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The Cretaceous-Tertiary Boundary on the Cape Fear Arch, North Carolina, U.S.A.

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W. B. Harris, P. A. Thayer, and H. A. Curran. The Cretaceous-Tertiary Boundary on the Cape Fear Arch, North Carolina, U.S.A. *Cretaceous Research* (1986) **7**, 1–17. Petrologic and faunal study of a 72.5 m continuous corehole drilled in southeastern North Carolina has provided an opportunity to study a relatively uninterrupted vertical sequence across the Cretaceous–Tertiary boundary. The following stratigraphic sequence occurs; upper middle Maastrichtian Peedee Formation, −65.8 m to −51.8 m below mean sea-level (BMSL), upper middle Maastrichtian Rocky Point Member of the Peedee Formation, −51.8 m to −27.4 m BMSL, and middle to upper (?) Eocene Castle Hayne Limestone, −27.4 m to −15.2 m BMSL (base of casing).

The Peedee Formation consists of moderately indurated, very fine to fine, sandy foraminiferal biomicrite and sandy biomicrite. Silt-size zoned dolomite rhombohedra form up to 30% of the upper Peedee Formation and are most abundant where bioturbation is common. A diverse and well-preserved foraminiferal fauna indicates a middle to outer continental shelf environment.

The Rocky Point Member conformably overlies typical Peedee Formation lithology and consists of well-indurated sandy, fossiliferous biomicrite that grades upward into sandy, pelecypod biomicrosparite, and finally pelecypod biomicrudite. The Peedee Formation and the Rocky Point Member represent an overall shallowing-upward sequence with the upper surface forming the Cretaceous–Tertiary boundary.

The Castle Hayne Limestone disconformably overlies the Rocky Point Member and consists of lithoclast-bearing, bryozoan-molluscan biomicrudite grading upward into bryozoan biomicrudite. The Castle Hayne Limestone was deposited in an open, normal salinity environment between 30 m and 100 m in water depth.

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Key Words: Cretaceous–Tertiary boundary; Peedee Formation; Castle Hayne Limestone; Sedimentary petrography.

1. Introduction

The Cretaceous–Tertiary boundary in southeast North Carolina, which usually separates Cretaceous from Eocene strata, is rarely exposed in

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outcrop. A 72.5 m continuous corehole located about 4.8 km north of Southport, Brunswick County, North Carolina, on the axis of the Cape Fear arch has provided the opportunity to study the boundary outside the immediate zone of subaerial weathering (Figure 1). The Cape Fear arch is a northwest–southeast trending positive feature that extends from the piedmont to the coast in southeast North Carolina (Figure 1). The axis of the arch generally exposes Cretaceous rocks whereas Palaeogene rocks are preserved northeast and southwest of the axis. The major purpose of this study is to provide criteria that can be used to distinguish the Castle Hayne Limestone, the Rocky Point Member and the Peedee Formation in the subsurface and to provide information on the geologic history of southeast North Carolina.

The stratigraphic position of the Mesozoic–Cenozoic boundary in southeast North Carolina has been a subject of controversy since 1841 (see Hodge, 1841). However, work by Fallaw and Wheeler (1963), Cunliffe and Textoris (1969), Wheeler and Curran (1974), Harris and Bottino (1974), Harris (1978), and Harris *et al.* (1978) has provided detailed information on its nature. When the Cretaceous Peedee Formation is disconformably separated from the Eocene Castle Hayne Limestone, the surface is irregular and usually marked by phosphate and glauconite mineralisation and a thin, discontinuous phosphate-pebble biomicrudite. When the surface is overlain by post-Eocene sediments, phosphate and glauconite mineralisation is less common.

The Peedee Formation, which ranges in age from Campanian (?) to Maastrichtian, represents the youngest Mesozoic strata recognised in North Carolina Coastal Plain outcrops. It is a neritic, dark micaceous, argillaceous glauconitic sand (Swift and Heron, 1969) characterised by an abundant molluscan fauna (Stephenson, 1923). The formation is divided into an inner shelf suite composed of sand and muddy sand ("lower Peedee") and an outer shelf suite composed of calcareous muddy sand and sandy mud ("upper Peedee') (Swift, 1964). In Brunswick, New Hanover, Pender and Onslow counties, a sandy, pelecypod-rich carbonate (Rocky Point Member) occurs as a mappable unit in the upper part of the Peedee Formation (Harris, 1978).

Ward and Blackwelder (1979) renamed the Rocky Point Member as the Scotts Hill Member and suggested that nomenclatural priority precluded its use. However, the Stratigraphic Code of Nomenclature (1983, p. 853, Article 7, paragraph C) states that "... priority alone does not justify displacing a well-established name by one neither well-known nor commonly used ...". Because the name Rocky Point Member is well-established in the literature, it will be used in this paper.

The Castle Hayne Limestone, of middle to late Eocene (Bartonian–Priabonian) age, is the oldest Tertiary strata present in outcrop in southeastern North Carolina. It consists of a basal phosphate-pebble biomicrudite overlain by a friable bryozoan and sponge biomicruidite and biosparrudite (Upchurch, 1973; Baum *et al.*, 1978*a*). A dolomitised zone occurs in the biomicrudite in New Hanover County (Baum *et al.*, 1978*b*, 1985). The basal conglomerate contains a mixture of late Cretaceous and Eocene faunas. Previous workers have suggested that the Castle Hayne Limestone was deposited in warm, relatively shallow waters (Cunliffe, 1968; Baum, 1977; 1980; Jones, 1983); however, Otte (1981) suggested that part of the Castle Hayne Limestone was deposited in waters greater than 100 m in depth.

