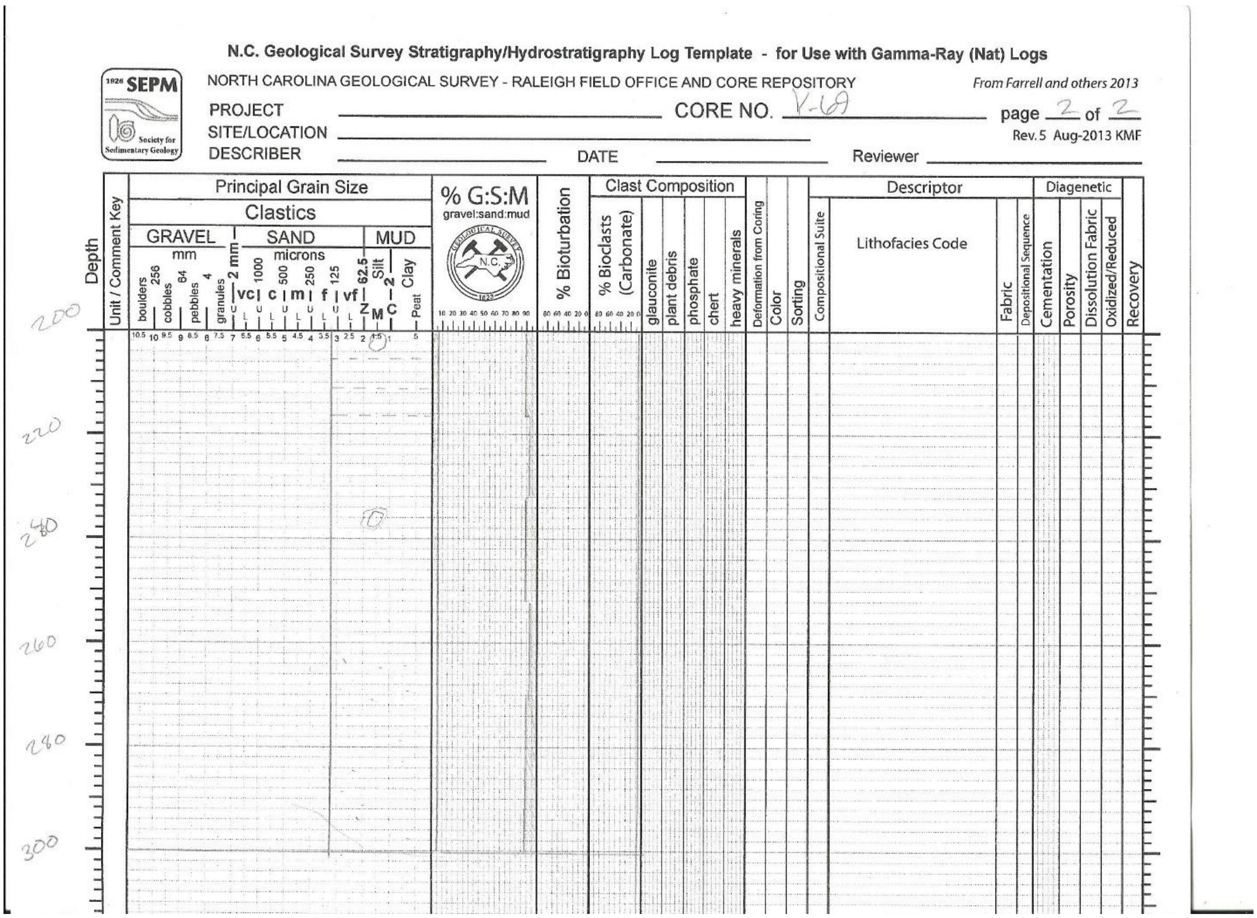
	Y-91 8-11cm			Y-91 40-43cm			Y-91 77-80cm	
Elphidium excavatum	1	33.3%	Elphidium excavatum	42	59.2%	Cibicides lobatulus	38	34.2%
Haynesina germanica	1	33.3%	Gavelinopsis praegori	15	21.1%	Elphidium excavatum	27	24.3%
Rosalina floridensis	1	33.3%	Rosalina floridana	4	5.6%	Gavelinopsis praegori	22	19.8%
			Cibicides lobatulus	2	2.8%	Hanzawaia Strattoni	6	5.4%
			Hanzawaia Strattoni	2	2.8%	Rosalina floridana	6	5.4%
			Ammonia parkinsoniana	1	1.4%	Elphidium mexicanum	2	1.8%
			Bolivina lowmani	1	1.4%	Fursenkoina fusiformis	2	1.8%
			Elphidium gunteri	1	1.4%	Ammonia parkinsoniana	1	0.9%
			Sagrina pulchella	1	1.4%	Bolivina lowmani	1	0.9%
			Guttulina lactea	1	1.4%	Buliminella elegantissima	1	0.9%
			Vasiglobulina reticulata	1	1.4%	Elphidium gunteri	1	0.9%
						Elphidium sp.	1	0.9%
						Elphidium translucens	1	0.9%
						Haynesina germanica	1	0.9%
						Bolivina sp.A	1	0.9%
Planktonic	0			2	2.8%		1	0.9%
No. specimens (modern)	3			73			112	
No. species (modern)	3			11			15	
Alpha				3.6			4.6	
FOSSIL								
			Cibicides lobatulus	5				
			ind. Rotalid	3		ind. Rotalid	1	
			Hanzawaia strattoni	1				
			Bucella inusitata	1				
			Guttulina austriaca	1				
No. specimens (fossil)	0			11			1	
No. species (fossil)	0			5			1	
Percent fossil	0%			13.1%			0.9%	

