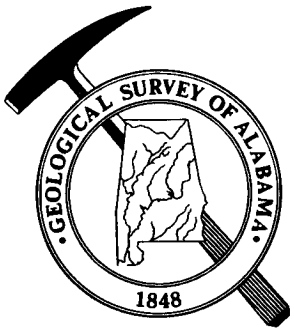
PLANKTONIC FORAMINIFERAL AND OSTRACODE BIOSTRATIGRAPHY OF UPPER SANTONIAN THROUGH LOWER MAASTRICHTIAN STRATA IN CENTRAL ALABAMA

GEOLOGICAL SURVEY OF ALABAMA REPRINT SERIES 104



GEOLOGICAL SURVEY OF ALABAMA

Ernest A. Mancini
State Geologist

REPRINT SERIES 104

PLANKTONIC FORAMINIFERAL AND OSTRACODE BIOSTRATIGRAPHY OF UPPER SANTONIAN THROUGH LOWER MAASTRICHTIAN STRATA IN CENTRAL ALABAMA

By

T. Markham Puckett

Reprinted from
Gulf Coast Association of Geological Societies Transactions,
v. 44, 1994, p. 585-595

Tuscaloosa, Alabama
1994

Planktonic Foraminiferal and Ostracode Biostratigraphy of Upper Santonian through Lower Maastrichtian Strata in Central Alabama

T. Markham Puckett
Geological Survey of Alabama, P.O. Box O, Tuscaloosa, AL 35486-9780

Abstract

A composite reference section of exposed marine Upper Cretaceous sediments in central Alabama was generated to define its biostratigraphic framework. Sections were correlated on the basis of two excellent lithostratigraphic marker horizons, the Arcola Limestone Member of the Mooreville Chalk and the uppermost sand of the Eutaw Formation. Stratigraphic units include the Tombigbee Sand Member of the Eutaw Formation, the Mooreville Chalk, and the Demopolis Chalk. The ranges of ostracode and planktonic foraminiferal species are plotted in reference to these sections. All or part of four planktonic foraminiferal zones and five ostracode zones are delineated. The units range in age from late Santonian through early Maastrichtian.

The Tombigbee Sand and the lower 105 ft of the Mooreville Chalk are of late Santonian age (*Dicarinella asymetrica* Zone). The top of the *D. asymetrica* Zone marks the Santonian-Campanian Stage boundary. The upper 250 ft of the Mooreville Chalk and lower 265 ft of the Demopolis Chalk are of early to late Campanian age (*Globotruncanita elevata* Zone). An ostracode zone, the *Ascetoleberis plummeri* Zone, brackets the Arcola Limestone Member of the Mooreville Chalk. The *Globotruncanita calcarata* Zone, the top of which marks the Campanian-Maastrichtian Stage boundary, occurs in the upper third of the Demopolis Chalk, well below the Bluffport Marl Member. The upper 100 ft of the Demopolis and the lower 50 ft of the Ripley Formation are assigned to the *Globotruncana "tricarinata"* Zone of early Maastrichtian age.

Neither the Santonian-Campanian nor the Campanian-Maastrichtian Stage boundary occurs at any change in lithology or formational contact.

Introduction

The Upper Cretaceous marine sediments of central Alabama are well exposed in the Dallas County area, principally along the Alabama and Cahaba Rivers, and total about 1,000 ft in thickness. In this area, there are cliffs of chalk and marl in excess of 150 ft above normal river level. There are also two lithostratigraphic surfaces that provide excellent key beds for correlation, the top of the Arcola Limestone Member of the Mooreville Chalk and the top of the uppermost sand bed in the Eutaw Formation. Although the general ages of the stratigraphic units have been known for some time, the precise positions of the highest and/or lowest occurrence of significant species of calcareous microfossils have not been published until recently, and those are only for restricted intervals. There also are published versions of the ages of these Upper Cretaceous units that vary considerably from one another and from the results interpreted in this study (i.e., King and Skotnicki, 1992; King, 1993). For these reasons the study of planktonic foraminiferal and ostracode biostratigraphy of the Upper Cretaceous marine sediments was undertaken in the Dallas County area.

Methods

Figures 1 and 2 show locations of the measured sections and structure contour maps of the top of the Arcola Limestone Member of the Mooreville Chalk (Fig. 1) and the uppermost sand bed of the Eutaw Formation (Fig. 2). Correlation of the sections was done by projections above two excellent lithostratigraphic marker beds, the top of the Arcola Limestone Member of the Mooreville Chalk and the top of the sandstones of the Eutaw Formation. Both of the horizons produce distinctive "kicks" on electric logs. In addition, the Alabama Power Company drilled nine core holes in the immediate vicinity of the Alabama River measured sections. These cores were examined to determine the elevations of the various contacts, including the top of the Arcola Limestone Member. Table 1 lists core and well log information used to construct the structure contour map

