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RESIDUAL COLOR PATTERNS IN MOLLUSKS FROM THE GOSPORT SAND (EOCENE), ALABAMA

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INTRODUCTION

Color pattern is one of the most conspicuous characteristics of living mollusks. The coloration is apparently a waste product of metabolism in both gastropods and bivalves (Cox, 1960; Nuttall, 1969). Particular color patterns are often consistent within molluscan taxa and thus represent a valuable taxonomic tool.

Excellent preservation is an essential factor in retention of color patterns by fossil mollusks. Although traces of coloraton have been discovered on specimens as old as Ordovician, most specimens retaining coloration are Tertiary or Quaternary in age. Color patterns have been reported previously for mollusks from Gulf Coast Tertiary faunas (for example, Dockery, 1980; Palmer, 1937). The patterns described in this report are based on specimens collected from the Little Stave Creek exposure of the Eocene Gosport Sand near Jackson, Alabama (Figure 13).

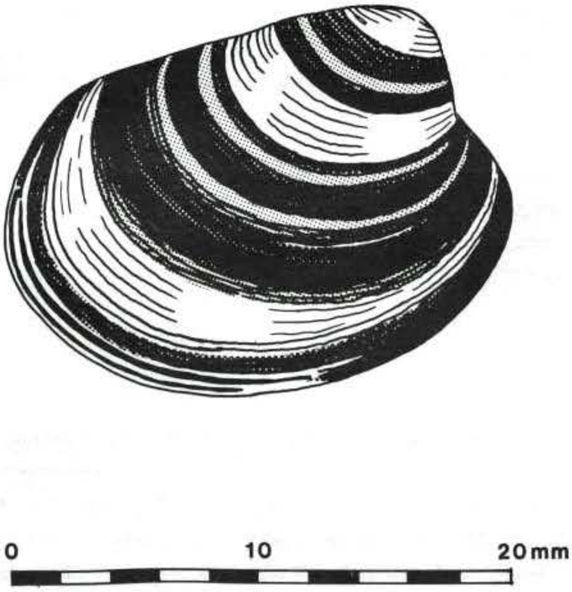

Figure 1. **Nucula magnifica** (Conrad). Mississippi Bureau of Geology (MGS) figured specimen 1480.

STRATIGRAPHY

The Gosport Sand is the uppermost unit of the Claiborne Group. The formation was first described by Smith (1907) for exposures at Gosport Landing on the Alabama River. In the type area, the Gosport includes up to 30 feet of calcareous, medium- to coarse-grained, abundantly fossiliferous sands. The Gosport extends eastward no farther than Monroe County, Alabama, and in Mississippi it changes facies into the cross-laminated sands of the Cockfield Formation (Toulmin, 1977).

The Gosport Sand is well exposed at Little Stave Creek, in Clarke County, Alabama. This section is notable for its continuity and excellent faunal preservation. Jones (1967) divided the Gosport at Little Stave Creek into three informal units totaling eleven feet of section. The basal unit is a glauconitic, medium- to coarse-grained sand in sharp, unconformable contact with the underlying clay of the Lisbon Formation. The basal unit contains broken and worn shark teeth and mollusk fossils. The middle unit consists of medium- to coarse-grained, glauconitic sands with abundant well-preserved mollusk fossils. The upper unit is a medium- to coarse-grained, silty, calcareous, fossiliferous sand. The Gosport is overlain unconformably by the Moodys Branch Formation.

METHODS

The material used in this investigation was collected from the middle unit of the Gosport Sand. Specimens were cleaned, identified (following Toulmin, 1977), and then examined for traces of color patterns.

The presence of coloration was determined by viewing the specimens both in visible and in ultraviolet light. In most cases, color patterns were enhanced when examined under ultraviolet light; some patterns were apparent only in ultraviolet light. Patterns were also enhanced by bleaching specimens in sodium hypochlorite (Clorox), which promotes fluorescence of coloration under long wave ultraviolet light (Dockery, 1980).

DESCRIPTION OF COLOR PATTERNS

Fifteen mollusk taxa from the Gosport Sand were found to exhibit color patterns. These patterns vary little among individuals of a taxon and thus are reliable tools for species identification. Because patterns in visible light differ from those viewed under ultraviolet light, we report results for both visible and ultraviolet light.

Class Bivalvia

Nucula magnifica (Conrad) (Figure 1)

Visible light: Concentric bands are well preserved extending from the anterior valve margin to the posterior valve margin. The bands narrow at the valve margins and reach maximum width along the area of maximum shell curvature. Band width varies considerably.

Ultraviolet light: The pattern is the same as in visible light.

Eomiltha pandata (Conrad) (Figure 2)

Visible light: Concentric bands extend from the anterior valve margin to the posterior valve margin. The bands are of almost uniform width except at valve margins, where they are slightly narrower.

Ultraviolet light: The pattern is the same and better defined. There is a very weak indication of poorly defined bands radiating from the beak to the ventral margin.

Corbis undata = **Fimbria undata** (Conrad) (Figure 3)

Visible light: No apparent pattern.

Ultraviolet light: Four radial bands extend from the beak to the ventral valve margin. The bands are symmetrically arranged about the dorsal-ventral midline of the valve. Near the ventral margin the bands bifurcate into a number of very fine subordinate bands.

Venericardia alticostata = **Glyptoactis alticostata** (Conrad) (Figure 4)

Visible light: Concentric bands are very poorly preserved in the anterodorsal regions of both valves and extend only a short distance from the valve margin.

Ultraviolet light: The concentric bands are more continuous and can be traced with difficulty across the valve from the anterior margin to the posterior margin. The bands

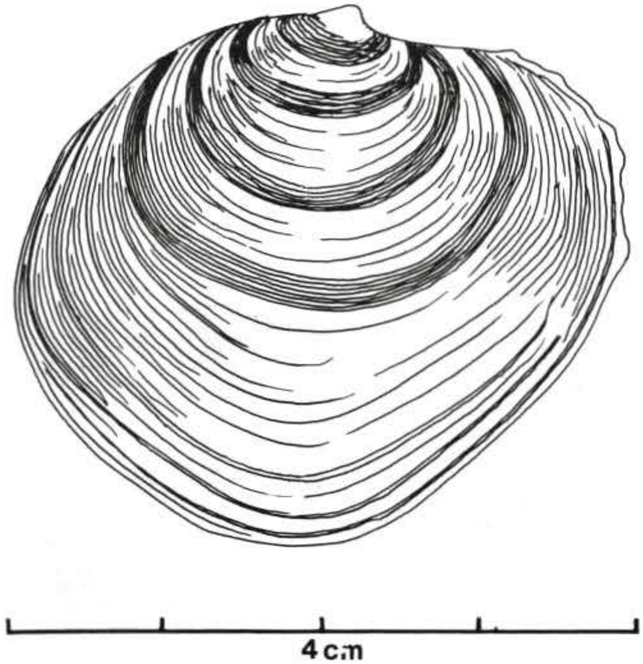

Figure 2. **Eomiltha pandata** (Conrad). Mississippi Bureau of Geology (MGS) figured specimen 1481.