Appendix F: Table of ALL foraminiferal data for core Y-103

	Y-103 25-28cm	
Elphidium excavatum	24	32.4%
Ammonia parkinsoniana	11	14.9%
Ammonia tepida	9	12.2%
Gavelinopsis praegori	6	8.1%
Elphidium mexicanum	5	6.8%
Rosalina floridana	3	4.1%
Hanzawaia Strattoni	2	2.7%
Quinqueloculina lamarkiana	2	2.7%
Quinqueloculina sm.	2	2.7%
Asteriginata pulchella	1	1.4%
Bolivina lowmani	1	1.4%
Bucella inusitata	1	1.4%
Buliminella elegantissima	1	1.4%
Cibicides sp.	1	1.4%
Elphidium advenum	1	1.4%
Quinqueloculina seminula	1	1.4%
Quinqueloculina sp.	1	1.4%
Valvulineria laevigata	1	1.4%
Bolivina sp.	1	1.4%
	1	1.4%
	75	
	19	
	8.2	
ind. Rotalid	2	
Uvigerina auberiana	2	
	4	
	2	
	5.1%	

Appendix G: Original core log for Y-69


N.C. Geological Survey Stratigraphy/Hydrostratigraphy Log Template - for Use with Gamma-Ray (Nat) Logs
SEPM Society for Sedimentary Geology
NORTH CAROLINA GEOLOGICAL SURVEY - RALEIGH FIELD OFFICE AND CORE REPOSITORY
From Farrell and others 2013
PROJECT
CORE NO. V-69
page 1 of 2
SITE/LOCATION
Rev.5 Aug-2013 KMF
DESCRIBER
DATE
Reviewer
Depth (cm)
Unit / Comment Key
Principal Grain Size
Clastics
GRAVEL
mm
SAND
microns
MUD
boulders
cobbles
pebbles
granules
vc c m f vf
Silt
Clay
Peat
% G:S:M
gravel:sand:mud
% Bioturbation
% Bioclasts (Carbonate)
Clast Composition
glauconite
plant debris
phosphate
chert
heavy minerals
Deformation from Coring
Color
Sorting
Compositional Suite
Descriptor
Lithofacies Code
Fabric
Depositional Sequence
Diagenetic
Cementation
Porosity
Dissolution Fabric
Oxidized/Reduced
Recovery
20
40
60
80
100
120
140
160
180
200
© SEPM 2013
For use in conjunction with: Farrell, K.M., Harris, W. Burleigh., Mallinson, S.J., Culver, S.J., Riggs, S.R., Pierson, J., Self-Trail, J.M., and Lautier, J.C., 2012, Standardizing texture and facies codes for a process-based classification of clastic rocks and sediment. Journal of Sedimentary Research, v.82, p.364-378.



