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Physical Stratigraphy, Paleontology, and Magnetostratigraphy of the USGS - Santee Coastal Reserve Core (CHN-803), Charleston County, South Carolina

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ABSTRACT

The Santee Coastal Reserve core, a 545-ft-deep corehole in northeastern Charleston County, South Carolina, recovered sediments of Late Cretaceous, Paleocene, Eocene, and Quaternary age. The deepest sediments, the Donoho Creek Formation (545-475.7 ft), consist of 69.3 ft of muddy calcareous sand of marine origin. This formation is placed within the upper Campanian calcareous nannofossil Subzone CC 22c. The overlying Peedee Formation (475.7-367.1 ft) in the core consists of 108.6 ft of silty clay of marine origin. It is placed in upper Maastrichtian calcareous nannofossil Subzones CC 25b, CC 26a, and CC 26b. Combined fossil and paleomagnetic information indicates nearly continuous deposition. Foraminifers indicate an outer neritic paleobathymetric setting. The Rhems Formation *sensu stricto* (367.1-267.3 ft) consists of 99.8 ft of silty clay, muddy sand, and minor calcite-cemented, shelly sand of marine origin. It is apparently the product of rapid sediment accumulation during a short period of time in the early Paleocene (calcareous nannofossil Zone NP 1). The upper part of the Rhems Formation *sensu* Bybell and others (1998) (267.3-237.4 ft) consists of 29.9 ft of calcite-cemented muddy sand and burrowed fine sand of marine origin. It is placed in calcareous nannofossil Zone NP 4 and, because it shows normal polarity, likely represents the upper part of the lower Paleocene. This unit may be correlative with the lower part of the Lower Bridge Member of the Williamsburg Formation in its type area. The Lower Bridge Member of the Williamsburg Formation (237.4-125.0 ft) has an unconformable contact at 205.0 ft that divides the member into lower muddy sand beds and upper calcareous clay beds. Both are placed in the upper Paleocene calcareous nannofossil Zone NP 5. The Chicora Member of the Williamsburg Formation (125-51.5 ft) consists of 73.5 ft of muddy, shelly sand of marine origin. It is poorly dated but includes late Paleocene nannofossils (Zones NP 5 and NP 6). A mollusk-bryozoan limestone (51.5-42.0 ft) above the Chicora Member of the Williamsburg yields early Eocene calcareous nannofossils representing both Zone NP 9/10 and Zone NP 12, together with pollen and dinocysts that are younger.

Sediments of middle and late Eocene, Oligocene, Miocene, and Pliocene ages were not recovered in the Santee Coastal Reserve core. The upper 42.0 ft of sediments represent Quaternary deposits and are included in the Wando Formation (42.0-28.0 ft) and the informal Silver Bluff beds (28.0-0 ft).

INTRODUCTION

In November 1996, the U.S. Geological Survey (USGS) drilled a stratigraphic test hole in northeastern Charleston County, S.C. (fig. 1). The Santee Coastal Reserve test hole (CHN-803) was drilled and cored on the Santee Coastal Reserve, a preserve managed by the South Carolina Department of Natural Resources (SCDNR). The drill site is located in the Minim Island 7.5 min. quadrangle at lat 33º09’21” N., long 79º21’50” W. Altitude of the site is 5 ft above mean sea level. This test hole was continuously cored to a total depth of 545 ft and recovered Upper Cretaceous, Paleocene, Eocene, and Quaternary sediments. The core is currently stored at the College of Charleston.

In this report, we provide stratigraphic, lithologic, paleontologic, magnetostratigraphic, and chemostratigraphic data and analyses for the Santee Coastal Reserve core. Calcareous nannofossils, foraminifera and other calcareous microfossils, dinoflagellates, and pollen were studied. The results from this core may be compared with results from the intensively studied USGS-Clubhouse Crossroads No. 1 core, located in southern Dorchester County (fig. 1) (Gohn and others, 1977; Hazel and others, 1977; Frederiksen and Christopher, 1978; Frederiksen, 1980; Gohn, 1992; Gohn and others, 1983), the St. George and Pregnall cores (Self-Trail and Gohn, 1996; Edwards and others, 1997) in north-central Dorchester County, the C-15 core in Jasper County (Self-Trail and Bybell, 1997), and the Cannon Park core (Bybell and others, 1998) in central Charleston County. This is the fifth in a series of studies of benchmark cores in the Coastal Plain of South Carolina that were drilled to elucidate the substantial regional differences in the distributions, facies, and thicknesses of Cretaceous and Cenozoic stratigraphic units.

Calcareous nannofossils, dinoflagellates, and magnetostratigraphy were studied from both the Cretaceous and Cenozoic units; pollen was studied from Cenozoic samples; foraminifera were studied from the Cretaceous Peedee Formation and strontium isotopes were measured on planktic foraminifera from the Cretaceous Peedee Formation. Leon P. Bardot conducted magnetostratigraphic studies of the core; Laurel M. Bybell provided Cenozoic calcareous nannofossil data; Lucy E. Edwards studied the dinocysts and compiled and synthesized the information for the report; John V. Firth studied Cretaceous dinocysts; Norman O. Frederiksen studied the Cenozoic pollen; Gregory S. Gohn summarized the lithologies and physical stratigraphy of the core; Brian T. Huber studied the foraminifera; Kenneth G. MacLeod studied strontium isotopes; David C. Prowell described the core lithologically; and Jean M. Self-Trail studied the Cretaceous calcareous nannofossils.

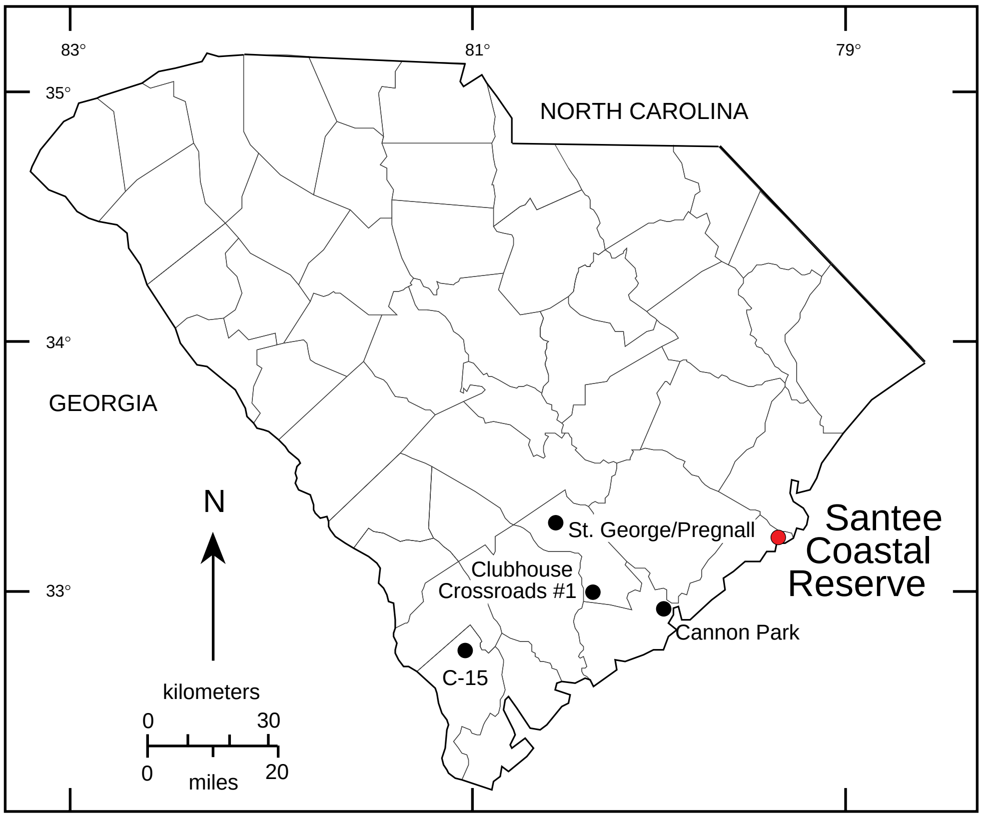

Figure 1. Map of South Carolina showing location of coreholes discussed in text.

Acknowledgments

The corehole was drilled by the U.S. Geological Survey's Eastern Region National Cooperative Geologic Mapping Team drill crew. USGS drillers at the Santee Coastal Reserve site were Gene Cobbs, Gene Cobbs III, and Don Queen. Karen Waters (SCDNR) and Kevin Conlon (USGS, Sullivans Island) provided valuable assistance during all phases of drilling. Andrew Wachob (SCDNR) logged the hole. We express our gratitude to Thomas Strange, Jr. of the SCDNR for coordinating access to the Santee Coastal Reserve. We thank Tom Sheehan for processing the palynological samples and Alys Faxon and Amanda Chapman for processing the calcareous nannofossil samples. We thank Gary Acton and the staff at the Ocean Drilling Program (ODP) repository at Texas A & M University for the use of their facilities. Rob Weems (USGS) and Joe Gellici (SCDNR) provided thoughtful reviews of this paper.

Unit conversions

U.S. customary units are used throughout this report, except for descriptions of grain size and pore size, and for measurements used in processing methods, both of which are given in metric units. To convert millimeters to inches, multiply the value in millimeters by 0.03937. To convert micrometers to inches, multiply the value in micrometers by 0.00003937. To convert feet to meters, multiply the value in feet by 0.3048. Paleomagnetic measurements initially were taken in metric units and subsequently were converted to feet for comparison with the other data.

METHODS

Physical stratigraphy and lithology

General lithologic descriptions of the core were made at the site during drilling operations. Subsequently, supplementary descriptions of core lithologies in selected intervals were added to the onsite description. Porosity in the limestones was described using Choquette and Pray's (1970) terminology for the classification of carbonate porosity. However, percentages of basic porosity types were not estimated. Instead, qualitative estimates of total porosity are given as low, moderate, high, and very high. In Choquette and Pray's classification, modifiers used for the size of pore spaces are micro- (less than 0.0625 mm), meso- (0.0625 to 4.0 mm), and mega- (4 to 256 mm). Sediment colors are based on The Geological Society of America Rock Color Chart (Goddard and others, 1984), and all refer to wet samples. The stratigraphic nomenclature for the Cretaceous units in the Santee Coastal Reserve core follows Gohn (1992) and Self-Trail and Gohn (1996). Stratigraphic nomenclature for the Cenozoic section is modified from Van Nieuwenhuise and Colquhoun (1982), Weems and Lemon (1993), and Bybell and others (1998).

Paleontology

Calcareous nannofossils. Thirty-four Cretaceous and fifty-nine Cenozoic calcareous nannofossil samples were examined from the Santee Coastal Reserve core at approximately 5- to 10-ft intervals. For each sample, a small amount of sediment was extracted from the central portion of a core segment (freshly broken where possible). The samples were dried in a convection oven to remove residual water, and the resultant dry sediment was placed in vials for long-term storage in the calcareous nannofossil laboratory at the U.S. Geological Survey in Reston, Va. Semi-consolidated or consolidated samples were ground with a mortar and pestle. A small portion of each sample was placed in a beaker, stirred, and settled through 20 ml of water. An initial settling time of one minute was used to remove the coarse fraction, and a second settling time of 10 minutes was used to concentrate the silt-sized fraction. Smear slides were prepared from the settled slurry of the remaining material. Cover slips were attached to the slides using Norland Optical Adhesive (NOA-65), a clear adhesive that bonds glass to glass and cures when exposed to ultraviolet radiation. Samples were examined with either a Zeiss Photomicroscope III or a Zeiss Axiophot 2 microscope.

Palynology. Nineteen samples were examined for pollen content, and twenty-three samples were examined for dinocysts at the U.S. Geological Survey in Reston. Seventeen additional samples were processed and examined in College Station, Texas. All samples were treated with hydrochloric and hydrofluoric acid. For some samples, organic material was separated by using nitric acid, by a series of soap washes and swirling, or by heavy liquid separation (zinc bromide, specific gravity 2.0) and Schultz solution. Material was stained with Bismark brown (Reston) or acetolyzed (College Station), sieved between 10-200 μm, and mounted for light microscope observation using glycerin jelly. Many of the 19 samples from the Santee Coastal Reserve core that were examined for pollen were screened at >10 μm and <40 μm to concentrate the angiosperm pollen. Samples studied for dinocysts were sieved >20 µm.

Foraminifera. Fourteen samples were analyzed for their planktic foraminifer content at five- to ten-ft intervals within the interval 466.2 to 371.1 feet. The samples were disaggregated at room temperature in a 3 percent hydrogen peroxide solution, washed over a 63 µm sieve, dried in a convection oven set at 50°C, and placed in vials for storage. Species identification and relative abundance estimates were made on the >63 µm fraction.

Abundance ratings for foraminifera, ostracodes, and inoceramid prisms are based on comparison with lithic fragments and other microfossil constituents. Planktic:benthic ratios are based on visual estimates rather than numerical determination.

Taxonomic concepts follow Nederbragt (1991) for heterohelicid planktic foraminifera and Caron (1985) and Robaszynski and others (1984) for trochospiral planktic foraminifera. The zonal scheme and chronostratigraphy used in this study follows that of Premoli Silva and Sliter (1995).

Strontium-isotope measurements

Foraminiferal separates from 466.2, 436.5, 416.8, 403.8, and 371.1 ft were used to test utility of $^{87}Sr/^{86}Sr$ measurements as an independent stratigraphic signal for the Peedee Formation. Under a light microscope, approximately 30 of the best preserved planktic foraminifera were picked from each sample and placed in centrifuge tubes with 0.2 ml of approximately 1.7 M acetic acid. Foraminiferal tests dissolved in 1-2 hours. The samples were then spun at 1100 rpm for 10 minutes, and the supernatant fluid was collected. After drying, the samples were redissolved in 3 M nitric acid, and strontium was separated using EiChrom SrSpec resin. Samples were loaded onto a rhenium filament in 4 µl of phosphoric acid and tantalum chloride and analyzed on the VG Sector 54 thermal ionization mass spectrometer at the University of North Carolina, Chapel Hill.

Paleomagnetic measurements

Paleomagnetic measurements were performed on whole-core sections and discrete samples from the Santee Coastal Reserve core. Remanence measurements were performed on whole-core sections using a pass-through cryogenic superconducting DC-SQUID rock magnetometer manufactured by 2-G Enterprises (Model 760R), at the Ocean Drilling Program, Texas A&M University, College Station, Texas. The sensing coils in the cryogenic magnetometer measure the magnetic signal over an interval of approximately 15 cm, and the coils for each axis have slightly different response curves. The widths of the sensing regions correspond to about 200-300 cm^3 of cored material, which all contributes to the signal at the sensors. The large volume of core material within the sensing region permits the accurate determination of remanence for weakly magnetized samples. There is an in-line alternating field (AF) demagnetizer, capable of 25 mT (2-G Model 2G600), included on the pass-through cryogenic magnetometer track for demagnetization of continuous sections, and both the magnetometer and its AF demagnetizer are interfaced with a PC-AT-compatible computer and are controlled by a BASIC program that has been modified from the original SUPERMAG program provided by 2-G Enterprises.

The natural remanent magnetization and remanence measurements after AF demagnetization of 10, 20, and 25 mT were measured using the pass-through cryogenic magnetometer at 10-cm intervals. Measurements were performed on all whole-core sections except for some sections from the top 38 m (125 ft) that were not measured because the cores had expanded and were too large to pass through the magnetometer.

Twenty-eight discrete samples also were thermally demagnetized at the Paleomagnetism Laboratory, University of Oxford, UK. Discrete samples were taken from soft sediment using oriented plastic cylinders (10 cm^3), and minicores were drilled from lithified sedimentary rocks using a water cooled nonmagnetic drill bit attached to a standard drill press. Samples were thermally demagnetized using a Shaw MMTD1 furnace, which has a residual field less than 5 nT. Demagnetization was carried out in temperature steps ranging between 30-40ºC from 100ºC to 400ºC. Magnetization of the samples was measured after each temperature step using a Cryogenic Consultants Ltd. SQUID magnetometer. Susceptibility measurements were carried out after each demagnetization step to monitor alteration.

RESULTS AND STRATIGRAPHIC DISCUSSIONS

Stratigraphy

The Santee Coastal Reserve corehole penetrated 545 feet of Cretaceous and Cenozoic sediments (fig. 2). The Cretaceous section is assigned to the upper Campanian Donoho Creek Formation of the Black

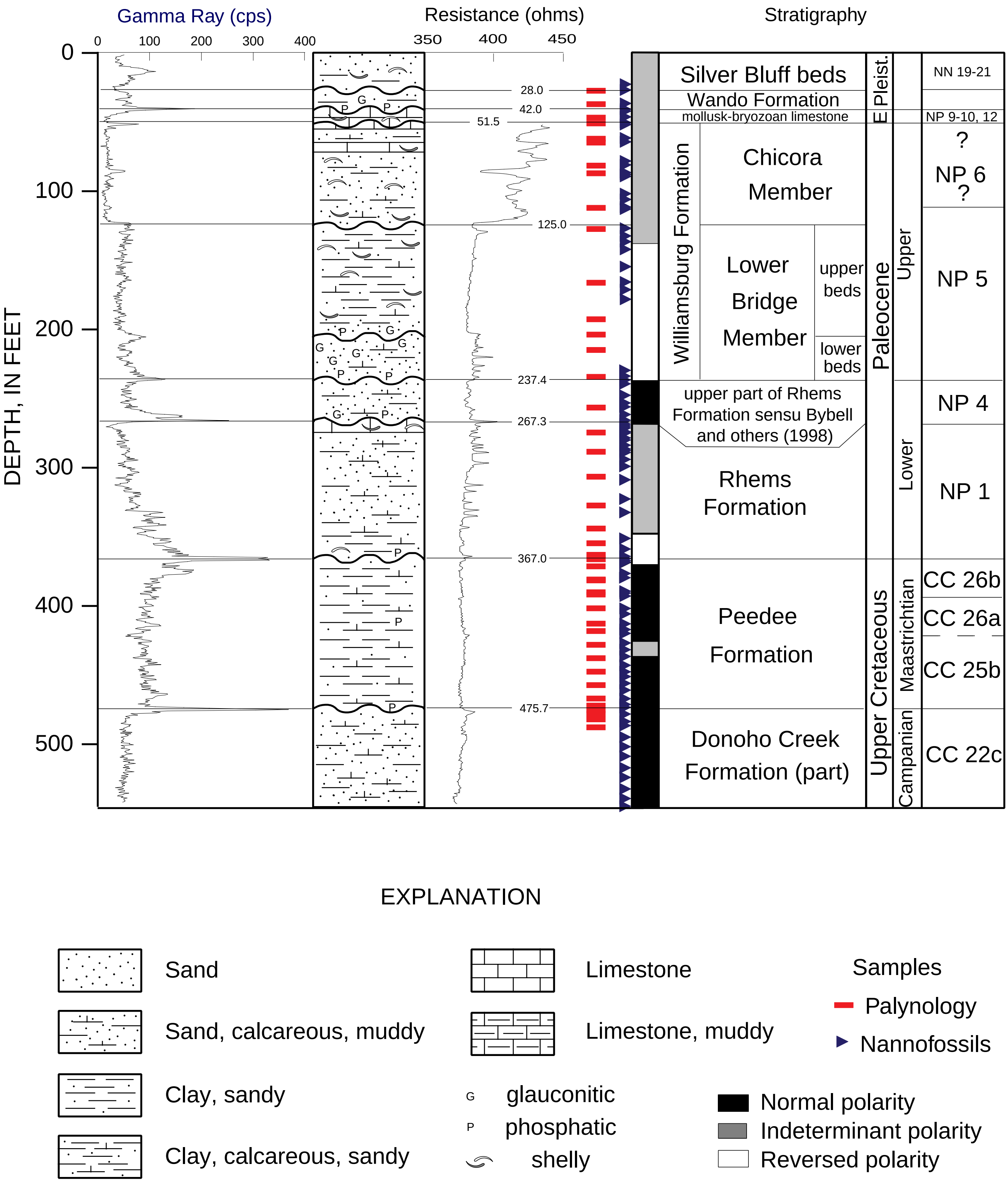

Figure 2. Stratigraphy and geophysical logs for the Santee Coastal Reserve core.

Upper Cretaceous																																		Series
upper Campanian											upper Maastrichtian																							Stage
Donoho Creek Formation											Peedee Formation																							Formation
CC 22c											CC 25b											CC 26a						CC26b						Nannofossil Zones (Perch-Nielsen, 1985)
544.0	539.0	531.3	524.0	516.5	508.5	501.0	493.8	486.0	482.8	477.3	474.1	471.5	466.2	461.1	456.0	451.1	446.6	442.8	436.5	431.4	426.0	420.1	416.8	412.0	405.0	400.7	393.2	390.4	389.3	380.3	375.8	370.4	368.3	Depth (ft)
.	.	.	.	.	.	.	F	F	R	.	.	R	.	F	.	.	.	.	.	.	.	.	.	.	.	.	.	C	.	F	.	F	F	*Acuturris scotus*
C	C	C	C	C	C	C	C	C	C	C	R	R	F	F	R	F	F	C	C	.	F	R	F	F	F	F	F	C	C	C	F	F	.	*Ahmuellerella octoradiata*
F	F	F	F	F	C	F	F	.	C	F	F	F	C	F	C	C	F	R	F	F	C	F	F	C	F	C	F	C	F	C	F	F	F	*Ahmuellerella regularis*
.	F	.	.	F	.	R	.	.	.	C	C	C	C	C	C	C	F	C	C	C	C	C	C	C	C	A	C	C	F	C	C	C	F	*Arkhangelskiella cymbiformis*
R	F	R	F	F	F	R	F	F	F	F	F	F	F	F	R	F	.	R	F	.	.	R	F	F	F	F	F	F	F	F	R	C	R	*Arkhangelskiella speciallata*
F	F	F	F	F	F	F	F	F	F	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*Aspidolithus parcus constrictus*
.	.	F	.	R	F	F	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*Aspidolithus parcus expansus*
R	R	F	F	R	R	C	F	C	F	.	.	.	.	.	.	.	.	rw	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*Aspidolithus parcus parcus*
C	F	C	C	C	C	C	C	C	C	C	R	.	F	F	C	F	C	C	C	F	C	.	C	F	.	C	.	C	F	.	R	.	.	*Biscutum constans*
F	C	C	C	F	C	C	C	C	C	C	F	F	F	R	F	F	C	F	F	F	C	C	F	F	F	C	.	C	F	F	F	C	R	*Biscutum zulloi*
R	.	F	F	.	F	F	.	F	.	R	F	R	F	.	.	.	.	R	F	.	F	.	.	F	.	.	.	C	F	F	.	.	.	*Biscutum* sp.
.	.	.	.	.	.	.	.	.	.	.	R	.	R	.	.	.	F	.	.	.	F	.	R	.	.	.	.	.	.	.	.	.	R	*Braarudosphaera bigelowii*
.	.	.	F	.	.	.	.	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*Braarudosphaera* sp.
.	.	.	.	.	.	.	.	.	.	R	.	.	R	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*Broinsonia dentata*
.	.	.	.	R	F	.	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*Broinsonia enormis*
F	.	F	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*Bronsonia furtiva*
F	F	F	C	F	C	F	C	F	F	.	.	.	.	.	.	.	.	.	R	.	.	.	.	.	.	R	.	.	.	R	.	.	.	*Calculites obscurus*
F	C	F	C	F	F	C	C	F	F	F	F	F	F	F	F	F	R	C	C	C	F	.	F	.	F	R	R	.	.	.	.	R	R	*Ceratolithoides aculeus*
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	F	C	C	F	F	F	F	F	C	F	R	.	*Ceratolithoides kamptneri*
.	.	.	.	.	.	.	.	.	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*Ceratolithoides* sp. cf. *kamptneri*
F	F	F	C	C	C	C	C	F	C	F	R	F	F	F	F	F	F	.	C	F	.	.	F	F	F	F	F	F	F	R	F	F	F	*Chiastozygus amphipons*
C	F	.	F	F	C	C	F	F	F	C	R	F	F	F	C	C	C	C	C	F	F	F	C	C	F	C	F	F	F	C	F	F	F	*Chiastozygus litterarius*
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	F	.	.	.	.	.	F	.	.	.	.	.	*Chiastozygus propagulis*
F	F	.	.	.	F	.	F	C	.	F	F	F	C	.	F	F	C	F	C	.	F	C	C	F	F	C	R	C	F	F	F	C	R	*Chiastozygus* spp.
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	F	.	.	.	.	.	.	.	.	.	.	.	.	.	*Corollithion ? completum*
F	F	F	F	F	F	F	C	F	F	F	C	F	C	F	F	R	F	R	F	C	R	F	C	F	F	F	R	C	F	F	.	C	R	*Corollithion exiguum*
F	F	F	F	F	C	F	F	F	.	.	.	.	.	.	.	.	rw	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*Corollithion signum*
R	.	R	R	.	F	F	F	F	.	.	R	R	F	.	R	.	.	.	F	.	F	.	F	R	.	R	R	.	F	.	.	R	.	*Cretarhabdus conicus*
.	R	R	.	.	.	.	F	R	F	R	.	.	.	R	F	.	F	.	F	.	.	.	F	R	F	.	R	.	R	.	.	F	F	*Cretarhabdus multicavus*
F	.	.	.	.	F	.	.	.	.	R	.	.	F	.	R	.	.	.	R	.	.	F	R	R	.	F	R	R	.	.	.	R	.	*Cretarhabdus schizobrachiatus*
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	F	R	.	R	F	.	F	F	R	.	F	R	R	.	F	R	.	.	*Cribrocorona gallica*
C	C	C	C	C	C	C	C	C	C	F	C	C	C	C	F	C	F	F	C	C	C	C	C	C	F	C	F	C	C	C	C	C	C	*Cribrosphaerella ehrenbergii*
.	.	.	.	.	R	.	F	.	.	R	R	F	F	.	R	.	R	F	R	.	F	.	R	F	.	F	F	F	F	F	.	.	.	*Cyclagelosphaera margarellii*
F	F	.	.	R	F	F	R	.	.	.	F	.	F	.	.	.	.	.	R	.	R	.	R	.	.	R	.	F	.	.	.	.	.	*Cylindralithus crassus*
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	F	.	.	.	.	.	.	.	.	F	.	.	.	.	*Cylindralithus nudus*
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	.	.	.	.	.	.	.	.	.	F	.	*Cylindralithus oweinae*
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*Cylindralithus serratus*
C	C	C	F	F	C	C	C	C	F	C	F	F	C	F	C	F	C	C	C	F	C	C	C	F	F	F	R	C	C	F	.	F	R	*Discorhabdus ignotus*
.	.	.	.	.	.	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	.	.	.	.	.	.	*Discorhabdus* sp.
.	.	.	.	.	.	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*Dodekapodorhabdus noeliae*
.	F	C	F	F	.	F	F	F	.	C	F	C	C	F	C	C	C	F	C	C	C	C	F	F	F	C	F	C	C	C	F	C	C	*Eiffellithus gorkae*
.	.	.	.	.	.	F	.	.	.	R	F	F	C	F	C	F	F	F	F	F	F	F	F	C	F	F	R	C	F	F	F	R	R	*Eiffellithus parallelus*
C	C	C	C	F	C	C	F	C	C	C	F	C	C	C	C	C	C	C	C	F	F	F	C	C	F	C	F	C	F	C	C	C	F	*Eiffellithus turriseiffellii*
F	F	F	F	F	C	R	F	F	F	R	F	R	R	.	R	F	R	F	C	F	F	F	F	C	R	C	F	F	F	C	R	F	F	*Gartnerago diversum*
C	C	C	C	C	.	C	C	F	C	C	F	F	F	F	C	F	C	F	C	.	.	F	C	F	F	F	F	C	C	R	F	F	F	*Gartnerago obliquum*
.	.	R	.	.	F	.	F	.	.	R	.	.	.	.	.	.	.	.	F	F	.	.	.	F	.	R	R	R	.	.	.	.	.	*Gephyrorhabdus coronadventis*
F	F	F	F	F	C	F	F	C	C	F	.	.	.	.	F	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*Glaukolithus compactus*
C	F	F	C	F	C	F	F	C	F	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	F	.	.	.	.	.	.	*Glaukolithus diplogrammis*
.	.	.	.	F	.	.	.	.	.	R	R	R	F	R	.	F	.	.	R	.	.	F	F	F	.	.	.	F	F	F	R	R	F	*Goniolithus fluckigeri*
F	R	R	R	.	R	F	.	F	.	F	F	R	F	F	.	F	F	F	C	.	.	F	F	C	F	C	F	C	F	C	R	C	F	*Helicolithus trabeculatus*
.	F	F	.	F	.	F	R	F	R	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*Hexalithus gardetae*
.	.	F	.	.	.	R	.	.	R	F	R	.	R	R	F	F	F	C	F	C	F	F	C	.	F	F	R	F	R	C	.	F	.	*Kamptnerius magnificus*
F	F	C	F	F	F	F	F	F	F	F	.	.	.	.	.	.	.	.	.	.	.	.	F	F	.	.	.	.	.	.	F	F	F	*Kamptnerius punctatus*
C	C	C	C	C	A	C	C	C	C	C	C	C	C	C	C	C	C	C	C	.	C	C	C	C	F	C	F	C	C	C	F	C	F	*Lithraphidites carniolensis*
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	F	F	R	F	R	C	F	F	F	F	F	F	F	F	F	F	R	R	F	*Lithraphidites grossopectinatus*
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	.	.	.	.	.	.	F	F	.	F	.	.	R	F	R	.	.	*Lithraphidites kennethii*
.	.	.	.	.	.	.	.	.	.	.	F	R	F	R	C	R	F	F	.	F	R	.	C	.	F	F	R	.	.	.	.	.	.	*Lithraphidites praequadratus*
.	.	.	.	.	.	.	.	.	.	.	R	C	F	F	F	F	C	C	C	F	R	F	F	F	F	F	F	C	F	F	F	F	F	*Lithraphidites quadratus*
.	.	.	.	.	.	.	.	.	.	.	.	R	.	.	F	F	R	.	.	.	.	.	.	R	.	.	.	.	.	.	.	.	.	*Lithraphidites* sp.
.	.	.	.	.	.	.	F	.	.	.	.	.	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*Loxolithus armillus*
F	F	F	F	F	F	C	C	F	R	.	.	.	R	R	R	F	.	.	R	F	F	R	F	F	F	.	.	.	.	F	.	F	.	*Lucianorhabdus cayeuxii*
R	.	.	.	.	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*Lucianorhabdus maleformis*
.	.	F	R	F	F	R	F	F	R	F	R	.	F	.	.	.	.	.	F	.	.	F	F	F	R	F	.	F	.	F	.	.	.	*Manivitella pemmatoidea*
.	.	.	.	.	.	R	.	.	F	F	R	F	.	R	.	R	.	.	F	.	.	F	R	.	.	.	.	.	.	.	.	.	F	*Markalius inversus*
R	F	.	R	R	F	F	R	.	R	F	F	F	F	F	F	F	F	.	F	F	R	R	R	F	F	F	C	R	R	F	F	F	F	*Micula concava*
C	C	C	C	C	A	C	C	C	C	C	C	A	C	C	C	C	C	C	A	C	C	C	C	C	C	A	C	A	C	A	C	A	C	*Micula decussata*
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	R	.	R	.	.	R	R	.	*Micula murus*
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R	.	.	.	R	.	.	.	.	.	.	.	.	.	.	.	.	*Micula praemurus*
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	F	R	.	F	F	R	*Micula prinsii*
.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	F	R	.	.	.	.	.	.	.	*Micula* sp. cf. *M. prinsii*
.	F	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	*Micula* sp.
F	F	R	F	.	F	F	F	F	F	F	C	C	C	R	F	C	F	C	C	C	R	F	F	F	F	C	C	F	R	F	F	F	F	*Microrhabdulus attenuatus*
C	F	C	C	F	C	C	F	C	C	F	F	F	F	F	F	F	F	C	C	F	R	F	F	F	F	C	F	C	C	F	R	F	.	*Microrhabdulus belgicus*
F	F	R	F	C	C	C	F	F	F	F	C	F	F	F	C	F	F	F	F	F	F	F	C	F	F	C	F	C	F	F	F	F	F	*Microrhabdulus decoratus*
.	F	.	C	F	F	.	C	F	F	C	F	F	F	R	C	F	F	C	C	F	F	F	C	C	C	C	R	F	F	C	.	C	F	*Microrhabdulus undosus*

Figure 3. Late Cretaceous nannofossil occurrences in the Santee Coastal Reserve core. A=abundant, C=common, F=frequent, R=rare, rw=reworked.