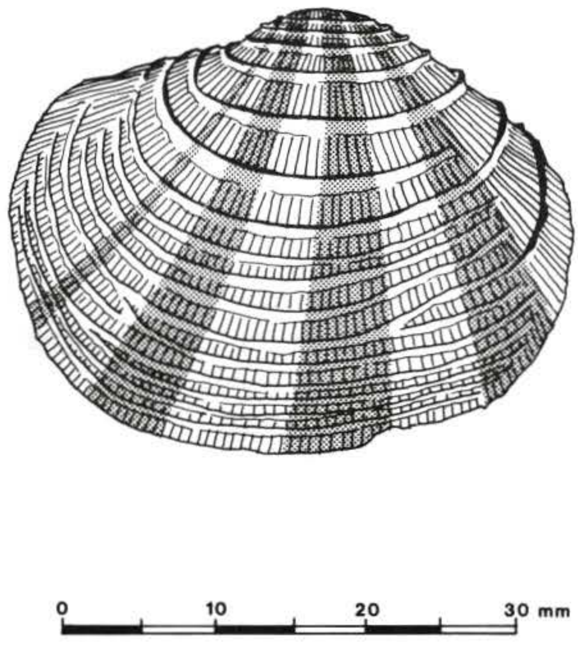

Figure 3. **Fimbria undata** (Conrad). Mississippi Bureau of Geology (MGS) figured specimen 1482.

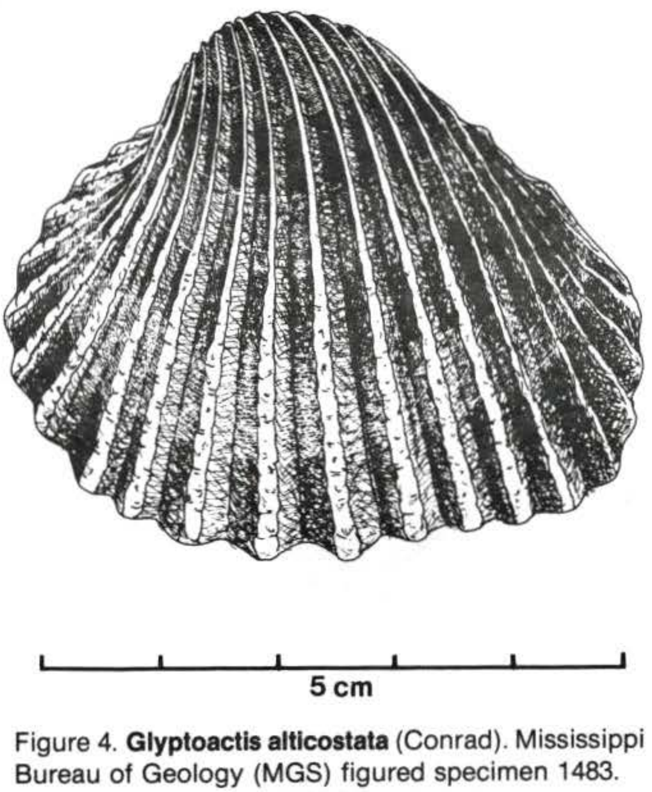

Figure 4. **Glyptoactis alticostata** (Conrad). Mississippi Bureau of Geology (MGS) figured specimen 1483.

Figure 5. **Venericardia claiboplata** Gardner and Bowles. Mississippi Bureau of Geology (MGS) figured specimen 1484.

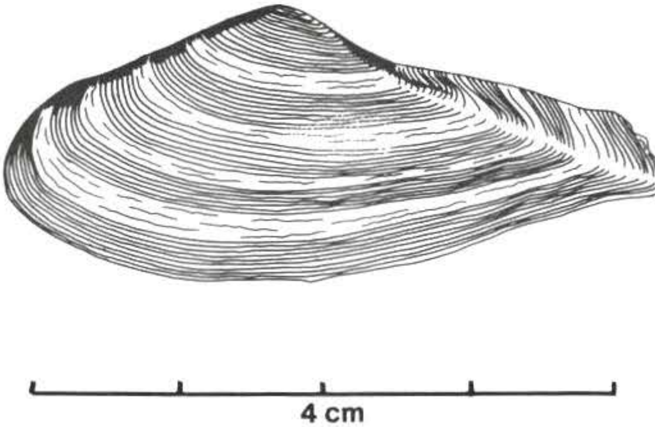

Figure 6. **Bathytormus protextus** (Conrad). Mississippi Bureau of Geology (MGS) figured specimen 1485.

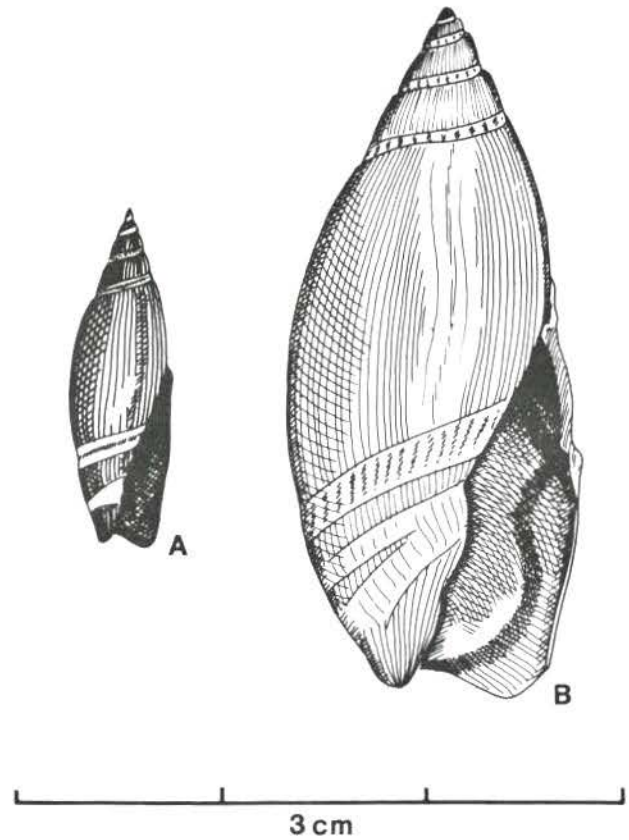

Figure 7. A - **Agaronia bombylis** (Conrad); B - **Agaronia alabamensis** (Conrad). Mississippi Bureau of Geology (MGS) figured specimens 1486 and 1487 respectively.

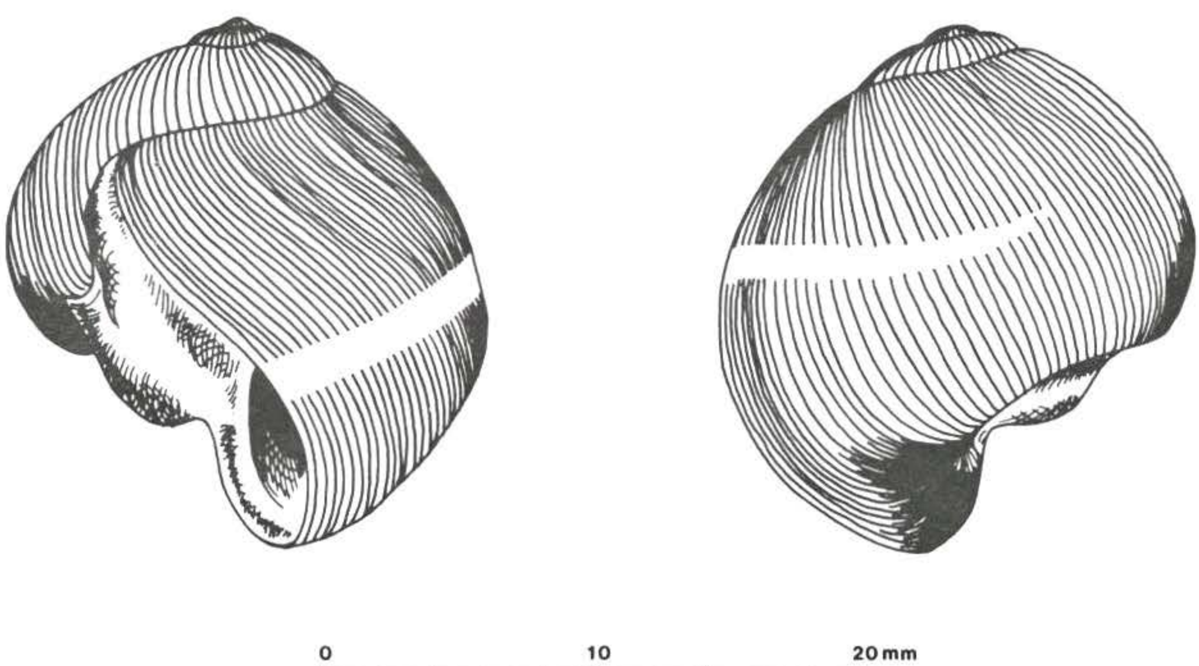

Figure 8. **Neverita limula** (Conrad). Mississippi Bureau of Geology (MGS) figured specimen 1488.