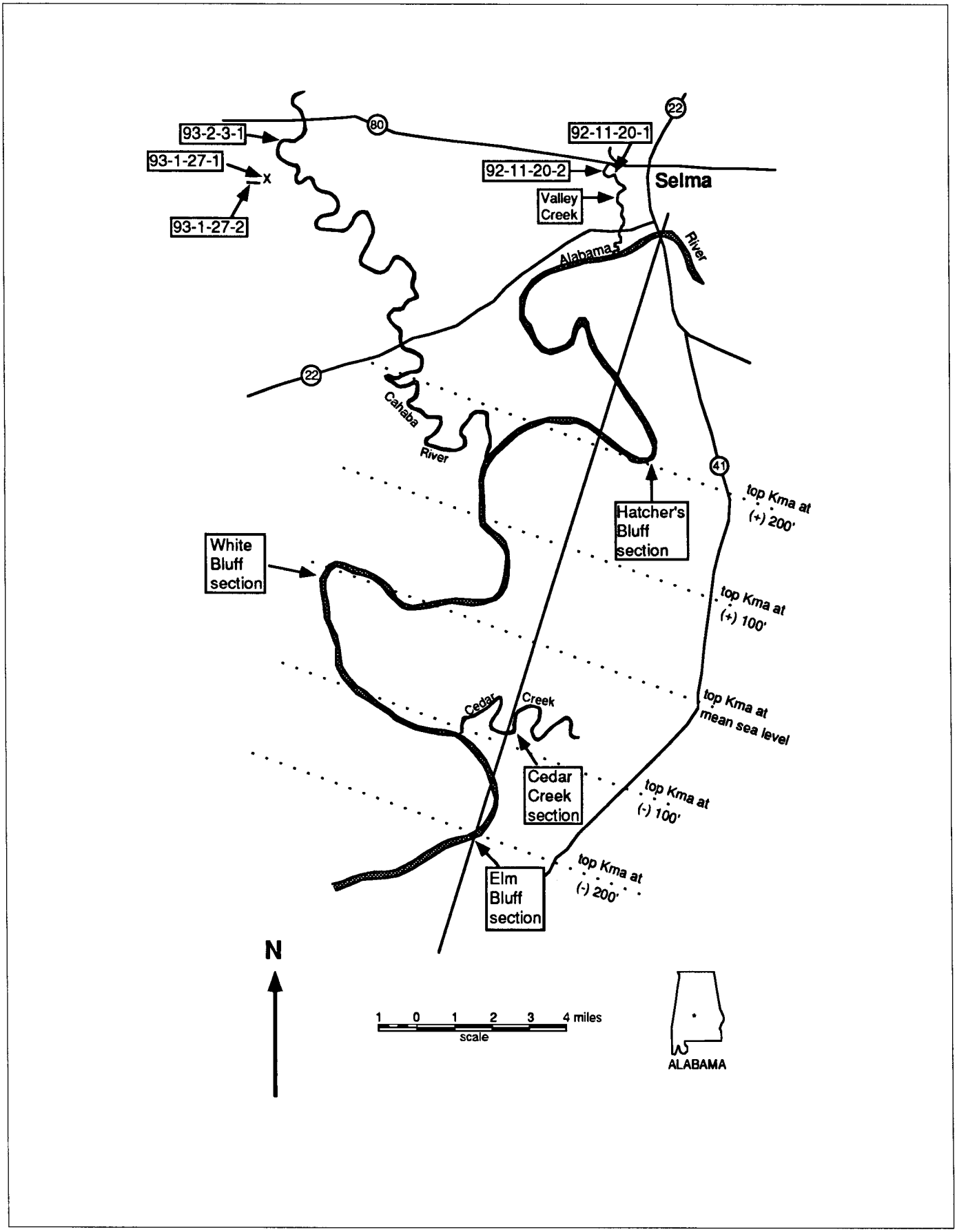


Figure 1. Geographic map of sample localities, with structure contour map of top of Arcola Limestone Member (Kma) of the Mooreville Chalk used to correlate sections along the Alabama River.

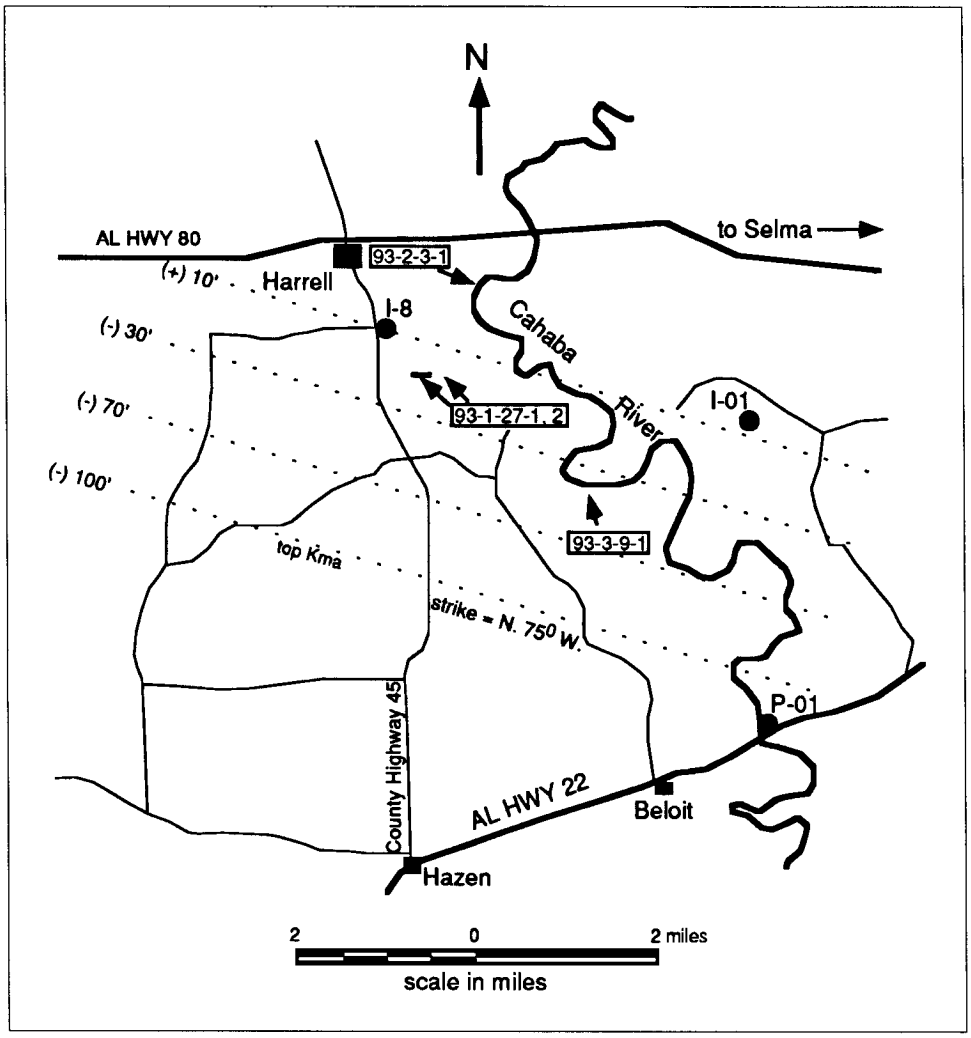


Figure 2. Geographic map of sample localities in the Cahaba River area, with structure contour map of top of sand of Tombigbee Sand Member of the Eutaw Formation (Ket).

of the top of the Arcola Limestone Member, and Table 2 lists this information for the uppermost sand of the Eutaw Formation.

Stratigraphy

Samples were collected from the Tombigbee Sand Member of the Eutaw Formation, the Mooreville Chalk, and the Demopolis Chalk. Total thickness of these sediments is about 750 ft. Deposition occurred in nearshore to offshore paleoenvironmental settings.