Upper Cretaceous																																		Series
upper Campanian											upper Maastrichtian																							Stage
Donoho Creek Formation											Peedee Formation																							Formation
CC 22c											CC 25b											CC 26a						CC26b						Nannofossil Zones (Perch-Nielsen, 1985)
544.0	539.0	531.3	524.0	516.5	508.5	501.0	493.8	486.0	482.8	477.3	474.1	471.5	466.2	461.1	456.0	451.1	446.6	442.8	436.5	431.4	426.0	420.1	416.8	412.0	405.0	400.7	393.2	390.4	389.3	380.3	375.8	370.4	368.3	Depth (ft)
F	·	·	R	·	·	·	·	·	·	·	·	·	F	·	F	·	R	·	·	·	·	·	F	F	·	·	·	·	·	·	·	·	·	*Munarius lesliae*
·	·	·	·	·	·	·	·	F	·	·	·	·	·	·	·	·	·	·	·	·	·	·	R	·	·	·	·	·	·	·	R	·	·	*Neocrepidolithus cohenii*
·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	R	·	·	·	·	·	·	·	·	·	·	·	·	·	·	*Neocrepidolithus neocrassus*
·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	F	·	·	*Neocrepidolithus* sp.
·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	C	F	C	F	F	·	·	·	*Nephrolithus frequens*
·	·	·	·	·	·	·	·	·	·	·	·	·	·	R	·	·	·	·	·	·	·	·	F	·	·	·	·	·	R	·	·	·	·	*Orastrum asarotum*
F	R	R	·	·	F	·	F	R	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	rw	·	·	·	·	·	·	·	*Orastrum campanensis*
·	·	·	·	·	·	·	·	·	·	·	·	·	R	·	R	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	*Ottavianus giannus*
·	·	·	·	·	·	·	·	·	·	·	R	F	·	·	·	·	F	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	*Ottavianus terrazetus*
·	·	·	F	·	F	R	F	·	F	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	*Percivalia porosa*
F	F	C	R	F	F	F	F	C	F	F	C	C	C	R	C	F	F	F	C	F	F	C	C	C	F	F	F	F	F	F	F	F	F	*Placozygus fibuliformis*
F	F	F	C	F	C	F	F	F	F	R	R	R	R	R	R	R	R	·	R	·	F	R	F	R	·	R	·	·	R	R	·	R	·	*Placozygus sigmoides*
·	·	·	·	·	·	·	·	F	·	R	·	·	F	·	·	·	·	·	R	·	·	·	·	·	·	·	·	·	·	·	·	·	·	*Pontosphaera multicarinata*
R	·	R	F	R	C	F	·	·	F	R	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	*Prediscosphaera arkhangelskyi*
C	C	C	C	C	A	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	F	*Prediscosphaera cretacea*
·	·	R	·	·	·	·	·	·	·	·	·	·	F	·	·	·	R	·	R	·	·	·	·	·	·	R	·	R	R	R	·	·	·	*Prediscosphaera grandis*
·	·	·	·	·	·	·	·	F	·	R	F	·	·	·	R	·	R	·	·	·	R	·	·	R	F	·	·	R	R	R	·	R	·	*Prediscosphaera intercisa*
·	·	·	·	·	·	·	F	·	·	·	F	·	·	·	·	·	·	·	·	·	·	·	·	·	·	R	·	R	R	R	F	·	R	*Prediscosphaera majungae*
F	F	R	R	F	F	R	C	F	·	R	R	F	F	F	F	F	F	R	F	F	R	C	F	F	F	F	F	F	F	F	R	·	R	*Prediscosphaera spinosa*
F	C	F	C	C	C	C	C	C	C	F	C	C	C	C	C	C	C	A	C	C	C	C	C	C	C	C	F	C	C	C	R	C	F	*Prediscosphaera stoveri*
·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	?	·	·	·	·	·	·	·	·	·	R	*Pseudomicula quadrata*
·	·	·	·	·	F	·	F	·	R	R	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	*Quadrum gothicum*
F	R	R	F	F	F	F	R	F	R	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	*Quadrum sissinghii*
R	R	F	F	F	F	F	F	F	R	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	*Quadrum trifidum*
·	R	·	·	·	·	·	·	·	·	·	·	·	R	·	·	·	·	F	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	*Ramsaya swanseana*
F	F	F	F	F	C	F	C	C	C	F	·	·	·	·	·	rw	·	·	·	·	·	·	·	·	·	·	rw	rw	·	·	·	·	·	*Reinhardtites anthophorus*
·	R	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	*Reinhardtites biperforatus*
C	R	F	F	F	F	F	F	F	·	F	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	*Reinhardtites levis*
·	·	·	·	·	·	·	·	·	·	·	R	·	R	F	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	*Reinhardtites* sp.
C	F	C	F	F	F	C	C	C	C	F	·	F	F	R	C	·	C	F	·	·	R	·	C	·	·	·	·	·	·	·	·	·	·	*Repagulum parvidentatum*
F	C	F	R	R	C	F	F	R	F	F	·	F	F	R	F	F	F	F	F	·	R	·	F	R	F	F	R	F	R	·	F	·	F	*Retacapsa angustiforata*
F	R	F	F	R	C	F	F	F	F	F	R	C	F	R	F	F	F	R	C	·	F	R	R	C	F	F	R	R	R	F	R	R	F	*Retemediaformis teneraretis*
·	C	F	F	F	F	F	F	F	F	F	C	C	C	F	F	C	C	C	F	·	F	R	C	C	F	C	R	F	F	F	F	C	F	*Rhagodiscus angustus*
F	F	F	R	F	F	F	·	F	·	·	F	F	F	F	F	F	F	F	C	F	F	F	F	F	F	F	F	F	F	C	R	F	F	*Rhagodiscus reniformis*
F	R	F	F	R	R	F	R	·	F	F	F	F	F	R	F	F	F	F	C	F	F	R	F	C	F	F	R	·	F	R	R	F	·	*Rhagodiscus splendens*
R	·	·	·	·	F	R	F	·	·	·	·	R	R	·	F	R	R	F	R	·	·	·	F	F	·	F	R	R	F	F	·	R	·	*Rhombolithion rhombicum*
F	R	F	F	F	F	F	F	F	F	F	F	F	F	·	C	F	F	F	C	·	R	R	C	F	F	C	F	C	F	F	·	F	F	*Rotellapillus crenulatus*
·	·	·	·	·	·	·	·	·	·	·	·	·	·	F	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	*Rotellapillus munitus*
·	·	·	·	·	·	·	·	·	·	·	·	·	R	·	·	·	·	·	·	·	R	·	·	·	·	·	·	·	·	·	·	·	·	*Rucinolithus* spp.
·	·	·	·	·	·	·	·	·	·	·	·	·	F	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	*Scampanella cornuta*
·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	R	·	·	·	·	·	·	·	·	·	·	*Scampanella magnifica*
F	R	·	F	·	R	R	R	F	F	·	R	·	R	R	F	·	F	·	R	·	·	·	R	F	·	R	R	F	F	·	·	·	·	*Scapholithus fossilis*
·	R	R	F	F	F	R	·	R	F	R	·	·	·	R	R	·	F	·	R	·	R	·	F	·	R	·	·	F	·	·	·	·	·	*Sollasites barringtonensis*
·	·	·	·	·	·	R	·	·	·	·	·	·	·	R	F	R	·	F	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	*Sollasites lowei*
·	·	·	·	·	·	·	·	·	·	rw	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	*Stovarius achylosus*
F	·	F	F	F	F	·	·	·	·	R	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	*Stovarius asymmetricus*
·	·	·	·	·	·	·	·	·	·	·	R	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	*Stovarius biarcus*
C	C	F	F	F	C	C	C	C	C	C	F	C	C	F	C	F	F	C	C	C	F	F	C	C	F	C	C	C	F	C	C	C	C	*Stradneria crenulata*
F	R	R	R	R	F	F	R	·	·	F	F	F	F	R	F	F	F	F	F	·	R	F	F	F	·	C	R	F	F	R	R	F	F	*Tetrapodorhabdus decorus*
C	F	R	F	F	F	F	F	·	F	C	C	C	C	R	·	C	C	C	F	C	R	F	C	C	F	C	C	F	F	F	F	C	F	*Thoracosphaera* spp.
F	·	·	R	R	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	*Tortolithus hallii*
·	·	·	·	·	·	·	·	·	·	·	·	·	·	R	F	·	F	·	·	F	·	·	·	·	·	·	·	·	·	R	·	·	·	*Tortolithus pagei*
·	R	R	·	·	R	·	·	R	·	·	·	·	F	·	F	R	·	F	R	·	R	R	F	F	·	F	·	·	R	F	·	·	·	*Tortolithus* spp.
F	F	F	F	F	F	C	·	·	F	R	F	C	C	F	C	C	C	C	F	C	R	F	F	F	F	F	F	F	F	F	F	·	·	*Tranolithus minimus*
·	·	R	·	·	·	·	F	·	·	R	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	*Tranolithus phacelosus*
F	R	F	F	F	C	F	R	F	·	F	F	R	R	R	C	F	F	F	C	F	·	C	F	C	F	F	F	R	F	F	R	F	R	*Vekshinella aachena*
R	·	F	F	C	C	C	F	R	F	·	·	·	·	·	·	·	·	·	·	·	·	·	C	·	·	F	·	·	·	·	·	·	·	*Vekshinella* sp.cf. *V. parma*
C	F	·	F	C	C	F	C	F	C	C	R	C	C	F	C	C	F	F	C	C	F	F	C	C	C	C	F	F	C	C	F	C	C	*Vekshinella stradneri*
C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	C	F	C	C	C	C	F	C	C	C	C	A	C	C	C	C	C	C	C	*Watznaueria barnesae*
·	·	·	·	·	R	R	R	R	R	R	R	F	F	·	·	·	R	R	F	·	·	·	F	F	·	F	·	F	R	R	·	R	·	*Watznaueria biporta*
F	·	F	F	·	F	C	·	R	F	F	F	C	C	F	C	C	F	·	F	F	F	F	C	F	R	C	F	F	C	F	R	C	F	*Watznaueria supracretacea*
F	F	F	R	·	F	F	R	F	F	F	·	·	·	·	F	F	F	·	F	F	·	·	F	·	·	F	·	R	·	·	·	·	·	*Watznaueria* sp.
F	F	R	C	·	F	C	F	F	F	F	C	C	F	F	F	R	F	F	C	·	F	F	F	F	F	C	·	F	F	C	F	C	F	*Zeugrhabdotus acanthus*
F	C	C	F	F	C	C	C	F	F	F	R	F	C	·	F	F	F	F	C	F	F	C	F	C	F	C	F	C	F	C	R	R	F	*Zeugrhabdotus erectus*
·	·	·	·	R	F	R	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	·	*Zeugrhabdotus obliqueclausus*
·	R	R	F	·	F	R	R	R	R	R	R	R	F	R	R	F	·	R	R	·	R	F	R	R	R	F	R	R	R	·	R	R	F	*Zeugrhabdotus pseudanthophorus*
F	F	F	F	F	F	F	R	C	·	R	·	C	F	R	F	F	C	F	C	·	C	·	C	R	F	F	·	R	F	F	·	F	F	*Zeugrhabdotus* sp.
C	A	A	A	A	A	A	A	A	A	C+	A	A	A	C	A	C	A	C	A	C	C	C	A	A	C+	A	C	A-	C+	A	C	A	C+	Abundance[1]
M	M	G	G	G	G	G	G	M	M	G	G	G	G	M	M	G	G	M	G	M	M-	M	G	G	G	G	M	G	M	G	M	G	M	Preservation[2]

Figure 3. Late Cretaceous nannofossil occurrences cont.
[1]Abundance: A=1 specimen per field of view, C=1 specimen per 1-10 fields of view.
[2]Preservation: G=good, M=moderate.

Creek Group and the upper Maastrichtian Peedee Formation. The Cenozoic section is assigned to the lower Paleocene Rhems Formation of the Black Mingo Group, a lower and (or) upper Paleocene unit referred to here as the upper part of the Rhems Formation *sensu* Bybell and others (1998), the upper Paleocene Lower Bridge and Chicora Members of the Williamsburg Formation of the Black Mingo Group, a lower Eocene mollusk-bryozoan limestone, and the late Pleistocene Wando Formation and Silver Bluff beds (informal). Discussions of the stratigraphy, lithologies, paleontology, and magnetostratigraphy of these units are given in the following sections. The detailed lithologic log is given in appendix 1.

Paleontology

Calcareous nannofossil biostratigraphy is based on the highest and lowest occurrences of species; FAD indicates a first appearance datum, and LAD indicates a last appearance datum. Cretaceous calcareous nannofossil biostratigraphy is based on the zonation of Sissingh (1977) as modified by Perch-Nielsen (1985b). Age estimates for the majority of Late Cretaceous calcareous nannofossil datums were taken from Erba and others (1995) and supplemented by Henriksson (1994). These datums were correlated to the time scale of Gradstein and others (1995).

Preservation of Cretaceous calcareous nannofossils was moderate to good, and assemblages were common to abundant throughout the core. Occasional reworking of late Campanian specimens into the overlying late Maastrichtian flora occurred. There was no apparent downcore contamination of the Cretaceous assemblages except in the uppermost Cretaceous sample.

The calcareous nannofossil zonation used for the Cenozoic strata is based primarily upon the zonation of Martini (1971) and secondarily on the zonation of Bukry (1973) and Okada and Bukry (1980). Useful Paleogene FAD's and LAD's are given in appendix 2. A list of calcareous nannofossil species that are considered in this report is given in appendix 3.

In all Cretaceous and nearly all Tertiary samples from the Santee Coastal Reserve core, the calcareous nannofossil assemblages were sufficient in number of specimens, diversity of taxa, and preservational state to allow placement within one specific zone or subzone. Campanian calcareous nannofossils are reworked sporadically into Maastrichtian sediments (fig. 3). Cretaceous calcareous nannofossils are reworked into various parts of the Paleocene Rhems Formation (fig. 4).

Occurrences of dinocysts in the Santee Coastal Reserve core are shown in figures 5 and 6. A list of dinocyst species that are considered in this report is given in appendix 3. Appendix 4 contains detailed information about dinocyst occurrences in the core. Cretaceous dinoflagellate biostratigraphy is based on data from the type Maastrichtian in the Netherlands (Schiøler and others, 1997), the North Sea (Schiøler and Wilson, 1993), Israel (Hoek and others, 1996), and from onshore and offshore New Jersey (May, 1980; Tocher, 1987). There is no widely accepted standard zonation for dinoflagellate cysts. However, there are lowest and highest occurrences that have proved to be useful in correlating dinocyst-bearing sediments both on a local and intercontinental basis, and where possible, they are used for the Santee Coastal Reserve sediments.

Occurrences of biostratigraphically useful pollen and spores are shown in table 1. A list of pollen species that are considered in this report is given in appendix 3; tables 2 and 3 contain information about pollen occurrences in the core. A pollen zonation has been proposed for the Paleocene of the eastern United States (Frederiksen, 1991, 1998), but no pollen zonation has been proposed for the Eocene of this region. However, higher resolution correlations can be obtained using lowest and highest occurrences of individual pollen taxa rather than zones, and that is the method used for pollen age determinations in this report.

Foraminifera were studied only from the Peedee Formation; they are abundant in all samples examined. The planktic foraminifer distribution data are presented in figure 7. Few planktic foraminifera occur in the greater than 250 μm sieve fraction, which is dominated by benthic foraminifera. Calcite infilling decreases upcore -- most tests in the lowermost sample are infilled whereas only minor amounts of infilling were observed in the shallowest sample. Because of the prevalence of shell infilling, efforts to obtain stable isotopic analyses were abandoned. Ostracodes are

Figure 4. (Next pages) Cenozoic calcareous nannofossil occurrences in the Santee Coastal Reserve core. mbl=mollusk-bryozoan limestone, SB=Silver Bluff beds (informal). For occurrences: X, present; ?, possible occurrence; C, specimens from downhole contamination; 1, only one specimen observed. For abundance: A, abundant or greater than 10 specimens per field of view; C, common or 1 to 10 specimens per field of view; F, frequent or 1 specimen per 1 to 10 fields of view; R, rare or 1 specimen per greater than 10 fields of view. All fields of view at 640x magnification. For preservation: G, good; M, moderate; F, fair; P, poor; T, terrible.

Formation	Rhems																					upper part of Rhems Fm. ***sensu*** Bybell and others (1998)					
Santee Coastal Reserve Core	lower																										
CHN-803 Series	Paleocene																										
Calcareous Nannofossil Zones	NP 1																					NP 4					
Species Depth (ft)	367.1	365.9	362.0	353.0	331.8	322.5	308.4	302.6	296.7	295.3	290.8	289.8	288.5	285.5	281.0	280.2	273.6	273.4	270.4	269.5	268.4	265.5	261.0	255.8	252.1	247.0	239.3
Biantholithus sparsus	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.
Biscutum spp.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Braarudosphaera bigelowii	X	X	X	X	X	X	.	X	X	X	X	X	X	X	X	.	.	.	.	.	.	X	X	.	X	.	.
Braarudosphaera discula	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	.
Braarudosphaera spp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.
Campylosphaera dela	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Chiasmolithus bidens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	C1	.	.	.	.	.	.	.	.	.	.	.	.
Chiasmolithus sp. aff. *bidens*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.
Chiasmolithus consuetus s.l.	.	.	.	.	.	.	.	.	.	.	C1	.	.	.	C1	.	.	.	.	C1	.	.	.	1	.	.	.
Chiasmolithus spp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Coccolithus cribellum	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.
Coccolithus eopelagicus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Coccolithus pelagicus	.	.	?	.	.	?	.	.	.	.	.	.	?	.	?	.	.	.	.	.	.	.	X	X	X	X	X
Cruciplacolithus asymmetricus	.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	.	X	X	X	.	.	.	.	.	.
Cruciplacolithus edwardsii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cruciplacolithus intermedius	X	X	.	X	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.	.	.	.	.	.
Cruciplacolitlhus primus	X	X	X	X	X	X	X	X	X	X	X	X	X	.	X	X	X	.	X	X	.	X	.	.	.	.	.
Cruciplacolithus tenuis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	X	X	X	X
Cruciplacolithus spp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cyclagelosphaera prima	.	X	.	.	.	X	.	.	.	.	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.
Cyclagelosphaera reinhardtii	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cyclagelosphaera spp.	.	.	.	.	X	.	.	.	X	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.
Cyclococcolithus formosus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cyclococcolithus robustus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cyclococcolithus spp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.
Discoaster barbadiensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Discoaster lenticularis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Discoaster multiradiatus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Discoaster spp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ellipsolithus bollii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ellipsolithus distichus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.
Ellipsolithus macellus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	X	.
Ericsonia subpertusa	.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	.	X	X	X	X	X	X	X	X	X
Fasciculithus involutus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Fasciculithus spp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gephyrocapsa oceanica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Goniolithus fluckigeri	.	.	.	.	.	X	.	.	.	X	.	.	.	.	X	.	.	.	.	.	.	X	.	.	.	.	.
Heliolithus cantabriae	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Heliolithus klelinpellii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hornibrookina arca	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hornibrookina spp.	.	.	X	X	.	.	.	.	X	X	X	X	X	X	X	.	.	X	.	X	.	.	.	.	.	.	.
Lanternithus duocavus	.	.	.	.	.	.	.	.	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.
Lanternithus sp.	.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Markalius apertus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Markalius inversus	X	X	X	.	X	X	.	.	X	X	.	X	X	.	.	.	.	.	X	.	.	.	.	.	X	X	X
Micrantholithus aequalis	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Micrantholithus attenuatus	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Micrantholithus fornicatus	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.
Micrantholithus pinguis	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Micrantholithus vesper	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Micrantholithus spp.	.	.	.	.	X	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.
Neochiastozygus concinnus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Neococcolithes sp. aff. *N. protenus*	.	.	.	X	X	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	X	X	X	X	X	.
Neococcolithes spp.	X	X	X	.	.	.	.	X	.	X	X	X	X	.	X	X	X	.	X	X	X	X	.	.	.	.	.
Neocrepidolithus spp.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Placozygus sigmoides	X	X	X	X	.	X	X	X	X	X	X	X	X	X	X	X	X	.	X	X	X	X	X	X	X	X	X
Pontosphaera multipora	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Praeprinsius spp.	.	.	X	X	X	.	.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	.	X	.	X	X	.
Sphenolithus anarrhopus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sphenolithus moriformis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sphenolithus primus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sphenolithus spp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Thoracosphaera spp.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	.	X	X	X	X	X	X	X	X	X
Toweius callosus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Toweius eminens eminens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Toweius eminens tovae	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Toweius occultatus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Toweius pertusus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	X	X	.
Transversopontis pulcher	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Zygolithus herlyni	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Zygrhablithus bijugatus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
placoliths	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.
Cretaceous forms	X	X	X	X	X	X	.	.	X	X	.	.	X	X	.	.	.	.	.	X	X	.	X	X	X	X	X
Abundance	C	C	C	F	C	F	F	F	C	A	C	F	C	C	C	C	F	R	F	F	F	C	F	C	C	C	F
Preservation	F	G	G	M	M	M	M	M	G	M	M	M	M	M	M	M	M	T	P	M	P	P	M	G	M	M	P

Formation	Williamsburg																						mbl			Wando			SB	
	Lower Bridge											Chicora Member																		
Santee Coastal Reserve Core	upper																						early							
CHN-803 Series	Paleocene																						Eocene			??			Quat.	
Calcareous Nannofossil Zones	lower NP 5											NP 5		?		NP 6			?				NP 9-10	NP 12		Barren	Barren	Barren	NN 19-21	
Species / Depth (ft)	235.5	233.5	228.7	178.4	171.4	165.4	154.0	141.9	136.0	131.6	126.4	112.9	111.2	106.0	101.0	88.7	87.1	86.1	81.2	77.8	63.3	60.7	51.5	50.4	46.4	41.2	39.9	35.9	26.0	21.7
Biantholithus sparsus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Biscutum spp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Braarudosphaera bigelowii	.	.	X	.	X	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	X	.	.	.	.	X
Braarudosphaera discula	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Braarudosphaera spp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Campylosphaera dela	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.
Chiasmolithus bidens	X	X	X	X	X	X	X	X	X	X	X	X	.	.	.	.	X	X	.	X	.	.	X	.	X	.	.	.	.	.
Chiasmolithus sp. aff. *bidens*	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Chiasmolithus consuetus s.l.	.	X	.	.	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.
Chiasmolithus spp.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.
Coccolithus cribellum	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Coccolithus eopelagicus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.
Coccolithus pelagicus	X	X	X	X	X	.	X	X	X	X	X	X	X	.	X	X	X	X	.	X	.	.	X	X	X	.	.	.	.	.
Cruciplacolithus asymmetricus	.	.	.	.	.	X	.	.	1	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cruciplacolithus edwardsii	.	.	.	.	.	.	.	?	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cruciplacolithus intermedius	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cruciplacolitlhus primus	.	.	X	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cruciplacolithus tenuis	X	X	X	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cruciplacolithus spp.	X	.	.	.	.	.	.	X	.	.	X	X	.	.	.	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.
Cyclagelosphaera prima	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cyclagelosphaera reinhardtii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cyclagelosphaera spp.	.	.	.	.	X	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cyclococcolithus formosus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	.	.	.
Cyclococcolithus robustus	.	.	.	.	.	.	.	.	.	.	.	?	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cyclococcolithus spp.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.
Discoaster barbadiensis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.
Discoaster lenticularis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.
Discoaster multiradiatus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.
Discoaster spp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.
Ellipsolithus bollii	.	X	X	.	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Ellipsolithus distichus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.
Ellipsolithus macellus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	1	.	.	.	.	.
Ericsonia subpertusa	X	X	X	X	X	.	.	X	X	X	X	X	.	.	.	X	X	X	.	.	.	.	X	.	.	.	.	.	.	.
Fasciculithus involutus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.
Fasciculithus spp.	.	.	.	.	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Gephyrocapsa oceanica	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X
Goniolithus fluckigeri	.	X	.	.	.	X	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Heliolithus cantabriae	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.
Heliolithus klelinpellii	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.
Hornibrookina arca	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.
Hornibrookina spp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lanternithus duocavus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Lanternithus sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Markalius apertus	.	.	.	.	.	.	.	.	.	?	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Markalius inversus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.
Micrantholithus aequalis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Micrantholithus attenuatus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Micrantholithus fornicatus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Micrantholithus pinguis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Micrantholithus vesper	.	?	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Micrantholithus spp.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Neochiastozygus concinnus	.	.	.	.	.	X	.	X	X	.	X	.	.	.	.	X	X	X	.	.	.	.	X	2	.	.	.	.	.	.
Neococcolithes sp. aff. *N. protenus*	X	X	X	.	X	X	X	.	.	X	X	X	.	.	.	X	.	X	.	X	.	.	X	.	.	.	.	.	.	.
Neococcolithes spp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.
Neocrepidolithus spp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Placozygus sigmoides	X	X	X	X	X	X	X	X	X	X	X	X	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.
Pontosphaera multipora	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	?	1	.	.	.	.	.	.
Praeprinsius spp.	.	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sphenolithus anarrhopus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.	.	.
Sphenolithus moriformis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	1	.	.	.	.	.
Sphenolithus primus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	?	.	.	.	.	.	.	.
Sphenolithus spp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	X	.	.	.	.	.
Thoracosphaera spp.	X	X	X	X	X	X	X	X	X	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.
Toweius callosus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	X	.	.	.	.	.
Toweius eminens eminens	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.
Toweius eminens tovae	.	.	X	.	.	.	.	.	X	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.
Toweius occultatus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.
Toweius pertusus	X	X	X	X	X	X	X	X	X	X	X	X	X	.	X	X	X	X	.	X	X	X	X	X	1	.	.	.	.	.
Transversopontis pulcher	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.
Zygolithus herlyni	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.
Zygrhablithus bijugatus	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	X	.	.	.	.	.
placoliths	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	X	.	.	.	.	.	.	.	.
Cretaceous forms	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Abundance	F	A	C	F	A	C	F	C	C	F	F	F	F	R	F	F	F	C	R	F	R	R	C	F	F	.	.	.	F	F
Preservation	F	G	G	M	M	M	M	M	M	P	P	P	M	P	M	M	M	G	M	M	P	M	F	P	P	.	.	.	M	M

consistently present as a rare component in the greater than 250 µm fraction. *Inoceramus* prisms were observed in all but the highest Peedee sample. Echinoid spines and fish teeth were observed throughout the studied interval.