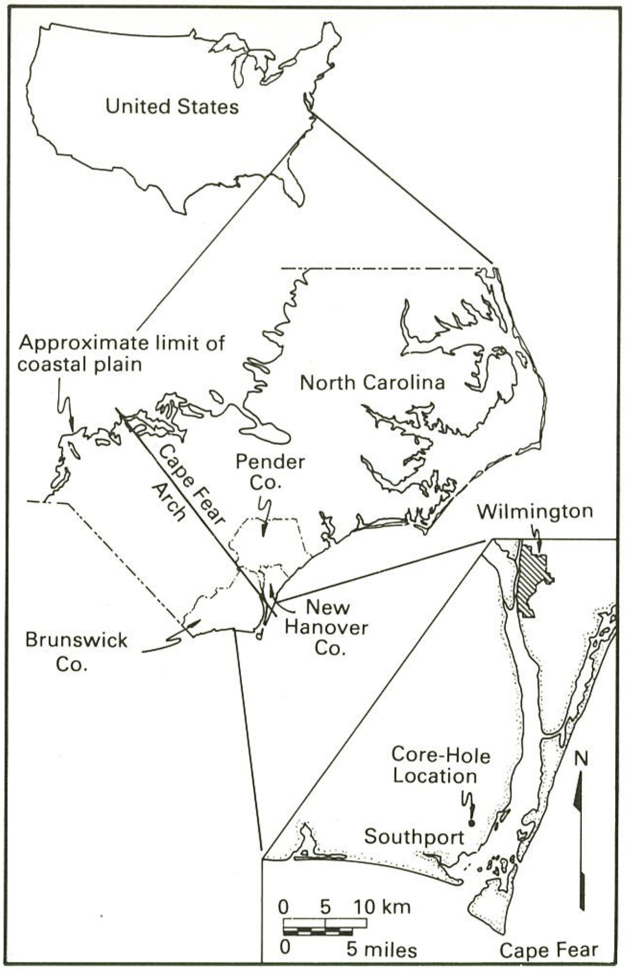

Figure 1. Location of the core-hole studied, Brunswick County, North Carolina.

1.1. Procedure.

The entire core was logged and 21 samples slabbed, etched in 10% HCl and studied for texture, fabric, sedimentary structures and fossil content. Selected slabs were stained with alizarin red-S to facilitate identification of dolomite and calcite. In addition, selected samples were studied by X-ray diffraction to determine the percentage of dolomite present. Thin-sections were prepared for each sample and the number frequency of the components was determined by counting 300–500 points per slide. In addition, insoluble residues were obtained from each sample by dissolving between 50 and 115 g of sample in 10% HCl. The residues were seived on optically calibrated screens at 0.5 phi unit intervals and Folk and Ward (1957) grain-size parameters were calculated by computer. The limestone and terrigenous rock terminology used are those of Folk (1968) and the porosity terminology is that used by Choquette and Pray (1970). All the samples were analysed for their diagnostic micro- and megafauna.

2. Peedee Formation

The Peedee Formation occurs from −65.8 m (base of core) to −51.8 m below mean sea-level (Figure 2). It is a moderately indurated, medium light gray to light olive gray, very fine to fine sandy foraminiferal biomicrite and sandy biomicrite (Figure 3). Although indistinct laminae are occasionally present, the unit is usually massive often with evidence of extensive burrowing. Distinctive megafossils are absent. In some zones, the micrite matrix has aggraded to microspar. The contact with the overlying Rocky Point Member is gradational and is marked by finely disseminated, silt-sized dolomite rhombohedra. All the original bivalve aragonite has dissolved and the Mg-calcite has inverted to calcite.

Framework constituents consist of about equal amounts of terrigenous material and fossil allochems (Figure 2). Table 1 indicates the principal fossil allochems in the Peedee Formation. Although little systematic variability of the allochemical constituents occurs, Foraminifera decrease slightly in abundance in the upper part of the Peedee (Figure 2).

Weight percent insoluble residue averages about 40% and shows a general abundance and size increase upwards (Figure 2). The residue is dominated by very fine to fine, subangular and subrounded quartz sand (Table 1), which is consistently well-sorted. Subordinate silt and clay also occur; the clay percentage increases systematically with depth (Figure 2).

Peedee samples are characterised by a diverse, well-preserved foraminiferal fauna of early to middle Maastrichtian age. Although the foraminiferal fauna contains abundant planktonic and benthonic species, it is dominated by such benthonic forms as *Anomalinoides pseudopapillosa*, *Gavelinella correcta*, and *Pseudouvigerina seligi*. The most abundant planktonic species are *Guembelitria cretacea*, *Heterohelix globosa*, *Heterohelix striata*, and several species belonging to the genus *Globotruncana*. The typical Peedee foraminiferal assemblage represents a middle to outer continental shelf environment (Curran, 1968). This paleodepositional environment determination is based on the percentage of planktonic specimens present in the samples following the depth scale of Tipsword *et al.* (1966, p. 124). The foraminiferal samples analysed from the Peedee beds all contained between 20–50% planktonic specimens.