Tombigbee Sand Member of the Eutaw Formation

The entire thickness of the Tombigbee Sand Member of the Eutaw Formation is exposed at one section, 92-11-20-1, in Valley Creek in Selma, Alabama. At this locality, the Tombigbee Sand is about 15 ft thick and is composed generally of massive glauconitic sand with abundant oysters (*Ostrea battensis* Stephenson) occurring along discrete horizons and forming prominent ledges. The lower contact is marked by a change from laminated shale to massive sand containing *O. battensis*. The lower unnamed member of the Eutaw Formation consists of herringbone crossbedded sandstone with clay drapes and interbeds and does not contain calcareous microfossils. The upper contact is gradational with the overlying Mooreville Chalk. The Tombigbee Sand Member was deposited in a generally nearshore paleoenvironment (Soens, 1984).

Mooreville Chalk

The Mooreville Chalk consists of a dark-gray marl with interbeds of chalky marl, the lower portion being characteristically glauconitic. The lower part of the Mooreville Chalk is exposed near Valley Creek in Selma near the Tombigbee Sand outcrop, and the lower and middle parts are well exposed along the Cahaba River west of Selma. The upper part, including the Arcola Limestone Member, is well exposed at Hatcher's Bluff on the Alabama River south of Selma. Total thickness of the Mooreville Chalk is about

Table 1. Wells and core information used to construct the structure contour map of the top of the Arcola Limestone Member of the Mooreville Chalk (Kma) in the area of the Alabama River, including well numbers, locations, surface elevation, depth to the top of the Arcola Limestone, and elevation of the Arcola Limestone Member in mean sea level.

Well #(*)	Location	Elevation (a.m.s.l.**)	Depth to Kma	Elevation of top of Kma
Site #1				
Well #2	SW 1/4 NE 1/4 sec. 31, T. 15 N., R. 10 E., Elm Bluff 7 1/2 minute topographic quadrangle, Dallas County, Alabama	105'	186'	(-) 81'
Well #3	NW 1/4 NW 1/4 sec. 31, T. 15 N., R. 10 E., Elm Bluff 7 1/2 minute topographic quadrangle, Dallas County, Alabama	108'	185'	(-) 77'
Site #2				
Well #1	NW 1/4 SE 1/4 sec. 5, T. 14 N., R. 10 E., Elm Bluff 7 1/2 minute topographic quadrangle, Dallas County, Alabama	98'	216'	(-) 118'
Well #2	NE 1/4 NW 1/4 sec. 8, T. 14 N., R. 10 E., Elm Bluff 7 1/2 minute topographic quadrangle, Dallas County, Alabama	123'	277'	(-) 153'
Well #3	N 1/2 of line between NE 1/4 and NW 1/4 sec. 8, T. 14 N., R. 10 E., Elm Bluff 7 1/2 minute topographic quadrangle, Dallas County, Alabama	179'	331'	(-) 152'

* Numbers refer to Alabama Power Company test well numbers for cores and electric log information generated in 1971 by Geological Survey of Alabama personnel. Electric logs are stored at the Geological Survey of Alabama.

** a.m.s.l. = above mean sea level.

Table 2. Well numbers, locations, elevations of land surface, depth to the top of the Tombigbee Sand Member of the Eutaw Formation (Ket), and elevation of the top of the Eutaw Formation in mean sea level.

Well #(*)	Location	Elevation (a.m.s.l.)	Depth to Eutaw Fm	Elevation to top of Eutaw
I-8**	Just east of center of dividing line between secs. 19 and 30, T. 17 N., R. 9 E., Marion Junction 7 1/2 minute topographic quadrangle, Dallas County, Alabama	220' (based on topographic map)	210'	(+) 10'
I-01***	NE 1/4 sec. 35, T. 17 N., R. 9 E., Marion Junction 7 1/2 minute topographic quadrangle, Dallas County, Alabama	120'	108'	(+) 12'
P-01***	NW 1/4 SW 1/4 sec. 13, T. 16 N., R. 9 E., Orrville 7 1/2 minute topographic quadrangle, Dallas County, Alabama	115' (based on topographic map)	248'	(-) 133'

* Well numbers refer to Geological Survey of Alabama Water Resources indices.