Strontium-isotope results

The amount of calcitic infilling of foraminiferal tests decreases upcore through the Peedee Formation. In the lower two samples (466.2 and 436.5 ft), all tests were largely to completely infilled. Specimens selected from the upper three samples (416.8, 403.8, and 371.1 ft) contained minor to partial infilling based on visual screening and preservation of the assemblage was notably better in the upper sample. Observed $^{87}Sr/^{86}Sr$ ratios in the upper three samples are generally appropriate for their age as estimated from calcareous nannofossils, but the ratio in the lower two samples is much higher than expected for its age (fig. 8).

Paleomagnetic results

The whole-core inclination measurements were filtered by removing anomalous intensity spikes, ignoring measurements with positive inclinations greater than 75 degrees (assumed to be a drilling-induced overprint), and deleting data from the top and bottom 5 cm of each core. A three-point moving average was applied to the inclination data to filter some of the random noise, but the stratigraphic plot still displays a high degree of scatter of the data (fig. 9). On the figure, the data have been subdivided into polarity clusters by applying two simplifying assumptions: (1) stratigraphic intervals displaying a relative abundance of negative inclinations represent incomplete demagnetization of *reversed* polarity zones, and (2) intervals that display only rare negative inclinations are *normal* polarity zones. Polarity assignments based on discrete samples show good agreement with the whole-core data and show the reversed intervals more clearly. Polarity determinations were not possible for a number of discrete samples due to very weak magnetization. These very weak values are indicated by INT on figure 8 and on table 4. Chron assignments are interpretative, are based on the micropaleontology, and use the chronostratigraphy of Berggren and others (1995) and Gradstein and others (1995).

Donoho Creek Formation (Black Creek Group)

Upper Campanian - Calcareous Nannofossil Subzone CC 22c
(545.0-475.7 ft)

Age	Formation	depth (ft)	*Palynodinium grallator*	*Disphaerogena carposphaeropsis*	*Thalassiphora pelagica*	*Deflandrea galeata*	*Isabelidinium cooksoniae*	*Xenascus ceratioides*	*Alterbidinium acutulum*
Maastrichtian	Peedee	370.3	X	X	.	X	.	.	.
		380.2	.	.	X	.	.	.	.
		389.3	.	X	.	.	.	.	.
		390.8	.	.	X	.	.	.	.
		400.8	.	.	.	.	.	.	.
		411.9	.	.	.	.	.	.	.
		417.3	.	.	.	.	.	.	.
		426.3	.	.	.	.	.	.	.
		436.4	.	.	.	X	X	.	.
		446.8	.	.	.	.	.	.	.
		456.5	.	.	.	.	.	.	.
		466.0	.	.	.	.	.	.	.
		471.4	.	.	.	.	.	.	.
		474.2	.	.	.	.	X	.	X
Campanian	Donoho Cr.	477.3	.	.	.	.	X	.	X
		481.0	.	.	.	.	.	X	X
		485.9	.	.	.	.	.	X	.

Figure 5. Occurrences of selected dinocyst taxa in the Cretaceous part of the Santee Coastal Reserve core. X=present.

Physical Stratigraphy and Lithology. The Donoho Creek Formation in the Santee Coastal Reserve core consists of 69.3 ft of muddy, calcareous quartz sand of marine origin. It extends from the base of the core at 545 ft to an unconformable contact with the Peedee Formation at 475.7 ft. The basal contact of the Donoho Creek Formation was not penetrated in the Santee Coastal Reserve core.

The Donoho Creek is a homogeneous section of slightly calcareous, muddy quartz sand. The sand fraction typically is very fine to fine, but locally may include 5 to 15 percent medium sand. The sediments typically appear massive or texture-mottled due to intense bioturbation. The clay fraction is present as disseminated matrix and as irregularly shaped, small concentrations (0.1-0.25 in.) that represent the truncated clay linings of burrows. Microfossils are present but sparse, and sand-sized glauconite (very fine to medium sand) and white mica (silt to fine sand) are present in trace amounts to about 1 percent. In the lower part of the recovered Donoho Creek section (below 507 ft), widely spaced zones of non-coalesced calcite-cemented nodules and zones of secondary irregular calcite cementation are present. The upper 3 ft of the Donoho Creek is quite calcareous and has fabric-selective calcite cementation of the sands. The muddy sands of the Donoho Creek section typically are olive gray (5Y4/1). The color is broadly gradational to dark greenish gray (5GY4/1) in the upper ten feet of the unit.

Paleontology. The Donoho Creek Formation is dated as late Campanian, and it represents calcareous nannofossil Subzone CC 22c.

Eleven samples of the Donoho Creek Formation were examined for calcareous nannofossil content. Overall preservation is moderate to good, and diversity and abundance of nannofossil species are high. The eleven samples are placed within calcareous nannofossil Subzone CC 22c on the basis of the co-occurrence of *Reinhardtites levis* (FAD defines the base of Subzone CC 22c) and *Reinhardtites anthophorus* (LAD defines the top of Subzone CC 22c). The presence of *Hexalithus gardetae* further corroborates a late Campanian age.

The Donoho Creek Formation is bounded unconformably at its top by the upper Maastrichtian Peedee Formation, as evidenced by a large number of LAD’s below and FAD’s above the contact (fig. 10). Approximately 16 species have their last occurrence at the top of the Donoho Creek Formation, seven of which are marker species for the late Campanian and early Maastrichtian. This floral turnover coincides with a lithologic break between the Peedee and Donoho Creek Formations. A diversification of the *Lithraphidites* and *Micula* genera and the appearance of late Maastrichtian flora (for example, *Cribrocorona gallica* and *Prediscosphaera grandis*) in the Peedee characterizes the changeover from a latest Campanian to a late Maastrichtian flora (fig. 3).

Three samples were examined for dinoflagellates from the uppermost part of the Donoho Creek Formation. Overall preservation is good, diversity is moderate, and abundance is high. Samples from 485.9 and 481 ft contain common *Fromea fragilis* and also contain less common *Cerodinium pannuceum, Andalusiella polymorpha, Andalusiella spicata*, *Alisogymnium* spp., and *Spinidinium* spp. *Xenascus ceratioides* occurs in these two samples, and its highest occurrence has been used to mark the top of the Campanian (Tocher, 1987; Hoek and others, 1996). The sample at 477.3 ft contains abundant *Areoligera* spp. and common *Exochosphaeridium bifidum*, and less common *Fromea fragilis*, *Andalusiella* spp., and *Cerodinium pannuceum.*

Magnetostratigraphy. Whole-core measurements indicate that the entire recovered Donoho Creek section is of normal polarity. Throughout, the unit displays normal inclinations except for one reversed spike that is likely to be the product of alteration. Because the Donoho Creek is placed in nannofossil Zone CC 22c, this normal polarity interval is interpreted to represent part of chron C33n (fig. 9).

Peedee Formation

Upper Maastrichtian - Calcareous Nannofossil Subzones CC 25b, 26a, and 26b (475.7-367.1 ft)

Physical Stratigraphy and Lithology. The Peedee Formation in the Santee Coastal Reserve core consists of 108.6 ft of silty clay of marine origin. It extends from the unconformable contact with the underlying Donoho Creek Formation at 475.7 ft to an unconformable contact with the Rhems Formation at 367.1 ft.

The contact of the Peedee Formation with the Donoho Creek Formation is sharp, is heavily burrowed, and shows 0.5 in. of relief in the core. The lower 2 ft of the Peedee is a lag deposit consisting of phosphate pebbles up to 1 inch in diameter in a muddy matrix with phosphate and quartz sand. The percentage and grain size of the phosphate fraction decreases upsection to about 470 ft, above which sand-sized phosphate occurs in trace amounts. The basal Peedee section (475.7 to 470.0 ft) is highly burrowed with phosphate, quartz, and microfossils concentrated in the burrows.

Above the basal lag deposit, the Peedee Formation is a homogeneous section of calcareous silty clay. Silt-sized white mica is ubiquitous in small amounts

Formation	PD	Rhems							uR	Williamsburg								m-b limestone			SB
Member										Lower Bridge					Chicora						
Species / depth (ft)	380	366	358	343	326	306	287	273	256	234	214	203	191	166	111	81	63	51	46.4	46.0	26
Achomosphaera alcicornu	.	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.
Adnatosphaeridium sp.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Amphorosphaeridium multispinosum	.	X	.	.	.	.	.	.	.	X	X	X	X	X	.	.	.	.	.	.	.
Andalusiella polymorpha	X	X	X	X	.	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.
Andalusiella sp. aff. *A. polymorpha* of Edwards (1980)	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.
? *Andalusiella rhombohedra* of Edwards and others (1984)	.	.	.	.	.	.	.	X	X	X	.	.	.	.	.	X	.	.	.	.	.
Areoligera volata	.	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
? *Canningia* sp.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.
Carpatella cornuta	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.
Cassidium ? sp.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.
Catillopsis ? sp.	.	.	X	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cerodinium sp.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cerodinium striatum	X	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cordosphaeridium spp.	.	.	.	.	.	.	.	.	X	.	.	.	.	X	X	.	.	.	.	.	.
Cordosphaeridium fibrospinosum	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
Cordosphaeridium inodes	.	X	X	X	X	X	.	.	.	X	X	X	.	.	.	.	.	.	.	.	.
Cribroperidinium sp.	?	X	X	X	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.
Disphaerogena carposphaeropsis	.	X	?	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Damassadinium californicum	.	.	X	X	.	.	X	X	X	.	X	X	X	X	.	.	.	.	.	.	.
Dapsilidinium pseudocolligerum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.
Deflandrea delineata	.	.	.	.	.	.	.	.	.	X	.	X	X	.	.	X	X	.	.	.	.
Deflandrea cf. *D. diebelii* Alberti of Drugg (1967)	.	X	X	X	X	X	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.
Deflandrea n. sp. aff. *D. truncata*	.	X	X	.	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.
Diphyes colligerum	.	X	X	X	.	X	.	X	X	X	X	X	X	.	X	.	X	.	.	.	.
Diphyes ficusoides	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.
Cyclopsiella sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.	.	.	.
Fibrocysta lappacea	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Fibrocysta spp.	X	X	X	X	X	X	X	X	.	X	.	X	X	.	.	.	.	.	.	.	.
Florentinia ferox	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.
Fromea fragilis	X	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.
Hafniasphaera spp.	X	.	.	X	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.
Hafniasphaera septata	.	.	X	.	.	X	X	X	X	X	X	.	.	X	X	X	.	.	.	.	.
Hystrichokolpoma spp.	.	.	X	.	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Hystrichosphaeridium tubiferum	?	X	.	X	X	X	X	X	.	.	.	.	.	.	.	X	.	.	.	.	.
Impagidinium sp.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Isabelidinium cooksoniae	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.
Kallosphaeridium brevibarbatum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	?	.	.	.	.
Kallosphaeridium ? sp.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	X	.	.	.	.	.	.
Lejeunecysta spp.	.	.	.	.	.	.	.	.	X	X	.	.	.	.	.	.	X	.	.	.	.
Lingulodinium machaerophorum	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	.	.	X
Micrhystridium fragile	.	.	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	.	.
Multispinula quanta	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X
Nematosphaeropsis spp.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	X	.	.	.	X
Oligosphaeridium complex	?	.	?	.	?	.	.	?	?	.	.	.	.	.	.	.	.	.	.	.	.
Operculodinium centrocarpum	.	.	.	.	.	.	.	.	X	.	X	X	X	X	X	.	X	.	.	.	.
Operculodinium spp.	?	.	.	.	.	.	X	.	.	X	.	.	.	.	.	.	.	.	.	X	X
Palaeocystodinium golzowense	.	.	.	.	.	.	.	X	.	.	.	.	.	X	.	.	.	.	.	.	.
Palaeocystodinium sp. (fat)	X	X	.	X	X	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.
Palaeoperidinium pyrophorum	X	X	X	X	X	X	.	X	X	.	X	X	X	X	.	.	.	.	.	.	.
Palynodinium grallator	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Paralecaniella indentata	.	.	.	.	.	.	.	X	.	.	X	.	.	.	X	X	X	.	.	.	.
Phelodinium magnificum	X	.	.	.	.	.	X	.	X	.	.	.	.	X	.	.	.	.	.	.	.
Phelodinium sp. of Edwards (1989)	.	.	.	.	.	.	.	.	X	X	X	X	X	X	X	X	X	.	.	.	.
Phelodinium spp.	.	X	X	X	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Polysphaeridium zoharyi	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	.
Selenopemphix sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X
Senoniasphaera inornata	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Spinidinium pulchrum	.	.	.	.	.	X	X	.	.	?	?	.	.	.	.	.	.	.	.	.	.
Spinidinium spp.	.	X	X	X	X	X	X	X	.	.	.	X	X	X	.	.	.	.	.	.	.
Spiniferella cornuta	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Spiniferites mirabilis	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X
Spiniferites pseudofurcatus	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	X	?	.	.	.	.
Spiniferites spp.	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Spongodinium delitiense	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tanyosphaeridium xanthiopyxides	.	X	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.
Tectatodinium pellitum	.	.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	X	.	X
Tectatodinium rugulatum	.	.	.	.	.	.	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.
Tenua sp. cf. *T. formosa* of Kurita and McIntyre (1995)	.	.	.	.	.	X	X	X	.	.	.	.	.	.	.	.	.	.	.	.	.
Thalassiphora delicata	.	.	.	.	.	.	.	.	.	.	.	.	.	.	?	X	X	.	.	.	.
? *Thalassiphora* sp.	X	X	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.
Trigonopyxidia ginella	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.	.
Turbiosphaera sp.	.	.	.	.	.	.	.	.	X	.	.	.	.	.	.	.	.	.	.	.	.
Turbiosphaera sp. aff. *T. magnifica* of Edwards (1989)	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X	X	X	.	.	.	.
Xenikoon australis sensu Benson (1976)	.	.	.	.	.	.	.	.	.	X	.	.	.	.	X	.	.	.	.	.	.
Wetzeliella sp.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	R
miscellaneous areoligeracean forms	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	.	.	.	X	R
miscellaneous cladopyxiaceaen forms	.	.	.	.	.	.	.	X	X	.	X	.	X	.	X	X	.	.	.	.	.
small peridiniacean forms	X	X	.	.	.	X	X	X	X	X	X	X	X	X	X	X	X	?	.	.	.
freshwater alga *Pediastrum*	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	X

Figure 6. Occurrences of dinocyst taxa in the Santee Coastal Reserve core. PD=Peedee, uR=upper part of Rhems Formation *sensu* Bybell and others (1998), m-b= molluscan-bryozoan, SB=Silver Bluff beds (informal); X=present, ?=questionably present, R=reworked.

(trace to 1 percent), and very fine quartz sand is locally present. Glauconite is present in trace amounts. Calcareous microfossils and sand-sized mollusk fragments are common to locally abundant throughout the Peedee section.

The Peedee sediments appear massive or texture-mottled due to intense bioturbation. Discrete burrows typically are not seen although small sulfide-cemented burrows and partially calcite-cemented, sand-filled burrows are sparsely disseminated throughout the formation. A minor concentration of phosphate in the form of granules, small pebbles, and vertebrate fragments is present at 415 to 414 ft. The color of the Peedee sediments varies from olive gray (5Y4/1) to light olive gray (5Y6/1).

Paleontology. The Peedee Formation is dated as late Maastrichtian. It represents calcareous nannofossil Subzones CC 25b, 26a, and 26b and sediments deposited during the timespan of the *Gansserina gansseri* and *Abathomphalus mayaroensis* foraminiferal Zones.

Twenty-three samples from the Peedee Formation were examined for calcareous nannofossil content. Preservation throughout the formation is good to moderate, and abundances are typically high. The lower ten samples, from 474.1 to 426.0 ft, are placed in Subzone CC 25b on the basis of the presence of *Lithraphidites quadratus* (FAD defines the base of Subzone CC 25b) and on the absence of *Ceratolithoides kamptneri* and *Nephrolithus frequens,* two species used to identify the base of Zone CC 26. Further informal subdivision of Subzone CC 25b into lower and upper sections is possible on the basis of the FAD of *Lithraphidites grossopectinatus* at 456.0 ft.

Subzone CC 25c appears to be missing in this core on the basis of the delayed first occurrence of *Micula murus* (FAD defines the base of Subzone CC 25c). Although this subzone is recorded from sediments offshore of South Carolina on the Blake Nose (Norris and others, 1998), it is rarely documented from the marine Upper Cretaceous of onshore South Carolina (Self-Trail and Gohn, 1996; Self-Trail and Bybell, 1997). The delayed first occurrence of *M. murus*, within Subzone CC 26a, suggests that, although Subbiozone CC 25c is missing, its chronozone is possibly present. In the nearby Cannon Park core, *M. murus* also has a delayed first occurrence (Bybell and others, 1998).

The base of Subzone CC 26a is placed at 420.1 ft on the basis of the first occurrence of *Ceratolithoides kamptneri*. The first appearance of *Lithraphidites kennethii* at 416.8 ft, just one sample above the base of Subzone CC 26a, suggests either that this subzone is truncated in the Santee Coastal Reserve core or that *L. kennethii* occurs earlier here than elsewhere. Typically, the first appearance of *L. kennethii* occurs midway through Subzone CC 26a, rather than near the base. Subzone CC 26b is present from 390.4 through 368.3 ft; its base is marked by the first occurrence of *Micula prinsii*. Due to the paucity of calcareous nannofossil datums in the latest late Maastrichtian, it is sometimes difficult to determine whether Subzone CC 26b is complete. However, comparison of the biostratigraphic data with the paleomagnetic and lithologic data reveals that a small hiatus (less than 1 m.y.) exists at the Cretaceous/Tertiary boundary and most likely encompasses the top of Zone CC 26b. Scattered specimens of *Aspidolithus parcus parcus, Reinhardtites anthophorus,* and *Orastrum campanensis* throughout this formation are evidence of reworking of Campanian sediments up into the Peedee.

The planktic foraminifer distribution data are presented on figure 7. Preservation of the foraminiferal tests is moderate for most samples from 466.2 to 436.5 ft and good from 426.0 to 371.1 ft. Foraminifera are abundant in all samples examined, and planktic:benthic ratios vary between 0.7 and 0.3. *Inoceramus* prisms are common at 466.2 ft and consistently present through 376.6 ft, but were not observed at 371.1 ft. Echinoid spines and fish teeth were observed throughout the studied interval.

Planktic foraminifer assemblages are dominated by species of *Heterohelix* and *Globigerinelloides*. Double-keeled species are rare, and single-keeled species and multiserial heterohelicid taxa are very rare. The only Late Cretaceous zonal biomarker is *Gansserina gansseri,* which occurs sporadically from 456 to 381.7 ft. The first occurrence of this species defines the base of the upper Campanian-lower Maastrichtian *G. gansseri* Zone, and the species is known to range into upper Maastrichtian sediments (Robaszynski and others, 1984). Despite intensive searching, *Abathomphalus mayaroensis* was not found in any sample and thus, the overlying *A. mayaroensis* Zone cannot be identified and the Maastrichtian Stage cannot be subdivided biostratigraphically. A Maastrichtian age is assigned to all samples on the basis of occurrences of *Trinitella scotti* and *Planoglobulina acervulinoides*, which are known to range from the middle *G. gansseri* Zone through the *A. mayaroensis* Zone elsewhere in low latitudes (Robaszynski and others, 1984; Nederbragt, 1991). Absence of *Plummerita hantkeninoides* from the top of the Cretaceous sequence suggests that uppermost Maastrichtian sediments are not represented in the Peedee Formation from this site.

Age	depth (ft)	Preservation	Foraminifer abundance	Planktic:benthic ratio	Ostracodes	*Inoceramus* prisms	*Gansserina gansseri*	*Globigerinelloides prairiehillensis*	*Globigerinelloides subcarinatus*	*Globotruncana aegyptiaca*	*Globotruncana arca*	*Globotruncana orientalis*	*Globotruncana rosetta*	*Globotruncana ventricosa*	*Globotruncanella havanensis*	*Globotruncanella petaloidea*	*Globotruncanita stuartiformis*	*Guembelitria cretacea*	*Hedbergella monmouthensis*	*Heterohelix globulosa*	*Heterohelix navarroensis*	*Heterohelix striata*	*Laeviheterohelix glabrans*	*Planoglobulina acervulinoides*	*Planoglobulina multicamerata*	*Pseudoguembelina costulata*	*Pseudoguembelina kempensis*	*Pseudoguembelina palpebra*	*Pseudotextularia elegans*	*Pseudotextularia intermedia*	*Pseudotextularia nuttali*	*Racemiguembelina fructicosa*	*Rugoglobigerina hexacamerata*	*Rugoglobigerina rugosa*	*Trinitella scotti*
Maastrichtian	371.1	G	A	0.7	R	.	.	C	.	P	.	.	R	.	.	R	P	P	.	A	F	F	R	R	P	R	P	R	P	.	.	P	.	C	R
	376.6	G	A	0.3	R	P	.	F	.	.	.	.	.	.	.	.	.	C	.	A	C	R	.	.	.	.	.	.	.	.	.	.	.	R	.
	381.7	G	A	0.5	P	P	R	F	.	.	.	.	.	.	.	.	.	C	.	A	C	.	.	.	.	.	.	P	.	.	.	.	.	P	.
	387.9	G	A	0.6	R	P	.	C	.	.	.	.	P	.	.	.	.	F	P	A	F	F	.	.	.	.	.	.	.	.	.	.	.	P	.
	390.4	G	A	0.6	R	P	.	F	.	P	.	.	.	.	.	.	.	C	.	A	C	R	R	.	.	P	.	.	.	.	.	.	P	R	.
	393.0	M	A	0.5	R	P	.	F	.	.	.	.	.	.	.	.	.	C	.	A	C	R	.	.	.	.	.	.	.	.	.	.	.	R	.
	403.8	G	A	0.5	R	P	R	C	.	.	P	P	.	.	.	.	.	C	.	A	C	R	.	.	.	P	.	P	P	.	.	.	.	R	.
	412.0	G	A	0.5	R	P	.	F	.	.	P	.	.	.	.	.	.	C	.	A	C	P	.	.	.	.	.	.	.	.	.	.	P	R	.
	416.8	G	A	0.4	R	P	P	F	.	P	P	.	.	.	.	.	.	C	.	A	C	.	P	P	.	.	.	.	.	.	.	.	P	P	P
	426.0	G	A	0.6	R	P	.	F	.	P	.	.	.	.	.	P	.	C	.	A	C	.	.	.	.	.	.	.	.	.	P	.	P	R	.
	436.5	M	A	0.4	R	P	P	C	R	P	.	.	.	P	.	P	.	A	.	A	C	P	P	.	.	.	.	.	.	.	P	.	P	P	.
	446.6	M	A	0.6	R	F	.	C	F	P	P	.	.	.	.	.	.	R	.	A	C	.	.	.	.	.	.	P	.	.	P	.	P	R	P
	456.0	M	A	0.6	R	F	P	C	F	.	P	.	.	.	P	P	.	P	.	A	F	P	P	.	.	.	.	.	.	.	P	.	P	R	.
	466.2	M	A	0.7	R	C	.	A	R	P	P	.	.	P	.	P	.	P	.	A	F	P	P	P	.	.	.	.	.	P	.	.	P	R	.

Figure 7. Occurrences of foraminifera in the Santee Coastal Reserve core. G=good preservation, M=moderate preservation, A = abundant (>30%), C = common (10-30%), F = few (5-10%), R = rare (1-5%), P = present (<1%).

The benthic foraminifer assemblage is dominated by large lenticulinids and species of *Anomalinoides* and *Cibicides* and includes few to common occurrences of dentalinids and nodosariids. Absence of inner neritic milioline species and bathyal indicators such as *Gavelinella beccariiformis* and *Nuttalides truempyi* suggest an outer neritic paleobathymetric setting. Observed planktic:benthic ratios between 0.7 and 0.3 are consistent with such a depth assignment (Gibson, 1989).

Identification of *Inoceramus* prisms in all but the uppermost sample would suggest a middle Maastrichtian age or an older age on the basis of correlation with the inoceramid extinction datum at deep-sea sites (MacLeod, 1994a; MacLeod and others, 1996). The extinction of this group is known to be time-transgressive across paleolatitudes and paleodepths. The local LAD of inoceramids occurs earliest in high southern latitudes and relatively onshore sites (making predictions for the Santee Coastal Reserve core difficult), but the observed LAD within Subzone CC 26b is considerably younger than any previous reports (MacLeod and others, 1996). The inoceramid genus *Tenuipteria* does range to the Cretaceous/Tertiary boundary (MacLeod, 1994b; MacLeod and Orr, 1993), and *Tenuipteria* prisms have been reported throughout upper Maastrichtian strata ODP Hole 605A drilled off southern New Jersey (MacLeod and others, 1996). While prisms in the Santee Coastal Reserve core are morphologically similar to the *Tenuipteria* prisms identified elsewhere, it should be noted that differences in prism morphology between *Tenuipteria* and *Inoceramus* are subtle and have yet to be rigorously documented (MacLeod and Orr, 1993; MacLeod and others, 1996). Thus, without independent support such as macrofossil ranges (MacLeod and Orr, 1993) or bimodal size distribution (MacLeod and others, 1996), this explanation for the prisms must be qualified with alternative hypotheses that include reworking and local survivorship of *Inoceramus*.

Fifteen samples were examined for dinoflagellates from the Peedee Formation. Overall preservation is good, diversity and abundance are high, and the overall assemblage is typical of the Maastrichtian. The lower part of the Peedee Formation, between samples at 474.2 and 466.0 ft, has assemblages dominated by small peridiniacean forms including *Senegalinium* sp. and *Piercites pentagonum*. In the upper part of the Peedee between 456.5 and 370.3 ft, the assemblages are characterized by a high abundance of *Glaphyrocysta* spp. A succession of datums through this formation indicates mostly a late Maastrichtian age, which is in close agreement with the calcareous nannofossil data. The highest occurrence of *Alterbidinium acutulum* is at 474.2 ft, just above the base of the Peedee Formation.