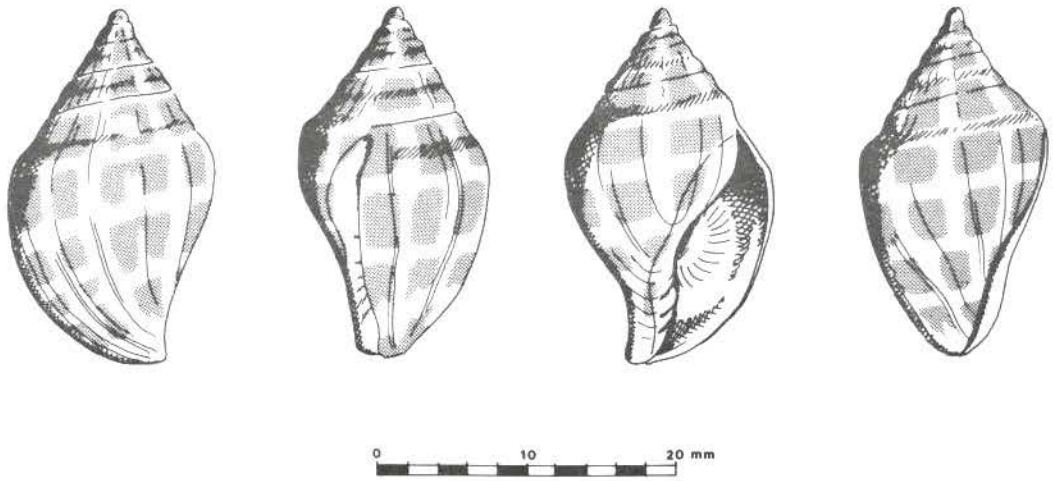

Figure 9. **Caricella bolaris** (Conrad). Mississippi Bureau of Geology (MGS) figured specimen 1489.

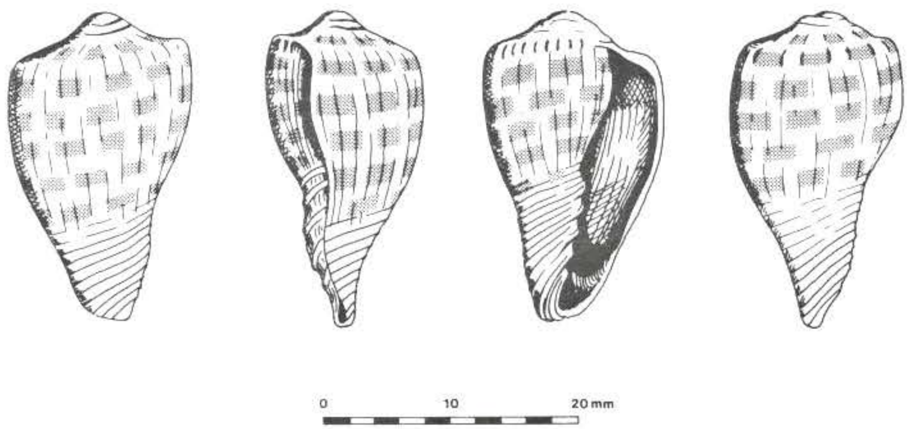

Figure 10. **Caricella doliata** (Conrad). Mississippi Bureau of Geology (MGS) figured specimen 1490.

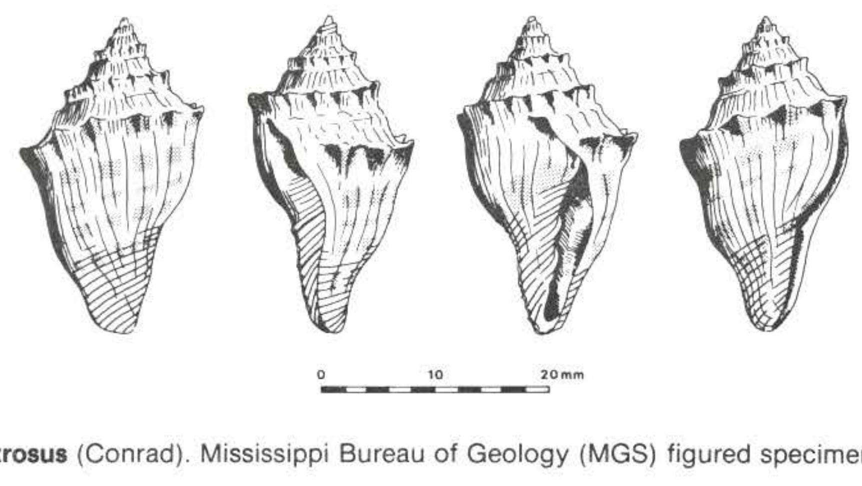

Figure 11. **Athleta petrosus** (Conrad). Mississippi Bureau of Geology (MGS) figured specimen 1491.

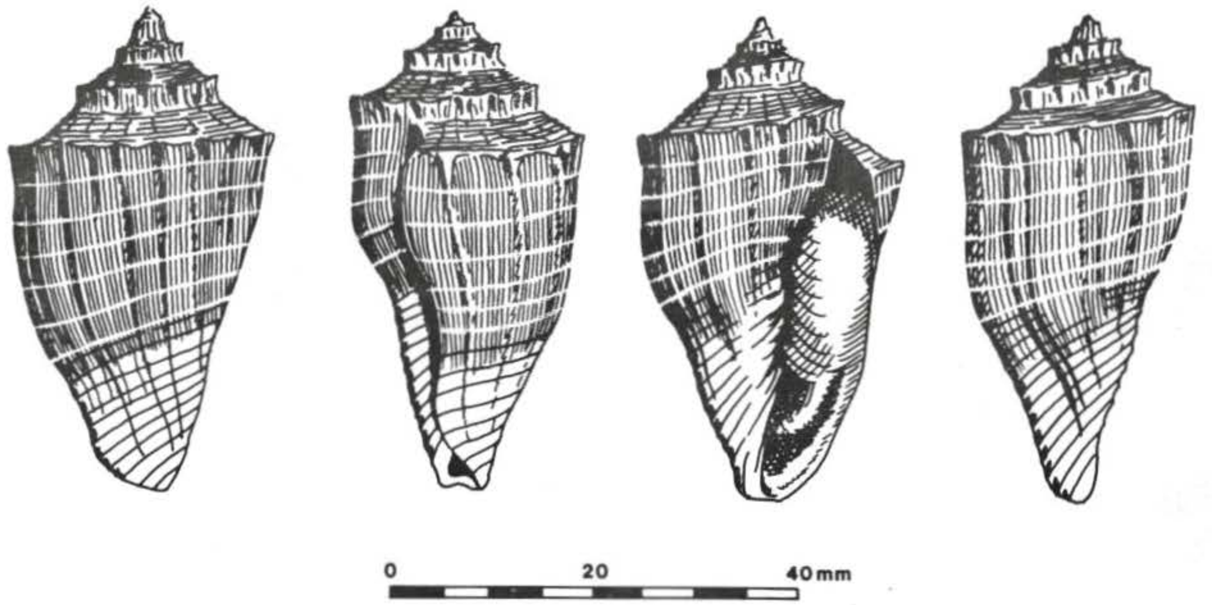

Figure 12. **Athleta sayanus** (Conrad). Mississippi Bureau of Geology (MGS) figured specimen 1492.

narrow considerably at the valve margins, reaching a maximum width along the area of maximum shell curvature.