** Data from Scott et al. (1981).

*** Data from Gillett (1988).

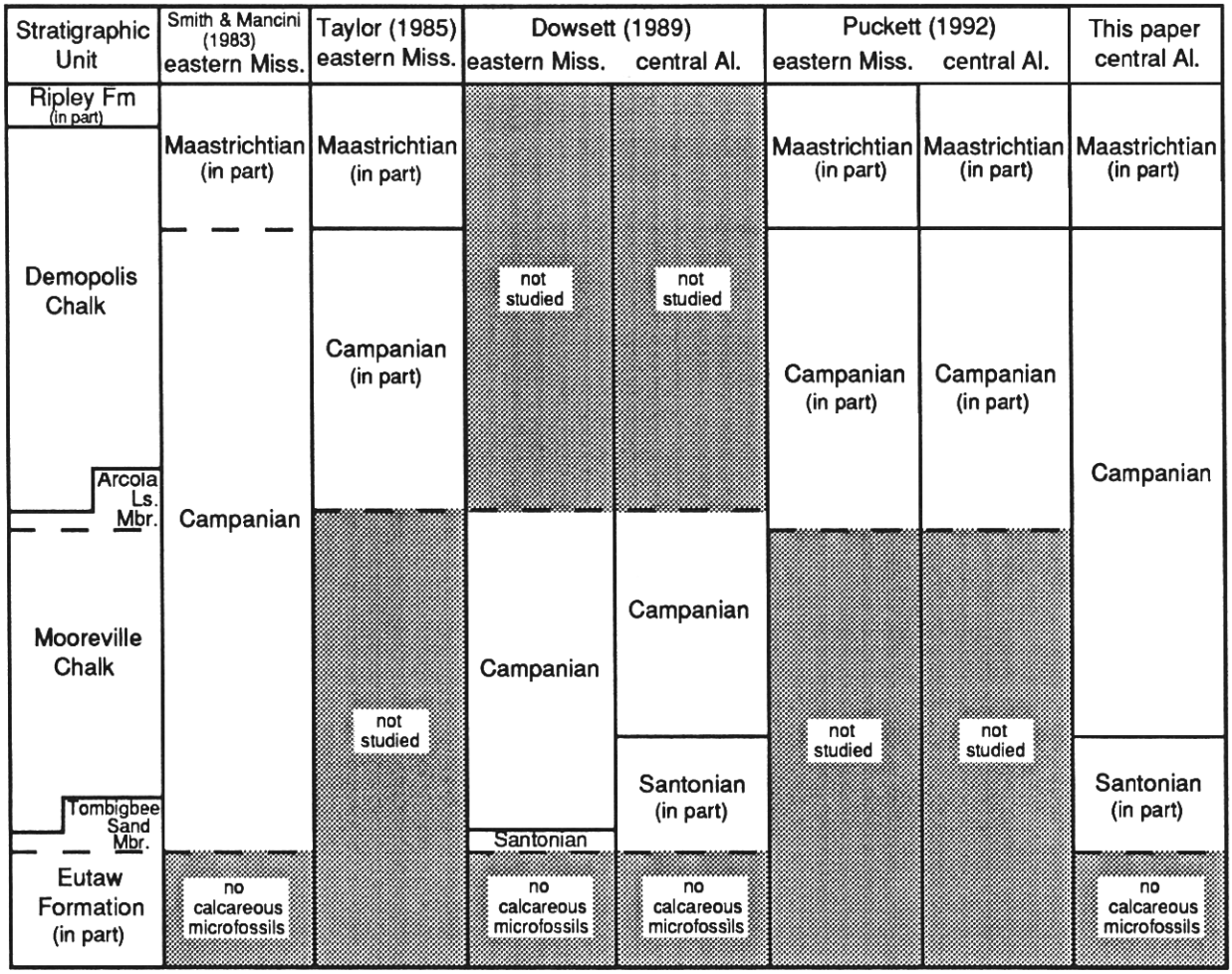


Figure 3. Summary and comparison of biostratigraphic studies of the exposed marine Upper Cretaceous strata of eastern Mississippi and central Alabama based on planktonic foraminifera. Stratigraphic units in relative scale.

358 ft. The Arcola Limestone Member is about 15 ft in thickness and consists of four calcisphere-rich limestone beds with interbeds of marl that are lithologically identical to the underlying marl of the lower unnamed member.

Demopolis Chalk

The Demopolis Chalk is well exposed along the Alabama River and Cedar Creek south of Selma. However, the interval from 45 to 100 ft above the base of the Demopolis is not exposed in this area, and thus one of the cores taken by the Alabama Power Company (Site No. 1, Well No. 3; see Table 1) was sampled within this interval. The lower contact is marked by the upper limestone bed of the Arcola. The upper contact with the Ripley Formation is gradational from a medium-gray, massive chalky marl to a dark-brownish-gray, silty marl with aragonitic shell debris. The Demopolis Chalk is about 395 ft thick along the Alabama River. For more details of the Demopolis Chalk, see Puckett (1992).

Biostratigraphy

Previous Investigations

The planktonic microfossil biostratigraphy of the upper Santonian through lower Maastrichtian sediments of central Alabama to eastern Mississippi was studied by Masters (1970), Smith and Mancini (1983), Taylor (1985), Dowsett (1989), and Puckett (1992). A comparison of the results of some of these studies is presented in Figure 3. Figure 4 shows the results of Dowsett (1989), which include planktonic foraminifera, ostracodes, and calcareous nannofossils. In general, all of these studies agree, although in certain cases the placement of the stage boundaries differs due to differences in emphasis placed on particular taxa. Because there is no universal agreement as to which taxon or datum level defines a particular stage boundary, it seems likely that these problems will persist and that it is best at this point to establish the precise locations of the datums of the particular taxa.

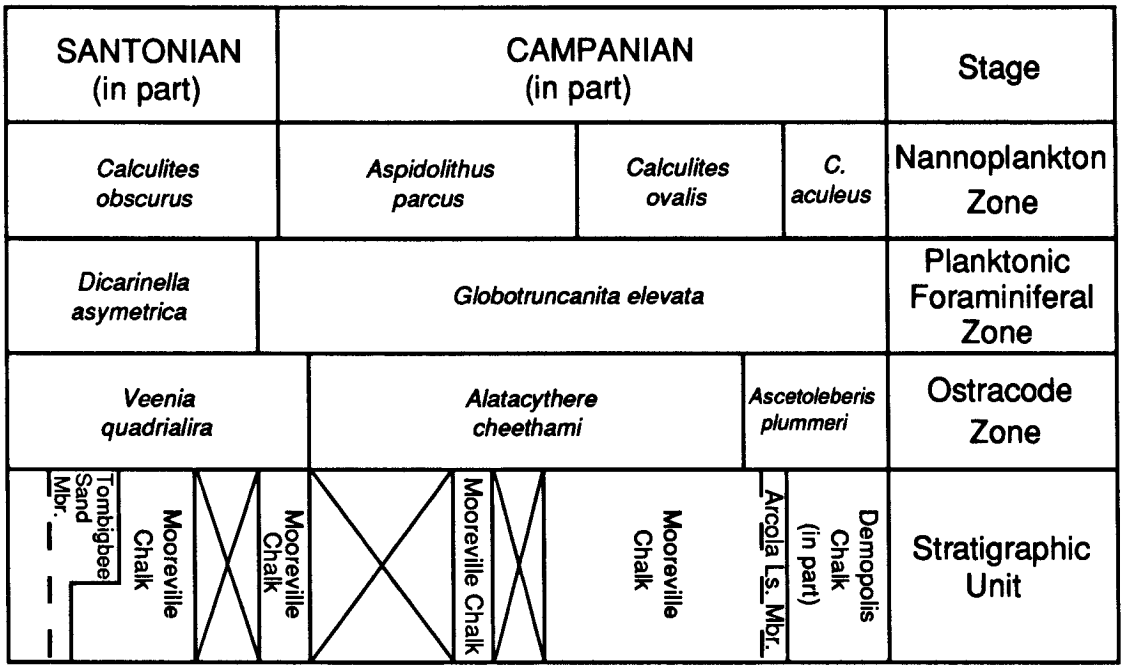


Figure 4. Summary of nannoplankton, planktonic foraminiferal, and ostracode biostratigraphy of the Tombigbee Sand Member, Eutaw Formation, to the Demopolis Chalk in central Alabama (Dowsett, 1989). Stratigraphic units in relative scale.

Biostratigraphic Units— Planktonic Foraminifera

The *Dicarinella asymetrica* Taxon Range Zone

Definition: Interval of the total range of *Dicarinella asymetrica* (Sigal).

Age: Later half of the Santonian Stage.

Remarks: The planktonic foraminiferal definition of the Santonian-Campanian boundary has varied with different authors. Many have used the lowest occurrence surface (LOS) of single-keeled globotruncanids (i.e., *Globotruncanita* spp.) to define the boundary, whereas others have used the highest occurrence surface (HOS) of *D. asymetrica*. These two datum levels are not coincidental, as the LOS of *G. elevata* (*Brotzen*) is lower than the HOS of *D. asymetrica* (Caron, 1985). This report will follow the zonation of Caron (1985) and use the HOS of *D. asymetrica* to define the Santonian-Campanian boundary. Significantly, *D. asymetrica* is generally abundant throughout its range, particularly at its HOS, whereas *G. elevata* is generally a rare and sporadic taxon.