N.C. Geological Survey Stratigraphy/Hydrostratigraphy Log Template - for Use with Gamma-Ray (Nat) Logs

1926 SEPM Society for Sedimentary Geology

NORTH CAROLINA GEOLOGICAL SURVEY - RALEIGH FIELD OFFICE AND CORE REPOSITORY

From Farrell and others 2013

PROJECT ____ CORE NO. V-69 ____ page 2 of 2

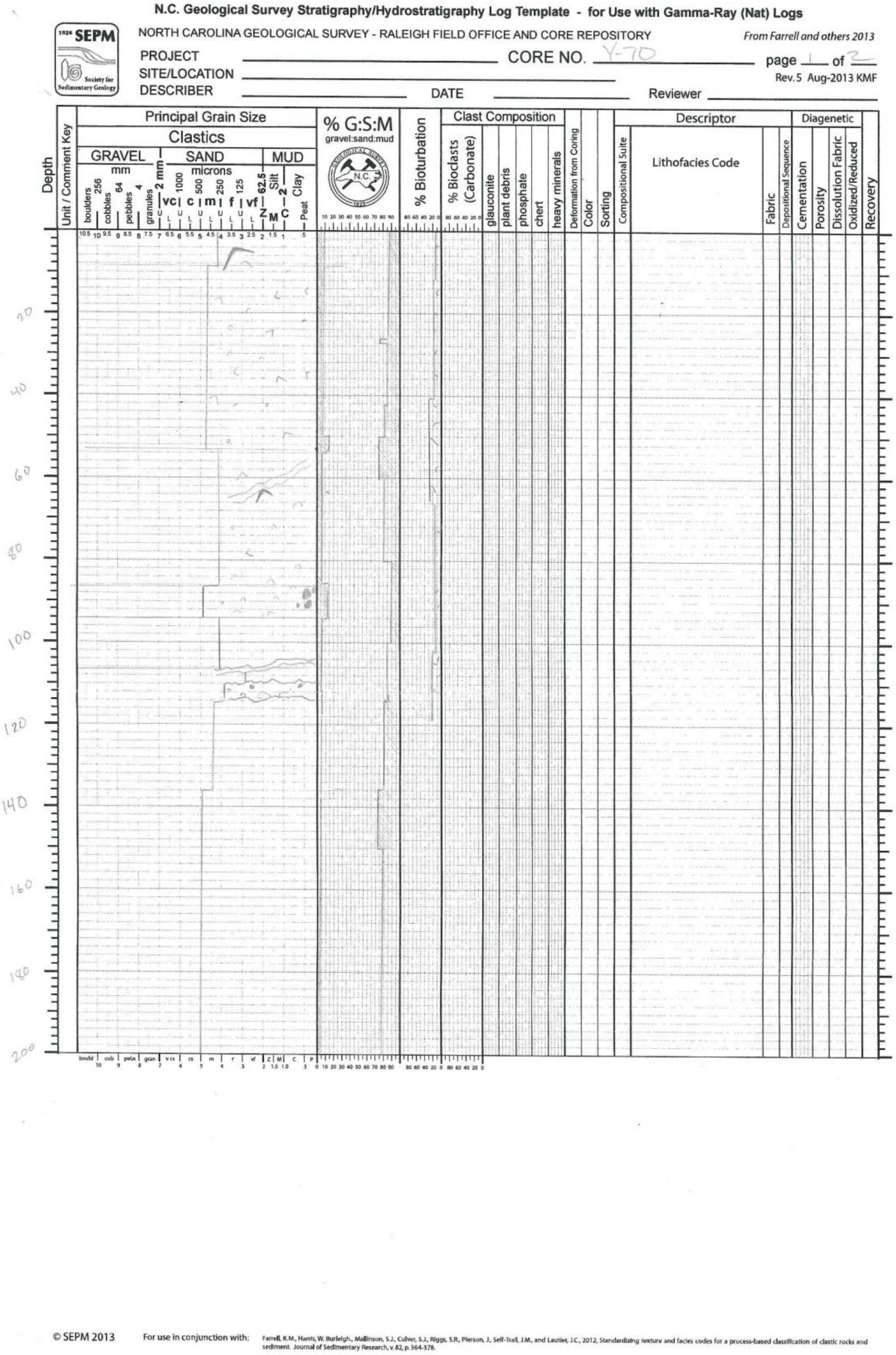
SITE/LOCATION ____ Rev. 5 Aug-2013 KMF

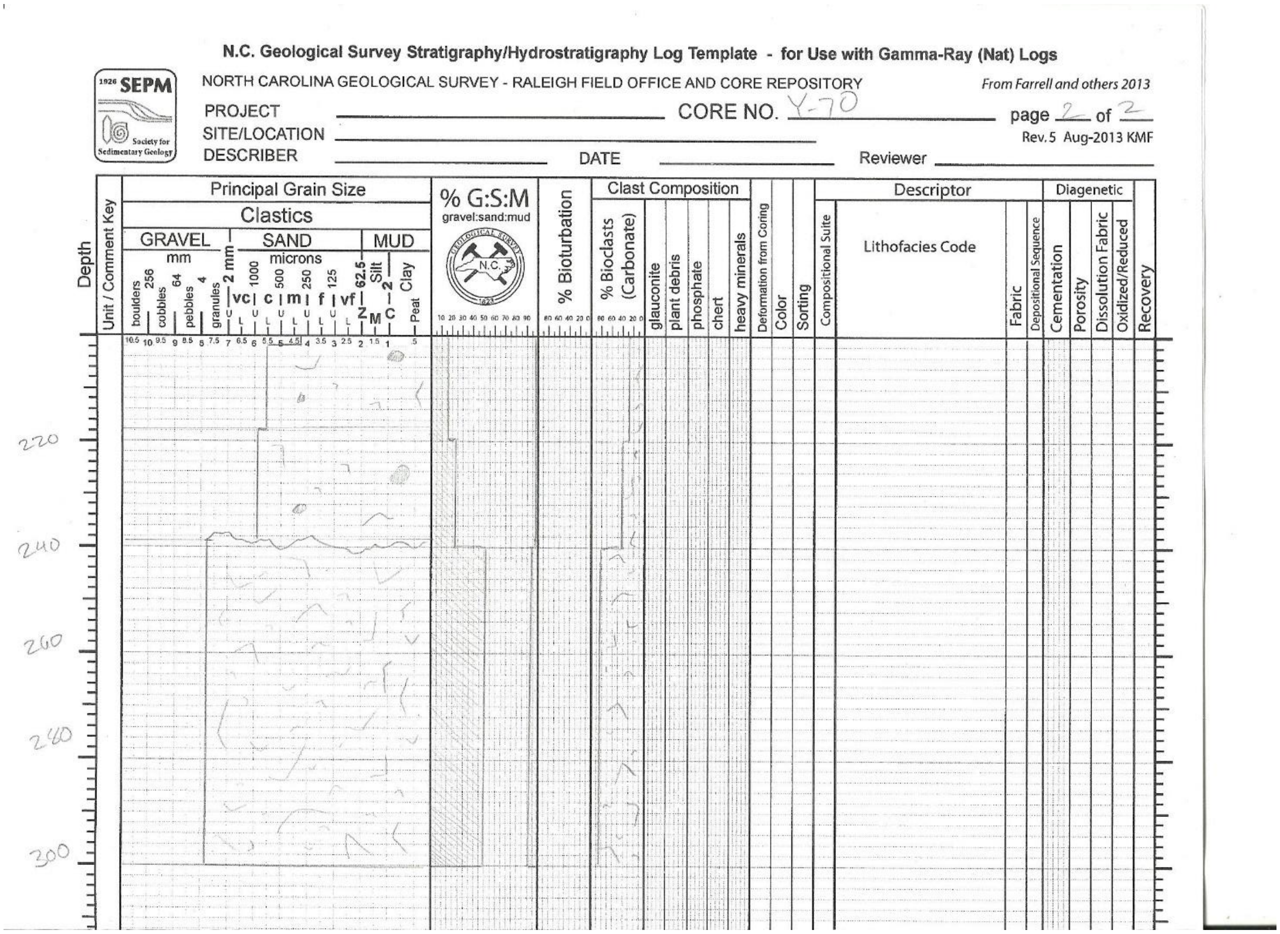
DESCRIBER ____ DATE ____ Reviewer ____

Depth | Unit / Comment Key | Principal Grain Size — Clastics — GRAVEL (mm): boulders 256, cobbles 64, pebbles 4, granules 2 mm; SAND (microns): vc 1000, c 500, m 250, f 125, vf 62.5; MUD: Silt 2, Clay; Peat | % G:S:M (gravel:sand:mud) | % Bioturbation | Clast Composition: % Bioclasts (Carbonate), glauconite, plant debris, phosphate, chert, heavy minerals | Deformation from Coring | Color | Sorting | Compositional Suite | Descriptor: Lithofacies Code | Fabric | Depositional Sequence | Diagenetic: Cementation, Porosity, Dissolution Fabric, Oxidized/Reduced | Recovery

Depth: 200, 220, 240, 260, 280, 300

Appendix H: Original core log for Y-70





N.C. Geological Survey Stratigraphy/Hydrostratigraphy Log Template - for Use with Gamma-Ray (Nat) Logs