Venericardia claiboplata Gardner and Bowles (Figure 5)

Visible light:	No apparent pattern.
Ultraviolet light:	Concentric bands are poorly preserved along the valve margin in the anterodorsal and posterodorsal regions. The bands in the area of the valve margin and the anterior and posterior extremities are poorly preserved. The bands can be traced across the dorsal-ventral midline only with difficulty. The imperfect preservation of color banding is probably due to the poor condition of the valve.

Bathytormus protextus (Conrad) (Figure 6)

Visible light:	Fine concentric bands are poorly preserved, extending from the anterior valve margin to the posterior valve margin.
Ultraviolet light:	The pattern is the same as in visible light and better defined. The bands are only slightly wider in the dorsal-ventral midline region.

Callista aequorea (Conrad)

Visible light:	Concentric bands extend from the anterior valve margin to the posterior valve margin. The bands are only slightly darker than the background color. The band width is maximal along the region of maximum shell curvature.
Ultraviolet light:	The concentric bands described above are present along with conspicuous radial bands that extend from the umbo to the ventral margin. The radial bands are very conspicuous in the immature valves, but the concentric banding is the predominant pattern in the more mature valves. Pattern illustrated by Dockery (1980).

Class Gastropoda

Agaronia bombylis (Conrad) (Figure 7A)

Visible light:	A single band is present parallel to the suture and extending upward from the suture. The band is present throughout the spire and ends where the suture ends at the aperture.
Ultraviolet light:	The same pattern is present and is not significantly better defined

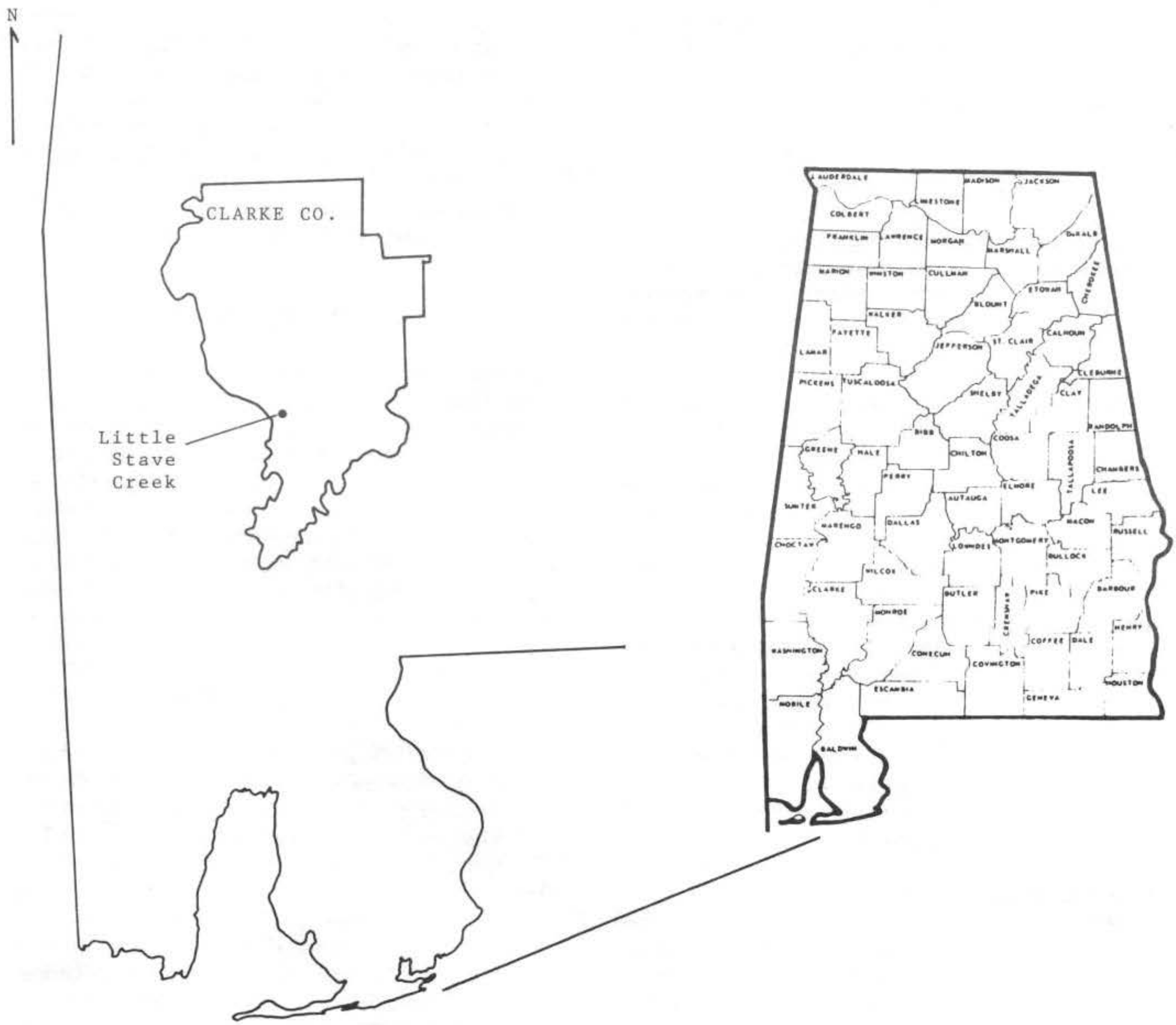

Figure 13. Location of Little Stave Creek, Clarke County, Alabama.

by ultraviolet light.

Agaronia alabamensis (Conrad) (Figure 7B)

Visible light: The pattern is the same as that exhibited by *A. bombylis.* Pattern previously described by Palmer (1937).

Ultraviolet light: The color pattern is the same as in visible light and is not significantly enhanced.

Neverita limula (Conrad) (Figure 8)

Visible light: A broad spiral band is present on the body whorl parallel to the suture and approximately midway between the suture and base of whorl.

Ultraviolet light: The pattern is the same as in visible light and is not better defined.

Caricella bolaris (Conrad) (Figure 9)

Visible light: No apparent pattern.

Ultraviolet light: Body whorl has five closely spaced rows of rectangular to square spots with rounded corners. Spots are much larger than spaces between them. A single row of spots is visible on previous whorls.

Caricella pyruloides (Conrad)
Visible light: No apparent pattern.
Ultraviolet light: The pattern is the same as that displayed by *C. bolaris.*

Caricella doliata (Conrad) (Figure 10)
Visible light: Five rows of rectangular spots with rounded corners are present on the body whorl. Rows are parallel to the suture and regularly spaced.
Ultraviolet light: Six rows of rectangular spots are present on the body whorl, and a single row of spots is visible on previous whorls as well. The spots are approximately equal in size to the spaces between them.