Silt-size dolomite rhombohedra occur in the upper part of the Peedee Formation and the lower part of the Rocky Point Member. The percentage increases vertically upwards and reaches a maximum just above the contact between the two units (Figure 2). The rhombs are generally clear with cloudy centres and average about 40 μ. Some have rounded perimeters and most occur preferentially where bioturbation is greatest. Dolomite also appears to increase where the percentage of insoluble residue is most abundant (Figure 4). In some cases, the dolomite rhombohedra occur in intraparticle pores and also selectively replace foraminiferal walls.

Thin-section porosity averages almost 8% and is dominantly mouldic; minor intraparticle porosity in Foraminifera and molluscs is also present. The mouldic porosity has resulted from the dissolution of the aragonite fauna by freshwater meteoric diagenesis.

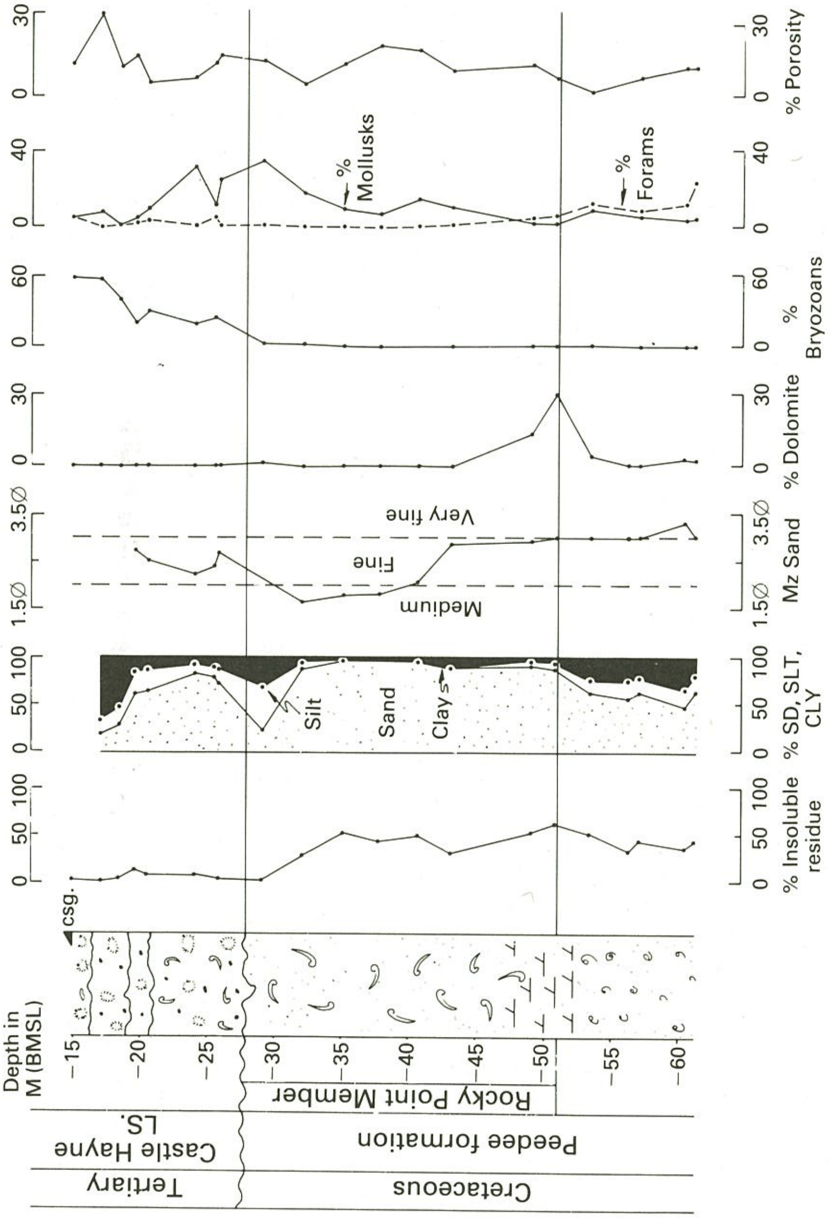

Figure 2. Core-hole stratigraphy with graphs of several parameters plotted against depth.