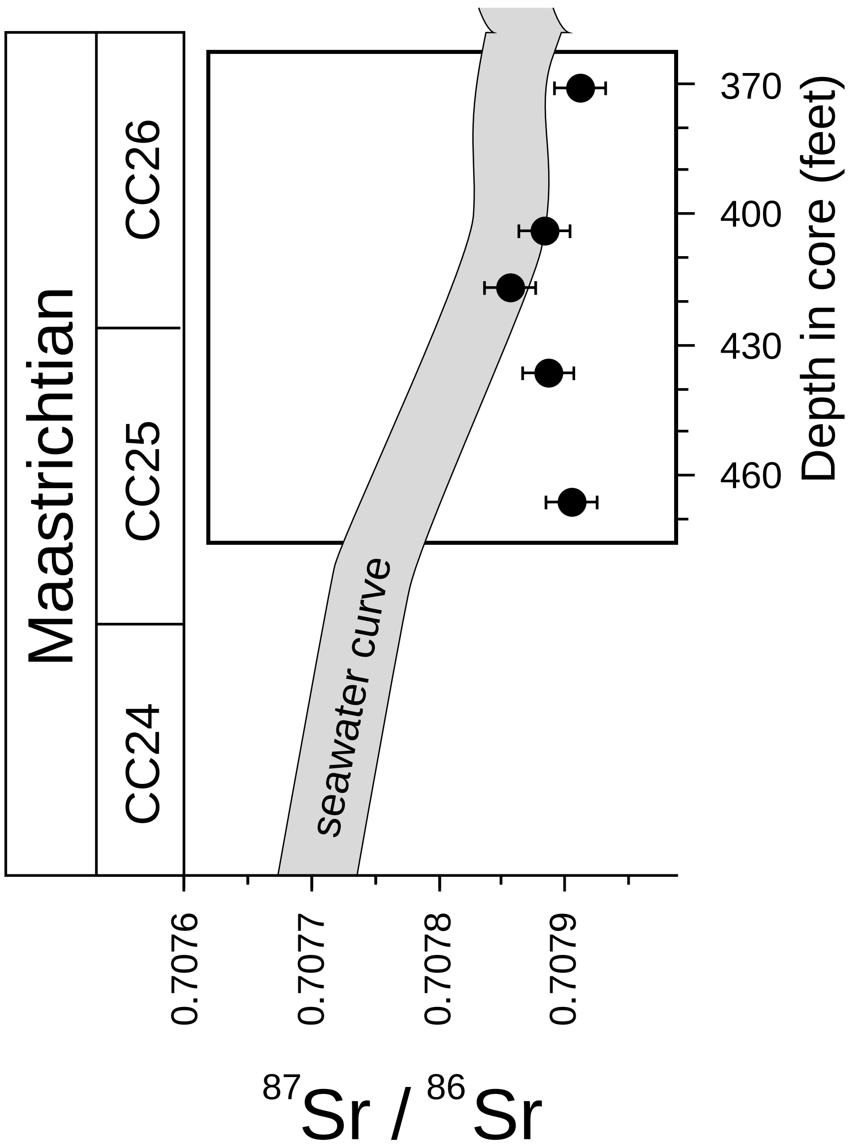

Figure 8. Strontium-isotopic results from the Peedee Formation plotted against an expected seawater curve inferred from Martin and MacDougall (1991), Nelson and others (1991), Barrera (1994), McArthur and others (1994), and MacLeod and Huber (1996). Preservation is better in upper samples and declines downcore. The departure of the lower samples from the seawater curve likely represents diagenetic alternation. The upper samples may preserve original ^{87}Sr/^{86}Sr ratios, or diagenetic values may coincidentally match values of paleoseawater in this interval. Plotted ^{87}Sr/^{86}Sr ratios were corrected for a ^{86}Sr/^{88}Sr mass discrimination of 0.1194 and adjusted by the difference between the within turret average value of NBS-987 (n= 3 or 4) and 0.710250. The long term average for NBS-987 over the course of this study is 0.710259 ± 0.000016 (2-sigma standard deviation, n=65); error bars plotted as ± 0.00002.

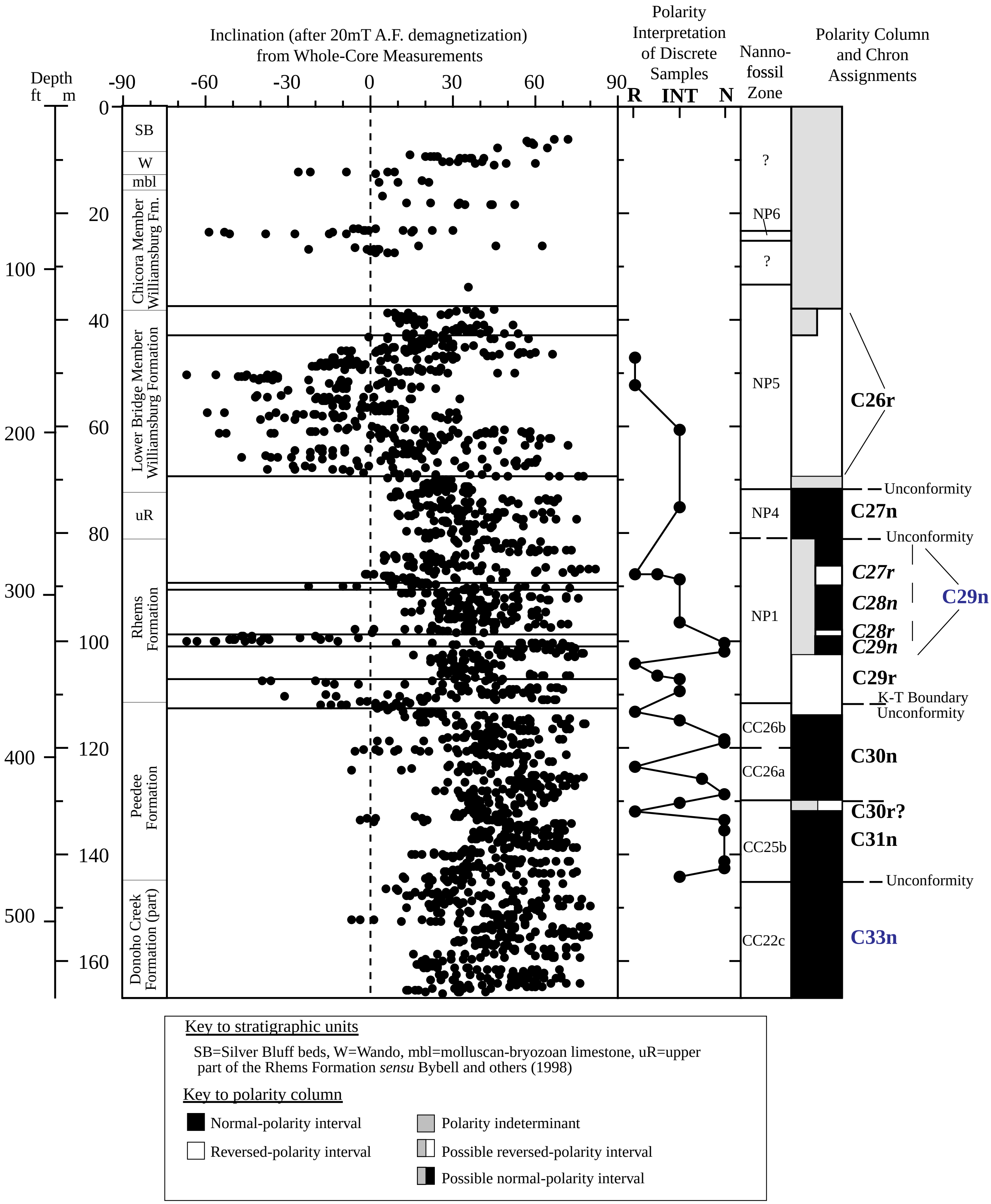

Figure 9. Santee Coastal Reserve core magnetostratigraphy. Chron assignments in italics represent an alternate, less likely interpretation.

Based on the correlations of Schiøler and Wilson (1993), this datum occurs slightly below the boundary between the lower and upper Maastrichtian, which suggests that the lowest part of the Peedee Formation could be of latest early Maastrichtian age. *Isabelidinium cooksoniae* ranges up to 436.4 ft, which is in the upper part of the nannofossil Subzone CC 25b. This species has a reported LAD in the type Maastrichtian in the lower part of nannofossil Subzone CC 26a (Schiøler and others, 1997). The lowest occurrence of *Deflandrea galeata* also is at 436.4 ft. The FAD's of the following three species occur in succession within the upper part of the Peedee Formation: *Thalassiphora pelagica* at 390.8 ft, *Disphaerogena carposphaeropsis* at 389.3 ft, and *Palynodinium grallator* at 370.3 ft. These taxa corroborate the nannofossil assignment of late Maastrichtian age to this interval. The occurrences of key dinocyst species in the Peedee are shown on figure 5. A detailed species list for one of the samples is given in appendix 4.

Strontium-isotope stratigraphy. Strontium isotopes can provide independent chronostratigraphic data (Hodell, 1994; McArthur, 1994). Because of the occurrence of inoceramid remains as high as nannofossil Subzone CC 26b, strontium isotopes were measured on samples from the Peedee Formation in an attempt to confirm nannofossil age determinations. Unfortunately, these analyses yielded equivocal results (fig.8). Where foraminiferal tests are only partially infilled by diagenetic calcite, measured values are at the high end of values expected for contemporary seawater based on nannofossil age determinations. For largely infilled specimens, values are similar to those observed in the better preserved specimens but do not match expected seawater values. Thus, better preserved specimens may retain depositional seawater $^{87}Sr/^{86}Sr$ values (and strontium-isotopic analyses may be useful higher in the core). On the other hand, even non-infilled specimens may be modified by a diagenetic overprint that coincidentally approximates seawater values for the latest Maastrichtian.

Magnetostratigraphy. From the base of the Peedee up to about 373 ft, whole-core measurements display mostly normal inclinations. Two discrete samples display reversed polarity at or near where whole-core measurements show reversed spikes (horizons 0.5-1.5 ft thick), and one discrete sample displays a normal inclination where whole-core measurements show a reversed spike. These thin horizons could possibly indicate brief intervals of reversed polarity, or they could be the products of alteration (possibly due to remobilization of iron). These brief spikes also appear as intensity spikes and therefore are more likely to be products of alteration. Correlation with calcareous nannofossil Subzones CC 25b, CC 26a, and CC 26b indicates that the normal-polarity interval represents chron C30n (and possibly chron C30r) and part of C31n. Whole-core measurements of the uppermost 6 ft of the Peedee (about 373 to 367 ft) display very low positive inclinations, and the discrete sample at 371.4 ft displays a reverse polarity. This interval is interpreted to represent chron C29r.

Rhems Formation (Black Mingo Group) *sensu stricto*

Lower Paleocene - Calcareous Nannofossil Zone NP 1
(367.1-267.3 ft)

Physical Stratigraphy and Lithology. The Rhems Formation *sensu stricto* in the Santee Coastal Reserve core consists of 99.8 ft of silty clay, muddy sand, and minor calcite-cemented, shelly sand of marine origin. It extends from the unconformable contact with the Peedee Formation at 367.1 ft to an unconformable contact at 267.3 ft. At present, we can not positively correlate the Rhems Formation in the Santee Coastal Reserve with either the Browns Ferry Member and (or) the Perkins Bluff Member of the Rhems defined by Van Nieuwenhuise and Colquhoun (1982) from outcrop sections in Georgetown County, S.C.

The Rhems Formation *sensu stricto* extends from 367.1 to 267.3 ft and consists of fine-grained marine deposits. The basal contact of the Rhems with the underlying Peedee Formation is lithologically sharp but burrowed. Burrows with diameters of 0.5 to 1.0 in., which contain phosphatic Rhems sediments, extend down at least 3 ft into the Peedee section. The basal six feet of the Rhems (367.1-361.1 ft) consists of silty clay that contains 5 to 10 percent phosphate sand and granules, common sand- and granule-sized mollusk fragments, and an abundant microfauna. The phosphate decreases in abundance upsection. This section appears massive and is grayish olive green (5GY3/2).

The section above about 361.0 ft consists of fine-grained marine deposits that become better sorted and sandier upward. This section is broadly gradational from micaceous sandy and silty clay (361.0 to about 332.0 ft) to clayey, very fine sand (332.0 to 275.0 ft). Common microfossils and sand- and granule-sized mollusk fragments are present throughout these deposits along with trace amounts to a few percent of

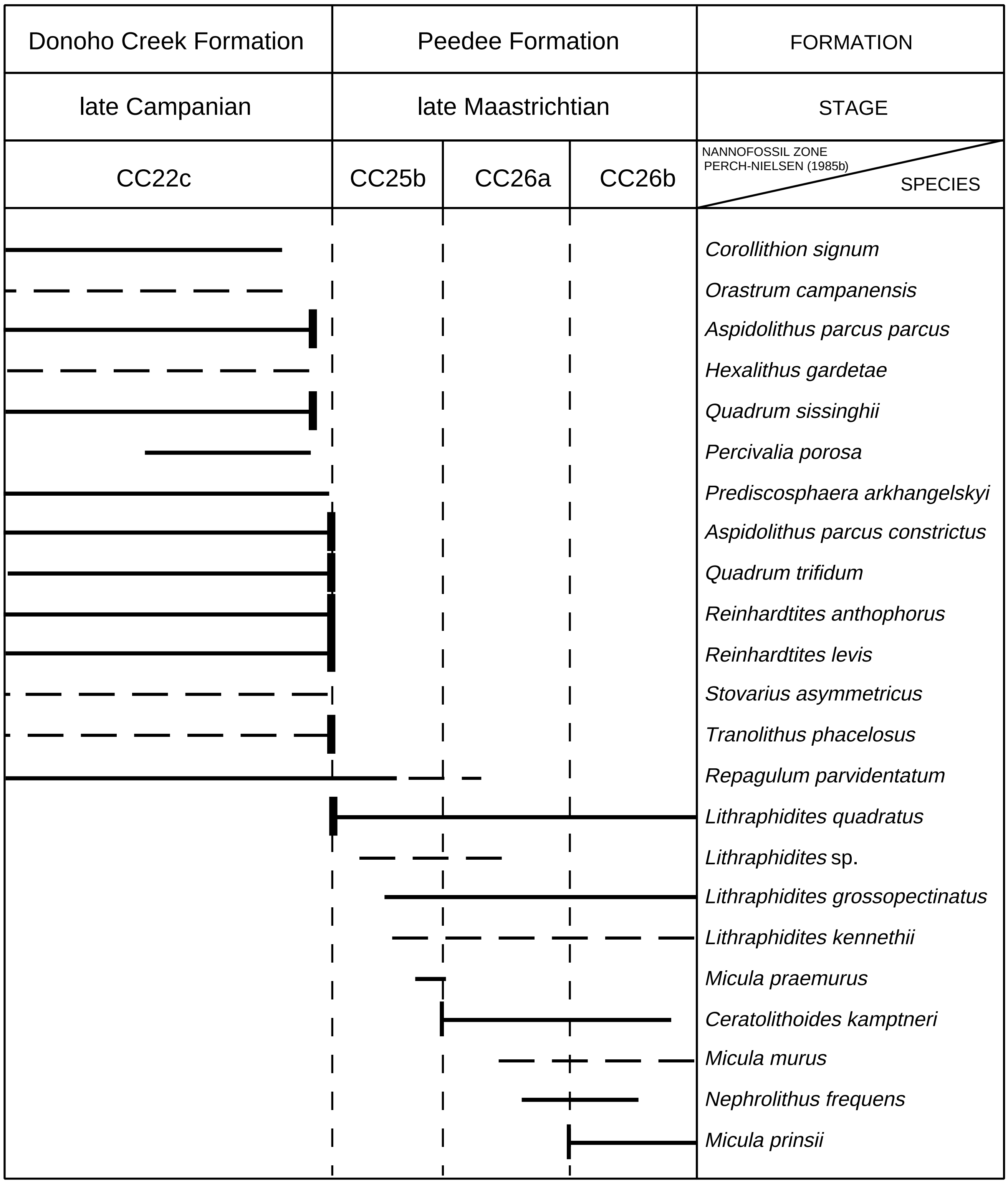

Figure 10. Ranges of Cretaceous calcareous nannofossils in the Santee Coastal Reserve core. Solid line indicates consistent occurrences; dashed line indicates sporadic occurrences; horizontal lines indicate range bases (FAD's) or tops (LAD's).

silt- to fine-sand-sized glauconite and mica. Molds of thin-valved, aragonitic (?) pelecypods were seen locally. Abundant sand-filled burrows with spreiten are present throughout the section from 361.0 to 275.0 ft. Calcite-cemented zones that vary from 0.25 to 1.0 ft in thickness are spaced irregularly throughout this interval, and one or two cemented zones typically are present in a given 10-ft section. The top 7.7 ft also is calcite cemented and has the appearance of a quartzose, fossiliferous limestone. The color of the clayey sediments in the lower member varies from olive gray (5Y3/2 and 5Y4/1) to dark greenish gray (5GY4/1) to greenish black (5GY2/1). The cemented intervals are distinctly lighter in color, varying from light olive gray (5Y5/2) to very light gray (N8).

Paleontology. The Rhems Formation *sensu stricto* is dated as early Paleocene, and it represents calcareous nannofossil Zone NP 1. Nannofossil Zones NP 2 and NP 3 are not recognized in the Santee Coastal Reserve core, and an unconformity that represents a hiatus of at least 2.4 million years (Berggren and others, 1995) is presumed to be present between the Rhems *sensu stricto* and overlying upper part of the Rhems Formation *sensu* Bybell and others (1998).

Twenty-one calcareous nannofossil samples were examined from the Rhems Formation between 367.1 and 267.3 ft (fig. 4). These samples are assigned to Zone NP 1 on the basis of the presence of *Cruciplacolithus primus* and *Cruciplacolithus intermedius* (FAD's in Zone NP 1) and on the absence of *Cruciplacolithus tenuis* (FAD defines the base of Zone NP 2). A series of first occurrences in the lower part of Zone NP 1 has been used by Heck and Prins (1987) to subdivide this zone. This series of FAD's, from oldest to youngest, is *C. primus*, *Placozygus sigmoides*, *C. intermedius*, and *Cruciplacolithus asymmetricus*. The presence of the first three species in this series in the lowest Rhems samples in the Santee Coastal Reserve core, and the lowest occurrence of *C. asymmetricus* in the sample at 365.9 ft support the use of this series to recognize the absence of the lowest part of Zone NP 1 in the Rhems here. Occasional downhole contamination is present in the Zone NP 1 samples, particularly in the sandier parts of the Rhems. This contamination, which consists of single specimens, is considered to be the result of drilling mud penetrating the core.

Eight samples from the Rhems were studied for dinocysts (fig. 6, appendix 4). These samples contain moderately well preserved assemblages of early Paleocene age and include such species as *Andalusiella polymorpha*, *Areoligera volata*, *Damassadinium californicum*, *Carpatella cornuta*, *Deflandrea* cf. *D. diebelii* Alberti of Drugg (1967), *Deflandrea* n. sp. aff. *D. truncata*, *Tectatodinium rugulatum*, and *Tenua* sp. cf. *T. formosa* of Kurita and McIntyre (1995). Reworking of Cretaceous specimens is noticeable in the lowest sample (365.9 ft).

Five samples from the Rhems were examined for pollen (table 1). These did not yield sufficient material for further study.

Magnetostratigraphy. Whole-core data for the Rhems Formation *sensu stricto* display mainly positive inclinations except for three intervals displaying an abundance of negative inclinations (fig. 9). Discrete samples for this interval (table 4, fig. 9) are of reversed polarity near the bottom and top and normal around 330 ft. The interval from 367.1 to 338 ft is interpreted to represent a continuation of chron C29r. This interpretation is made because the sediments are included in calcareous nannofossil Zone NP 1 and because whole-core measurements are mainly reversed and, where they display positive inclinations, discrete samples have reversed polarity. The interval from 338 to 267.3 ft is considered problematic, as the whole-core and discrete measurements do not show good agreement. Because these sediments are included in Zone NP 1, they must be either chron C29r or C29n. We favor C29n because of the positive inclination of discrete samples at 335.1 and 329.5 ft. An alternative interpretation of the magnetostratigraphy is that the reversed-normal-reversed-normal-reversed pattern represents the complete sequence from chron C29r to C27r. This interpretation requires that sediments from the chronozones of NP 2 and NP 3 be present.

Upper part of the Rhems Formation (Black Mingo Group) *sensu* Bybell and others (1998)

Lower Paleocene - Calcareous Nannofossil Zone NP 4 (part)
(267.3-237.4 ft)

Physical Stratigraphy and Lithology. The Rhems Formation *sensu* Bybell and others (1998) in the Santee Coastal Reserve core consists of 29.9 ft of calcite-cemented muddy sand and burrowed fine sand of marine origin. It extends from the unconformable contact with the Rhems Formation *sensu stricto* at 267.3 ft to an unconformable contact with the Lower Bridge Member of the Williamsburg Formation at 237.4 ft. This unit is correlative with the upper part of the Rhems Formation as identified by

Table 1. Summary of samples from the Santee Coastal Reserve corehole that were examined for pollen [X=yes, do.=ditto]

Palynology number		Depth (ft)	Stratigraphic unit	Shown in pollen occurrence table 2 or 3	Provides data about sample ages
R5306	AE	26.0	Silver Bluff beds	3	X
	AG	46.0	mollusk-bryozoan limestone	3	X
	AC	46.4	mollusk-bryozoan limestone	3	X
	AF	51.0	mollusk-bryozoan limestone	3	X
	Z	63.3	Chicora Member, Williamsburg Fm.	2	X
	X	81.2	do.	2	X
	W	86.1	do.		
	S	111.2	do.		
	R	126.5-126.7	Lower Bridge Member, Williamsburg Fm.		
	P	165.5-165.7	do.		
	O	191.6	do.	2	
	N	203.0-203.2	do.		
	M	214.3-214.5	do.	2	
	L	255.7-256.0	Rhems Fm. *sensu* Bybell and others (1998)	2	
	J	287.5	Rhems Fm. *sensu stricto*		
	I	306.0-306.2	do.		
	H	326.0	do.		
	G	342.9	do.		
	D	358.5	do.		

Bybell and others (1998) in the Cannon Park core. In both cores, the unit is lithologically similar to, and biostratigraphically correlative with, the lower part of the Lower Bridge Member of the Williamsburg Formation in its type area (L. Edwards, R. Weems, A. Sanders, unpublished data, 1998).

The basal unconformity at 267.3 ft is sharp and has little relief. The lower 10.3 ft consists of slightly muddy, very fine to fine, quartz-glauconite-phosphate sand. Phosphate granules are abundant in the basal 0.5 ft. This sand contains a few percent of mica and common microfosssils. This interval is locally strongly to moderately cemented with calcite.

From 257.0 ft to its top at 237.4 ft, the unit consists of muddy very fine to fine sand with the sand fraction concentrated in very abundant sand-filled burrows. This interval contains a few percent of mica, trace amounts of glauconite, and moderately common microfossils.

Paleontology. The upper part of the Rhems Formation *sensu* Bybell and others (1998) is placed in calcareous nannofossil Zone NP 4. According to the time scale of Berggren and others (1995), this zone is both early and late Paleocene.

Six calcareous nannofossil samples were examined between 265.5 and 239.3 ft. They are placed in Zone NP 4 on the basis of the occurrences of *Chiasmolithus* sp. aff. *C. bidens* and *Toweius pertusus* at 265.5 ft (FAD's in NP 4) and *Ellipsolithus macellus* (FAD defines the base of Zone NP 4), and the absence of any species that first appear in Zone NP 5. It was not possible to subdivide the Zone NP 4 sediments in this core with calcareous nannofossils.

A single sample was examined for dinocysts (255.7-256.0 ft). It lacks many of the species found in the Rhems Formation *sensu stricto* samples and contains the only occurrence in the Santee Coastal Reserve core of the short-ranging, but unnamed form *Andalusiella* sp. aff. *A. polymorpha* of Edwards (1980)

Table 2. Distribution of Early Tertiary pollen taxa in the Santee Coastal Reserve core
[X = present; P = identification is probable]

Depth (ft)	255.7-256.0	214.3-214.5	191.6	81.2	63.3
Bombacacidites reticulatus			X		X
Carya <29µm				X	X
Caryapollenites prodromus group			P	X	
Choanopollenites conspicuus					P
Choanopollenites patricius					X
Favitricolporites baculoferus	X				
Holkopollenites chemardensis	X			X	X
Intratriporopollenites pseudinstructus			X		
Milfordia minima				X	X
Momipites coryloides		X	X		
Momipites microfoveolatus		X			
Momipites strictus				X	
Momipites tenuipolus group	X		X		
Nudopollis terminalis	X	X		X	X
Pseudoplicapollis limitatus				X	X
Thomsonipollis magnificus				X	X
Triatriopollenites subtriangulus					X
Trudopollis plenus		X	X		
Trudopollis spp.			X		
Ulmipollenites tricostatus			X		

Table 3. Distribution of Late Tertiary to Quaternary pollen taxa in the Santee Coastal Reserve core
[X = present; P = identification is probable.]

depth (ft)	51.0	46.4	46.0	26.0
Abies (fir)	X			
Compositae (sunflower family), long-spined	X		X	
Carya (hickory)	X	X	X	X
Fagus (beech)			P	
Gramineae (grass family)	X			
Liquidambar (sweet-gum)	X	X	X	X
Nyssa (black gum)		X		X
Pinus (pine)	X	X	X	X
Quercus (oak)	X	X	X	X
Tsuga (hemlock)				X
Ulmus/*Zelkova* (elm or a close relative)	X			

Table 4. Magnetic-polarity ratings for discrete samples
[R=reversed polarity, R/2=weakly reversed polarity, INT=intermediate polarity, N=normal polarity, N/2=weakly reversed polarity]

Sample	Depth (m)	Depth (ft)	Polarity rating
SCR-154	47.09	154.5	R
SCR-171	52.27	171.5	R
SCR-199	60.66	199.0	INT
SCR-246	75.04	246.2	INT
SCR-287	87.63	287.5	R
SCR-288	87.66	287.6	R/2
SCR-290	88.48	290.3	INT
SCR-317	96.62	317.0	INT
SCR-329	100.43	329.5	N
SCR-335	102.14	335.1	N
SCR-342	104.24	342.0	R
SCR-349	106.50	349.4	R/2
SCR-351	107.11	351.4	INT
SCR-359	109.50	359.2	INT
SCR-372	113.48	372.3	R
SCR-377	114.97	377.2	INT
SCR-389	118.63	389.2	N
SCR-391	119.27	391.3	N
SCR-406	123.69	405.8	R
SCR-413	125.97	413.3	N/2
SCR-423	128.89	422.9	N
SCR-428	130.33	427.6	INT
SCR-434	132.19	433.7	R
SCR-438	133.56	438.2	N
SCR-445	135.73	445.3	N
SCR-464	141.43	464.0	N
SCR-468	142.65	468.0	N
SCR-474	144.41	473.8	INT

and the lowest occurrence of *Phelodinium* sp. of Edwards (1989). The lowest occurrence of the latter species is found in other cores near the base of the upper Paleocene.

One sample was examined for pollen (table 1). This sample (from 255.7-256.0 ft, table 2) yielded only a few taxa that are not very age diagnostic, but do corroborate the Paleocene age indicated by other microfossil groups.

Magnetostratigraphy. Whole-core data from the upper part of the Rhems Formation *sensu* Bybell and others (1998) (267.3-237.4 ft) display normal polarity; the discrete sample from this unit was indeterminate. We interpret the unit to be a normal-polarity interval. Because these sediments represent nannofossil Zone NP 4, this normal-polarity interval represents chron C27n. According to Berggren and others (1995), only a small part on this nannofossil zone is of normal polarity; this part is considered to be the uppermost part of the lower Paleocene and represents less than half a million years (61.3-60.9 Ma).

Lower Bridge Member of the Williamsburg Formation (Black Mingo Group)

Upper Paleocene - Calcareous Nannofossil Zone NP 5 (lower part)
(237.4-125. 0 ft)

Physical Stratigraphy and Lithology. The Lower Bridge Member of the Williamsburg Formation is present from 237.4 to 125.0 ft in the Santee Coastal Reserve core, a thickness of 112.4 ft. An unconformable contact at 205.0 ft divides the Lower Bridge Member into two parts that are referred to herein as the lower beds and upper beds.

Lower beds. The lower beds of the Lower Bridge Member (Williamsburg Formation) extend from 237.4 to 205.0 ft, a thickness of 32.4 ft. The contact of the lower beds with the underlying upper part of the Rhems Formation *sensu* Bybell and others (1998) at 237.4 ft is a flat, horizontal, lithologically sharp unconformity. Approximately the lower 10 ft of the lower beds, from 237.4 to about 227.4 ft, consists of muddy quartz-phosphate-glauconite sand. Phosphate granules and small pebbles also are present along with locally sparse to common microfossils. The phosphate-glauconite fraction decreases upward in this interval. Parts of this basal lithology are calcite cemented. The color in this interval varies from greenish black (5GY2/1) in the lower part to olive gray (5Y3/2) in the upper part.