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NORTH CAROLINA GEOLOGICAL SURVEY - RALEIGH FIELD OFFICE AND CORE REPOSITORY

From Farrell and others 2013

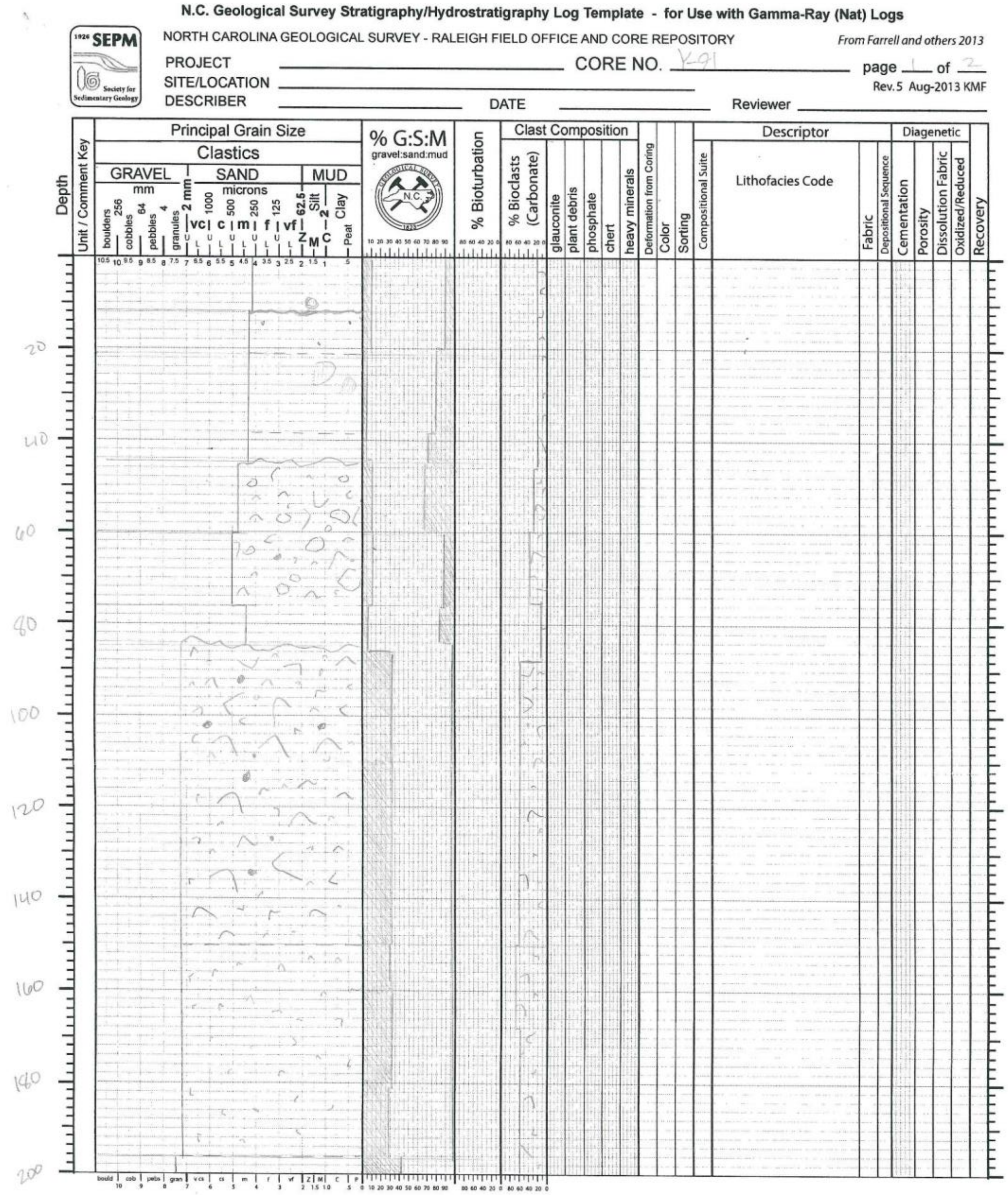
PROJECT ____________ CORE NO. Y-70 ____________ page 2 of 2