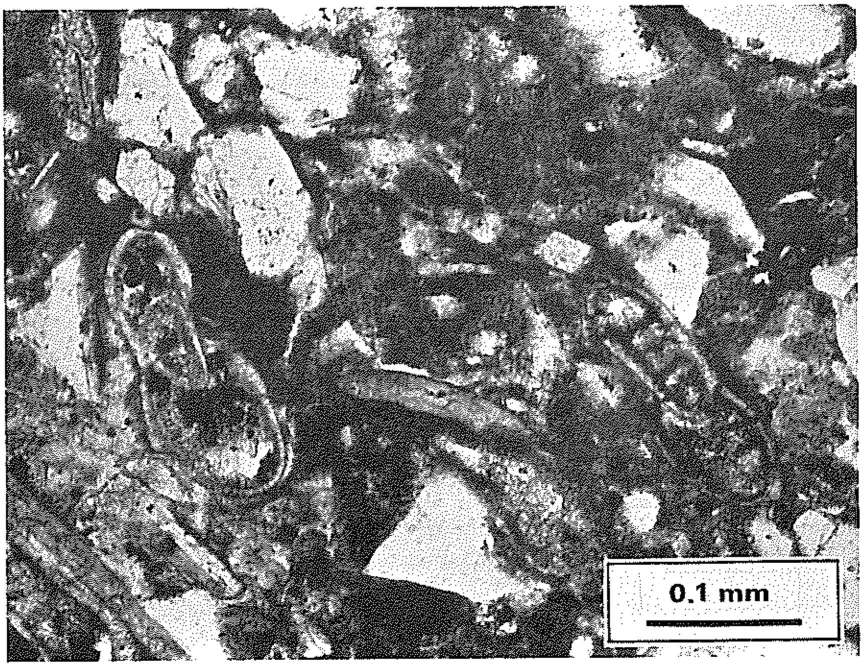

Figure 3. Photomicrograph of sandy, foraminiferal biomicrite, from the Peedee Formation (Depth −64.8 m below mean sea-level, plane polarised light).

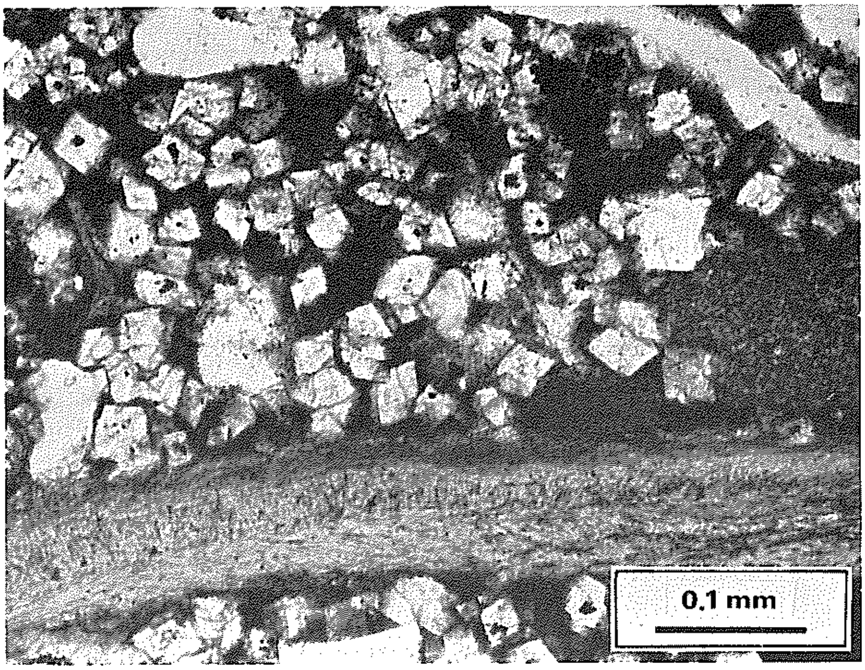

Figure 4. Photomicrograph of silt-size dolomite rhombohedra from the Peedee Formation. Note that some of the euhedral dolomite rhombs have cloudy centres. (Depth −53.6 m below mean sea-level, plane polarised light).

Table 1. Composition of data for the Cretaceous and Eocene lithostratigraphical units

Unit	Framework											Matrix			Cement				Insoluble residue						
																			Sand					Silt	Clay
	Bryozoans	Molluscs (undiff.)	Aragonitic Pelecypods	Calcitic Pelecypods	Scaphopods	Benthonic Foraminifera	Planktonic Foraminifera	Echinoderms	Intraclasts	Peloids	Others	Micrite	Microspar	Pseudospar	Dogtooth Calcite Spar	Blocky Calcite Spar	Acicular Calcite	Dolomite	Quartz	Plagioclase	K-Feldspar	Muscovite	Others		
Castle Hayne Limestone	A	C				R		R	R	R	R	A	T	T	R				A		T			C	C
Rocky Point Member																									
Pelecypod biomicrudite	R		R	C		T	T	R			T	A	R	R	R	T		T	T	T	T	T		T	T
Sandy, pelecypod biomicrosparite	T		C	R	T	T	T	T	T	T	T	R	C	C	R				A	T	T			T	R
Sandy, fossiliferous biomicrite	T		R	R		R	T	T		T	R	A	R	R			R	T	A	T	T	T		R	R
Peedee Formation	T			R	T	C	R	R			T	A	T	T				R	A	T	T	T	T	C	C

Key: A = abundant (>30%); C = common (10–29.9%); R = rare (1–9.9%); T = trace (<1%).

3. Rocky Point Member

The Rocky Point Member occurs from −51.8 to −27.4 m below mean sea-level (Figure 2). It is light gray to grayish orange (iron stains), well-indurated and grades upward from sandy, fossiliferous biomicrite to sandy, pelecypod biomicrosparite and finally into pelecypod biomicrudite. The sandy, pelecypod, biomicrosparite and sandy, fossiliferous biomicrite are the dominant rock types. The upper surface, which is the Cretaceous–Tertiary boundary, is a highly irregular, phosphatised and glauconitised disconformity with solution cavities extending for at least a metre below the boundary.