The remainder of the lower beds from about 227.4 ft to the upper contact at 205.5 ft is a homogeneous section of moderately muddy, very fine to fine sand. The interval is moderately glauconitic (about 5 percent) and also contains a few percent of mica, common microfossils, and sparse, comminuted shell fragments. The unit is extensively bioturbated. Common, irregularly distributed calcite-cemented layers typically are about 0.5 ft thick, and two or three usually occur in a given 10-ft interval. The sediment color changes from dark greenish gray (5GY4/1) in the lower part of the interval to olive gray (5Y3/2) and light olive gray (5Y5/2) in the upper part.

Upper beds. The upper beds of the Lower Bridge Member extend from 205.0 ft to the upper contact of the Lower Bridge with the Chicora Member of the Williamsburg Formation at 125.0 ft, a thickness of 80.0 ft. The contact between the lower and upper beds is an irregular burrowed surface; and the burrows, which are filled with glauconitic and phosphatic sand from the basal part of the upper beds, extend at least two feet into the lower beds.

The lower three feet of the upper beds consists of muddy, very fine to medium quartz-glauconite-phosphate sand. Common microfossils, as well as mollusk fragments, shark teeth, and spicules, are present in this basal lag deposit. The color of these basal deposits is olive black (5Y2/1). From 202 ft to the upper contact of the Lower Bridge Member at 125 ft, the upper beds consist of a homogeneous section of calcareous, silty and sandy clay. The quartz-sand fraction is very fine grained and increases slightly in percent upward in the section. Moderately common microfossils and sand-sized mollusk fragments are present throughout this interval as is a small amount (less than 5 percent) of silt-sized mica. Fabrics in these fine-grained deposits vary from laminated to partially bioturbated to completely bioturbated. Sediment colors vary from greenish black (5GY2/1) to dark greenish gray (5GY4/1).

Paleontology. The Lower Bridge Member of the Williamsburg Formation is dated as early in the late Paleocene. The entire member is placed in the lower part of calcareous nannofossil Zone NP 5.

Eleven calcareous nannofossil samples were examined from the Lower Bridge Member of the Williamsburg Formation. All are placed in the lower part of Zone NP 5 on the basis of the presence of *Chiasmolithus bidens* (FAD occurs near the base of Zone NP 5) and the absence of species that first appear in the upper part of Zone NP 5 (*Heliolithus cantabriae*) or Zone NP 6 (*Heliolithus kleinpellii*). *Fasciculithus tympaniformis* (FAD defines the base of Zone NP 5) is absent in the Santee Coastal Reserve core, and members of the genus *Fasciculithus* have not been observed in large numbers in any South Carolina sections.

Five samples from the Lower Bridge were studied for dinocysts (fig. 6, appendix 4). They contain moderately diverse assemblages that include *Amphorosphaeridium multispinosum*, *Damassadinium californicum*, *Deflandrea delineata*, *Palaeoperidinium pyrophorum*, *Phelodinium* sp. of Edwards (1989), and *Spinidinium* spp. Here, as in the Cannon Park core, *D. delineata* has its lowest occurrence and *P. pyrophorum* has its highest occurrence in the Lower Bridge (Bybell and others, 1998).

Five samples from the Lower Bridge were examined for pollen (table 1). Three did not yield sufficient material for further study. Two samples (from 214.3-214.5 and 191.6 ft, table 2) yielded only a few taxa that are not very age diagnostic, but do corroborate the Paleocene age indicated by other microfossil groups.

Magnetostratigraphy. From 237.4 to approximately 140 ft, the whole-core data display an abundance of negative inclinations. Of the discrete samples, two are reversed and one is indeterminate. We interpret this part of the Lower Bridge as a reversed-polarity interval. Because this interval is placed in the lower part of nannofossil Zone NP 5, it is interpreted to represent part of chron C26r. Above 140 ft in the Lower Bridge, whole-core measurement are positive, and no discrete samples were taken.

Chicora Member of the Williamsburg Formation (Black Mingo Group)

Upper Paleocene - Calcareous Nannofossil Zones NP 5 and NP 6
(125.0-51.5 ft)

Physical Stratigraphy and Lithology. The Chicora Member of the Williamsburg Formation consists of 73.5 ft of muddy, shelly sand of marine origin. It extends from an unrecovered basal contact at approximately 125 ft to an unconformable contact with the overlying mollusk-bryozoan limestone at 51.5 ft. A sharp, burrowed contact at 84.7 ft within the Chicora section may indicate an additional unconformity.

The contact of the Chicora Member with the underlying Lower Bridge Member was not recovered; the contact is assigned to a depth of 125 ft at the base of a one-foot-thick unrecovered interval. Cores collected directly above and below the unrecovered interval serve to characterize the lithologic change at this boundary. The section at the top of the Lower Bridge Member consists of bioturbated, calcareous, sandy (very fine) and silty clay. The clay contains common sand-sized mollusk fragments and microfossils. The lowest core from the Chicora Member consists of calcite-cemented, shelly, very fine to fine quartz sand. The sand contains fragments of oysters and other calcitic mollusks up to 2 inches in size. This material could be described as sandy limestone; however the presence of calcitic mollusks and a moderately high moldic (mollusk) porosity suggests that the original sediment was shelly sand that subsequently was cemented with calcium carbonate supplied by the dissolution of aragonitic mollusks.

Core recovery was comparatively poor in the Chicora Member because of the tendency for cemented and macrofossiliferous intervals to plug the drill bit. However, recovery was sufficient to characterize the Chicora lithologies. The principal lithology is calcareous, variably muddy, shelly, quartz sand. The quartz-sand fraction varies in individual layers from very fine to fine, fine to medium, or fine to coarse. Microfossils are moderately common throughout the unit. Mollusk fragments, principally calcitic pelecypods, are present in the sand and granule fraction and as larger fragments up to several inches long. The mollusk fragments are locally moderately abundant to very abundant. Large, thick-valved oysters are a characteristic component of the Chicora sediments. The most shell-rich beds appear as quartzose limestone due to a secondary calcite cement. These shell-rich deposits typically have moderate to very high moldic (mollusk) porosities that are only slightly reduced by sparry cement. Low-angle inclined bedding surfaces are present at several places in the Chicora section and may represent hummocky cross stratification. Sediment colors typically are olive gray (5Y4/1) and light olive gray (5Y6/1). The sandy and porous character of the Chicora sediments is reflected by the low radiation values and high electrical resistances seen on the gamma-ray and resistance logs. These log signatures contrast sharply with those associated with the underlying fine-grained Cretaceous and Paleocene units.

Paleontology. The Chicora Member of the Williamsburg Formation is dated as late Paleocene. Although much of the unit is difficult to date precisely in the Santee Coastal Reserve core, the lower part of the unit is assigned to calcareous nannofossil Zone NP 5, and the middle part of the unit is assigned to Zone NP 6. Elsewhere in South Carolina, the Chicora Formation is known to include sediments in Zones NP 8 or 9 (Edwards and others, 1997; Bybell and others, 1998)

Eleven calcareous nannofossil samples were examined from the Chicora (fig. 4). The lowest sample (112.9 ft) is placed in Zone NP 5 on the basis of the presence of *Chiasmolithus bidens* (FAD occurs near the base of Zone NP 5). The absence of *Heliolithus cantabriae* (FAD in the upper part of Zone NP 5) normally would indicate the lower part of Zone NP 5. The next higher sample (111.2 ft) contains a single specimen of *H. cantabriae* and is most likely in the upper part of Zone NP 5. Neither of these samples can be placed incontestably in the lower or upper part of Zone NP 5, but it is most likely that both are in the upper part of Zone NP 5. Three samples from 88.7 to 86.1 ft are placed in Zone NP 6 on the basis of the presence of *Heliolithus kleinpellii* (FAD defines the base of Zone NP 6) and the absence of discoasters (FAD in Zone NP 7) and *Heliolithus riedellii* (FAD defines base of Zone NP 8). Samples from 81.2 ft to the top of the Chicora did not yield diagnostic nannofossils.

Three samples from the Chicora were examined for dinocysts (fig. 6, appendix 4). All contain relatively low abundances of dinocysts. The lowest occurrence of *Turbiosphaera* sp. aff. *T. magnifica* and the highest occurrence of *Xenikoon australis sensu* Benson (1976) are in the lowest Chicora sample at 111.2 ft. These species have also been found in the upper Paleocene Aquia Formation in Virginia (Edwards, 1989).

Four samples from the Chicora were examined for pollen (table 1). Although two yielded little or no pollen, the two upper samples (81.2 and 63.3 ft, table 2) contain *Carya* <29 µm, whose range base is within the upper part of calcareous nannofossil Zone NP 5. The sample at 63.3 ft contains *Choanopollenites patricius* and probable *C. conspicuus*, indicating a probable correlation with calcareous nannofossil Zones NP 6 to lower NP 8.

Magnetostratigraphy. Inclination data for the first 125 ft of the Santee Coastal Reserve core are sparse, and polarity determinations were not possible.

Mollusk-bryozoan Limestone

Lower Eocene - Calcareous Nannofossil Zones NP 9/10 and NP 12.
(51.5-42.0 ft)

Physical Stratigraphy and Lithology. A 9.5-ft-thick section of mollusk-bryozoan limestone above the Chicora Member of the Williamsburg Formation in the Santee Coastal Reserve core is not assigned to a formation at this time. The location of the Santee Coastal Reserve core site within the subcrop belt of the Santee Limestone (Weems and Lewis, 1997) would support the assignment of this limestone to the Santee. This poorly recovered limestone is not the same age as the Santee and may consist of two units of different ages. It may be equivalent to the lower Eocene Fishburne Formation (Gohn and others, 1983), or the lower Eocene Congaree Formation (Fallaw and Price, 1995), or parts of both. It could represent the upper Eocene Harleyville

Formation (Ward and others, 1979; Weems and Lemon, 1984) or, less likely on the basis of physical characteristics, the Pliocene Goose Creek Limestone (Weems and Lewis, 1997); in either case it would have to include reworked lower Eocene material. It could also represent one or more previously undescribed units. The Santee Limestone *sensu stricto* is of middle Eocene age (Ward and others, 1979, Willoughby and Nystrom, 1992; Fallaw and Price, 1995).

The contact between the mollusk-bryozoan limestone and the underlying Chicora Member of the Williamsburg Formation at 51.5 ft is a highly burrowed, highly irregular unconformity. The Chicora section immediately below the contact consists of sandy (quartzose) mollusk limestone with a moderately high meso- to megamoldic porosity. The uppermost foot of this section is a rubble zone containing clasts (or pseudoclasts produced during drilling) with phosphatic coatings and encrusting serpulid worm tubes, which collectively mark the unconformity. Burrows containing fill from the basal part of the overlying limestone extend at least 4 ft below the contact. The burrow fill consists of phosphate sand and granules, bryozoans, and mollusk fragments. These phosphatic deposits are represented by a moderate-sized spike on the gamma-ray log (fig. 2).

This unassigned unit consists of macrofossil limestone (pelecypod-bryozoan-gastropod packstone and grainstone). The limestone contains several percent of medium quartz sand, probably reworked from the underlying Chicora Member, and trace amounts of phosphate and glauconite. The typical color is yellowish gray (5Y8/1).

Paleontology. Paleontological evidence for the age of the mollusk-bryozoan limestone in the Santee Coastal Reserve core is ambiguous. Two different assemblages of calcareous nannofossils were found, in addition to pollen that is late Oligocene or, more likely, younger and dinocysts that are late Eocene or younger. No microfossils restricted to middle Eocene age were encountered. We infer that sediments of two different early Eocene ages (Zone NP 9/10 and Zone NP 12) are present and that the palynomorphs are transported from above.

Five samples were examined for calcareous nannofossils. The lowest sample at 51.5 ft is assigned to the very uppermost part of Zone NP 9 or Zone NP 10. Although the Paleocene/Eocene boundary has not yet been set by international agreement, this sample is most probably of earliest Eocene age. It contains *Transversopontis pulcher* (FAD in the very top of NP 9) and *Discoaster lenticularis*, *Hornibrookina arca*, *Placosygus sigmoides*, and *Toweius eminens eminens* (LAD's within Zone NP 10). The samples at 50.4 and 46.4 ft are assigned to early Eocene Zone NP 12 on the basis of occurrence in each of *Cyclococcolithus formosus* (FAD in Zone NP 12) and *Ellipsolithus macellus*, *Toweius callosus*, and *Toweius pertusus* (LAD's in Zone NP 12), and on the absence of *Discoaster multiradiatus* and *Zygodiscus herlyni* (LAD's in Zone NP 11). Two additional samples at 51.0 and 46.0 ft did not yield diagnostic assemblages.

Four samples were examined for dinocysts (fig. 6, appendix 4). The samples at 51.0 and 46.4 ft each contain only a few specimens of long-ranging forms. The sample at 46.0 contains *Dapsilidinium pseudocolligerum* which ranges from late Eocene to Pliocene. The sample at 35.9 ft does not contain dinocysts.

A sample at 46.4 ft (table 3) contains pollen grains of temperate forest genera that together range from late Oligocene to Holocene. Because *Pinus* is represented mostly by *P. diploxylon* types, and because Miocene (and Pliocene) genera such as *Momipites*, *Sciadopitys*, and *Pterocarya* were not observed, the pollen in this sample may be Quaternary. These results suggest contamination, but because no modern-looking herb pollen (such as ragweed) was seen, the contamination, if it is contamination, likely would be from higher in the core rather than from modern airborne pollen.

Magnetostratigraphy. Inclination data for the first 125 ft of the Santee Coastal Reserve core are sparse, and polarity determinations were not possible.

Wando Formation

Upper Pleistocene
(42.0 to 28.0 ft)

Physical Stratigraphy and Lithology. The Wando Formation consists of 14 ft of muddy gravel and sands. The contact with the underlying mollusk-bryozoan limestone is within an unrecovered interval; it is placed at 42.0 ft on the basis of the gamma-ray log. The Wando is overlain by the Silver Bluff beds (informal) at 28.0 ft. In South Carolina, the Wando Formation consists mostly of barrier and backbarrier facies. Isotopic ages of the unit cluster around 100,000 yrs ago (Soller and Mills, 1992).

From 42.0 to 38.5 ft, the basal part of the Wando Formation consists of muddy gravel containing fine to very coarse quartz, phosphate, and glauconite sand; quartz and limestone granules and pebbles; and sparse limestone cobbles. The color of this section varies from grayish green (5G5/2) to medium dark gray (N4).

This lag deposit overlies and is derived in part from the underlying mollusk-bryozoan limestone.

Above the lag deposit, the Wando consists of muddy sands. The coarser fraction of the deposits from 38.5 to 35.0 ft consists primarily of fine to very coarse quartz sand, whereas fine to coarse quartz sand is present from 35.0 to 32.0 ft. The section from 32.0 to 26.3 ft was not recovered. The section from 38.5 to 32.0 ft contains a few percent of mica and trace amounts of glauconite and shell fragments (possibly reworked), and sparse to locally common comminuted plant material. Colors vary from medium dark gray (N4) to light gray (N7). A very organic-rich layer is present at 35.0 to 34.6 ft. The Wando Formation has been recognized in numerous auger holes in the study area by Weems and Lewis (1997).

Paleontology. The Wando Formation in the Santee Coastal Reserve core could not be dated paleontologically. Corals from marine beds elsewhere in the Wando have U/Th ratios that correspond to the Sangamon interglacial of 130,000 to 70,000 years ago (Cronin and others, 1981).

Three samples from the Wando Formation in this core were examined for calcareous nannofossils. All are barren.

A single sample from the Wando was examined for dinocysts and found to be barren. No samples were examined from the Wando for pollen.

Magnetostratigraphy. Inclination data for the upper part of the Santee Coastal Reserve core are sparse, and polarity determinations were not possible.

Silver Bluff beds (informal)

Quaternary (probably upper Pleistocene)
Calcareous Nannofossil Zones NP 19-21
(28.0-0 ft)

Physical Stratigraphy and Lithology. The upper 28.0 ft of the Santee Coastal Reserve core probably consists of upper Pleistocene deposits. The informal terms “Silver Bluff beds” (Weems and Lewis, 1997) and “Silver Bluff Terrace” (Colquhoun, 1974) have been applied to these sediments. The contact between the Wando Formation and the Silver Bluff beds is placed in an unrecovered interval at 28.0 ft on the basis of the gamma-ray log and adjacent recovered cores. Core recovery was relatively poor.

Poorly consolidated, very shelly quartz sand was recovered in the lower part of the Silver Bluff beds from 26.3 to 25.0 ft. This lower part consists of nearly equal proportions of very coarse quartz sand and granule- and pebble-sized mollusk fragments with a few percent of clay matrix and about 1 percent of phosphate sand. The color of this shelly sand is greenish black (5G2/1). This lithology likely extends from 28.0 to 23.0 ft according to the gamma-ray log.

Material recovered from 22.0 to 17.3 ft consists of layers of silty clay and well-sorted quartz silt and very fine sand that alternate on a scale of tenths of inches to 2.0 inches. The sand layers locally contain shell fragments and have low-angle cross-laminations. These deposits are typically greenish black (5G2/1) with lighter brown colors in the sands.

Material recovered above 12.2 ft consists of well-sorted, fine to medium quartz sand with fine to very coarse sand present above 3.4 ft. The Silver Bluff beds also are recognized in auger holes in this area by Weems and Lewis (1997).

A radiocarbon date of 33,000 yr before present was obtained from the base of the Silver Bluff beds in a pit in central Charleston County (Weems and Lemon, 1993).

Paleontology. Samples from the Silver Bluff beds are Quaternary. Two calcareous nannofossil samples (26.0 and 21.7 ft) contain *Gephyrocapsa oceanica* and are thus Pleistocene or younger. A sample at 26.0 ft contains pollen grains of temperate forest genera that together range from late Oligocene to Holocene (table 3). Because *Pinus* is represented mostly by *P. diploxylon* types, and because Miocene (and Pliocene) genera such as *Momipites*, *Sciadopitys*, and *Pterocarya* were not observed, the sample is probably Quaternary. No modern-looking herb pollen (such as ragweed) was seen, so the sample is probably older than modern settlement. Similarly, *Tsuga* (hemlock) is now an upland and not a coastal plain tree in the Carolinas (Radford and others, 1968); therefore, the presence of *Tsuga* in the sample from 26.0 ft is consistent with the Pleistocene radiocarbon date.

Magnetostratigraphy. Inclination data for the upper part of the Santee Coastal Reserve core are sparse, and polarity determinations were not possible.

IMPLICATIONS AND CONCLUSIONS

Sediment accumulation rates were calculated using calcareous nannofossil datums and magnetostratigraphy, with maximum thicknesses based on lithologic contacts (fig. 11). Because the bottom of the core did not penetrate the entire Donoho Creek Formation,

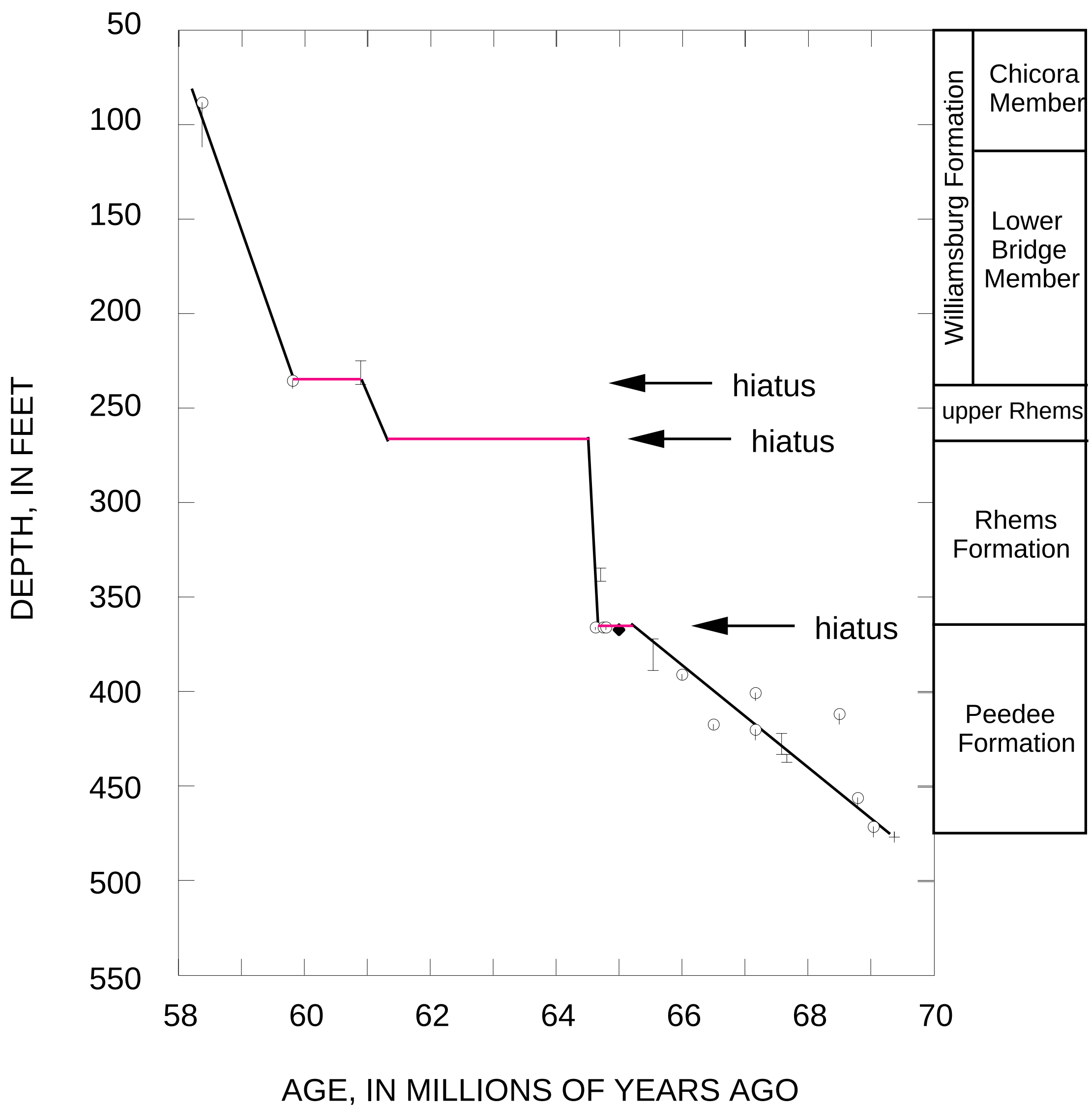

Figure 11. Age-depth relations for the Santee Coastal Reserve core, S.C., using calcareous nannofossil and magnetostratigraphic datums. Ages of datums are as assigned by Berggren and others (1995). ⚲, FAD; +, LAD; ◆, Cretaceous/Tertiary boundary; ⌶ paleomagnetic datum. See table 5 for values. Upper Rhems is the upper part of the Rhems Formation *sensu* Bybell and others (1998).

Table 5. Values used in calculations of sediment accumulation rates for the Santee Coastal Reserve core.

[Next sample is the next lower or next higher sample from the event and gives an approximate error range for the event, FAD=first appearance datum, LAD=last appearance datum. Ages of datums are from Henriksson (1994), Berggren and others (1995), and Erba and others (1995). Interpolated ages (int.) are based on Berggren and others (1995) and unpublished data of Bybell. *As discussed in text]

Event	Age (Ma)	Depth (ft)	Next sample
FAD *Heliolithus kleinpellii*	58.40	-88.7	-111.2
base Zone NP 5	59.70	-235.5	-239.3
FAD *Cruciplacolithus asymmetricus* (int.)	64.65	-365.9	-367.1
FAD *Cruciplacolithus intermedius* (int.)	64.75	-365.9	-367.1
FAD *Cruciplacolithus primus*	64.80	-365.9	-367.1
FAD *Micula prinsii*	66.00	-390.4	-393.2
FAD *Lithraphidites kennethii* (int.)	66.50	-416.8	-420.1
FAD *Ceratolithoides kampteri**	67.20	-420.1	-426.0
FAD *Nephrolithus frequens*	67.20	-400.7	-405.0
FAD *Micula murus*	68.50	-412.0	-416.8
FAD *Lithraphidites grossopectinatus* (int.)	68.80	-456.0	-461.1
FAD *Lithraphidites quadratus*	69.00	-471.4	-477.3
LAD *Reinhardtites levis*	69.40	-477.3	-474.1
K/T boundary	65.00	-367.0	
Paleomagnetics			
C27n/C26r	60.920	-225.7	-237.5
C29r/C29n	64.745	-342.0	-335.1
C30n/C29r	65.578	-389.2	-372.3
C30r/C30n	67.610	-433.7	-422.9
C31n/C30r	67.735	-433.7	-438.2

nannofossil FAD's are not sufficient to deduce an accumulation rate for this formation. The assumption of nearly continuous sedimentation throughout the Peedee yields an accumulation rate of 27 ft/m.y. (8.2 m/m.y.). An unconformity is visible at the Cretaceous/Tertiary boundary and represents a small part of each period. The highest accumulation rate is computed for the Rhems Formation *sensu stricto.* The whole unit is dated as Zone NP 1, and, on the basis of the presence of *Cruciplacolithus intermedius* and the absence of *Cruciplacolithus tenuis* (FAD's at 64.75 and 64.50 Ma, respectively), the rate is 400 ft/m.y. (122 m/m.y.) or greater. Because the entire upper part of the Rhems Formation *sensu* Bybell and others (1998) has normal polarity, the sediment accumulation rate for it is constrained by the length of chron C27n; the resulting rate is 83.9 ft/m.y. (25.6 m/m.y.) or greater. Within the Williamsburg, the base of calcareous nannofossil Zone NP 5 and the FAD of *Heliolithus kleinpellii* are used to calculate a minimum rate of 9.8 ft/m.y. (3.0 m/m.y). Sedimentation rates could not be calculated above the Chicora Member of the Williamsburg Formation.

The part of figure 11 that represents the Peedee Formation shows a constant rate of sediment accumulation. This constant-rate interpretation has several important consequences. First, it suggests that, although Biozone CC 25c is absent, sediment representing the time span of this biozone is present. The lowest occurrence of *Micula murus* in the Santee Coastal Reserve core does not represent its evolutionary first occurrence, but rather represents a delayed arrival due to environmental conditions. Data from this and other cores (such as ODP Leg 171 sites, Self-Trail, unpublished data) indicate that *M. murus* is more abundant in offshore environments. Its delayed arrival in the Santee Coastal Reserve core suggests that sediments from the lower part of the Peedee Formation represent relatively shallow water conditions, whereas sediments from the upper part represent somewhat deeper conditions. The slight increase in gamma-ray counts toward the top of the Peedee is compatible with the increased clay content that would occur in a deeper and more offshore environment. Second, the intersection of the line of correlation with the lowest occurrence of *Ceratolithoides kamptneri* indicates that this species can indeed be used as a proxy for the base of Biozone CC 26a, as suggested by Perch-Nielsen (1985b) and Burnett (1998). It is herein recommended that the first occurrence of *C. kamptneri* be assigned an age of 67.2 Ma on the basis of correlation of this biostratigraphic event to the recently revised global polarity time scale of Gradstein and others (1995). Continued documentation of this biostratigraphic event and its correlation to the time scale and polarity chrons will be needed in order to verify the accuracy of this age. Third, the constant-rate interpretation suggests that sediment deposited during magnetochron C30r is present from about 436 to 433 ft. Whole-core measurements and a discrete sample in this interval were thought to represent either a brief interval of reversed polarity or the products of alteration (possibly due to remobilization of iron). The combined fossil and paleomagnetic data favor the interpretation of original reversed polarity. The discrete sample at 405.8 ft also displayed reversed polarity, but it does not correspond to any known reversed chron. It is likely to represent alteration. Fourth, the latest Cretaceous section is nearly complete. The age-depth plot, and the relative thickness of Subzone CC 26b within chron 30n when compared to the thickness of Subzone CC 26b in chron 29r, indicates that sediment representing only the uppermost 0.1 m.y. of the Cretaceous is absent at the top of the Peedee Formation.

Both inoceramid prisms and the succession of dinocyst occurrences indicate either that the base of the Peedee is near the lower/upper Maastrichtian boundary or that latitudinal effects of taxon ranges are a factor in this core.

The rapid rate of sediment accumulation during Rhems time is striking, especially since only part of Zone NP 1 is represented. Despite re-examination of many samples, no evidence of Zone NP 2 or NP 3 sediments was found, although sediments of this age have been found in other coastal South Carolina cores (L. Bybell, unpublished data).

The paleomagnetic data for the Rhems (three reversed-polarity intervals separated by two normal-polarity intervals) does not match the expected magnetostratigraphy for this part nannofossil Zone NP 1 (a reversed-polarity interval overlain by a normal-polarity interval). One possibility, although this is unlikely, is that this interval may represent a complete sequence from C29r to C27r, in which case, sediments representing the chronozones of NP 2, NP 3, and part of NP 4 would be present without bearing the diagnostic calcareous nannofossils.