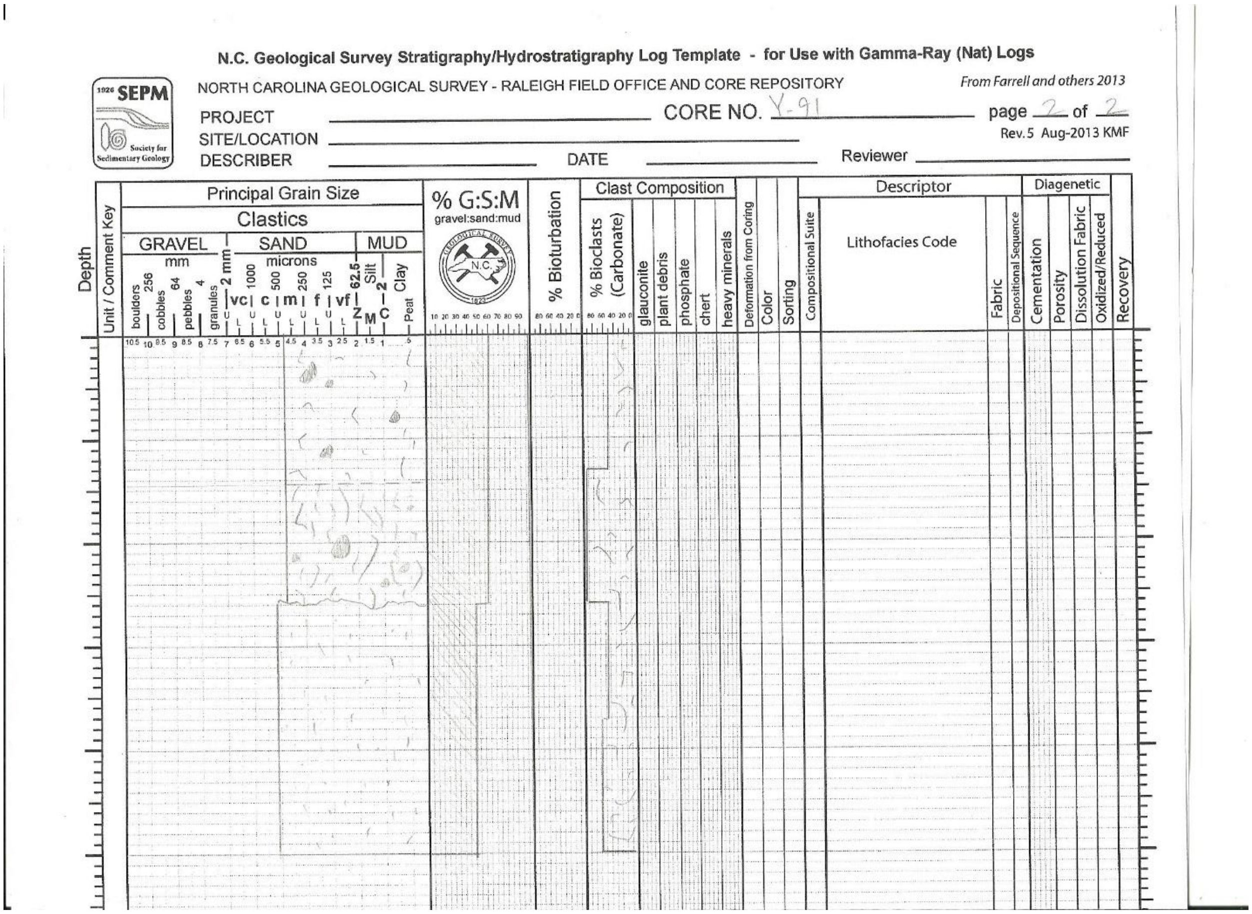
SITE/LOCATION ____________

Rev.5 Aug-2013 KMF

DESCRIBER ____________ DATE ____________ Reviewer ____________

Appendix I: Original core log for Y-91




N.C. Geological Survey Stratigraphy/Hydrostratigraphy Log Template - for Use with Gamma-Ray (Nat) Logs