The weight-percent insoluble residue averages 38% and displays a systematic vertical decrease in percentage from the base to the top (Figure 2). The insoluble residue is dominated by quartz sand with minor silt and clay (Figure 2).

3.1. *Sandy, fossiliferous biomicrite*

About 15.5 m of sandy, fossiliferous biomicrite occurs at the base of the Rocky Point Member and underlies a sandy, pelecypod biomicrosparite. Although no specific fossil allochem dominates this lithology, pelecypods are more abundant near the top whereas foraminifera are more abundant near the base. Both lower and upper contacts are gradational. Most bivalves display prominent fungal and algal microborings or rare bivalve borings that are usually filled with iron-stained micrite or limonite. Table 1 shows the framework constituents of the biomicrite lithology.

The terrigenous framework is dominated by subangular and subrounded, fine to medium quartz sand. Medium quartz sand occurs in the upper part of this unit whereas fine quartz sand dominates the lower part (Figure 2). The terrigenous fraction is typically well-sorted. The matrix is principally a gray-brown micrite that is concentrated in burrows and laminae parallel to bedding. In the lower part of the unit, very fine euhedral dolomite rhombohedra occur in the matrix and form nearly 30% of the rock just above the boundary with the Peedee Formation (Figure 2). The dolomite is similar to that described from the Peedee.

Fine acicular calcite spar cement radiates from fossil allochems into intraparticle and shelter pores. Commonly the cement is syntaxial with the pelecypod shell microstructure or with the radial-axial foraminiferal walls. The shape, size and location of the crystals are similar to cement that is described as forming by subsea cementation (Bathurst, 1971). The porosity averages almost 13% and in order of abundance is vug, channel, mouldic, and interparticle. Most types formed through the dissolution of the aragonitic fauna by freshwater meteoric diagenesis. Dissolution in some cases has been intense enough to dissolve micrite envelopes.

3.2. *Sandy, pelecypod biomicrosparite*

Nine metres of sandy, pelecypod biomicrosparite overlie the sandy, fossiliferous biomicrite. Both the upper and lower contacts are gradational and are identified only where matrix or framework components change in size and abundance.

The fossil allochems (Table 1) are principally calcitic and aragonitic pelecypods. Aragonitic forms are preserved as moulds with micrite envelopes marking their exteriors. Fungal and algal microborings, that are generally filled with micrite, limonite, or haematite, are common. Other fossil and non-fossil allochems are listed in Table 1.

The terrigenous framework is dominated by subangular to subrounded medium quartz sand. In places grain angularity has been significantly enhanced by carbonate corrosion. The matrix averages about 50% microspar and less common pseudospar with trace quantities of disseminated micrite. Pyrite crystals, 6–15 μm in size, occur throughout the matrix and often have iron-stained exteriors. Cement, although generally absent, consists of fine calcite scalenohedra that partially fills some intraparticle areas (Table 2). The porosity averages 7% and is chiefly mouldic and vug, which formed by dissolution of the aragonitic bivalve fauna.

3.3. *Pelecypod biomicrudite*

Pelecypod biomicrudite comprises about the upper two metres of the Rocky Point Member. The top of this unit forms the Cretaceous–Tertiary boundary (Figure 2). The lower contact is gradational with the underlying sandy, pelecypod biomicrosparite.

Fossil allochems are the main framework constituents and are principally calcitic and aragonitic pelecypod fragments, the former being more than twice as abundant (Figure 5). All the aragonitic fauna has been dissolved and is preserved as moulds, sediment-reduced moulds, or cement-reduced moulds. Many fossil allochems display bivalve borings or occasionally fungal or algal microborings.

The insoluble residue averages three weight-percent (Figure 2) and consists of approximately equal amounts of sand, silt and clay (Table 1).

Matrix in the biomicrudite is of two generations. The first generation formed contemporaneously with deposition and is a tan-brown micrite that averages about 43% of the lithology. Recrystallisation to neomorphic calcite spar occurs in some areas. A second generation of matrix, herein referred to as sediment-fill, averages about 7% of the lithology. It consists of iron-stained micrite with minor terrigenous material and occurs in channels, moulds, and vugs and commonly rests on a blocky calcite cement. Coarse silt-sized dolomite rhombohedra with cloudy centres comprise a small part of the sediment-fill. Most dolomite rhombohedra display euhedral crystal faces; however, some have round edges suggestive of a vadose silt origin.

The cement consists of dogtooth calcite spar that grades into blocky calcite spar; it always occurs on framework constituents, first generation matrix, or in moulds, channels, or vugs. Sediment-fill always occurs on top of the calcite cement. The cement is typical of that described as forming by meteoric water diagenesis (Bathurst, 1971). The porosity averages 10% and in order of abundance is mouldic, channel, and vug. Most are megapores that formed by solution of the aragonitic bivalve fauna. Some pores are reduced by calcite cement and sediment-fill.