Athleta petrosus (Conrad) (Figure 11)
Visible light: Several broad spiral bands are present on the body whorl below the shoulder and parallel to the suture. Individual bands are broken into a series of rectangular spots.
Ultraviolet light: The pattern is the same as in visible light.

Athleta sayanus (Conrad) (Figure 12)
Visible light: Four or five narrow spiral lines are present on the body whorl below the shoulder and parallel to the suture. The lines are most apparent near the aperture.
Ultraviolet light: Six or more spiral lines are visible on the body whorl below the shoulder and one or two are present on the shoulder. The pattern is barely visible on previous whorls.

CONCLUSIONS

Color patterns were determined for fifteen species of mollusks from the Eocene Gosport Sand of Alabama. The most common color pattern among the bivalve species consists of concentric banding extending from the anterior to the posterior valve margin. Radial banding is present in *Corbis* (= *Fimbria*) *undata*, and *Callista aequorea* displays both radial and concentric bands. The gastropod taxa possess one or more bands parallel to the suture or regularly arranged rows of spots. Consistency of patterns within species or genera may represent a useful taxonomic tool. For example, similarity of morphology and color patterns of *Agaronia bombylis* and *A. alabamensis* suggests a close relationship between the two taxa. *Caricella pyruloides* and *C. bolaris* are also very similar in morphology and color pattern and may be closely related.

ACKNOWLEDGMENTS

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CALCAREOUS NANNOPLANKTON BIOSTRATIGRAPHY OF SELECTED TERTIARY LOCALITIES IN THE PARIS, ADOUR, AND BEARN BASINS OF FRANCE AND THEIR CORRELATION WITH THE NORTH AMERICAN GULF COAST TERTIARY SEQUENCE

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INTRODUCTION

The Cenozoic sequence of Europe contains the type sections of the Tertiary epochs and thus provides the standard by which the geologic ages of the North American Tertiary formations must be determined. The age of Tertiary formations in Mississippi and Alabama has been studied for over one hundred and fifty years based on the comparison of their fossils with those of European stages. Early studies of these fossils include those of Conrad (1832) and Lea (1833), who studied the very fossiliferous sands at Claiborne Bluff on the Alabama River, Clarke County, Alabama. Conrad (1856) established the terms Claiborne, Jackson, and Vicksburg in ascending order as formal stratigraphic units in the Gulf Coastal Plain and recognized their age as Eocene, an epoch erected by Lyell in 1833. This age assignment was based on a comparison of molluscan faunas within these units with those of the Paris Basin Eocene sequence. Later, Conrad (1866) recognized the Claiborne Group in part as middle Eocene, the Jackson Group as upper Eocene, and the Vicksburg Group as Oligocene, an epoch erected by Beyrich in 1854. These age assignments, all based on comparisons of North American and European molluscan faunas, have remained largely unchanged to this date, a period of over one hundred years.

More recent biostratigraphic work has focused largely on planktic rather than benthic organisms. Refined biostratigraphic zonations have been made possible by the large number of deep-sea cores analyzed for planktic microfossils as part of the JOIDES program. These zonations provide standards for worldwide correlations that are independent of formal land-based stratigraphic stages and which allow a finer division of geologic time. A recent publication by Siesser (1983) assigns NP zones of the calcareous nannoplankton zonation of Martini (1971) to the Paleogene formations and members of Mississippi, Alabama, and Tennessee.

The present study examines calcareous nannoplankton from selected Eocene, Oligocene, and Miocene localities in the Paris and Aquitaine basins of France that are noted for their excellent molluscan faunas. These localities are assigned to the NP zones of Martini (1971) when possible and are correlated with the Tertiary sequence of the North American Gulf Coastal Plain. This correlation not only provides a synchronization of certain North American and French Tertiary units but also gives an important biostratigraphic framework for future work with molluscan distributions and lineages in two broadly separated provinces, both noted for their excellent molluscan faunas.

DESCRIPTION OF LOCALITIES

Fossils and sediment samples from nine Tertiary localities in the Paris, Adour, and Bearn basins of France were collected in July and August of 1983 by the field party of Cyrille Dolin, Luc and Therese Dolin, Pierre Lozouet, and David and Mary Dockery. The Paris Basin is a large epicontinental basin in north-central France, whereas the Adour and Bearn basins are subbasins of the Aquitaine Basin, a coastal basin in southwestern France. A majority of the localities treated here are in the Oligocene of the Adour Basin. This basin is of particular interest as the recent works

Figure 1. Stampian sands of the Morigny-Jeurre Formation in a borrow pit at Morigny. Luc Dolin at left and Pierre Lozouet at right sieving fossils from the unconsolidated sands. Photograph taken on July 18, 1983.

of Dockery (1982) and MacNeil and Dockery (1984) on the lower Oligocene Mollusca of the Vicksburg Group show several related species to exist between the Gulf Coast and Adour Basin Oligocene. Similar relationships also exist between the North American and Aquitaine Basin Eocene and Miocene molluscan faunas.

The province and age of the Tertiary localities studied here are given as follows in the order in which they were visited: Paris Basin - (1) Morigny (lower Oligocene - Stampian); Adour Basin - (2) Abbesses parish of Saint-Paul-les-Dax (upper Oligocene - Chattian), (3) Estoti parish of Saint-Paul-les-Dax (upper Oligocene - Chattian), (4) Mineur parish of Pontonx (upper Oligocene - Chattian), (5) Lagouarde parish of Gaas (lower Oligocene - Stampian), (6) Espibos parish of Gaas (lower Oligocene - Stampian), and (7) Moulin de Carreau parish of Corbieu (lower Miocene); Bearn Basin - (8) Tuilerie quarry at Gan (middle Eocene - Lutetian), and (9) Acot parish of Gan (middle Eocene - Lutetian). Samples from each of these localities were examined by the senior author for calcareous nannoplankton.

Stampian of Morigny

The Stampian localities at Morigny have been largely excavated by collectors and are now protected from further excavation. Fortunately, a new exposure was available in a fresh borrow pit at the time the samples were collected (Figure 1). The Stampian at this locality is a very fossiliferous, clean sand. Bivalves here are commonly articulated and in life position (Figure 2). Large articulated valves of *Glycymeris* are abundant in a bed near the base of the excavation. Two samples from this locality were examined for calcareous nannoplankton. The first sample (1a) is from the interior of *Glycymeris* valves collected from the *Glycymeris* bed near the base of the borrow pit. The second sample (1b) is from the interior of bivalves collected above the *Glycymeris* bed.