The *Globotruncanita elevata* Interval Zone

Definition: The interval between the HOS of *Dicarinella asymetrica* and the LOS of *Globotruncanita calcarata* (Cushman).

Age: Early and middle to late Campanian.

Remarks: Although the "*G. elevata* Zone" has long been in use, the definitions of the boundaries have varied with different workers, and, therefore, the age(s) of the zone has ranged from middle Santonian (van Hinte, 1976) to latest Campanian (Pessagno, 1967). According to Caron (1985), *G. elevata* has its LOS slightly below the Santonian-Campanian Stage boundary and its HOS at about the middle of the *G. calcarata* Range Zone, although other authors (e.g., Pessagno, 1967; Premoli Silva and Bolli, 1973; Premoli Silva and Boersma, 1977; Premoli Silva and Sliter, 1981) noted *G. elevata* to occur through the middle or late Maastrichtian. In the Upper Cretaceous of Alabama and Mississippi, *G. elevata* ranges from slightly below the Santonian-Campanian boundary through at least the early Maastrichtian and thus occurs well above the top of the *G. elevata* Interval Zone.

The *Globotruncana ventricosa* Interval Zone was used by some authors (i.e., Dalbiez, 1955; Caron, 1985) as the interval between the LOS of the nominal taxon and the LOS of *Globotruncanita calcarata*, which is middle to late Campanian in age. It was found during this study that *G. ventricosa* White, although being fairly common in the late Campanian and early Maastrichtian sediments, was extremely rare in its lower range, and thus the LOS could not be accurately placed.

The *Globotruncanita calcarata* Taxon Range Zone

Definition: Total range of *Globotruncanita calcarata* (Cushman).

Age: Late Campanian.

Remarks: The *Globotruncanita calcarata* Zone is important because the nominal species has the shortest stratigraphic range of any species of planktonic foraminifera in the Upper Cretaceous. The species is easy to recognize and identify, is widely distributed, and the top of the range zone is generally considered by foraminiferal specialists to mark the Campanian-Maastrichtian Stage boundary, although this latter point is certainly not universally agreed upon (cf. Burnett and others, 1992). Unfortunately, *G. calcarata* is often quite rare, only recently being documented in Mississippi (Taylor, 1985) and Alabama (Masters, 1970; Puckett, 1992).

The *Globotruncana "tricarinata"* Interval Zone

Definition: The interval between the HOS of *Globotruncanita calcarata* and the LOS of *Gansserina gansseri* (Bolli).

Age: Early Maastrichtian.

Remarks: The interval between the HOS of *G. calcarata* and the LOS of *Gansserina gansseri* has been referred to by various names, including *Globotruncanita stuartiformis* concurrent range zone (Postuma, 1971), *Globotruncana "tricarinata"* zone (Premoli Silva and Bolli, 1973), and the *Rugotruncana subcircumnodifer* Subzone (Pessagno, 1967), although the definitions of these zones are somewhat different. For purposes here, the *G. "tricarinata"* Interval zone will be used as defined above for the assignment of faunas to the early Maastrichtian Stage.

Biostratigraphic Units—Ostracodes

The *Veenia quadrialira* Interval Zone

Definition: The interval between the LOS of *Veenia quadrialira* (Swain) and the LOS of *Pterygocythereis (Pterygocythereis) cheethami* Hazel and Paulson.

Age: Early to late Santonian.

The *Pterygocythereis (Pterygocythereis) cheethami* Interval Zone

Definition: The interval between the LOS of *P. (P.) cheethami* (= *Alatacythere cheethami*) and the LOS of *Ascetoleberis plummeri* (Israelsky).

Age: Late Santonian through early Campanian.

The *Ascetoleberis plummeri* Interval Zone

Definition: The interval between the LOS of *Ascetoleberis* spp. and the LOS of *Limburgina verricula* (Butler and Jones).

Age: Middle Campanian.

Remarks: The definition of the base of this zone is herein amended from that originally defined by Hazel and Brouwers (1982) by the acceptance of any species of the genus *Ascetoleberis* to define the base. This is used because the LOS of all species in the genus is nearly at the same horizon in the area of study.

The *Limburgina verricula* Interval Zone

Definition: The interval between the LOS of *Limburgina verricula* (Butler and Jones) and the LOS of *Escharacytheridea pinochii* (Jennings).

Age: Middle to late Campanian.

The *Escharacytheridea pinochii* Interval Zone

Definition: The interval between the LOS of *Escharacytheridea pinochii* (Jennings) and the LOS of *"Cythereis" lixula* Crane.

Age: Late Campanian to early Maastrichtian.

Results

Figure 5 presents the stratigraphic ranges of the more important species of planktonic foraminifera and ostracodes.

Planktonic Foraminiferal Biostratigraphy

The *Dicarinella asymetrica* Zone

Dicarinella asymetrica (Sigal) was found in samples ranging through the Tombigbee Sand Member to sample 93-2-3-1(150), about 104 ft above the base of the Mooreville Chalk. In general, individuals of *D. asymetrica* are abundant and well preserved. Species associated with *D. asymetrica* include *Archaeoglobigerina cretacea* (d'Orbigny), *Rugoglobigerina rugosa* (Plummer), *Heterohelix globulosa* (Ehrenberg), *Pseudotextularia elegans* (Rzehak), *Globigerinelloides prairiehillensis* Pessagno, *G. multispina* (Lalicker), *Rosita fornicata* (Plummer), *Globotruncana bulloides* Volger, *G. arca* (Cushman), *G. lapparenti* Brotzen, and *G. linneiana* (d'Orbigny). Both *Ventilabrella glabrata* Cushman and *Globigerinelloides multispina* have their LOS about 22 ft above the base of the Mooreville Chalk (sample 92-11-20-2[35.0]). *Globotruncana linneiana* has its LOS about 104 ft above the base of the Mooreville Chalk.

The LOS of the single-keeled globotruncanids, *Globotruncanita* spp., occurs in sample 92-11-20-2[35.0], which is about 24 ft above the base of the Mooreville Chalk. Both *G. elevata* and *D. asymetrica* are found in the interval between 24 and about 104 ft above the base of the Mooreville Chalk.