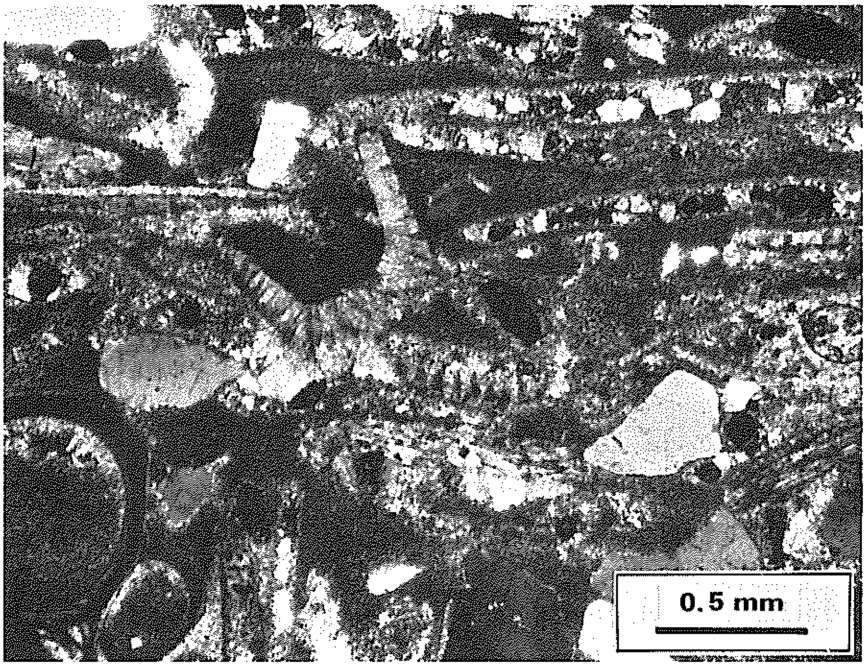

Figure 5. Photomicrograph of pelecypod biomicrudite from the upper part of the Rocky Point Member of the Peedee Formation. Note that the original aragonitic pelecypods have been dissolved and are now preserved as moulds, cement reduced moulds, or sediment-fill reduced moulds. (Depth −29.5 m below mean sea-level, just below Cretaceous–Tertiary boundary, crossed-nicols).

Although mega-invertebrates are significantly more abundant in the Rocky Point Member than in the underlying Peedee Formation, their preservation as moulds generally precludes precise identification. Specimens of the echinoid *Hardouinia mortonis*—an Upper Cretaceous index fossil (Wheeler and Curran, 1974)—and *Cardium* moulds are found in core samples from the Rocky Point Member in the upper part of the unit directly below the contact with the Castle Hayne Limestone.

Foraminifera in the Rocky Point Member are significantly less abundant and less diverse than in the underlying Peedee Formation. Their poor preservation precludes systematic identification.

4. Castle Hayne Limestone

The Castle Hayne Limestone, of Eocene age, which occurs from −27.4 m to −15.2 m below mean sea-level (bottom of casing), disconformably overlies the Rocky Point Member of the Cretaceous Peedee Formation (Figure 2). It is a well indurated, very light white to light gray, lithoclast-bearing, bryozoan-molluscan biomicrudite that grades upward into bryozoan biomicrudite (Figure 6). Three irregular disconformities, coated with phosphate and glauconite, occur in the unit at −21.3, −19.8, and −16.8 m below mean sea-level (Figure 2). Lithoclasts of phosphatised pebbles occur below −16.8 m (the upper unconformity) and increase in abundance toward the base of the unit.

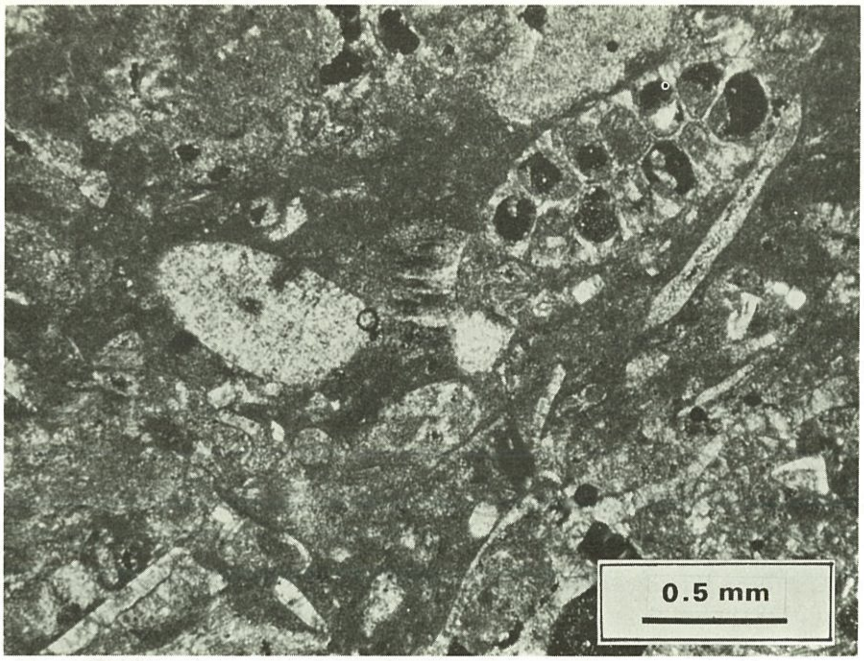

Figure 6. Photomicrograph of bryozoan biomicrudite from the Castle Hayne Limestone (Depth −15.3 m below mean sea-level, crossed-nicols).