Fossil mollusks were abundant in surface exposures and on spoil piles at the Morigny locality. However, the majority of the collecting for these fossils was done by screening the sands of the *Glycymeris* bed, which contained the most diverse fauna. Nestled no. 6 (6 lines/inch) and no. 14 (14 lines/inch) screens were

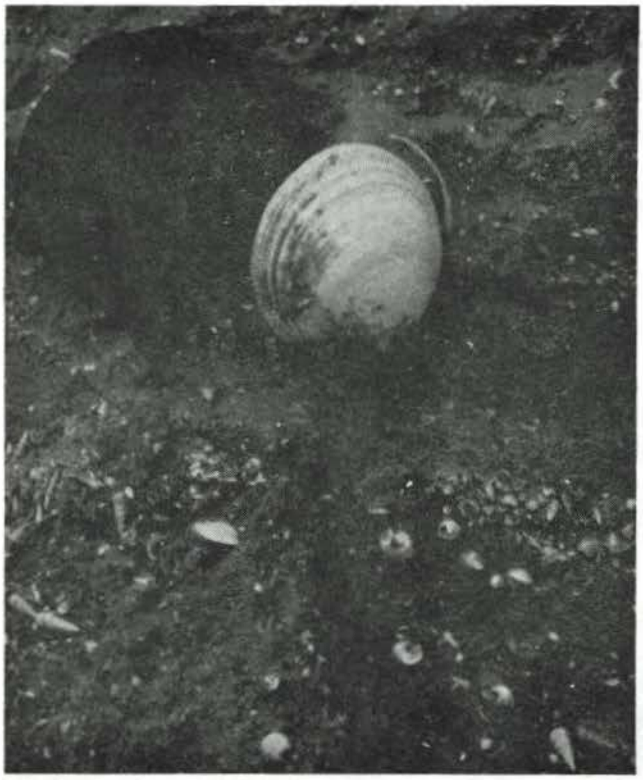

Figure 2. The articulated bivalve *Pelecyora incrassata* (Sowerby) in situ in wall of borrow pit shown in Figure 1. Photograph taken on July 18, 1983.

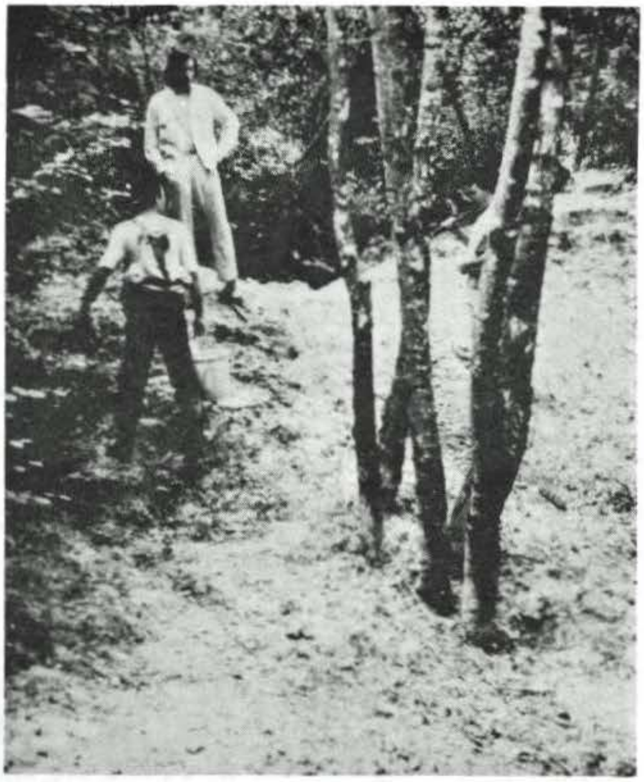

Figure 3. Stampian locality at Espibos near Gaas. Sediments excavated from the *Strombus* zone were carried by bucket and sieved for fossils in a creek below. The foreground is covered with tailings from previous excavations by amateur collectors. Cyrille Dolin is at top, Pierre Lozouet is carrying the bucket, and Luc Dolin is behind tree at right. Photograph taken on July 26, 1983.

used for this purpose. These screens have circular hardwood frames with a diameter of 16 inches. They come in several mesh sizes, are sold in French department stores and supermarkets for sorting aggregate, and are used extensively by French paleontologists for collecting in the Paris Basin. The clean sands at Morigny allow the sediment to be screened for fossils without the use of water. Fossiliferous sands of this nature are not known from the North American Gulf Coast region but are common in the Paleogene sequence of the Paris Basin.

Upper Oligocene (Chattian) of Abbesses, Estoti, and Mineur

Samples from two upper Oligocene localities were collected in the vicinity of Dax. The first of these localities, Abbesses, is located along the bluff line of a small stream and contains a complex variety of facies that vary from laminated sands with a sea-grass community to reef facies with massive coral heads. Samples from two facies were collected at this locality and examined for calcareous nannoplankton. The first facies contained a mixture of reef corals and mollusks (3a) and the second was rich in cypraeids (3b). Fossil mollusks were collected at this locality by digging with the use of a pick into the hard reef facies exposed on the vertical cliff face and screening the sediment in the stream below.

The second locality at Estoti was collected by digging downward to the fossiliferous horizon. Sediments excavated from this horizon were transported by car to a nearby stream and screened. These sediments are rich in mollusks and contain specimens of a large *Tibia, Tibia dentata.* Two samples from Estoti were examined for calcareous nannoplankton, one taken from the matrix of molluscan shells (4a) and one from screened sediment (4b).

A third upper Oligocene locality was collected at Mineur just southwest of Pontonx. This site is a tributary of a small stream and contains a *Strombus* zone, noted for the large *Strombus, Strombus sublatissimus.* Sediments from this zone were excavated from the tributary bank and were screened in an impoundment made by damming up a spring which fed into the tributary. One sample (5) taken from the matrix

Figure 4. Sieving the lower Miocene sands of Moulin de Carreau for fossils in the Douze River. Cyrille Dolin at left, Therese Dolin at center, and Luc Dolin at right. Photograph taken on July 17, 1983.

of molluscan shells was examined for calcareous nannoplankton.

Lower Oligocene (Stampian) of Lagouarde and Espibos

Lower Oligocene sediments of Stampian age were collected at two localities in the vicinity of Gaas, Lagouarde and Espibos. Both of these localities have been heavily excavated (Figure 3) by collectors who wished only to collect the large specimens, and at both localities a downward excavation was necessary to reach the fossiliferous *Oostrombus auriculatus* horizon (*Strombus* zone). Sediments from this horizon were screened for fossils in nearby streams at each locality. Samples from these localities that were examined for calcareous nannoplankton include: (6a) Lagouarde - matrix from molluscan shells, (6b) Lagouarde - screened sediment, (7a) Espibos - matrix from molluscan shells, and (7b) Espibos - screened sediment.

Lower Miocene of Moulin de Carreau

The lower Miocene sediments at Moulin de Carreau crop out along a nearly vertical bluff line on the south side of the Douze River near its confluence with the Gouaneyre River. This bluff has been undercut in several places by the excavations of collectors, especially at the base of the marine sand sequence above its contact with nonfossiliferous or sparsely fossiliferous bedded estuarine silts and sands. Fossils were collected at this locality by digging into the marine sands of the bluff line and screening them in the river (Figure 4). Fossil mollusks are abundant at Moulin de Carreau and vary in preservation from strongly abraided (probably from rolling in the surf) to nonabraided and well preserved. Two samples from this locality were examined for calcareous nannoplankton, one from the matrix filling molluscan shells (2a) and another taken from screened sediments (2b).

Middle Eocene (Lutetian) of Tuilerie and Acot

Two lower Eocene localities, which have been previously placed as Cuisian (upper Ypresian) in age, were collected in the vicinity of Gan, a town south of Pau. The first of these localities contains the well known "Gan Marls" of the tile plant quarry at Tuilerie (Figures 5-6). The second is a lesser known and more sparsely fossiliferous locality at Acot just south of

Figure 5. Eocene sequence "Gan Marls" of the Tuilerie quarry at Gan. Collecting in the foreground from left to right are Cyrille Dolin, Mary Dockery, Therese Dolin, and Luc Dolin. An amateur collector stands to the left of his sun umbrella on the quarry slope in the background. Photograph taken on July 30, 1983.