The *Globotruncanita elevata* Zone

In Dallas County, this zone extends from 104 ft above the base of the Mooreville Chalk to 265 ft above the base of the Demopolis Chalk. This stratigraphic interval is about 520 ft in thickness and constitutes the bulk of the chalky

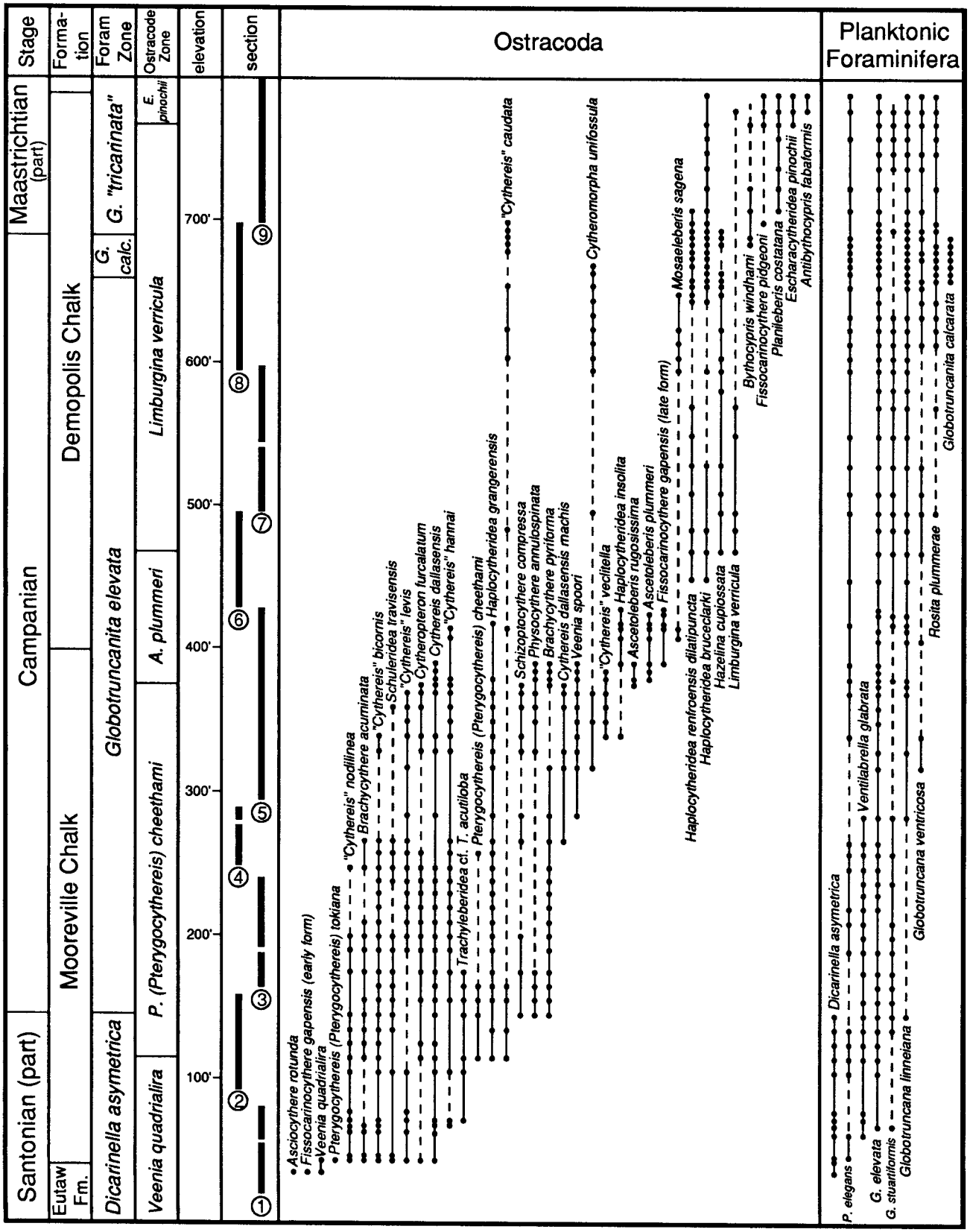


Figure 5. Range chart of significant species of ostracodes and planktonic foraminifera, with measured sections, relative elevations, ostracode and planktonic foraminiferal zonations, stratigraphy, and age. Numbers under sections refer to measured sections on Figure 1. 1 = 92-11-20-1, 2; 2 = 93-2-3-1; 3 = 93-1-27-1, 2; 4 = 93-3-9-1; 5 = Hatcher's Bluff; 6 = section of core collected by Alabama Power Company (Site #1, Well #3; see Table 1 for locality); 7 = White Bluff section; 8 = Cedar Creek section; 9 = Elm Bluff section.

deposits (i.e., "Selma Group") of the Upper Cretaceous of Alabama. Planktonic foraminifera are very abundant, diverse, and well preserved in this interval. Associated species of planktonic foraminifera include *Archaeoglobigerina cretacea*, *Globigerinelloides prairiehillensis*, *G. multispina*, *Heterohelix globulosa*, *Globotruncana bulloides*, *G. arca*, *G. lapparenti*, *G. linneiana*, *Globotruncanita elevata*, and *Rugoglobigerina rugosa*. *Globotruncanita stuartiformis* is also present but less abundant than the other species.

The *Globotruncanita calcarata* Zone

Globotruncanita calcarata occurs from 265 to 295 ft above the base of the Demopolis Chalk, in a 110-ft cut bank along Cedar Creek, a tributary of the Alabama River. The zone is in a lithologically repetitious interval of chalk and marl but occurs about 23 ft above a horizon of the oyster *Pycnodonte convexa* (Say). This oyster bed apparently extends from near Tupelo, Mississippi, to near Montgomery, Alabama, at the same elevation above the top of the Arcola Limestone (Keady, 1989; Puckett, 1992). The Campanian-Maastrichtian stage boundary as defined by the HOS of *G. calcarata* is not marked by any obvious change in lithology.

The *Globotruncana "tricarinata"* Zone

As neither *G. gansseri* nor *Globotruncana aegyptiaca* Nakkady was observed in the interval studied, the upper Demopolis Chalk and basal Ripley Formation are assigned to the *G. "tricarinata"* Zone. Associated common to abundant species include *A cretacea*, *G. arca*, *G. linneiana*, *G. lapparenti*, *G. ventricosa*, *R. fornicata*, *R. plummerae* (Gandolfi), and *G. elevata*.

Ostracode Biostratigraphy

Ostracodes were recovered from all 74 samples analyzed for this study and are, in general, abundant, well preserved, and often diverse. Ostracodes, as with the planktonic foraminifera, are very rare in the sandy sediments of the Tombigbee Sand Member; diversity is also reduced in the middle of the Demopolis Chalk, the purest chalk interval.