The fossil allochems are dominated by bryozoans and molluscs; bryozoans being more abundant in the upper part of the section while molluscs dominate in the lower part (Figure 2). Bryozoans, which form more than 50% of the bryozoan biomicrudite lithology are mainly lunate, ramose, and fenestrate types that display little abrasion. Molluscs are the only other important fossil allochem and are chiefly pelecypods with minor gastropods. The molluscs show a systematic vertical decrease in abundance from almost 25% at the base of the Castle Hayne Limestone to less than 5% at the top (Figure 2). Aragonitic pelecypods, preserved as moulds or spar-reduced moulds, are dominant; minor calcitic pelecypods also occur. Most molluscan allochems, as well as many of the bryozoans, have well developed micrite envelopes that are attributed to the boring of blue-green algae. Fillings of sponge borings are present in some pelecypods. Minor fossil allochems are echinoderm fragments and Foraminifera; other allochems are peloids and rounded or lobate glauconite grains.

The weight-percent insoluble residue averages almost 6%; however, most of this occurs in calcareous, quartz arenite lithoclasts. It is mainly sand size quartz with lesser amounts of silt and clay (Figure 2). The insoluble residue not occurring in the lithoclasts shows a systematic increase from less than 1% at the top of the Castle Hayne Limestone to about 3% at the base.

Micrite shows no systematic vertical variability. Void-filling calcite spar is more abundant in the lower part of the unit. It occurs as fillings of moulds formed by solution of aragonitic molluscs and in original interparticle voids and is typical of that described as forming by freshwater meteoric water diagenesis (Bathurst, 1971).

The porosity averages about 15%, ranging from 6% to slightly greater than 30%. Although little systematic vertical variability occurs, porosity generally is greater below the three disconformities. The pore types are varied and include mouldic, vug, channel, interparticle, and intraparticle. Channel porosity usually occurs below the disconformities.

The fauna of the Castle Hayne Limestone is well known and has been studied by numerous workers (e.g. Canu and Bassler, 1920; Kellum, 1926; Cooke, 1959; Cooper, 1959; Worsley and Turco, 1979; Baum, 1980; Kier, 1980; Powell and Baum, 1982; Jones, 1983) and has been summarised by Harris and Zullo (1980). Although the age is currently in dispute, it is not the purpose of this paper to identify specific genera or species of fauna within the core samples to resolve the age relationships.

5. Geological History

The late Cretaceous and early Paleogene geological history of south eastern North Carolina has recently been discussed in part by Brown *et al.* (1972), Harris (1978), Baum *et al.* (1978*a*), Baum (1980), and Powell and Baum (1982). Analysis of the core-hole generally supports the previous interpretations. However, as the core provides a relatively uninterrupted vertical section through the Upper Cretaceous and the Eocene, it allows for evaluation of the late Cretaceous and early Tertiary part of the Vail *et al.* (1977) global coastal onlap chart.

The Peedee Formation and overlying Rocky Point Member represent a single depositional cycle separated by a gradational contact. Sediment and faunal types (Foraminifera) suggest a middle to outer continental shelf environment for the typical Peedee Formation lithology. Coarsening of the terrigenous material, the change in faunal content from microfauna dominated below to mollusc dominated above, and the presence of a karstic surface at the top, suggest upward shallowing for the Rocky Point Member. Vail *et al.* (1977) indicate that the top of the Cretaceous (65 m.y. B.P.) is marked by a major lowering of sea-level. However, faunal and radiometric evidence from the Rocky Point Member suggests that this lowering of sea-level occurred earlier than 65 m.y. B.P.

Foraminifera from the Peedee Formation are representative of an early to middle Maastrichtian age. Finneran (1980) suggested, on the basis of nannofossils, that the youngest Cretaceous in North Carolina is upper middle Maastrichtian. Harris (1982) utilised the new decay constant for 87_{Rb} and recalculated the 68.1 ± 1 m.y. B.P. isochron age previously reported for the Peedee Formation–Rocky Point Member (Harris, 1976) and determined a new age of 66.7 ± 1 m.y. B.P. Therefore, the absence of latest Maastrichtian sediments in the Cape Fear arch region suggest that the major lowering of sea-level at the end of the Cretaceous occurred after 66.7 m.y. B.P. Although Mörner (1982) and Berggren *et al.* (in press) have suggested that the Cretaceous–Tertiary boundary is either 66.7 m.y. B.P. or 66.4 m.y. B.P., respectively, the lack of latest Maastrichtian sediments in the Cape Fear region would suggest that this new age for the boundary is too old.

Utilising the concepts of Vail *et al.* (1977), Vail and Mitchum (1979), and Vail and Todd (1981), the Peedee Formation and Rocky Point Member would represent a shallowing upward highstand deposit.

The Castle Hayne Limestone disconformably overlies the Rocky Point Member in the core. However, examination of several other cores in the area reveals that a 20 cm thick, dark gray, mudrock or sandy biomicrudite occasionally occurs between the Rocky Point Member and the Castle Hayne Limestone. Although no definitive age can be assigned to the unit because of the absence of an age diagnostic microfauna, it may be Palaeocene. Palaeocene sediments have been recognised overlying the Cretaceous about 15 km southwest, in Long Bay, by Meisburger (1981) and in southern Pender County core-holes (Worsley, 1981, personal communication).