Gan. At both localities the sediment is composed of fossiliferous fine silt which may be easily carved with a knife when wet but is hard and brittle when dry. Collections were made at these localities by drilling out blocks of the damp silty sediment and breaking them into small fragments in search for fossils along the breakage surfaces. Fossils embedded in these silts are fragile and often are distorted by compaction. Upon drying the more fragile specimens were hardened by the application of a solution of polystyrene (Styrofoam) dissolved in trichlorethylene. Two sediment samples collected at the Tuilerie quarry (8a and 8b) and one sediment sample at Acot (9) were examined for calcareous nannoplankton.

BIOSTRATIGRAPHY

Calcareous nannoplankton fossils in samples from the Stampian and Aquitainian Basin localities are listed in Table 1. Bibliographical references for most of these species are found in Loeblich and Tappan (1966, 1968, 1969, 1970a, 1970b, 1971, 1973); species not included in the Loeblich and Tappan series are listed under "References Cited" and are identified by an asterisk in Table 1 and in the References.

Table 2 shows the distribution and relative abundance of various Tertiary species in the sections sampled. Reworked Cretaceous species are ubiquitous and fairly abundant in all the samples studied; Cretaceous species are not listed individually in Table 2. Relative abundance is indicated as follows: A = Abundant, more than 10 specimens of a single species per field of view at a magnification of 800X. C = Common, 1 to 10 specimens per field. F = Few, one specimen per 2 - 10 fields. R = Rare, one specimen per 11-100 fields. S = Single specimen found.

Plate 1 illustrates age-diagnostic and other species present in two of the Eocene samples studied. All species recorded and illustrated here are housed in the micropaleontological collection, Department of Geology, Vanderbilt University.

Figure 6. The gastropod *Tibia* (cf. *Sulcogladius*) *spirata* (Rouault, 1848) and the foraminifer *Nummulites* as seen along a freshly broken surface of the "Gan Marls" at Tuilerie. Lens cap for scale. Photograph taken July 30, 1983.

Stampian Basin

Morigny: This section contains a moderately well-preserved assemblage of calcareous nannoplankton. However, the species present are long ranging and indicate only an Eocene-Oligocene age (Table 2). Other paleontological and stratigraphic data place this Stampian locality as lower Oligocene in stratigraphic position and as equivalent to the upper Vicksburg Group of the North American Gulf Coast sequence (Aubry, 1983).

Adour Basin

Abbesses parish of Saint-Paul-les-Dax: Samples collected at this locality contain only a sparse, poorly preserved Eocene-Oligocene assemblage (Table 2). Other paleontological data place this outcrop as upper Oligocene.

Estoti parish of Saint-Paul-les-Dax: A poorly preserved assemblage is present, but the forms are long ranging, and the age is indeterminate. Stratigraphic and paleontological data place the Estoti and Abbesses sections in the upper Oligocene.

Mineur parish of Pontonx: This section, as is the case of the previously mentioned upper Oligocene localities, contains a poorly preserved Eocene-Oligocene assemblage (Table 2). Muller and Pujol (1979) studied the planktic foraminifers and calcareous nannoplankton at Pontonx in strata below that examined here and placed the strata as NP 25.

Lagouarde parish of Gaas: Calcareous nannoplankton fossils are common and moderately well preserved in samples collected at this locality (Table 2). The overlapping stratigraphic ranges of *Discoaster barbadiensis* (NP 12-NP 20) and *Sphenolithus predistentus* (NP 20 - NP 24) suggest a zonal assignment to NP 20 (Martini, 1971). However, other paleontological and stratigraphic data indicate a lower Oligocene position for this locality. Specimens of *Discoaster barbadiensis* in the Lagouarde sample were probably reworked from older Eocene sediments of adjacent regions as is the case of Cretaceous species found in the samples.

Espibos parish of Gaas: The nannoplankton assemblage is poorly preserved, but the presence of *Sphenolithus predistentus* in one of the samples (Table 2) indicates a zonal range of NP 20 to NP 24. The sequence at Espibos contains the same stratigraphic units exposed at Lagouarde and is probably assign-

Plate 1. Calcareous nannoplankton in French Tertiary localities. Phase-contrast illumination indicated by uppercase letters; cross-polarized illumination by lower case. Sample numbers are in parentheses. A,a, **Braarudosphaera bigelowii** (8b); B,b, **Zygrhablithus bijugatus** (8a); C, **Discoaster deflandrei** (8b); D,d, **Blackites creber** (lower left) and **Coccolithus pelagicus** (upper right) (8a); E,e, **Cruciplacolithus delus** (8b); F, **Discoaster elegans** (8a); G,g, **Cyclococcolithus formosus** (8b); H, **Chiasmolithus grandis** (8b); i, **Micrantholithus inaequalis** (8a); J,m, **Discoasteroides kuepperi** (8a); K,k, **Rhabdosphaera inflata** (8b); L,l, **Rhabdosphaera** aff. **R. inflata** (8a); N, **Discoaster lodoensis** (8b); O, **Discoaster mediosus** (8b); P,p, **Transversopontis pulcher** (8a); q, **Sphenolithus radians** (8b); R, **Braarudosphaera rosa** (8b); s, **Thoracosphaera saxea** (8b); T,t, **Helicosphaera seminulum** (8a); U, **Chiasmolithus solitus** (8b). Approximate magnifications: 1000X, except C, D, d, H, N (800X), and E, e, J, L, l, m, q, R (1200X).

TABLE 1

CALCAREOUS NANNOPLANKTON IN FRENCH TERTIARY LOCALITIES

Micrantholithus aequalis Sullivan 1964
Discoaster barbadiensis Tan Sin Hok 1927
Braarudosphaera bigelowii (Gran & Braarud) Deflandre 1947
Zygrhablithus bijugatus (Deflandre) Deflandre 1959
Dictyococcites bisectus (Hay, Mohler & Wade) Bukry & Percival 1971
Discoaster calculosus Bukry 1971
Blackites creber (Deflandre) Sherwood 1974*
Reticulofenestra daviesi (Haq) Haq 1971
Discoaster deflandrei Bramlette & Riedel 1954
Cruciplacolithus delus (Bramlette & Sullivan) Perch-Nielsen 1971
Reticulofenestra dictyoda (Deflandre & Fert) Stradner *in* Stradner & Edwards 1968
Discoaster elegans Bramlette & Sullivan 1961
Clathrolithus ellipticus Deflandre *in* Deflandre & Fert 1954
Coccolithus eopelagicus (Bramlette & Riedel) Bramlette & Sullivan *in* Bramlette & Wilcoxon, 1967
Cyclicargolithus floridanus (Roth & Hay) Bukry 1971
Micrantholithus flos Deflandre 1950
Cyclococcolithus formosus Kamptner 1963
Corannulus germanicus Stradner 1962
Chiasmolithus grandis (Bramlette & Riedel) Gartner 1970
Thoracosphaera heimi (Lohmann) Kamptner 1920
Micrantholithus inaequalis Martini 1961
Rhabdosphaera inflata Bramlette & Sullivan 1961
Discoasteroides kuepperi (Stradner) Bramlette & Sullivan 1961
Discoaster lodoensis Bramlette & Riedel 1961
Discoaster mediosus Bramlette & Sullivan 1961
Lanternithus minutus Stradner 1962
Sphenolithus moriformis (Bronnimann & Stradner) Bramlette & Wilcoxon 1967
Pontosphaera multipora (Kamptner) Roth 1970
Discoaster nodifer (Bramlette and Riedel) Bukry 1973
Transversopontis obliquipons (Deflandre) Hay, Mohler & Wade 1966
Tribrachiatus orthostylus Shamrai 1963
Coccolithus pelagicus (Wallich) Schiller 1930
Rhabdosphaera perlonga (Deflandre) Bramlette & Sullivan 1961
Sphenolithus predistentus Bramlette & Wilcoxon 1967
Micrantholithus procerus Bukry & Bramlette 1969
Neococcolithes protenus (Bramlette & Sullivan) Hay & Mohler 1967
Transversopontis pulcher (Deflandre) Hay, Mohler & Wade 1966
Reticulofenestra pseudoumbilica (Gartner) Gartner 1969
Sphenolithus radians Deflandre 1952
Helicosphaera recta Haq 1966
Braarudosphaera rosa Levin & Joerger 1967
Thoracosphaera saxea Stradner 1961
Helicosphaera seminulum Bramlette & Sullivan 1961
Chiasmolithus solitus (Bramlette & Sullivan) Locker 1968
Blackites tenuis (Bramlette & Sullivan) Bybell 1975*
Reticulofenestra umbilica (Levin) Martini & Ritzkowski 1968
Rhabdosphaera vitrea (Deflandre) Bramlette & Sullivan 1961