The *Veenia quadrialira* Zone

Veenia quadrialira occurs only in the lower two samples incorporated in this study, one collected from the uppermost Tombigbee Sand Member and one from the basal Mooreville Chalk. The LOS of *P. (P.) cheethami* is about 75 ft above the base of the Mooreville Chalk. Thus there is a gap of about 71 ft between the HOS of *V. quadrialira* and the LOS of *P. (P.) cheethami*.

The *Pterygocythereis (Pterygocythereis) cheethami* Zone

Pterygocythereis (Pterygocythereis) cheethami first occurs about 75 ft above the base of the Mooreville Chalk and occurs fairly consistently up to about 125 ft above the base, then was not found again until about 200 ft above the base, a gap of 75 ft. The LOS of *Ascetoleberis* spp. is 334 ft above the base of the Mooreville Chalk, 6 ft below the Arcola, which marks the top of the *P. (P.) cheethami* Zone.

The stratigraphic interval between the LOS of *Pterygocythereis (Pterygocythereis) cheethami* and the HOS of *Dicarinella asymetrica*, which marks the Santonian-Campanian stage boundary, is only about 30 ft, and thus the LOS of *P. (P.) cheethami* is of latest Santonian age.

The *Ascetoleberis plummeri* Zone

Although Hazel and Brouwers (1982) define the *Ascetoleberis plummeri* Zone as the interval between the LOS of the nominal species and the LOS of *Limburgina verricula*, the zone as defined here uses the LOS of any species of *Ascetoleberis* to mark its base (*A. rugosissima* [Alexander] in this case). This amended definition is proposed because all species of the genus apparently occur at nearly the same horizon (Hazel and Brouwers, 1982). Species of *Ascetoleberis* range from 6 ft below the base of the Arcola to about 26 ft above the top of the Arcola, a stratigraphic interval of about 50 ft. The LOS of *Limburgina verricula* is about 70 ft above the base of the Demopolis, or about 45 ft above the HOS of *A. plummeri*.

A species which has a stratigraphic range similar to that of *Ascetoleberis* spp. is *Fissocarinocythere gapensis* (Alexander) (late form). The LOS of *F. gapensis* is in the Arcola Limestone Member, about 10 or 11 ft above the LOS of *Ascetoleberis*, and the HOS of *F. gapensis* is about 30 ft above the top of the Arcola, which is about 4 ft above the HOS of *Ascetoleberis*. The HOS of *Haplocytheridea insolita* is coincidental with that of *F. gapensis*.

The *Limburgina verricula* Zone

The LOS of *L. verricula* is about 70 ft above the base of the Demopolis Chalk. While *L. verricula* occurs fairly consistently in the lower part of its range, it is completely absent in the middle part of its range, which corresponds to the interval of purest chalk in the Demopolis. This correspondence suggests that the distribution of *L. verricula* is a function of the paleoenvironment. For example, *L. verricula* is present from about 70 to 176 ft above the base of the Demopolis, then is absent up to 384 ft above the base, a gap of more than 200 ft. A similar distribution of *L. verricula* was observed in eastern Mississippi (Puckett, 1994).

The *Escharacytheridea pinochii* Zone

The LOS of *E. pinochii* is about 20 ft below the top of the Demopolis Chalk, but *"C." lixula* was not observed. In eastern Mississippi, the LOS of *E. pinochii* is about 90 ft below the top of the Demopolis (Puckett, 1994).

Discussion

The ages of the stratigraphic units defined herein on the basis of a composite reference section in central Alabama using planktonic foraminifera and ostracodes agree well with previous studies using calcareous microfossils. However, King and coworkers (e.g., King and Skotnicki, 1992; King, 1993) placed the stage boundaries at levels significantly different from those established by microfossils. For example, the Campanian-Maastrichtian boundary was placed in the lower part of the Ripley Formation, which suggests placement well over 100 ft above the levels defined herein. Apparently, stratigraphic intervals interpreted as genetically related sedimentary packages in the Upper Cretaceous strata of central and eastern Alabama were assumed to correlate chronostratigraphically with sequences in the Haq et al. (1987) coastal onlap curve, and thus the ages of these sequences were taken from the coastal onlap curves to date the sediments of Alabama. The ages of the units as published by King and coworkers (King and Skotnicki, 1992; King, 1993) are not based on any biostratigraphic or chronostratigraphic data, and are consequently suspect.

Summary and Conclusions

The exposed marine portion of the Upper Cretaceous sediments of central Alabama has been correlated to form a composite reference section using two excellent lithostratigraphic marker horizons, the uppermost sandstone bed of the Eutaw Formation and the top of the Arcola Limestone Member of the Mooreville Chalk. The ranges of planktonic foraminifera and ostracodes have been determined within these sections and used to define the ages of the units. All or part of four planktonic foraminiferal zones and five ostracode zones are recognized.

The Tombigbee Sand Member of the Eutaw Formation and the lower 104 ft of the Mooreville Chalk are of late Santonian age, as defined by the presence of *Dicarinella asymetrica*. The interval from 28 to 104 ft above the base of the Mooreville Chalk is in the concurrent range of single-keeled globotruncanids, *Globotruncanita stuartiformis* and *G. elevata*, and *D. asymetrica*. The Tombigbee Sand Member and the lower 75 ft of the Mooreville Chalk are assigned to the *Veenia quadrialira* ostracode interval zone, although the nominal species is absent from all but the lower two samples. The interval from 104 ft above the base of the Mooreville Chalk to 265 ft above the base of the Demopolis Chalk is assigned to the *Globotruncanita elevata* Interval Zone of early to late Campanian age. The interval from 75 to 334 ft above the base of the Mooreville Chalk is assigned to the *Pterygocythereis (Pterygocythereis) cheethami* ostracode interval zone, although, again, the nominal species occurred in only 5 out of 22 samples from this interval. The interval from 6 ft below the base of the Arcola Limestone Member to 70 ft above the top of the member is assigned to the *Ascetoleberis plummeri* ostracode interval zone; however, neither the nominal species nor any other species of the same genus occurs higher than 26 ft above the top of the member. The interval from 70 to 370 ft above the base of the Demopolis Chalk is assigned to the *Limburgina verricula* ostracode interval zone, although the nominal species occurs in only 5 of the 30 samples in this interval. The *Globotruncanita calcarata* planktonic foraminiferal taxon range zone occurs between 265 and 295 ft above the base of the Demopolis Chalk. The top of the *G. calcarata* Zone, considered to mark the Campanian-Maastrichtian Stage boundary, occurs in a lithologically homogeneous section. The LOS of *Escharacytheridea pinochii*, marking the lower boundary of the *E. pinochii* Interval Zone, occurs about 20 ft below the Demopolis-Ripley contact. *Gansserina gansseri*, the lowest occurrence of which marks the top of the *Globotruncanita "tricarinata"* Interval Zone, was not observed within the lower 50 ft of the Ripley Formation; thus the upper 95 ft of the Demopolis Chalk and the lower 50 ft of the Ripley Formation is assigned to the *G. "tricarinata"* Interval Zone.