1926 SEPM Society for Sedimentary Geology

NORTH CAROLINA GEOLOGICAL SURVEY - RALEIGH FIELD OFFICE AND CORE REPOSITORY

From Farrell and others 2013

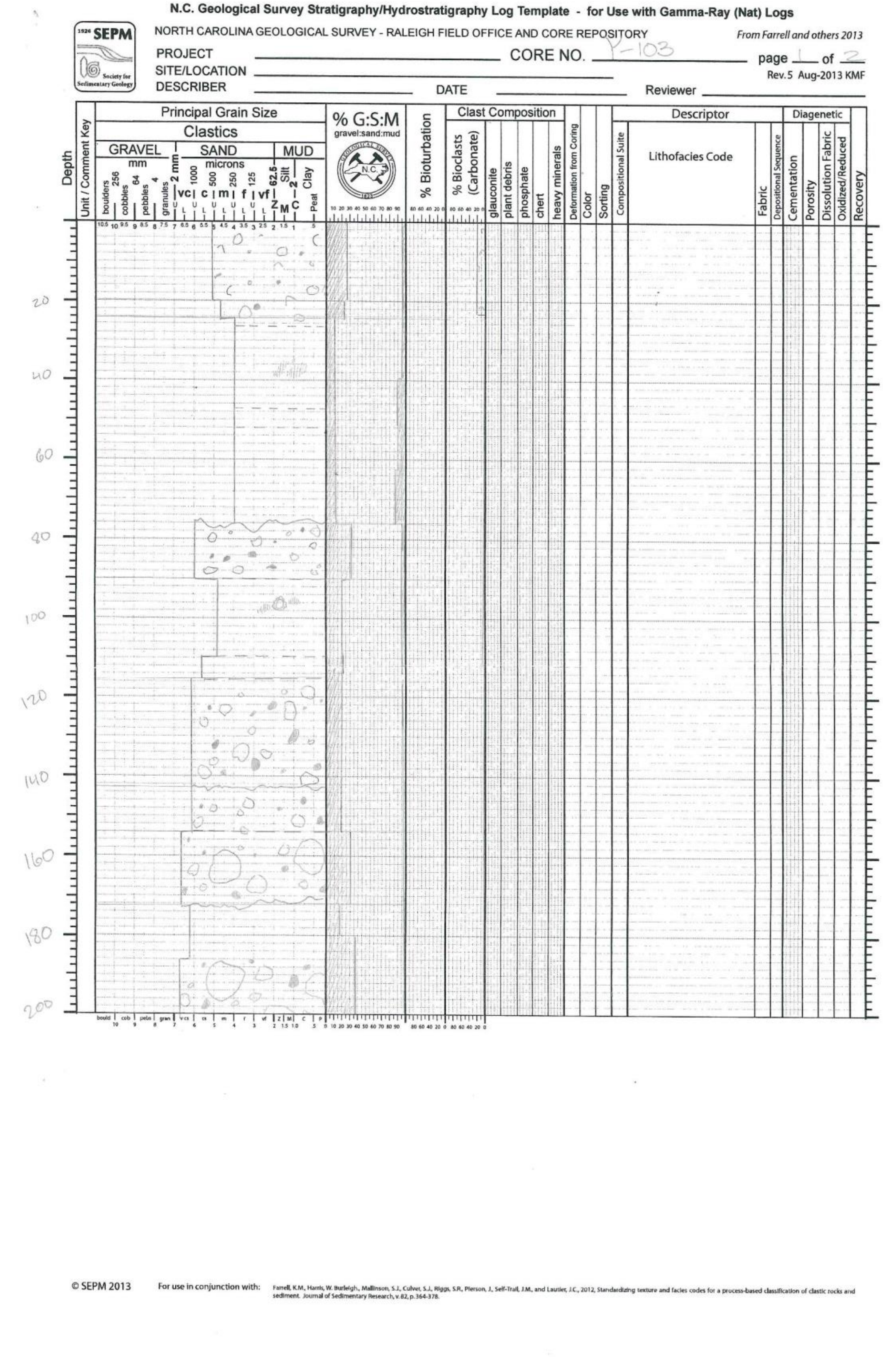
PROJECT ______ CORE NO. Y-91 ______ page 2 of 2