TABLE 2

DISTRIBUTION AND ABUNDANCE OF CALCAREOUS NANNOPLANKTON
IN FRENCH TERTIARY LOCALITIES

	Morigny		Moulin de Carreau		Abbesses		Estoti		Mineur	Lagouarde		Espibos		Tuilerie		Acot
	1a	1b	2a	2b	3a	3b	4a	4b	5	6a	6b	7a	7b	8a	8b	9
Micrantholithus aequalis														R	R	
Discoaster barbadiensis										R						
Braarudosphaera bigelowii	R		R		R		R			R					R	
Zygrhablithus bijugatus	F	R				R			R	F	R	R	R	F	C	R
Dictyococcites bisectus										R	R	R				
Discoaster calculosus			S													
Blackites creber														R	R	
Reticulofenestra daviesi												R				
Discoaster deflandrei															R	
Cruciplacolithus delus												R			R	
Reticulofenestra dictyoda										R		R		R	F	
Discoaster elegans														R	R	
Clathrolithus ellipticus														R		
Coccolithus eopelagicus								R						R		
Cyclicargolithus floridanus	C	C	R	R	R	F	R	R	R	F	F	F	R	F	F	R
Micrantholithus flos															R	
Cyclococcolithus formosus										R				R	F	R
Corannulus germanicus														R		
Chiasmolithus grandis														R	R	
Thoracosphaera heimi						R	R			R						
Micrantholithus inaequalis														R		
Rhabdosphaera inflata														R	R	
Discoasteroides kuepperi														R	R	
Discoaster lodoensis														R	R	
Discoaster mediosus															R	
Lanternithus minutus										R						
Sphenolithus moriformis						R	R					R	R			
Pontosphaera multipora	R								R							
Discoaster nodifer														R	R	
Transversopontis obliquipons														R	R	
Tribrachiatus orthostylus										R				R		
Coccolithus pelagicus	F	R	R	R		R			R		R	R		R		
Rhabdosphaera perlonga														R		
Sphenolithus predistentus										R	R	R				
Micrantholithus procerus														R		
Neococcolithes protenus														R		
Transversopontis pulcher														R	R	
Reticulofenestra aff. pseudoumbilica			R													
Sphenolithus radians														R	R	
Helicosphaera recta										R	R					
Braarudosphaera rosa															R	
Thoracosphaera saxea															R	
Helicosphaera seminulum														R		R
Chiasmolithus solitus														R	R	
Blackites tenuis											R			R	R	
Reticulofenestra umbilica										R						
Rhabdosphaera vitrea		R													R	
Reworked Cretaceous spp.	F	F	R	R	R	R	R	R	R	F	F	R	F	C	C	C

able to NP 22. The samples taken from these localities came from the *Oostrombus auriculatus* layer and are equivalent in age to the upper part of the Vicksburg Group in the Southeastern United States.

Moulin de Carreau: The nannoplankton assemblage is poorly preserved in this section, and only two fossils give clues to its age: *Discoaster calculosus*, which ranges from NP 24 to NN 4, and a small reticulofenestrid, which Siesser (1979) referred to as *Reticulofenestra* aff. *R. pseudoumbilica* (Table 2). Siesser (1979) found this species in early Miocene zones NN 1 to NN 4, but not in the underlying Oligocene. This suggests an early Miocene age for the Moulin de Carreau section and an approximate equivalence to the lower Alum Bluff Group of the Southeastern United States.

Bearn Basin

Tuilerie quarry at Gan: Calcareous nannoplankton are abundant and moderately well preserved in samples collected at this locality (Table 2). The presence of *Rhabdosphaera inflata* (NP 14 only; Muller, 1978, and Beckmann et al., 1981) indicates a zonal assignment to NP 14. Zone NP 14 spans the Ypresian-Lutetian (lower Eocene - middle Eocene) boundary according to Berggren et al. (in press). However, Aubry (1983) placed the Cuisian of the Paris Basin in NP 12 and the basal glauconitic sands of the Lutetian in NP 14. Though the "Gan Marls" have been previously correlated with the Cuisian based on the presence of the benthic foraminifers *Nummulites planulatus* and *Alveolina oblonga*, they are placed here as lower Lutetian in age.

Acot parish of Gan: Calcareous nannoplankton are common but poorly preserved in the samples collected at this locality (Table 2). The presence of *Helicosphaera seminulum* (NP 12 - NP 16) indicates only that the samples are lower or middle Eocene in age. The stratigraphic position of this site indicates that it is lower in the section than is the Tuilerie locality, and the benthic foraminifers indicate that it is Cuisian (upper Ypresian) in stratigraphic position. The sequences at both Tuilerie and Acot are roughly equivalent to the Tallahatta Formation of the North American Gulf Coastal Plain (Siesser, 1983, and Bybell and Gibson, 1985).

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POSTSCRIPT: A companion article, "Paleoecology of some classic Tertiary localities in the Aquitaine and Paris basins of France," by Cyrille Dolin, Luc Dolin, and Pierre Lozouet, will be published in the June 1985 issue of *Mississippi Geology.* This article will examine the paleoecology of the localities studied here.

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CALENDAR OF EVENTS
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September 17-21 - American Institute of Professional Geologists, annual meeting, St. Paul, Minnesota. (Robert E. Pendergast, 1925 Oakcrest Ave., Roseville, Minnesota 55113. Phone: 612/636-7744).

September 23-27 - Earth Remote Sensing, workshop, Flagstaff, Arizona. (Geosat Committee, Suite 209, 153 Kearny, San Francisco, California 94108. Phone: 415/981-6265).

September 30-October 2 - Institute for Tertiary - Quaternary Studies, annual meeting, Lawrence, Kansas. (Wakefield Dort, Jr., Dept. of Geology, University of Kansas, Lawrence, Kansas 66045. Phone: 913/864-4974).

October 6-10 - Society of Exploration Geophysicists, annual meeting, Washington, D.C. (Robert Van Nostrand, 1424 Kingston Ave., Alexandria, Virginia 22302. Phone: 703/751-1306).

October 7-11 - Association of Engineering Geologists, annual meeting and field trips, Winston-Salem, North Carolina. (Norman R. Tilford, Ebasco Services, 2211 Meadowview, Greensboro, N.C. 27047. Phone: 919/855-7500).

October 16-19 - Gulf Coast Association of Geological Societies and Gulf Coast Section, Society of Economic Paleontologists and Mineralogists, annual meeting, Austin, Texas. (Bill Ehni, Geotronics Corp., 10317 McKalla Place, Austin, Texas 78758. Phone: 512/837-7564).