Acknowledgments

Thanks are extended to the Gulf Coast Association of Geological Societies for financial assistance to the author while a student at the University of Alabama.

References

Burnett, J. A., Hancock, J. M., Kennedy, W. J., and Lord, A. R., 1992, Macrofossil, planktonic foraminiferal and nannofossil zonation at the Campanian/Maastrichtian boundary: Newsletters in Stratigraphy, v. 27, no. 3, p. 157–172.

Caron, M., 1985, Cretaceous planktic foraminifera, *in* Bolli, H. M., Saunders, J. B., and Perch-Nielsen, K., eds., Plankton stratigraphy: Cambridge, Cambridge University Press, p. 17–86.

Dalbiez, F., 1955, The genus *Globotruncana* in Tunisia: Micropaleontology, v. 1, no. 2, p. 161–171.

Dowsett, H. J., 1989, Documentation of the Santonian-Campanian and Austinian-Tayloran stage boundaries in Mississippi and Alabama using calcareous microfossils: U.S. Geological Survey Bulletin, v. 1884, p. 1–20.

Gillett, B., 1988, Selected wells and springs in west-central Alabama: Alabama Geological Survey Special Map 201-D and accompanying text, 52 p.

Haq, B. U., Hardenbol, J., and Vail, P. R., 1987, Chronology of fluctuating sea levels since the Triassic: Science, v. 235, p. 1156–1167.

Hazel, J. E., and Brouwers, E. M., 1982, Biostratigraphic and chronostratigraphic distribution of ostracodes in the Coniacian-Maastrichtian (Austinian-Navarroan) in the Atlantic and Gulf Coastal Provinces, *in* Maddocks, R. F., ed., Texas Ostracoda: Houston, Texas, Department of Geosciences, University of Houston, p. 166–198.

Keady, D. M., 1989, The *Gryphaea convexa* Zone in the Demopolis Chalk in Mississippi and Alabama: Journal of the Mississippi Academy of Sciences, v. 34, p. 57.

King, D. T., Jr., 1993, Eustatic and tectonic effects within sequence stratigraphy of the outcropping paralic-marine section, Upper Cretaceous, Alabama: Gulf Coast Association of Geological Societies Transactions, v. 43, p. 157–164.

King, D. T., Jr., and Skotnicki, M. C., 1992, Upper Cretaceous stratigraphy and relative sea-level changes, Gulf Coastal Plain of eastern and central Alabama, *in* Watkins, J. S., Zhiqiang, F., and McMillen, K. J., eds., Geology and geophysics of continental margins: Tulsa, Oklahoma, American Association of Geological Societies Memoir 53, p. 317–331.

Masters, B. A., 1970, Stratigraphy and planktonic foraminifera of the Upper Cretaceous Selma Group, Alabama: University of Illinois, Urbana, unpublished Ph.D. dissertation, 372 p.

Pessagno, E. A., Jr., 1967, Upper Cretaceous planktonic foraminifera from the western Gulf Coastal Plain: Palaeontographica Americana, v. 5, no. 37, p. 243–445.

Postuma, J. A., 1971, Manual of planktonic foraminifera: Amsterdam, Elsevier Publishing Company, 420 p.

Premoli Silva, I., and Boersma, A., 1977, Cretaceous planktonic foraminifers—DSDP Leg 39 (South Atlantic), *in* Perch-Nielsen K., et al., Initial reports of the Deep Sea Drilling Project, Leg 39: Washington, D.C., U.S. Government Printing Office, p. 615–640.

Premoli Silva, I., and Bolli, H. M., 1973, Late Cretaceous to Eocene planktonic foraminifera and stratigraphy of Leg 15 sites in the Caribbean Sea, *in* Edgar, N. T., et al., Initial reports of the Deep Sea Drilling Project: Washington, D.C., U.S. Government Printing Office, p. 499–537.

Premoli Silva, I., and Sliter, W. V., 1981, Cretaceous planktonic foraminifers from the Nauru Basin, Leg 61, Site 462, western equatorial Pacific, *in* Larson, R. L., et al., Initial reports of the Deep Sea Drilling Project: Washington, D.C., U.S. Government Printing Office, p. 423–437.

Puckett, T. M., 1992, Planktonic foraminiferal biostratigraphy and ostracode paleoecology of the Demopolis Chalk (Campanian and Maastrichtian) of Alabama and Mississippi, northern Gulf Coastal Plain: The University of Alabama, unpublished Ph.D. dissertation, 363 p.

Puckett, T. M., 1994, Ostracode biostratigraphy of the Demopolis Chalk (Campanian and Maastrichtian) in eastern Mississippi: Mississippi Geology, v. 15, no. 1, p. 3–7.

Scott, J. C., Golden, H. G., and Newton, J. G., 1981, Geology and water availability of Dallas County, Alabama: Alabama Geological Survey Special Map 180, 94 p.

Smith, C. C., and Mancini, E. A., 1983, Calcareous nannofossil and planktonic foraminiferal biostratigraphy, *in* Russell, E. E., Keady, D. M., Mancini, E. A., and Smith, C. C., eds., Upper Cretaceous lithostratigraphy and biostratigraphy in northeast Mississippi, southwest Tennessee and northwest Alabama, shelf chalks and coastal clastics, Guidebook for the Society of Economic Paleontologists and Mineralogists Spring Field Trip, 1983: Tuscaloosa, Alabama, Alabama Geological Survey, p. 16–28.

Soens, D. D., 1984, Stratigraphy and sedimentology of the Tombigbee Sand Member, Eutaw Formation (Cretaceous-Campanian Stage), of northeastern Mississippi: The University of Alabama, unpublished M. S. thesis, 184 p.

Taylor, R. H., 1985, Planktonic foraminiferal biostratigraphy of the Demopolis Formation (Campanian/Maastrichtian) in Lowndes and Oktibbeha Counties, Mississippi: Mississippi State University, unpublished M. S. thesis, 134 p.

van Hinte, J. E., 1976, A Cretaceous time scale: American Association of Petroleum Geologists Bulletin, v. 60, no. 4, p. 498–516.