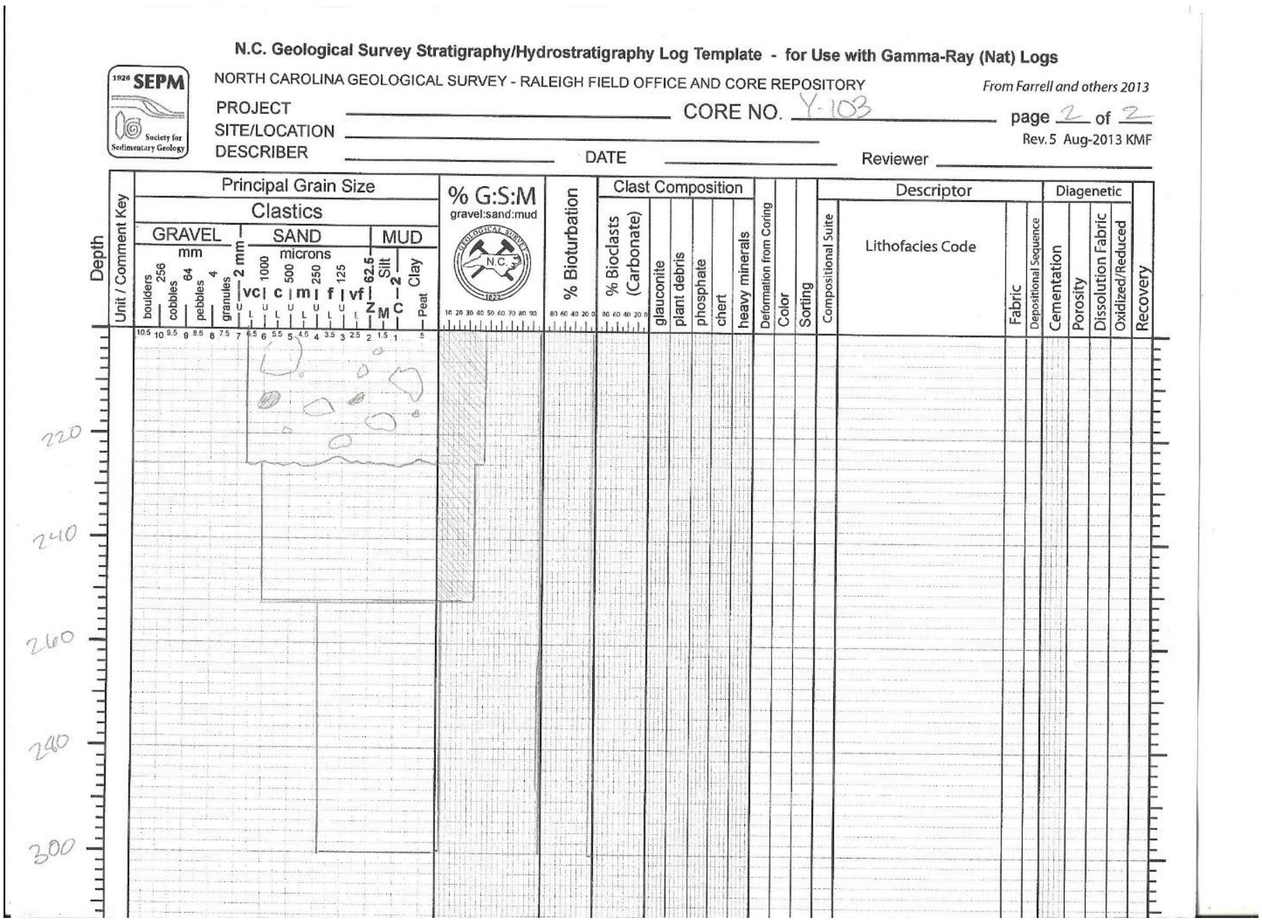
SITE/LOCATION ______ Rev.5 Aug-2013 KMF

DESCRIBER ______ DATE ______ Reviewer ______

Depth	Unit / Comment Key	Principal Grain Size – Clastics: GRAVEL (mm: boulders 256, cobbles 64, pebbles 4, granules 2 mm); SAND (microns: vc 1000, c 500, m 250, f 125, vf 62.5); MUD (Silt 2, Clay; Z M C; Peat)	% G:S:M gravel:sand:mud	% Bioturbation	Clast Composition: % Bioclasts (Carbonate)	glauconite	plant debris	phosphate	chert	heavy minerals	Deformation from Coring	Color	Sorting	Compositional Suite	Descriptor: Lithofacies Code	Fabric	Depositional Sequence	Diagenetic: Cementation	Porosity	Dissolution Fabric	Oxidized/Reduced	Recovery

Appendix J: Original core log for Y-103





N.C. Geological Survey Stratigraphy/Hydrostratigraphy Log Template - for Use with Gamma-Ray (Nat) Logs

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NORTH CAROLINA GEOLOGICAL SURVEY - RALEIGH FIELD OFFICE AND CORE REPOSITORY

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PROJECT ______ CORE NO. Y-103 ______ page 2 of 2

SITE/LOCATION ______ Rev. 5 Aug-2013 KMF

DESCRIBER ______ DATE ______ Reviewer ______