The unit referred to here as the upper part of the Rhems Formation *sensu* Bybell and others (1998) clearly warrants more study because of its lithostratigraphic uncertainty and its position relative to the lower/upper Paleocene boundary. The unit shows wholly normal polarity. Unless it has been remagnetized, it represents only a small part of calcareous nannofossil Zone NP 4 (chron C27n). The latest correlations of Berggren and others (1995) place this part of NP 4 in the uppermost part of the lower Paleocene.

The Lower Bridge Member of the Williamsburg Formation contains an unconformity at 205.0 ft which separates it into two parts (lower and upper beds). Both parts of the member are assigned to the lower part of calcareous nannofossil Zone NP 5 (lower part of the upper Paleocene).

The Chicora Member of the Williamsburg Formation is dated as late Paleocene. Although much of the unit is difficult to date precisely, part of the unit is assigned to calcareous nannofossil Zone NP 5 and part of the unit to Zone NP 6.

A 9.5-ft-thick, poorly recovered section of mollusk-bryozoan limestone above the Chicora Member of the Williamsburg in the Santee Coastal Reserve core is unlikely to represent the Santee Limestone, although it has been assigned to the Santee in nearby auger holes. Two different assemblages of nannofossils were found: one assigned to the very uppermost part of Zone NP 9 or Zone NP 10 (earliest Eocene age) and one assigned to Zone NP 12 (early Eocene). No microfossils restricted to the middle Eocene, the age of the Santee, were encountered. Pollen recovered from this limestone are likely to have been transported down from younger material.

Sediments of middle and late Eocene, Oligocene, Miocene, and Pliocene ages were not recovered in the Santee Coastal Reserve core. The upper 42 ft of sediments represent Pleistocene deposits.

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Appendix 1. Lithologic log for the Santee Coastal Reserve core, generalized from site log.

Abbreviations: tr = trace, < = less than, % = percent. Sand-fraction grain size: vf = very fine, f = fine, m = medium, c = coarse, vc = very coarse. Percentages are semi-quantitative visual estimates. Colors refer to the Geological Society of America Rock Color Chart (Goddard and others, 1984).

Run 1: 1.0 - 5.0 ft

Silver Bluff beds: Top of recovered section.

1.0 - 3.4 ft: SAND, quartz, f-vc, slightly muddy (< 5%); mica (tr), noncalcareous; modern roots in top 1.5 ft; unconsolidated; dark-yellowish-orange (10YR6/6).
3.4 - 3.6 ft: SAND, quartz, f-m, mica (<5%), glauconite (tr), phosphate (tr), noncalcareous; unconsolidated; light-olive-gray (5Y6/1).
3.6 - 5.0 ft: No recovery.

Run 2: 5.0 ft - 10.0 ft

5.0 - 8.4 ft: SAND, quartz, f-m, mica (<5%), glauconite (tr), phosphate (tr), noncalcareous; unconsolidated; light-olive-gray (5Y6/1).
8.4 - 10.0 ft: No recovery.

Run 3: 10.0 - 15.0 ft

10.0 - 12.2 ft: SAND, quartz, f-m, slightly muddy (<5%); mica (<5%), glauconite (tr), phosphate (tr), noncalcareous, unconsolidated; stained dark-yellowish-orange (10YR6/6).
12.2 - 15.0 ft: No recovery.

Run 4: 15.0 - 20.0 ft

15.0 - 17.3 ft: No recovery.
17.3 - 20.0 ft: SILT, quartz, clayey (10-15%), sandy (quartz, 10-20%, vf); mica (<5%), noncalcareous; low angle (<5%) cross bedding and thin laminations, poorly consolidated, greenish-black (5G2/1).

Run 5: 20.0 - 25.0 ft

20.0 - 22.0 ft: SILT, quartz, clayey, as above, except with 0.3-ft-thick layers of mollusks, primarily pelecypods.
22.0 - 25.0 ft: No recovery.

Run 6: 25.0 - 30.0 ft

25.0 - 26.3 ft: SAND, quartz, vc, slightly muddy (<5%); phosphate (1%), mollusk fragments (40-50%, up to 25 mm), greenish-black (5G2/1).
26.3 - 30.0 ft: No recovery.

Wando Formation: Top of recovered section.

Run 7: 30.0-35.0 ft

30.0 - 32.0 ft: No recovery.

32.0 - 35.0 ft: CLAY, silty, sandy (f-c); mica (<5%), glauconite (tr), comminuted plant material (locally up to 10%; 95% in basal 0.4 ft); low-angle cross beds in plant-rich intervals; medium-dark-gray (N4).

Run 8: 35.0 - 38.5 ft

SAND, quartz, f-vc, muddy (30-40%); mica (<5%), mollusk fragments (locally 1-3%), massive, light-gray (N7) to medium-light-gray (N6).

Run 9: 38.5 - 40.5 ft

38.5 - 40.0 ft: SAND, quartz, f-vc, muddy, gravelly (quartz granules and pebbles, limestone pebbles and cobbles); phosphate (f-vc, <10%), glauconite (f-vc, <10%), medium-dark-gray (N4).

40.0 - 40.5 ft: CLAY, sandy (quartz, vf), silty (quartz); mica (<5%), phosphate (10%), glauconite (5%); microfossils (<5%), plant material (<5%); grayish-green (5G5/2).

Run 10: 40.5 - 45.0 ft

40.5 - 41.5 ft: CLAY, sandy and silty with phosphate and glauconite, as above. Limestone pebbles at base

41.5 - 45.0 ft: No recovery.

Run 11: 45.0 - 50.0 ft

Mollusk-bryozoan limestone: Top of recovered section.

45.0 - 46.9 ft: LIMESTONE (mollusk-bryozoan-foraminifer grainstone or packstone); phosphate (tr), glauconite (tr); yellowish-gray (5Y8/1).

46.9 - 50.0 ft: No recovery.

Run 12: 50.0 - 55.0 ft

50.0 - 51.5 ft: LIMESTONE, mollusk-bryozoan-foraminifer grainstone or packstone, as above.

Chicora Member, Williamsburg Formation, Black Mingo Group: Top of recovered section.

51.5 - 52.6 ft: Contact interval, broken core. LIMESTONE (cemented mollusk grainstone or packstone); limestone fragments partially covered with phosphate coatings and encrusting serpulid worm tubes in upper half of interval; phosphate and glauconite (sand and granules, 5-10%) in upper half, moderate meso- to megamoldic porosity, slightly cement-reduced; primarily yellowish-gray (5Y8/1).

52.6 - 55.0 ft: No recovery.

Run 13: 55.0 - 60.0 ft

55.0 -55.6 ft: LIMESTONE (cemented mollusk grainstone), quartzose (vf-f, 20%); irregular burrows filled with glauconite-bryozoans-mollusks from contact interval above; high solution-enhanced meso- and megamoldic (mollusk) porosity, slightly cement reduced; yellowish-gray (5Y8/1).

55.6-60.0 ft: No recovery.

Run 14: 60.0 - 65.0 ft

60.0 - 61.5 ft: SAND, quartz, vf, muddy; calcareous, abundant mollusk fragments (sand to pebble size), massive, light-greenish-gray (5GY8/1).

61.5 - 65.0 ft: SAND, quartz, vf-m, muddy: calcareous, glauconite (tr), sparse microfossils, common mollusk fragments; massive, locally calcite-cemented; light-olive-gray (5Y6/1).

Run 15: 65.0 - 70.0 ft

65.0 - 65.3 ft: LIMESTONE (cemented mollusk grainstone), quartzose (vf-m, 10-20%), glauconite (tr), phosphate? (tr), abundant mollusk fragments (dominantly oysters with abundant borings); high solution-enhanced megamoldic (mollusk) porosity, slightly cement-reduced; light-gray (N7).

65.3 - 70.0 ft: No recovery.

Run 16: 70.0 - 75.0 ft

70.0 - 71.5 ft: LIMESTONE (cemented mollusk grainstone), quartzose (vf-m, 40-50%), glauconite (tr), phosphate? (tr), abundant mollusk fragments (dominantly oysters with abundant borings); high solution-enhanced megamoldic (mollusk) porosity, slightly cement-reduced; light-olive-gray (5Y6/1).

71.5 - 75.0 ft: No recovery.

Run 17: 75.0 - 80.0 ft

75.0 - 78.5 ft: SAND, quartz, vf-f, muddy, calcareous, abundant mollusk fragments in upper half, decreasing in abundance downward (dominantly large oysters with abundant borings), phosphate (tr); locally calcite-cemented, local moldic porosity in cemented zones; light gray (N7).

78.5 - 80.0 ft: No recovery.

Run 18: 80.0 - 85.0 ft

80.0 - 84.7 ft: SAND, quartz, vf-f, muddy, calcareous, abundant mollusk fragments (dominantly oysters); massive; sharp, burrowed basal contact; light-olive-gray (5Y6/1) to olive-gray (5Y4/1).

84.7 - 85.0 ft: CLAY, silty (quartz) and sandy (quartz, vf); mica (<5%), calcareous, abundant microfossils, common disseminated mollusk fragments, bioturbated, olive-gray (5Y4/1).

Run 19: 85.0 - 90.0 ft

85.0 - 87.0 ft: CLAY, silty and sandy, calcareous, fossiliferous, as above.

87.0 - 89.5 ft: SAND, quartz, f-m, muddy, calcareous, very abundant sand- and granule-sized mollusk fragments, locally calcite-cemented, very high megamoldic porosity (mollusks) in cemented zones; olive-gray (5Y4/1).

89.5 - 90.0 ft: No recovery.

Run 20: 90.0 - 95.0 ft

90.0 - 91.0 ft: SAND, quartz, f-m, muddy, calcareous, abundant mollusk fragments, locally calcite-cemented, olive-gray (5Y4/1).

91.0 - 95.0 ft: No recovery.

Run 21: 95.0-100.0 ft

95.0 - 96.0 ft: SAND, quartz, f-m, muddy, calcareous, glauconite (tr), common mollusk fragments; locally calcite-cemented, high megamoldic (mollusk) porosity; light-olive-gray (5Y6/1).

96.0 - 100.0 ft: No recovery.

Run 22: 100.0 - 105.0 ft

100.0 - 100.6 ft: SAND, quartz, f-c, muddy, calcareous, common mollusk fragments; light-gray (N7).

100.6 - 102.3 ft: SAND, quartz, vf, muddy, calcareous, common mollusk fragments (sand- and granule-sized); light-gray (N7).

102.3 - 105.0 ft: No recovery.

Run 23: 105.0 - 110.0 ft

105.0 - 107.7 ft: SAND, quartz, vf, muddy, calcareous, macrofossiliferous, as above.

107.7 - 110.0 ft: No recovery.

Run 24: 110.0 - 115.0 ft

110.0 - 112.6 ft: SAND, quartz, vf, muddy, calcareous, common mollusk fragments in upper 0.7 ft, sparse mollusk fragments from 110.7 to 112.6 ft; high megamoldic (mollusk) porosity in upper 0.7 ft; light-gray (N7).
112.6 - 115.0 ft: No recovery.

Run 25: 115.0 - 120.0 ft

No recovery.

Run 26: 120.0 - 124.0 ft

No recovery.

Run 27: 124.0 - 125.0 ft

Sample from drill bit pulled from depth of 125.0 ft. Sample represents some part of the interval between 112.6 ft and 125.0 ft (1.2 ft recovery): LIMESTONE (cemented mollusk grainstone), quartzose (vf-f, 10%), phosphate and glauconite (<5%), moderately high megamoldic (mollusk) porosity; yellowish-gray (5Y8/1) .

Lower Bridge Member (upper beds): Top of recovered section.

Run 28: 125.0 - 129.0 ft

CLAY, silty and sandy (vf, 5%), calcareous, mica (silt, <5%), common disseminated mollusk fragments, common microfauna, bioturbated, calcite-cemented bed/nodule at 127.9-128.1 ft; dark-greenish-gray (5GY4/1) to greenish-black (5GY2/1).

Run 29: 129.0 - 134.0 ft

CLAY, silty and sandy, calcareous, fossiliferous, as above.

Run 30: 134.0 - 135.0 ft

CLAY, silty and sand, calcareous, fossiliferous, as at 125.0 - 129.0 ft.

Run 31: 135.0 - 140.0 ft

135.0 - 139.7 ft: CLAY, silty and sandy, calcareous, fossiliferous, as at 125.0 - 129.0 ft.
139.7 - 140.0 ft: No recovery.

Run 32: 140.0 - 145.0 ft

140.0 - 144.9 ft: CLAY, silty and sandy, calcareous, fossiliferous, as at 125.0 - 129.0 ft.
144.9 - 145.0 ft: No recovery.

Run 33: 145.0 - 150.0 ft

CLAY, silty and sand, calcareous, fossiliferous, as at 125.0 - 129.0 ft.

Run 34: 150.0 - 155.0 ft

150.0 - 154.9 ft: CLAY, silty and sandy, calcareous, fossiliferous, as at 125.0 - 129.0 ft.
154.9 - 155.0 ft: No recovery.

Run 35: 155.0 - 160.0 ft

CLAY, silty and sand, calcareous, fossiliferous, as at 125.0 - 129.0 ft.

Run 36: 160.0 - 165.0 ft

160.0 - 164.5 ft: CLAY, silty and sandy (vf, 5%), calcareous, mica (silt, <5%), common disseminated mollusk fragments (sand-sized), common microfauna, macro- and microfauna increasing downward; bioturbated; dark-greenish-gray (5GY4/1) to dark-gray (N3).
164.5 - 165.0 ft: No recovery.

Run 37: 165.0 - 170.0 ft

165.0 - 169.0 ft: CLAY, silty and sandy (vf, 5%), calcareous, mica (silt, <5%), common disseminated mollusk fragments (sand-sized), common microfauna; bioturbated, possible widely spaced, inclined bedding surfaces; dark-greenish-gray (5GY4/1) to dark-gray (N3).
169.0 - 170.0 ft: CLAY, silty and sandy (vf, 5%), calcareous, mica (silt, <5%), disseminated mollusk fragments (sand-sized, fewer than above), common microfauna (decreased from above); bioturbated; greenish-black (5G2/1).

Run 38: 170.0 - 175.0 ft

CLAY, silty and sandy (vf, 5%), calcareous, mica (silt, <5%), common disseminated mollusk fragments (sand-sized), common microfauna (decreased from above); bioturbated; greenish-black (5G2/1).

Run 39: 175.0 - 180.0 ft

CLAY, silty and sandy, calcareous, fossiliferous, as above.

Run 40: 180.0 - 185.0 ft

CLAY, silty and sandy, calcareous, fossiliferous, as at 170.0 - 175.0 ft.

Run 41: 185.0 - 190.0 ft

CLAY, silty and sandy, calcareous, fossiliferous, as at 170.0 - 175.0 ft.

Run 42: 190.0 - 195.0 ft

CLAY, silty and sandy (vf), calcareous, mica (silt, <5%), phosphate or glauconite (vf, tr), common disseminated mollusk fragments (sand-sized), sparse to common microfossils; bioturbate; some layers have decreased sand/silt and are dense, other layers appear to have increased disseminated calcium carbonate and have granular texture; greenish-black (5GY/21).

Run 43: 195.0 - 200.0 ft

CLAY, sandy and silty, calcareous, fossiliferous, as above.

Run 44: 200.0 - 204.0 ft

200.0 - 202.0 ft: CLAY, sandy and silty, calcareous, fossiliferous, as at 190.0 - 195.0 ft.
202.0 - 204.0 ft: SAND, quartz-glauconite, vf-f, muddy, calcareous, glauconite (m, 10-15%), phosphate (m, <5%), mica (silt, <5%); sparse mollusk fragments, fish teeth, and spicules; bioturbate; olive-black (5Y2/1).

Run 45: 204.0 - 206.5 ft

204.0 - 205.0 ft: SAND, quartz-glauconite, vf-f, muddy, calcareous, glauconitic and phosphatic as above. Basal contact is a lithologically sharp, but strongly burrowed unconformity.

Lower Bridge Member (lower beds): Top of recovered section.

205.0 - 206.5 ft: SAND, quartz, vf-f, slightly muddy, calcareous, glauconite (5%), mica (<5%), sparse mollusk fragments and spicules, sparse microfauna; bioturbate; burrows filled with quartz-glauconite sand extend down from the upper contact; olive-gray (5Y3/2) to light-olive-gray (5Y5/2).

Run 46: 206.5 - 210.0 ft

SAND, quartz, vf-f, slightly muddy, calcareous, glauconite (5%), mica (<5%), sparse mollusk fragments and spicules, sparse microfauna; bioturbate; burrows filled with quartz-glauconite sand extend down from the upper contact to below 210 ft; two 0.5-ft-thick, calcite-cemented zones; olive-gray (5Y3/2) to light-olive-gray (5Y5/2).

Run 47: 210.0 - 215.0 ft

SAND, quartz, vf-f, slightly muddy, calcareous, glauconite (5%), mica (<5%), sparse mollusk fragments and spicules, sparse microfauna; bioturbate; burrows filled with quartz-glauconite sand from the overlying unit extend down to 211 ft; irregularly spaced, 0.5-ft-thick, calcite-cemented zones, about 2 per 10 ft of section; olive-gray (5Y3/2) to light-olive-gray (5Y5/2).

Run 48: 215.0 - 220.0 ft

SAND, quartz, vf-f, slightly muddy, calcareous, glauconite (5-10%), mica (<5%), sparse mollusk fragments and spicules, common microfauna; bioturbate; irregularly spaced, 0.5-ft-thick, calcite-cemented zones, about 2 per 10 ft of section; dark- greenish-gray (5GY4/1).

Run 49: 220.0 - 225.0 ft

SAND, quartz, vf-f, slightly muddy, calcareous, glauconitic, as above.

Run 50: 225.0 - 230.0 ft

225.0 - 227.5 ft: SAND, quartz, vf-f, slightly muddy, calcareous, glauconitic, as at 215.0 - 220.0 ft.
227.5 - 229.5 ft: SAND, quartz-glauconite, vf-vc, slightly muddy, calcareous, glauconite (f-vc, 10%), phosphate (sand, granules, small pebbles, <5%), sparse mollusk fragments, common microfauna; bioturbate; olive-gray (5Y3/2).
229.5 - 230.0 ft: No recovery.

Run 51: 230.0 -235.0 ft

SAND, quartz-glauconite, f-vc, slightly muddy, calcareous, glauconite (f-vc, 10%), phosphate (sand, granules, small pebbles, <5%), sparse mollusk fragments, common microfauna; bioturbate; olive-gray (5Y3/2).

Run 52: 235.0 - 240.0 ft

235.0 - 237.4 ft: SAND, quartz-glauconite, f-vc, slightly muddy, calcareous, glauconite (f-vc) plus phosphate (sand, granules, small pebbles), 15-25%; sparse mollusk fragments, common microfauna; bioturbate; locally weakly calcite-cemented, greenish-black (5GY2/1). Lithologically sharp lower contact.

Upper part of the Rhems Formation *sensu* Bybell and others (1998): Top of recovered section.

237.4 - 239.6 ft: SAND, quartz, vf-f, muddy, calcareous, mica (<5%), glauconite (tr); common microfauna; abundant sand-filled (matrix-free) burrows; weakly calcite-cemented; dark-greenish-gray (5GY4/1).
239.6 - 240.0 ft: No recovery.

Run 53: 240.0 - 245.0 ft

SAND, quartz, vf-f, muddy, calcareous, mica (<5%), glauconite (tr); common microfauna; abundant sand-filled (matrix-free) burrows; weakly calcite-cemented; dark-greenish-gray (5GY4/1).

Run 54: 245.0 - 250.0 ft

SAND, quartz, vf-f, muddy, calcareous, as above.

Run 55: 250.0 - 255.0 ft

SAND, quartz, vf-f, muddy, calcareous, as at 240.0 - 245.0 ft.

Run 56: 255.0 - 260.0 ft

255.0 - 257.0 ft: SAND, quartz, vf-f, muddy, calcareous, as at 240.0 - 245.0 ft.
257.0 - 259.0 ft: SAND, quartz-glauconite, vf-f, muddy, calcareous, mica (<5%), glauconite (5-10%); common microfauna; bioturbated; dark-greenish-gray (5GY4/1).
259.0 - 260.0 ft: No recovery.

Run 57: 260.0 - 265.0 ft

265.0 - 262.7 ft: SAND, quartz-glauconite, vf-f, muddy, calcareous, as above.
262.7 - 265.0 ft: No recovery.

Run 58: 265.0 - 270.0 ft

265.0 - 267.3 ft: SAND, quartz-glauconite, vf-f, muddy, calcareous, as at 257.0 - 259.0 ft. Abundant phosphate sand, granules, and small pebbles in basal 0.3 ft. Sharp, irregular basal contact.

Rhems Formation *sensu stricto*: Top of recovered section.

267.3 - 270.0 ft: LIMESTONE, molluscan, quartzose (vf-f, 20-30%), mica (<5%), glauconite (5%), phosphate (<5%); common mollusk fragments and microfossils; massive; very light gray (N8).

Run 59: 270.0 - 275.0 ft

LIMESTONE, molluscan, quartzose, as above. Quartz fraction increases and calcite fraction decreases downsection; friable at base.

Run 60: 275.0 - 280.0 ft

275.0 - 279.3 ft: SAND, f, muddy, calcareous, mica (tr), glauconite (<5%); common mollusk fragments and microfossils; calcite-cemented layers (0.3- to 0.5-ft-thick, irregularly spaced; approximately 2 to 4 per 10 ft of section), bioturbate; light-olive-gray (5Y5/2).
279.3 - 280.0 ft: No recovery.

Run 61: 280.0 - 285.0 ft

SAND, f, muddy, calcareous, cemented zones, as above.

Run 62: 285.0 - 290.0 ft

SAND, f, muddy, calcareous, cemented zones, as at 275.0 - 279.3 ft.

Run 63: 290.0 - 295.0 ft

SAND, f, muddy, calcareous, cemented zones, as at 275.0 - 279.3 ft.

Run 64: 295.0 - 300.0 ft

295.0 - 299.8 ft: SAND, f, muddy, calcareous, cemented zones, as at 275.0 - 279.3 ft.
299.8 - 300.0 ft: No recovery.

Run 65: 300.0 ft - 305.0 ft

300.0 - 303.5 ft: SAND, f, muddy, calcareous, cemented zones, as at 275.0 - 279.3 ft.
303.5 - 305.0 ft: SAND, vf-f, very muddy, calcareous, mica (<5%), sparse small shell fragments, abundant microfauna; bioturbate; greenish-black (5G2/1).

Run 66: 305.0 - 310.0 ft

305.0 - 309.9 ft: SAND, vf-f, very muddy, calcareous, as above.
309.9 - 310.0 ft: No recovery.

Run 67: 310.0 - 315.0 ft

310.0 - 315.0 ft: SAND, vf-f, very muddy, calcareous, mica (<5%), glauconite (<5%), sparse mollusk fragments (sand-sized), common microfauna; calcite-cemented layers (0.4- to 1.1-ft-thick, irregularly spaced; 1 or 2 per 10 feet of section), bioturbate; clayey sand--greenish-black (5G2/1), cemented layers--olive-gray (5Y4/2).

Run 68: 315.0 - 320.0 ft

315.0 - 319.3 ft: SAND, vf-f, very muddy, calcareous, cemented layers, as above.
319.3 - 320.0 ft: No recovery.

Run 69: 320.0 - 325.0 ft

320.0 - 323.8 ft: SAND, vf-f, very muddy, calcareous, cemented layers, as at 310.0 - 315.0 ft.
323.8 - 325.0 ft: No recovery.

Run 70: 325.0 - 329.0 ft

SAND, vf-f, very muddy, calcareous, cemented layers, as at 310.0 - 315.0 ft.

Run 71: 329.0 - 334.0 ft

SAND, vf-f, very muddy, calcareous, cemented layers, as at 310.0 - 315.0 ft.

Run 72: 334.0 - 339.0 ft

334.0 - 337.4 ft: SAND, vf-f, very muddy, calcareous, cemented layers, as at 310.0 - 315.0 ft.
337.4 - 338.5 ft: No recovery.
338.5 - 339.0 ft: SAND, vf-f, very muddy, calcareous, as at 310.0 - 315.0 ft. Recovered in run 73.

Run 73: 339.0 - 342.5 ft

CLAY, silty, and sandy (vf), calcareous, micaceous (5-10%), sparse mollusk fragments (disseminated, sand-sized), common to abundant microfauna; bioturbate; greenish-black (5GY2/1).

Run 74: 342.5 - 345.0 ft

342.5 - 343.8 ft: CLAY, silty and sandy, calcareous, micaceous, as above.
343.8 - 345.0 ft: No recovery.

Run 75: 345.0 - 350.0 ft

345.0 - 347.1 ft: CLAY, silty and sandy (vf), calcareous, mica (<5%), sparse mollusk fragments (disseminated, sand-sized), abundant microfauna; bioturbate; greenish-black (5GY2/1).

347.1 - 350.0 ft: CLAY, silty, calcareous, mica (<5%), sparse mollusk fragments (disseminated, sand-sized), sparse to common microfauna; massive; dark-greenish-gray (5GY4/1).

Run 76: 350.0 - 355.0 ft

350.0 - 353.5 ft: CLAY, silty and sandy (vf), calcareous, mica (<5%), sparse mollusk fragments (disseminated, sand-sized), abundant microfauna; bioturbate; olive-gray (5Y4/1).

353.5 - 355.0 ft: No recovery.

Run 77: 355.0 - 359.0 ft

CLAY, silty and sandy (vf), calcareous, mica (<5%), sparse mollusk fragments (disseminated, sand-sized), abundant microfauna; calcite-cemented intervals at 356.1 - 356.4 ft and 357.1 - 357.7 ft; bioturbate; olive-gray (5Y4/1).

Run 78: 359.0 - 364.0 ft

359.0 - 361.1 ft: CLAY, silty and sandy, calcareous, as above.

361.1 - 364.0 ft: CLAY, silty and sandy (vf), calcareous, mica (<5%), phosphate (sand and granules, 5-10%), sparse mollusk fragments (disseminated, sand-sized), abundant microfauna; bioturbate; olive-gray (5Y3/2).

Run 79: 364.0 - 365.0 ft

CLAY, silty and sandy (vf), calcareous, mica (<5%), phosphate (sand and granules, 5-10%), sparse mollusk fragments (disseminated, sand-sized), abundant microfauna; most of interval is calcite-cemented, bioturbate; olive-gray (5Y3/2).

Run 80: 365.0 - 370.1 ft

365.0 - 367.1 ft: CLAY, silty and sandy (vf), calcareous, mica (<5%), phosphate (sand and granules, 5-10%), common mollusk fragments (disseminated, sand- to pebble-sized), abundant microfauna, fish teeth noted; massive; grayish-olive-green (5GY3/2). Irregular, burrowed basal contact.

Peedee Formation: Top of recovered section.

367.1 - 370.0 ft: CLAY, silty and sandy (vf, tr), calcareous, mica (tr), sparse mollusk fragments (disseminated, sand- to pebble-sized), common microfauna, texture-mottled - bioturbated; quartz-phosphate-filled burrows extend down from upper contact to at least 370.0; olive-gray (5Y3/2).

Run 81: 370.0 - 375.0 ft

CLAY, silty and sandy (vf, tr), calcareous, mica (tr), sparse mollusk fragments (disseminated, sand- to pebble-sized), common microfauna, texture-mottled - bioturbated; olive-gray (5Y3/2).

Run 82: 375.0 -380.0 ft

CLAY, silty and sandy, calcareous, as above.

Run 83: 380.0 - 381.0 ft

CLAY, silty and sandy, calcareous, as at 370.0 - 375.0 ft.

Run 84: 381.0 - 385.0 ft

CLAY, silty and sandy, calcareous, as at 370.0 - 375.0 ft.

Run 85: 385.0 - 390.0 ft

CLAY, silty and sandy, calcareous, as at 370.0 - 375.0 ft.

Run 86: 390.0 - 395.0 ft

CLAY, silty, calcareous, mica (<5%), very sparse mollusk fragments (disseminated, sand- and granule-sized), common microfauna; texture-mottled - bioturbate; very sparse, sulfide-replaced burrow fills; light-olive-gray (5Y6/1) to olive gray (5Y4/1).

Run 87: 395.0 - 400.0 ft

CLAY, silty, calcareous, as above.

Run 88: 400.0 - 405.0 ft

400.0 - 404.9 ft: CLAY, silty, calcareous, as at 390.0 - 395.0 ft.
404.9 - 405.0 ft: No recovery.