The Castle Hayne Limestone has recently been described by numerous workers (Baum *et al.*, 1978*a*; Ward *et al.*, 1978; Baum, 1980; Harris and Zullo, 1980; Otte, 1981; Otte and Textoris, 1982; and Jones, 1983). The lower 10.6 m of the Castle Hayne Limestone in the core consists of the New Hanover Member (following the subdivisions of Ward *et al.*, 1978) which is identified as a phosphate pebble biomicrudite. The New Hanover Member is particularly well developed where the Rocky Point Member occurs below the Castle Hayne Limestone. The top of the New Hanover Member is marked by an irregular phosphate and glauconite coated disconformity, which separates it from the overlying bryozoan biomicrudite. Although two other disconformities occur in the member, the lack of any major faunal or lithologic change above and below suggests that the sediment package represents a single overall transgression of the sea onto the coastal plain with minor regressive punctuations. In addition, the lack of subaerial diagenetic features at the unconformities, as well as the presence of phosphate and glauconite coatings suggests that the surfaces are submarine hardgrounds. The unit has previously been correlated with either the *Cubitostrea lisbonensis* Zone (Baum *et al.*, 1978*a*; Powell and Baum, 1982) or the *Cubitostrea sellaeformis* Zone (Ward *et al.*, 1978; Harris and Zullo, 1980) of the Gulf Coast.

The overlying, fine to coarse, bryozoan biomicrudite (the Comfort Member of Ward *et al.*, 1978) contains an abundance of stenohaline fauna and flora which indicates that the Castle Hayne Limestone was deposited in an open, normal salinity, environment. Baum (1980) suggested that the Comfort Member was deposited in a typical marine biogeographic zone in water depths between 30–50 m. This interpretation was based on the occurrence of specific bryozoan types, possible associations of green algae (*Penicillis*), and ahermatypic corals. The latter, however, can live at considerable depths and attain their best development between 200 and 600 m (Heckel, 1972). Otte (1981) suggested that the bryozoan biomicrudite facies of the Castle Hayne Limestone was deposited in water depths greater than 100 m based on the distribution of sponges, Foraminifera, and bryozoans.

Jones (1983) suggests that the Castle Hayne Limestone was deposited in "... broad seaward dipping bands of inner shelf (0–15 m water depth), middle shelf (15–50 m), and outer shelf (50–100 m) depositional environments". These water depths generally are the same as those suggested by Baum (1980).

Although the age of the Castle Hayne Limestone is much in dispute, Powell and Baum (1982) have suggested placement of the unit into specific cycles of the Tertiary coastal onlap chart of Vail and Hardenbol (1979). For example, they suggested that with minor revision, the Castle Hayne Limestone falls into the upper part of the TE 2.2 supercycle. This cycle is considered to be middle Eocene (Bartonian) age and is interpreted as representing two shoaling upward highstand deposits separated by a Type 2 unconformity (Powell and Baum, 1982). With no age diagnostic fauna present in the core samples of the Castle Hayne Limestone, correlation of the lithologies to specific facies or the members proposed by Baum *et al.* (1978*a*) or Ward *et al.* (1978) respectively, is difficult. However, lithologically the unit correlates to the type Castle Hayne Limestone and without further data, it is probably Bartonian or Priabonian in age. Harris and Zullo (1980) have also suggested that the Comfort Member may be Priabonian in age. If the Rb-Sr glauconite age of 34.9 ± 1.1 m.y. B.P. for the Comfort Member is accurate and the Oligocene–Eocene boundary is about 33 m.y. B.P. (Harris and Zullo, 1980; Harris, 1982), then the Castle Hayne Limestone is Bartonian and Priabonian in age. If this is the case, then the unit would represent parts of the TE 2.2 and TE 3 cycles of Vail *et al.* (1977).

6. Conclusions

6.1.

The Peedee Formation of Maastrichtian age consists of a sandy foraminiferal biomicrite and sandy biomicrite. It contains a diverse and well-preserved benthonic and planktonic foraminiferal fauna that suggests deposition in a middle to outer continental shelf environment.

6.2.

The Rocky Point Member of the Peedee Formation consists of a sandy, pelecypod biomicrite, a sandy, pelecypod biosparrudite and a pelecypod biomicrudite. The fauna suggest deposition of the member in an inner to middle shelf environment.

6.3.

The Castle Hayne Limestone of middle to late (?) Eocene age consists of a lithoclast-bearing, bryozoan-molluscan biomicrudite and a bryozoan biomicrudite. Molluscs dominate the lower part of the formation; bryozoans dominate the upper part.

6.4.

The Peedee Formation and overlying Rocky Point Member represent a shoaling upward vertical succession or highstand deposit. The upper surface forms the Cretaceous–Tertiary boundary and is upper middle Maastrichtian in age based on the microfauna and the Rb-Sr glauconite age.

6.5.

The Castle Hayne Limestone represents a series of transgressive deposits, separated by marine hardgrounds, of middle to upper (?) Eocene age.

6.6.

Porosity development in the Peedee Formation, Rocky Point Member, and Castle Hayne Limestone is principally secondary. It is best developed in close proximity to unconformities.

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