Run 89: 405.0 - 410.0 ft

405.0 - 409.9 ft: CLAY, silty and sandy (vf, increasing downward), calcareous, mica (<5%), very sparse mollusk fragments (disseminated, sand-sized), common microfauna, very sparse fish teeth and vertebrae; texture-mottled - bioturbate; olive-gray (5Y4/1).
409.9 - 410.0 ft: No recovery.

Run 90: 410.0 - 415.0 ft

410.0 - 414.0 ft: CLAY, silty and sandy, calcareous, as above.
414.0 - 414.9 ft: CLAY, silty and sandy (vf), calcareous, mica (<5%), phosphate (granules and small pebbles, <5%), sparse mollusk fragments, common microfauna; texture mottled - bioturbate; olive-gray (5Y4/1).
414.9 - 415.0 ft: No recovery.

Run 91: 415.0 - 420.0 ft

415.0 - 416.0 ft: CLAY, silty and sandy, calcareous, phosphatic, as above.
416.0 - 420.0 ft: CLAY, silty and sandy (vf, increasing downward), calcareous, mica (<5%), very sparse mollusk fragments (disseminated, sand-sized), common microfauna; texture-mottled - bioturbate; olive-gray (5Y4/1).

Run 92: 420.0 - 425.0 ft

SILT, clayey and sandy (vf), calcareous, mica (<5%), common microfauna; texture-mottled - bioturbate; light-olive-gray (5Y5/2).

Run 93: 425.0 - 430.0 ft

SILT, clayey and sandy, calcareous, as above.

Run 94: 430.0 - 434.0 ft

CLAY, silty, calcareous, mica (<5%), sparse mollusk fragments (disseminated, sand-sized), common microfauna; texture-mottled - bioturbate; lighter than olive-gray (5Y4/1).

Run 95: 434.0 - 439.0 ft

CLAY, silty, calcareous, as above.

Run 96: 439.0 - 444.0 ft

CLAY, silty, calcareous, as at 430.0 - 434.0 ft.

Run 97: 444.0 - 449.0 ft

CLAY, silty, calcareous, as at 430.0 - 434.0 ft.

Run 98: 449.0 - 454.0 ft

CLAY, silty, calcareous, as at 430.0 - 434.0 ft.

Run 99: 454.0 - 459.5 ft

CLAY, silty, calcareous, as at 430.0 - 434.0 ft.

Run 100: 459.5 ft - 465.0 ft

CLAY, silty, calcareous, as at 430.0 - 434.0 ft.

Run 101: 465.0 - 470.5 ft

CLAY, silty, calcareous, very sparse mollusk fragments (disseminated, sand- to pebble-sized), common microfauna; sparse pyrite-cemented burrows, texture-mottled - bioturbate; disseminated, yellowish-gray (5Y7/2) lens-shaped areas up to 2.0 in. in length of unknown origin; generally olive-gray (5Y4/1).

Run 102: 470.5 - 475.0 ft

CLAY, silty and sandy (quartz: vf-m, coarsening down section; phosphate, vf-c, coarsening down section, small pebbles at base), calcareous, common microfauna; bioturbated, horizontal burrow systems mimic bedding; grayish-olive (10Y4/2).

Run 103: 475.0 -476.5 ft

475.0 - 475.7 ft: CLAY, silty and sandy (quartzose, phosphatic), calcareous, as above. Irregular, burrowed basal contact.

Donoho Creek Formation: Top of recovered section.

475.7 - 476.5 ft: SAND, quartz, vf-m, muddy, calcareous, glauconite (tr), very sparse microfauna; massive to bioturbated, irregular clay segregations represent truncated clay-lined burrows; partially calcite-cemented; clay - pale brown (5YR5/2), sand - grayish-orange-pink (5YR5/2).

Run 104: 476.5 - 482.0 ft

476.5 - 481.6 ft: SAND, quartz, vf-m, muddy, calcareous, glauconite (tr), very sparse microfauna; massive to bioturbated, irregular clay segregations represent truncated clay-lined burrows; clay - dark-greenish-gray (5GY4/1), sand - yellowish-gray (5Y7/2).
481.6 - 482.0 ft: No recovery.

Run 105: 482.0 - 485.0 ft

SAND, quartz, vf-m, muddy, calcareous, mica (tr), glauconite (tr), very sparse microfauna; massive to bioturbated, irregular clay segregations represent truncated clay-lined burrows; clay - dark-greenish-gray (5GY4/1), sand - yellowish-gray (5Y7/2).

Run 106: 485.0 - 490.0 ft

SAND, quartz, vf-m, muddy, calcareous, as above.

Run 107: 490.0 - 495.0 ft

SAND, quartz, vf-m, muddy, calcareous, as at 482.0 - 485.0 ft.

Run 108: 495.0 - 500.0 ft

SAND, quartz, vf-m, muddy, calcareous, as at 482.0 - 485.0 ft.

Run 109: 500.0 - 505.0 ft

500.0 - 504.9 ft: SAND, quartz, vf-m, muddy, calcareous, as at 482.0 - 485.0 ft.
504.9 - 505.0 ft: No recovery.

Run 110: 505.0 - 510.0 ft

505.0 - 509.8 ft: SAND, quartz, vf-m, muddy calcareous, mica (<5%), glauconite (tr), very sparse microfauna; bioturbated, irregular clay segregations represent truncated clay-lined burrows; 0.4- to 0.7-ft-thick, calcite-cemented zones irregularly spaced approximately two per 10 ft of section; clay - dark-greenish-gray (5GY4/1), sand - olive-gray (5Y4/1).
509.8 - 510.0 ft: No recovery.

Run 111: 510.0 - 515.0 ft

SAND, quartz, vf-m, muddy, calcareous, as above.

Run 112: 515.0 - 520.0 ft

SAND, quartz, vf-m, muddy, calcareous, as at 505.0 - 509.8 ft.

Run 113: 520.0 - 525.0 ft

SAND, quartz, vf-m, muddy, calcareous, as at 505.0 - 509.8 ft.

Run 114: 525.0 - 530.0 ft

SAND, quartz, vf-m, muddy, calcareous, as at 505.0 - 509.8 ft.

Run 115: 530.0 - 535.0 ft

SAND, quartz, vf-m, muddy, calcareous, as at 505.0 - 509.8 ft.

Run 116: 535.0 - 540.0 ft

SAND, quartz, vf-m, muddy, calcareous, as at 505.0 - 509.8 ft.

Run 117: 540.0 -545.0 ft

SAND, quartz, vf-m, muddy, calcareous, as at 505.0 - 509.8 ft.

Bottom of hole.

Appendix 2. Useful Cenozoic calcareous nannofossil datums.

The following calcareous nannofossil species can be used to date sediments of Paleocene to Quaternary age. Many, but not all, of these species are present in the Santee Coastal Reserve core. FAD indicates a first appearance datum, and LAD indicates a last appearance datum. Zonal markers for the Martini (1971) NP zones are indicated with an *, and a # indicates a zonal marker for the Bukry (1973, 1978) and Okada and Bukry (1980) CP zones. One of us (Bybell) has found the remaining species to be biostratigraphically useful in the Gulf of Mexico and Atlantic Coastal Plains.

FAD *Gephyrocapsa oceanica* – near base of Quaternary
LAD **Rhomboaster orthostylus* - top of Zone NP 12
LAD *Toweius callosus* – within Zone NP 12
FAD *Helicosphaera seminulum* - mid Zone NP 12
LAD *Toweius pertusus* – within Zone NP 12
LAD *Ellipsolithus macellus* – within Zone NP 12
FAD *#*Discoaster lodoensis* - base of Zone NP 12, base CP 10
LAD *Discoaster multiradiatus* – within Zone NP 11
LAD *Zygodiscus herlyni* – within Zone NP 11
LAD *#*Rhomboaster contortus* - top of Zone NP 10, top CP 9a
LAD *Discoaster lenticularis* – upper Zone NP 10
FAD *Rhomboaster orthostylus* - upper Zone NP 10
FAD #*Rhomboaster contortus* - mid Zone NP 10, base CP9A; Bukry places the base of Zone CP 9a at the base of Martini's Zone NP 10, but this is much too low according to Perch-Nielsen (1985a) and Bybell and Self-Trail (1995)
FAD #*Discoaster diastypus* - mid-Zone NP 10, base CP 9a
LAD *Placozygus sigmoides* - lower Zone NP 10
LAD *Fasciculithus* spp. - lower Zone NP 10
LAD *Hornibrookina* spp. - lower Zone NP 10
FAD **Rhomboaster bramlettei* - base of Zone NP 10, early Eocene
---Paleocene/Eocene boundary---
FAD *Transversopontis pulcher sensu ampl.* - upper Zone NP 9, late Paleocene
FAD *Toweius occultatus* - within upper Zone NP 9
FAD #*Campylosphaera dela* - within Zone NP 9, base CP 8b (includes *C. eodela*)
FAD *Toweius callosus* – within Zone NP 9
FAD *Discoaster lenticularis* - near base of Zone NP 9
FAD *#*Discoaster multiradiatus* - base of Zone NP 9, base CP 8a
FAD **Heliolithus riedelii* - base of Zone NP 8
FAD #*Discoaster mohleri* - base CP 6, probably equivalent to base of Martini's Zone NP 7
FAD **Heliolithus kleinpellii* - base of Zone NP 6
FAD *Heliolithus cantabriae* - within upper part of Zone NP 5
FAD *Chiasmolithus bidens* - within Zone NP 5
FAD *Toweius eminens* var. *tovae* - within Zone NP 5
FAD *#*Fasciculithus tympaniformis* - base of Zone NP 5, base CP 4, late Paleocene
FAD *Chiasmolithus* sp. aff. *C. bidens* – within Zone NP 4
FAD *Toweius pertusus* - within Zone NP 4
FAD *Ellipsolithus distichus* - near base of Zone NP 4, early Paleocene
FAD **Ellipsolithus macellus* - base of Zone NP 4
FAD *Chiasmolithus consuetus* - within Zone NP 3
FAD **Chiasmolithus danicus* - base of Zone NP 3, early Paleocene
FAD *#*Cruciplacolithus tenuis* – base Zone NP 2, base CP 1b
FAD *Cruciplacolithus asymmetricus* – Zone NP 1
FAD *Cruciplacolithus intermedius* – Zone NP 1
FAD *Placozygus sigmoides* increase – lower part of Zone NP 1
FAD *Cruciplacolithus primus* – lower part of Zone NP 1
FAD *Thoracosphaera* increase – base of Zone NP 1
---Cretaceous/Tertiary boundary---

Appendix 3. Authors and year of publication for taxa considered in this report

Part A. Cretaceous calcareous nannofossil species (in alphabetical order by genus).

Acuturris scotus (Risatti 1973) Wind & Wise *in* Wise and Wind (1977)
Ahmuellerella octoradiata (Gorka 1957) Reinhardt 1964
Ahmuellerella regularis (Gorka 1957) Reinhardt & Gorka 1967
Arkhangelskiella cymbiformis Vekshina 1959
Arkhangelskiella speciallata Vekshina 1959
Aspidolithus parcus constrictus (Hattner, Wind, & Wise 1980) Perch-Nielsen 1984
Aspidolithus parcus expansus Wise & Watkins *in* Wise (1983)
Aspidolithus parcus parcus (Stradner 1963) Noël 1969
Biscutum constans (Gorka 1957) Black *in* Black and Barnes (1959)
Biscutum zulloi Covington 1994
Braarudosphaera bigelowii (Gran & Braarud 1935) Deflandre 1947
Broinsonia dentata Bukry 1969
Broinsonia enormis (Shumenko 1968) Manivit 1971
Broinsonia furtiva Bukry 1969
Calculites obscurus (Deflandre 1959) Prins & Sissinghi *in* Sissingh (1977)
Ceratolithoides aculeus (Stradner 1961) Prins & Sissingh *in* Sissingh (1977)
Ceratolithoides kamptneri Bramlette & Martini 1964
Chiastozygus amphipons (Bramlette & Martini 1964) Gartner 1968
Chiastozygus litterarius (Gorka 1957) Manivit 1971
Chiastozygus propagulis Bukry 1969
Corollithion? *completum* Perch-Nielsen 1973
Corollithion exiguum Stradner 1961
Corollithion signum Stradner 1963
Cretarhabdus conicus Bramlette & Martini 1964
Cretarhabdus multicavus Bukry 1969
Cretarhabdus schizobrachiatus (Gartner 1968) Bukry 1969
Cribrocorona gallica (Stradner 1963) Perch-Nielsen 1973
Cribrosphaerella ehrenbergii (Arkhangelsky 1912) Deflandre *in* Piveteau (1952)
Cyclagelosphaera margarellii Noël 1965
Cylindralithus crassus Stover 1966
Cylindralithus nudus Bukry 1969
Cylindralithus oweinae Perch-Nielsen 1973
Cylindralithus serratus Bramlette & Martini 1964
Discorhabdus ignotus (Gorka 1957) Perch-Nielsen 1968
Dodekapodorhabdus noeliae Perch-Nielsen 1968
Eiffellithus gorkae Reinhardt 1965
Eiffellithus parallelus Perch-Nielsen 1973
Eiffellithus turriseiffellii (Deflandre *in* Deflandre and Fert, 1954) Reinhardt 1964
Gartnerago diversum Thierstein 1972
Gartnerago obliquum (Stradner 1963) Noël 1970
Gephyrorhabdus coronadventis (Reinhardt 1966) Hill 1976
Glaukolithus compactus (Bukry 1969) Perch-Nielsen 1984
Glaukolithus diplogrammis (Deflandre *in* Deflandre and Fert, 1954) Reinhardt 1964
Goniolithus fluckigeri Deflandre 1957
Hexalithus gardetae Bukry 1969
Kamptnerius magnificus Deflandre 1959
Kamptnerius punctatus Stradner 1963
Lithraphidites carniolensis Deflandre 1963
Lithraphidites grossopectinatus Bukry 1969
Lithraphidites kennethii Perch-Nielsen 1984

Lithraphidites praequadratus Roth 1978
Lithraphidites quadratus Bramlette & Martini 1964
Loxolithus armillus (Black *in* Black and Barnes, 1959) Noël 1965
Lucianorhabdus cayeuxii Deflandre 1959
Lucianorhabdus maleformis Reinhardt 1966
Manivitella pemmatoidea (Deflandre *in* Manivit, 1965) Thierstein 1971
Markalius inversus (Deflandre *in* Deflandre and Fert, 1954) Bramlette & Martini 1964
Micula concava (Stradner *in* Martini and Stradner, 1960) Verbeek 1976
Micula decussata Vekshina 1959
Micula murus (Martini 1961) Bukry 1973
Micula praemurus (Bukry 1973) Stradner & Steinmetz 1984
Micula prinsii Perch-Nielsen 1979
Microrhabdulus attenuatus (Deflandre 1959) Deflandre 1963
Microrhabdulus belgicus Hay & Towe 1963
Microrhabdulus decoratus Deflandre 1959
Microrhabdulus undosus Perch-Nielsen 1973
Munarius lesliae Risatti 1973
Neocrepidolithus cohenii Perch-Nielsen 1984
Neocrepidolithus neocrassus (Perch-Nielsen 1968) Romein 1979
Nephrolithus frequens Gorka 1957
Orastrum asarotum Wind & Wise *in* Wise and Wind (1977)
Orastrum campanensis (Cepek 1970) Wind & Wise *in* Wise and Wind (1977)
Ottavianus giannus Risatti 1973
Ottavianus terrazetus Risatti 1973
Percivalia porosa Bukry 1969
Placozygus fibuliformis (Reinhardt 1964) Hoffmann 1970
Placozygus sigmoides (Bramlette & Sullivan 1961) Romein 1979
Pontosphaera multicarinata (Gartner 1968) Shafik & Stradner 1971
Prediscosphaera arkhangelskyi (Reinhardt 1965) Perch-Nielsen 1984
Prediscosphaera cretacea (Arkhangelsky 1912) Gartner 1968
Prediscosphaera grandis Perch-Nielsen 1979
Prediscosphaera intercisa (Deflandre *in* Deflandre and Fert, 1954) Shumenko 1976
Prediscosphaera majungae Perch-Nielsen 1973
Prediscosphaera spinosa (Bramlette & Martini 1964) Gartner 1968
Prediscosphaera stoveri (Perch-Nielsen 1968) Shafik & Stradner 1971
Pseudomicula quadrata Perch-Nielsen *in* Perch-Nielsen and others (1978)
Quadrum gothicum (Deflandre 1979) Prins & Perch-Nielsen *in* Manivit and others (1977)
Quadrum sissinghii Perch-Nielsen 1986
Quadrum trifidum (Stradner *in* Stradner and Papp, 1961) Prins & Perch-Nielsen *in* Manivit and others (1977)
Ramsaya swanseana Risaitti 1973
Reinhardtites anthophorus (Deflandre 1959) Perch-Nielsen 1968
Reinhardtites biperforatus (Gartner 1968) Shafik 1979
Reinhardtites levis Prins & Sissingh *in* Sissingh (1977)
Repagulum parvidentatum (Deflandre & Fert 1954) Forchhimer 1972
Retacapsa angustiforata Black 1971
Retemediaformus teneraretis Varol 1991
Rhagodiscus angustus (Stradner 1963) Reinhardt 1971
Rhagodiscus reniformis Perch-Nielsen 1973
Rhagodiscus splendens (Deflandre 1953) Verbeek 1977
Rhombolithion rhombicum (Stradner & Adamiker 1966) Black 1973
Rotellapillus crenulatus (Stover 1966) Perch-Nielsen 1984
Rotellapillus munitus (Perch-Nielsen 1973) Perch-Nielsen 1984
Scampanella cornuta Forchheimer & Stradner 1973
Scampanella magnifica Perch-Nielsen *in* Perch-Nielsen and Franz (1977)

Scapholithus fossilis Deflandre *in* Deflandre and Fert (1954)
Sollasites barringtonensis Black 1967
Sollasites lowei (Bukry 1969) Roth 1970
Stovarius achylosus (Stover 1966) Perch-Nielsen 1984
Stovarius asymmetricus (Bukry 1969) Perch-Nielsen 1984
Stovarius biarcus (Bukry 1969) Perch-Nielsen 1984
Stradnaria crenulata (Bramlette & Martini 1964) Noël 1970
Tetrapodorhabdus decorus (Deflandre *in* Deflandre and Fert, 1954) Wind & Wise *in* Wise and Wind (1977)
Tortolithus hallii (Bukry 1969) Crux *in* Crux and others (1982)
Tortolithus pagei (Bukry 1969) Crux *in* Crux and others (1982)
Tranolithus minimus (Bukry 1969) Perch-Nielsen 1984
Tranolithus phacelosus Stover 1966
Vekshinella aachena Bukry 1969
Vekshinella parma Wind & Wise *in* Wise and Wind (1977)
Vekshinella stradneri Rood et al. 1971
Watznaueria barnesae (Black *in* Black and Barnes, 1959) Perch-Nielsen 1968
Watznaueria biporta Bukry 1969
Watznaueria supracretacea (Reinhardt 1965) Wind & Wise 1976
Zeugrhabdotus acanthus Reinhardt 1965
Zeugrhabdotus erectus (Deflandre *in* Deflandre and Fert, 1954) Reinhardt 1965
Zeugrhabdotus obliqueclausus Varol 1991
Zeugrhabdotus pseudanthophorus (Bramlette & Martini 1964) Perch-Nielsen 1984

Part B. Cenozoic calcareous nannofossil species (in alphabetical order by genus).

Biantholithus sparsus Bramlette & Martini 1964
Braarudosphaera bigelowii (Gran & Braarud 1935) Deflandre 1947
Braarudosphaera discula Bramlette & Riedel 1954
Campylosphaera dela (Bramlette & Sullivan 1961) Hay & Mohler 1967
Chiasmolithus bidens (Bramlette & Sullivan 1961) Hay & Mohler 1967
Chiasmolithus consuetus (Bramlette & Sullivan 1961) Hay & Mohler 1967
Chiasmolithus danicus (Brotzen 1959) Hay & Mohler 1967
Coccolithus cribellum (Bramlette & Sullivan 1961) Stradner 1962
Coccolithus eopelagicus (Bramlette & Riedel 1954) Bramlette & Sullivan 1961
Coccolithus pelagicus (Wallich 1877) Schiller 1930
Cruciplacolithus asymmetricus van Heck & Prins 1987
Cruciplacolithus edwardsii Romein 1979
Cruciplacolithus intermedius van Heck & Prins 1987
Cruciplacolithus primus Perch-Nielsen 1977a
Cruciplacolithus tenuis (Stradner 1961) Hay & Mohler *in* Hay and others (1967)
Cyclagelosphaera alta Perch-Nielsen 1979
Cyclagelosphaera prima (Bukry 1969) Bybell & Self-Trail 1995
Cyclagelosphaera reinhardtii (Perch-Nielsen 1968) Romein 1977
Cyclococcolithus formosus Kamptner 1963
Cyclococcolithus robustus (Bramlette & Sullivan 1961) Locker 1973
Discoaster barbadiensis Tan Sin Hok 1927
Discoaster diastypus Bramlette & Sullivan 1961
Discoaster lenticularis Bramlette & Sullivan 1961
Discoaster lodoensis Bramlette & Riedel 1954
Discoaster mohleri Bukry & Percival 1971
Discoaster multiradiatus Bramlette & Riedel 1954
Ellipsolithus bollii Perch-Nielsen 1977
Ellipsolithus distichus (Bramlette & Sullivan 1961) Sullivan 1964
Ellipsolithus macellus (Bramlette & Sullivan 1961) Sullivan 1964

Ericsonia subpertusa Hay & Mohler 1967
Fasciculithus involutus Bramlette & Sullivan 1961
Fasciculithus tympaniformis Hay & Mohler *in* Hay and others (1967)
Gephyrocapsa oceanica Kamptner 1943
Goniolithus fluckigeri Deflandre 1957
Helicosphaera seminulum Bramlette & Sullivan 1961
Heliolithus cantabriae Perch-Nielsen 1971
Heliolithus kleinpellii Sullivan 1964
Heliolithus riedelii Bramlette & Sullivan 1961
Hornibrookina arca Bybell & Self-Trail 1995
Markalius apertus Perch-Nielsen 1979
Markalius inversus Bramlette & Martini 1964
Micrantholithus aequalis Sullivan 1964
Micrantholithus fornicatus Martini 1961
Micrantholithus pinguis Bramlette & Sullivan 1961
Micrantholithus vesper Deflandre *in* Deflandre and Fert (1954)
Neochiastozygus concinnus (Martini 1961) Perch-Nielsen 1971
Neococcolithes protenus (Bramlette & Sullivan 1961) Black 1967
Placozygus sigmoides (Bramlette & Sullivan 1961) Romein 1979
Pontosphaera multipora (Kamptner ex Deflandre 1959) Roth 1970
Rhomboaster bramlettei (Brönnimann & Stradner 1960) Bybell & Self-Trail 1995
Rhomboaster contortus (Stradner 1958) Bybell & Self-Trail 1995
Rhomboaster orthostylus (Shamrai 1963) Bybell & Self-Trail 1995
Sphenolithus anarrhopus Bukry & Bramlette 1969
Sphenolithus moriformis (Brönnimann & Stradner 1960) Bramlette & Wilcoxon 1967
Sphenolithus primus Perch-Nielsen 1971
Toweius callosus Perch-Nielsen 1971
Toweius eminens (Bramlette & Sullivan 1961) Gartner 1971 var. *eminens*
Toweius eminens var. *tovae* Bybell & Self-Trail 1995
Toweius occultatus (Locker 1967) Perch-Nielsen 1971
Toweius pertusus (Sullivan 1965) Romein 1979b
Transversopontis pulcher (Deflandre *in* Deflandre and Fert, 1954) Perch-Nielsen 1967
Zygodiscus herlyni Sullivan 1964
Zygrhablithus bijugatus (Deflandre *in* Deflandre and Fert, 1954) Deflandre 1959

Part C. Dinoflagellate species (in alphabetical order by genus).

Achomosphaera alcicornu (Eisenack 1954) Davey & Williams 1966
Adnatosphaeridium Williams & Downie 1966 sp.
Alisogymnium Lentin & Vozzhennikova 1990 spp.
Alterbidinium acutulum (Wilson 1967) Lentin & Williams 1985
Amphorosphaeridium multispinosum (Davey & Williams 1966) Sarjeant 1981
Andalusiella polymorpha (Malloy 1972) Lentin & Williams 1977
?*Andalusiella rhombohedra* of Edwards (1984)
Andalusiella spicata (May 1980) Lentin & Williams 1981
Areoligera volata Drugg 1967
Areoligera Lejeune-Carpentier 1938 spp.
?*Canningia* Cookson & Eisenack 1960
Carpatella cornuta Grigorovich 1969
Cassidium Drugg 1967 ? sp.
Catillopsis Drugg 1970 ? sp.
Cerodinium pannuceum (Stanley 1965) Lentin & Williams 1967
Cerodinium Lentin & Williams 1987 sp.
Cerodinium striatum (Drugg 1967) Lentin & Williams 1987

Cordosphaeridium fibrospinosum Davey & Williams 1966
Cordosphaeridium inodes (Klumpp 1953) Eisenack 1963
Cordosphaeridium Eisenack 1963 spp.
Cribroperidinium Neale & Sarjeant 1962 ?
Damassadinium californicum (Drugg 1967) Fensome et al. 1993
Deflandrea delineata Cookson & Eisenack 1965
Deflandrea galeata (Lejeune-Carpentier 1942) Lentin & Williams 1973
Deflandrea cf. *D. diebelii* Alberti of Drugg (1967)
Deflandrea n. sp. aff. *D. truncata* Eisenack 1938
Diphyes colligerum (Deflandre & Cookson 1955) Cookson 1965
Diphyes ficusoides Islam 1983
Disphaerogena carposphaeropsis Wetzel 1933, including *Cyclapophysis monmouthensis* Benson 1976
Exochosphaeridium bifidum (Clark & Verdier 1967) Clark et al. 1968
Fibradinium annetorpense Morgenroth 1968
Fibrocysta lappacea (Drugg 1970) Stover & Evitt 1978
Fibrocysta Stover & Evitt 1978 sp.
Florentinia ferox (Deflandre 1937) Duxbury 1980
Fromea fragilis (Cookson & Eisenack 1962) Stover & Evitt 1978
Glaphyrocysta Stover & Evitt 1978 spp.
Hafniasphaera septata (Cookson & Eisenack 1967) Hansen 1977
Hafniasphaera Hansen 1977 spp.
Hystrichokolpoma Deflandre 1935 sp.
Hystrichosphaeridium tubiferum (Ehrenberg 1838) Deflandre 1937
Impagidinium Stover & Evitt 1978 sp.
Isabelidinium cooksoniae (Alberti 1959) Lentin & Williams 1977
Kallosphaeridium brevibarbatum de Coninck 1969 ?
Kallosphaeridium de Coninck 1969 ? sp.
Lejeunecysta Artzner & Dörhöfer 1978 sp.
Lingulodinium machaerophorum (Deflandre & Cookson 1955) Wall 1967
Multispinula quanta Bradford 1975
Nematosphaeropsis Deflandre & Cookson 1955 sp.
Oligosphaeridium complex (White 1842) Davey & Williams 1966
Operculodinium centrocarpum (Deflandre & Cookson 1955) Wall 1967
Operculodinium Wall 1967 sp.
Palaeocystodinium golzowense Alberti 1961
Palaeocystodinium Alberti 1961 (fat)
Palaeoperidinium pyrophorum (Ehrenberg 1838) Sarjeant 1967
Palynodinium grallator Gocht 1970
Phelodinium magnificum (Stanley 1965) Stover & Evitt 1978
Phelodinium sp. of Edwards (1989)
Phelodinium Stover & Evitt 1978 sp.
Piercites pentagonum (May 1980) Habib & Drugg 1987
Polysphaeridium zoharyi (Rossignol 1962) Bujak et al. 1980
Selenopemphix Benedek 1972 sp.
Senegalinium Jain & Millepied 1973 sp.
Senoniasphaera inornata (Drugg 1970) Stover & Evitt 1978
Spinidinium pulchrum (Benson 1976) Lentin & Williams 1977
Spinidinium Cookson & Eisenack 1962 spp.
Spiniferella cornuta (Gerlach 1961) Stover & Hardenbol 1993
Spiniferites mirabilis (Rossignol 1964) Sarjeant 1970
Spiniferites pseudofurcatus (Klumpp 1953) Sarjeant 1970
Spiniferites Mantell 1850 spp.
Spongodinium delitiense (Ehrenberg 1838) Deflandre 1936
Tanyosphaeridium xanthiopyxides (Wetzel 1933) Stover & Evitt 1978

Tectatodinium pellitum Wall 1967
Tectatodinium rugulatum (Hansen 1977) McMinn 1988
Tenua sp. cf *T. formosa* of Kurita and McIntyre (1995)
Thalassiphora delicata Williams & Downie 1966 ?
Thalassiphora pelagica (Eisenack 1964) Eisenack & Gocht 1960
?*Thalassiphora* Eisenack & Gocht 1960 sp.
Trigonopyxidia ginella Cookson & Eisenack 1960
Turbiosphaera sp. aff *T. magnifica* Eaton of Edwards (1989)
Turbiosphaera Archangelsky 1969 sp.
Xenascus ceratioides (Deflandre 1937) Lentin & Williams 1973
Xenikoon australis sensu Benson (1976)
miscellaneous areoligeracean forms (including *Areoligera* Lejeune-Carpentier 1938 spp. and *Glaphyrocysta* Stover & Evitt 1978 spp.)
small peridiniacean forms

Part D. Cenozoic pollen taxa (in alphabetical order by genus).

Bombacacidites reticulatus Krutzsch 1961
Carya <29 µm of Frederiksen and Christopher (1978)
Caryapollenites prodromus group of Frederiksen (1991)
Choanopollenites conspicuus (Groot & Groot 1962) Tschudy 1973
Choanopollenites patricius Tschudy 1973
Favitricolporites baculoferus (Pflug *in* Thomson and Pflug, 1953) Srivastava 1972
Holkopollenites chemardensis Fairchild *in* Stover and others (1966)
Intratriporopollenites pseudinstructus Mai 1961
Milfordia minima Krutzsch 1970
Momipites coryloides Wodehouse 1933
Momipites microfoveolatus (Stanley 1965) Nichols 1973
Momipites strictus Frederiksen & Christopher 1978
Momipites tenuipolus group of Frederiksen and Christopher (1978)
Nudopollis terminalis (Pflug & Thomson *in* Thomson and Pflug, 1953) Elsik 1968
Pseudoplicapollis limitatus Frederiksen 1978
Thomsonipollis magnificus (Pflug *in* Thomson and Pflug, 1953) Krutzsch 1960
Triatriopollenites subtriangulus (Stanley 1965) Frederiksen 1979
Trudopollis plenus Tschudy 1975
Ulmipollenites tricostatus (Anderson 1960) Frederiksen 1980

Part E. Cretaceous foraminifer taxa.

Planktic:
Gansserina gansseri (Bolli 1951)
Globigerinelloides prairiehillensis (Pessagno 1967)
Globigerinelloides subcarinatus (Brönnimann 1952)
Globotruncana aegyptiaca Nakkady 1950
Globotruncana arca (Cushman 1926)
Globotruncana orientalis El Naggar 1966
Globotruncana rosetta (Carsey 1926)
Globotruncana ventricosa White 1928
Globotruncanella havanensis (Voorwijk 1937)
Globotruncanella petaloidea (Gansolfi 1955)
Globotruncanita stuartiformis (Dalbiez 1955)
Guembelitria cretacea Cushman 1933
Hedbergella monmouthensis (Olsson 1960)
Heterohelix globulosa (Ehrenberg 1840)

Heterohelix navarroensis Loeblich 1951
Heterohelix striata (Ehrenberg 1840)
Laeviheterohelix glabrans (Cushman 1938)
Planoglobulina acervulinoides (Egger 1899)
Planoglobulina multicamerata (De Klasz 1953)
Pseudoguembelina costulata (Cushman 1938)
Pseudoguembelina kempensis Egger 1968
Pseudoguembelina palpebra Brönnimann & Brown 1953
Pseudotextularia elegans (Rzehak 1891)
Pseudotextularia intermedia De Klasz 1953
Pseudotextularia nuttali (Voorwijk 1937)
Racemiguembelina fructicosa (Egger 1899)
Rugoglobigerina hexacamerata Brönnimann 1952
Rugoglobigerina rugosa (Plummer 1926)
Trinitella scotti (Brönnimann 1952)

Benthic:
Gavelinella beccariiformis (White 1928)
Nuttalides truempyi (Nuttall 1930)

Appendix 4. Dinocyst sample descriptions from the Santee Coastal Reserve core

Santee Coastal Reserve was assigned U.S. Geological Survey Paleobotanical number R5306.

Peedee Formation

R5306 BW (380.3 ft)
Preservation: poor. Diversity: moderate. No single species dominates.
Age: Cretaceous
Adnatosphaeridium Williams & Downie 1966 sp.
Andalusiella polymorpha (Malloy 1972) Lentin & Williams 1977
Cerodinium Lentin & Williams 1987 sp.
Cerodinium striatum (Drugg 1967) Lentin & Williams 1987
Fibrocysta Stover & Evitt 1978 sp.
Fromea fragilis (Cookson & Eisenack 1962) Stover & Evitt 1978
Cribroperidinium Neale & Sarjeant 1962 ? (fragment)
Hafniasphaera Hansen 1977 spp.
Hystrichosphaeridium tubiferum (Ehrenberg 1838) Deflandre 1937 ?
Oligosphaeridium complex (White 1842) Davey & Williams 1966 ?
Operculodinium Wall 1967 sp. ?
Palaeocystodinium Alberti 1961 (fat)
Palaeoperidinium pyrophorum (Ehrenberg 1838) Sarjeant 1967
Phelodinium magnificum (Stanley 1965) Stover & Evitt 1978
Spiniferella cornuta (Gerlach 1961) Stover & Hardenbol 1993
Spiniferites Mantell 1850 spp.
?*Thalassiphora* Eisenack & Gocht 1960 sp.
miscellaneous areoligeracean forms
small peridiniacean forms

Rhems Formation *sensu stricto*

R5306 A (365.9 ft)
Preservation: fair. Diversity: moderately high. No single species dominates.
Age: late Maastrichtian or early Danian
Amphorosphaeridium multispinosum (Davey & Williams 1966) Sarjeant 1981
Andalusiella polymorpha (Malloy 1972) Lentin & Williams 1977
Cordosphaeridium inodes (Klumpp 1953) Eisenack 1963
Cribroperidinium Neale & Sarjeant 1962 sp.
Deflandrea cf. *D. diebelii* Alberti of Drugg (1967)
Deflandrea n. sp. aff. *D. truncata* Eisenack 1938
Diphyes colligerum (Deflandre & Cookson 1955) Cookson 1965
Disphaerogena carposphaeropsis Wetzel 1933
Fibrocysta Stover & Evitt 1978 spp.
Hystrichosphaeridium tubiferum (Ehrenberg 1838) Deflandre 1937
Impagidinium Stover & Evitt 1978 sp.
Palaeocystodinium Alberti 1961 (fat)
Palaeoperidinium pyrophorum (Ehrenberg 1838) Sarjeant 1967
Palynodinium grallator Gocht 1970
Phelodinium Stover & Evitt 1978 sp.
Senoniasphaera inornata (Drugg 1970) Stover & Evitt 1978
Spinidinium Cookson & Eisenack 1962 sp.
Spiniferites Mantell 1850 spp.
Spongodinium delitiense (Ehrenberg 1838) Deflandre 1936

Tanyosphaeridium xanthiopyxides (Wetzel 1933) Stover & Evitt 1978
?*Thalassiphora* Eisenack & Gocht 1960 sp.
miscellaneous areoligeracean forms
small peridiniacean forms

R5306 D (358.5 ft)
Preservation: fair. Diversity: moderate. No single species dominates.
Age: early Paleocene
Andalusiella polymorpha (Malloy 1972) Lentin & Williams 1977
Areoligera volata Drugg 1967
Catillopsis Drugg 1970 ? sp.
Cerodinium striatum (Drugg 1967) Lentin & Williams 1987
Cordosphaeridium inodes (Klumpp 1953) Eisenack 1963
Cribroperidinium Neale & Sarjeant 1962 sp.
Damassadinium californicum (Drugg 1967) Fensome et al. 1993
Deflandrea cf. *D. diebelii* Alberti of Drugg (1967)
Deflandrea n. sp. aff. *D. truncata* Eisenack 1938
Diphyes colligerum (Deflandre & Cookson 1955) Cookson 1965
Disphaerogena carposphaeropsis Wetzel 1933 ?
Fibrocysta lappacea (Drugg 1970) Stover & Evitt 1978
Fibrocysta Stover & Evitt 1978 sp.
Hafniasphaera septata (Cookson & Eisenack 1967) Hansen 1977
Hystrichokolpoma Deflandre 1935 sp.
Oligosphaeridium complex (White 1842) Davey & Williams 1966 ?
Palaeoperidinium pyrophorum (Ehrenberg 1838) Sarjeant 1967
Phelodinium Stover & Evitt 1978 sp.
Spinidinium Cookson & Eisenack 1962 sp.
Spiniferites Mantell 1850 spp.
miscellaneous areoligeracean forms

R5306 G (342.9 ft)
Preservation: fair. Diversity: moderate. No single species dominates.
Age: early Paleocene
Andalusiella polymorpha (Malloy 1972) Lentin & Williams 1977
Catillopsis Drugg 1970 ? sp.
Cordosphaeridium inodes (Klumpp 1953) Eisenack 1963
Cribroperidinium Neale & Sarjeant 1962 sp.
Damassadinium californicum (Drugg 1967) Fensome et al. 1993
Deflandrea cf. *D. diebelii* Alberti of Drugg (1967)
Diphyes colligerum (Deflandre & Cookson 1955) Cookson 1965
Fibrocysta Stover & Evitt 1978 spp.
Hafniasphaera Hansen 1977 spp.
Hystrichosphaeridium tubiferum (Ehrenberg 1838) Deflandre 1937
Palaeocystodinium Alberti 1961 (fat)
Palaeoperidinium pyrophorum (Ehrenberg 1838) Sarjeant 1967
Phelodinium Stover & Evitt 1978 sp.
Spinidinium Cookson & Eisenack 1962 sp.
Spiniferites Mantell 1850 spp.
miscellaneous areoligeracean forms

R5306 H (326.0 ft)
Preservation: fair. Diversity: moderate. No single species dominates.
Age: early Paleocene
Areoligera volata Drugg 1967

Cerodinium striatum (Drugg 1967) Lentin & Williams 1987
Cordosphaeridium inodes (Klumpp 1953) Eisenack 1963
Deflandrea cf. *D. diebelii* Alberti of Drugg (1967)
Deflandrea n. sp. aff. *D. truncata* Eisenack 1938
Fibrocysta Stover & Evitt 1978 spp.
Hystrichokolpoma Deflandre 1935 sp.
Hystrichosphaeridium tubiferum (Ehrenberg 1838) Deflandre 1937
Oligosphaeridium complex (White 1842) Davey & Williams 1966 ?
Palaeocystodinium Alberti 1961 (fat)
Palaeoperidinium pyrophorum (Ehrenberg 1838) Sarjeant 1967
Spinidinium Cookson & Eisenack 1962 spp.
Spiniferites Mantell 1850 spp.
miscellaneous areoligeracean forms

R5306 I (306.0-306.2 ft depth)
Preservation: good. Diversity: moderate. Dominated by *Spinidinium* Cookson & Eisenack 1962 spp. and other small peridiniacean forms.
Age: early Paleocene
Andalusiella polymorpha (Malloy 1972) Lentin & Williams 1977
Catillopsis Drugg 1970 ? sp.
Cordosphaeridium inodes (Klumpp 1953) Eisenack 1963
Deflandrea cf. *D. diebelii* Alberti of Drugg (1967)
Deflandrea n. sp. aff. *D. truncata* Eisenack 1938
Diphyes colligerum (Deflandre & Cookson 1955) Cookson 1965
Fibrocysta Stover & Evitt 1978 spp.
Hafniasphaera septata (Cookson & Eisenack 1967) Hansen 1977
Hystrichosphaeridium tubiferum (Ehrenberg 1838) Deflandre 1937
Palaeocystodinium Alberti 1961 (fat)
Palaeoperidinium pyrophorum (Ehrenberg 1838) Sarjeant 1967
Phelodinium Stover & Evitt 1978 spp.
Spinidinium Cookson & Eisenack 1962 spp.
Spinidinium pulchrum (Benson 1976) Lentin & Williams 1977
Spiniferites Mantell 1850 spp.
Tenua sp. cf *T. formosa* of Kurita and McIntyre (1995)
miscellaneous areoligeracean forms
small peridiniacean forms

R5306 J (287.5 ft depth)
Preservation: good. Diversity: moderate. Dominated by *Spinidinium* Cookson & Eisenack 1962 spp. and other small peridiniacean forms.
Age: early Paleocene
Andalusiella polymorpha (Malloy 1972) Lentin & Williams 1977
Damassadinium californicum (Drugg 1967) Fensome et al. 1993
Deflandrea n. sp. aff. *D. truncata* Eisenack 1938
Fibrocysta Stover & Evitt 1978 spp.
Hafniasphaera septata (Cookson & Eisenack 1967) Hansen 1977
Hystrichokolpoma Deflandre 1935 sp.
Hystrichosphaeridium tubiferum (Ehrenberg 1838) Deflandre 1937
Operculodinium Wall 1967 sp.
Palaeocystodinium Alberti 1961 (fat)
Phelodinium magnificum (Stanley 1965) Stover & Evitt 1978
Spinidinium Cookson & Eisenack 1962 spp.
Spinidinium pulchrum (Benson 1976) Lentin & Williams 1977
Spiniferites Mantell 1850 spp.

Tectatodinium rugulatum (Hansen 1977) McMinn 1988
Tenua sp. cf *T. formosa* of Kurita and McIntyre (1995)
miscellaneous areoligeracean forms
small peridiniacean forms

R5306 K (273.4-273.6 ft)
Preservation: good. Diversity: high. No single species dominates.
Age: early Paleocene
?*Andalusiella rhombohedra* of Edwards (1984)
Andalusiella polymorpha (Malloy 1972) Lentin & Williams 1977
Carpatella cornuta Grigorovich 1969
Cribroperidinium Neale & Sarjeant 1962 sp.
Damassadinium californicum (Drugg 1967) Fensome et al. 1993
Deflandrea cf. *D. diebelii* Alberti of Drugg (1967)
Deflandrea n. sp. aff. *D. truncata* Eisenack 1938
Diphyes colligerum (Deflandre & Cookson 1955) Cookson 1965
Fibrocysta Stover & Evitt 1978 spp.
Hafniasphaera septata (Cookson & Eisenack 1967) Hansen 1977
Hystrichosphaeridium tubiferum (Ehrenberg 1838) Deflandre 1937
Kallosphaeridium de Coninck 1969 ? sp.
Nematosphaeropsis Deflandre & Cookson 1955 sp.
Oligosphaeridium complex (White 1842) Davey & Williams 1966 ?
Palaeocystodinium Alberti 1961 (fat)
Palaeocystodinium golzowense Alberti 1961
Palaeoperidinium pyrophorum (Ehrenberg 1838) Sarjeant 1967
Spinidinium Cookson & Eisenack 1962 spp.
Spiniferites Mantell 1850 spp.
Tanyosphaeridium xanthiopyxides (Wetzel 1933) Stover & Evitt 1978
Tectatodinium rugulatum (Hansen 1977) McMinn 1988
Tenua sp. cf *T. formosa* of Kurita and McIntyre (1995)
?*Thalassiphora* Eisenack & Gocht 1960 sp.
Trigonopyxidia ginella Cookson & Eisenack 1960
miscellaneous areoligeracean forms
miscellaneous cladopyxiaceaen forms
small peridiniacean forms
acritarchs including *Paralecaniella indentata* Cookson & Eisenack 1955) Cookson & Eisenack 1970 and *Micrhystridium fragile* Deflandre 1947

Upper part of the Rhems Formation *sensu* Bybell and others (1998)

R5306 L (255.7-256.0 ft depth)
Preservation: good. Diversity: moderately high. No single species dominates.
Age: Paleocene, near the early/late boundary

Achomosphaera alcicornu (Eisenack 1954) Davey & Williams 1966
Andalusiella sp. aff. *A. polymorpha* of Edwards (1980)
?*Andalusiella rhombohedra* of Edwards (1984)
?*Canningia* Cookson & Eisenack 1960
Cordosphaeridium Eisenack 1963 spp.
Cribroperidinium Neale & Sarjeant 1962 sp.
Damassadinium californicum (Drugg 1967) Fensome et al. 1993
Diphyes colligerum (Deflandre & Cookson 1955) Cookson 1965
Florentinia ferox (Deflandre 1937) Duxbury 1980
Hafniasphaera septata (Cookson & Eisenack 1967) Hansen 1977

Isabelidinium cooksoniae (Alberti 1959) Lentin & Williams 1977
Lejeunecysta Artzner & Dörhöfer 1978 sp.
Oligosphaeridium complex (White 1842) Davey & Williams 1966 ?
Operculodinium centrocarpum (Deflandre & Cookson 1955) Wall 1967
Palaeoperidinium pyrophorum (Ehrenberg 1838) Sarjeant 1967
Phelodinium magnificum (Stanley 1965) Stover & Evitt 1978
Phelodinium sp. of Edwards (1989)
Spiniferites Mantell 1850 spp.
Tanyosphaeridium xanthiopyxides (Wetzel 1933) Stover & Evitt 1978
Turbiosphaera Archangelsky 1969 sp.
miscellaneous areoligeracean forms
miscellaneous cladopyxiaceaen forms
small peridiniacean forms

Lower Bridge Member of the Williamsburg Formation

R5306 CA (233.8 ft)
Preservation: fair. Diversity: moderate. Dominated by small peridiniacean forms.
Age: late Paleocene
?*Andalusiella rhombohedra* of Edwards (1984)
Amphorosphaeridium multispinosum (Davey & Williams 1966) Sarjeant 1981
Cordosphaeridium inodes (Klumpp 1953) Eisenack 1963
Deflandrea delineata Cookson & Eisenack 1965
Diphyes colligerum (Deflandre & Cookson 1955) Cookson 1965
Fibradinium annetorpense Morgenroth 1968
Fibrocysta Stover & Evitt 1978 sp.
Hafniasphaera septata (Cookson & Eisenack 1967) Hansen 1977
Lejeunecysta Artzner & Dörhöfer 1978 sp.
Operculodinium Wall 1967 sp.
Phelodinium sp. of Edwards (1989)
Spinidinium pulchrum (Benson 1976) Lentin & Williams 1977 ?
Spiniferites Mantell 1850 spp.
Xenikoon australis sensu Benson (1976)
miscellaneous areoligeracean forms
small peridiniacean forms

R5306 M (214.3-214.5 ft)
Preservation: fair. Diversity: moderate. No single species dominates.
Age: late Paleocene, possible Eocene contamination (fragment of ? *Pentadinium* sp.)
Amphorosphaeridium multispinosum (Davey & Williams 1966) Sarjeant 1981
Cassidium Drugg 1967 ? sp.
Cordosphaeridium inodes (Klumpp 1953) Eisenack 1963
Damassadinium californicum (Drugg 1967) Fensome et al. 1993
Deflandrea cf. *D. diebelii* Alberti of Drugg (1967)
Diphyes colligerum (Deflandre & Cookson 1955) Cookson 1965
Fibradinium annetorpense Morgenroth 1968
Hafniasphaera Hansen 1977 sp.
Hafniasphaera septata (Cookson & Eisenack 1967) Hansen 1977
Operculodinium centrocarpum (Deflandre & Cookson 1955) Wall 1967
Palaeoperidinium pyrophorum (Ehrenberg 1838) Sarjeant 1967
Phelodinium sp. of Edwards (1989)
Spinidinium pulchrum (Benson 1976) Lentin & Williams 1977 ?
Spiniferites Mantell 1850 spp.
Spiniferites pseudofurcatus (Klumpp 1953) Sarjeant 1970

Tectatodinium pellitum Wall 1967
miscellaneous areoligeracean forms
miscellaneous cladopyxiaceaen forms
small peridiniacean forms
acritarchs including *Paralecaniella indentata* Cookson & Eisenack 1955) Cookson & Eisenack 1970 and *Micrhystridium fragile* Deflandre 1947

R5306 N (203.0-203.2 ft)
Preservation: good. Diversity: moderate. Dominated by miscellaneous areoligeracean forms.
Age: late Paleocene
Amphorosphaeridium multispinosum (Davey & Williams 1966) Sarjeant 1981
Cordosphaeridium inodes (Klumpp 1953) Eisenack 1963
Damassadinium californicum (Drugg 1967) Fensome et al. 1993
Deflandrea delineata Cookson & Eisenack 1965
Diphyes colligerum (Deflandre & Cookson 1955) Cookson 1965
Fibrocysta Stover & Evitt 1978 sp.
Fromea fragilis (Cookson & Eisenack 1962) Stover & Evitt 1978
Operculodinium centrocarpum (Deflandre & Cookson 1955) Wall 1967
Palaeoperidinium pyrophorum (Ehrenberg 1838) Sarjeant 1967
Phelodinium sp. of Edwards (1989)
Spinidinium Cookson & Eisenack 1962 spp.
Spiniferites Mantell 1850 sp.
miscellaneous areoligeracean forms
small peridiniacean forms

R5306 O (191.6 ft)
Preservation: good. Diversity: moderate. Dominated by miscellaneous areoligeracean forms.
Age: late Paleocene
Amphorosphaeridium multispinosum (Davey & Williams 1966) Sarjeant 1981
Cordosphaeridium fibrospinosum Davey & Williams 1966
Damassadinium californicum (Drugg 1967) Fensome et al. 1993
Deflandrea delineata Cookson & Eisenack 1965
Diphyes colligerum (Deflandre & Cookson 1955) Cookson 1965
Diphyes ficusoides Islam 1983
Fibrocysta Stover & Evitt 1978 sp.
Operculodinium centrocarpum (Deflandre & Cookson 1955) Wall 1967
Palaeoperidinium pyrophorum (Ehrenberg 1838) Sarjeant 1967
Phelodinium sp. of Edwards (1989)
Spinidinium Cookson & Eisenack 1962 sp.
Spiniferites Mantell 1850 spp.
miscellaneous areoligeracean forms
miscellaneous cladopyxiaceaen forms
small peridiniacean forms

R5306 P (165.5-165.7 ft depth)
Preservation: fair. Diversity: moderate. Dominated by small peridiniacean forms.
Age: late Paleocene
Amphorosphaeridium multispinosum (Davey & Williams 1966) Sarjeant 1981
Cordosphaeridium Eisenack 1963 sp.
Damassadinium californicum (Drugg 1967) Fensome et al. 1993
Hafniasphaera septata (Cookson & Eisenack 1967) Hansen 1977
Operculodinium centrocarpum (Deflandre & Cookson 1955) Wall 1967
Palaeocystodinium golzowense Alberti 1961
Palaeoperidinium pyrophorum (Ehrenberg 1838) Sarjeant 1967

Phelodinium magnificum (Stanley 1965) Stover & Evitt 1978
Phelodinium sp. of Edwards (1989)
Spinidinium Cookson & Eisenack 1962 sp.
Spiniferites Mantell 1850 spp.
miscellaneous areoligeracean forms
small peridiniacean forms

Chicora Member of the Williamsburg Formation

R5306 S (111.2 ft)
Preservation: fair. Diversity: moderate. No single species dominates, dinocysts sparse.
Age: late Paleocene
Achomosphaera alcicornu (Eisenack 1954) Davey & Williams 1966
Cordosphaeridium Eisenack 1963 sp.
Diphyes colligerum (Deflandre & Cookson 1955) Cookson 1965
Hafniasphaera septata (Cookson & Eisenack 1967) Hansen 1977
Kallosphaeridium de Coninck 1969 ? sp.
Operculodinium centrocarpum (Deflandre & Cookson 1955) Wall 1967
Phelodinium sp. of Edwards (1989)
Spiniferites Mantell 1850 spp.
Thalassiphora delicata Williams & Downie 1966 ?
Turbiosphaera sp. aff. *T. magnifica* Eaton of Edwards (1989)
Xenikoon australis sensu Benson (1976)
miscellaneous areoligeracean forms
miscellaneous cladopyxiaceaen forms
small peridiniacean forms
acritarchs including *Paralecaniella indentata* Cookson & Eisenack 1955) Cookson & Eisenack 1970

R5306 X (81.2 ft depth)
Preservation: fair. Diversity: moderate. No single species dominates, dinocysts sparse.
Age: late Paleocene
?*Andalusiella rhombohedra* of Edwards (1984)
Deflandrea delineata Cookson & Eisenack 1965
Hafniasphaera septata (Cookson & Eisenack 1967) Hansen 1977
Hystrichosphaeridium tubiferum (Ehrenberg 1838) Deflandre 1937
Phelodinium sp. of Edwards (1989)
Spiniferites Mantell 1850 sp.
Spiniferites pseudofurcatus (Klumpp 1953) Sarjeant 1970
Thalassiphora delicata Williams & Downie 1966
Turbiosphaera sp. aff. *T. magnifica* Eaton of Edwards (1989)
miscellaneous areoligeracean forms
miscellaneous cladopyxiaceaen forms
small peridiniacean forms
acritarchs including *Paralecaniella indentata* Cookson & Eisenack 1955) Cookson & Eisenack 1970, *Cyclopsiella* Drugg & Loeblich 1967 sp.

R5306 Z (63.3 ft)
Preservation: poor. Diversity: moderate. Dominated by *Turbiosphaera* sp. aff. *T. magnifica* Eaton of Edwards (1989), dinocysts sparse.
Age: late Paleocene
Deflandrea delineata Cookson & Eisenack 1965
Diphyes colligerum (Deflandre & Cookson 1955) Cookson 1965
Hafniasphaera Hansen 1977 sp.
Kallosphaeridium brevibarbatum de Coninck 1969 ?

Lejeunecysta Artzner & Dörhöfer 1978 sp.
Nematosphaeropsis Deflandre & Cookson 1955 sp.
Operculodinium centrocarpum (Deflandre & Cookson 1955) Wall 1967
Phelodinium sp. of Edwards (1989)
Spiniferites Mantell 1850 sp.
Spiniferites pseudofurcatus (Klumpp 1953) Sarjeant 1970/*Achomosphaera alcicornu* (Eisenack 1954) Davey & Williams 1966
Thalassiphora delicata Williams & Downie 1966
Turbiosphaera sp. aff. *T. magnifica* Eaton of Edwards (1989)
small peridiniacean forms
acritarchs including *Paralecaniella indentata* Cookson & Eisenack 1955) Cookson & Eisenack 1970, *Cyclopsiella* Drugg & Loeblich 1967 sp.

Mollusk-bryozoan limestone

R5306 AF (51.0 ft depth)
Preservation: poor. Diversity: low. Dinocysts sparse; only six specimens encountered.
Age: Cenozoic
Lingulodinium machaerophorum (Deflandre & Cookson 1955) Wall 1967
Spiniferites Mantell 1850 sp.
small peridiniacean form ?

R5306 AB (50.4 ft depth)
Does not contain dinocysts.

R5306 AC (46.4 ft depth)
Preservation: poor. Diversity: low. Dinocysts sparse; only three specimens encountered.
Age: Cenozoic
Polysphaeridium zoharyi (Rossignol 1962) Bujak et al. 1980
Spiniferites Mantell 1850 sp.
Tectatodinium pellitum Wall 1967

R5306 AG (46.0 ft depth)
Preservation: poor. Diversity: low. Dinocysts sparse.
Age: Late Eocene, Oligocene, Miocene, or Pliocene, or mixed ages
Dapsilidinium pseudocolligerum (Stover 1977) Bujak et al. 1980
Operculodinium Wall 1967 spp.
Polysphaeridium zoharyi (Rossignol 1962) Bujak et al. 1980
Spiniferites Mantell 1850 sp.
miscellaneous areoligeracean form (operculum)
small sphaerical form

Wando Formation

R5306 AD (35.9 ft depth)
Barren, does not contain dinocysts.

Silver Bluff beds

R 5306 AE (26.0 ft depth)
Preservation: fair. Diversity: low. Dominated by *Spiniferites* Mantell 1850 spp.
Age: Miocene or younger, with Eocene or Oligocene material reworked.
Lingulodinium machaerophorum (Deflandre & Cookson 1955) Wall 1967
Multispinula quanta Bradford 1975

Nematosphaeropsis Deflandre & Cookson 1955 sp.
Operculodinium Wall 1967 spp.
Selenopemphix Benedek 1972 sp.
Spiniferites Mantell 1850 spp.
Spiniferites mirabilis (Rossignol 1964) Sarjeant 1970
Tectatodinium pellitum Wall 1967
freshwater alga *Pediastrum*
(reworked) *Wetzeliella* Eisenack 1938 sp.
(reworked?) miscellaneous areoligeracean form (operculum)