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IS THERE GOLD IN MISSISSIPPI?

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Gold is highly prized for its value, beauty, and utility. Gold's workability, color, and resistance to tarnishing make it the metal of choice for jewelry. Thus, the simple answer to the question in the title is "Yes." We have a great deal of gold in Mississippi in the form of rings, necklaces, bracelets, and earrings. Collectors and investors certainly possess gold coins and medallions. Some of us may be carrying gold that was applied by our dentists in the form of inlays, crowns, bridges, and orthodontic appliances (Lucas, 1985). Gold's properties of conducting electricity, resisting corrosion, malleability, and ductility result in its use in our computers, communications equipment, and aircraft engines. Gold leaf is used for interior and exterior decoration of buildings. No doubt, gold can be found in Mississippi in these forms.

We need to qualify the question posed in the title. Does gold occur *naturally* in Mississippi? Again the answer is "Yes." Gold is a naturally occurring element that may be found almost anywhere in trace amounts. Gold is concentrated in some geologic settings, while in other places it is rare. The average abundance of gold in the earth's crust is 0.003 parts per million (ppm) and in seawater 0.000004 ppm (Krauskopf, 1979). For comparison, the same reference gives the average crustal abundance for titanium as 5000 ppm, copper as 50 ppm, lead as 12.5 ppm, and silver as 0.07 ppm. Thus copper, for example, is thousands of times more abundant than gold.

We are bound to have minute amounts of these elements in the state. Over geologic time as the clays, sands, and gravels have been transported to this area and deposited in Mississippi, these sediments certainly incorporated flakes of gold carried from their source rocks far to the north or in the Appalachian Mountains to the east. The greater the transport distance from the source rocks, the smaller the particle size of the gold. Abrasion in the carrying streams reduces the particle sizes from flakes to dust to flour-sized particles called colors (Simpson and Neathery, 1980). There are reliable reports of small amounts of gold particles being found in Mississippi by people panning as a hobby. Harper (1857) reported finding very small quantities of gold, silver, manganese, cobalt, and arsenic in samples of pyrites he had analyzed. Saunders (1993) found drill-hole samples of hydrothermally altered igneous rocks from the Jackson Dome with as much as 503 parts per billion of gold; that's a small amount, but detectable.

It is conceivable that recent sediments deposited since human occupation may contain pieces of gold lost by some unlucky person. A gold coin or ring might have been dropped over the side of a fishing boat on an oxbow lake that is slowly filling with sediment. A lost gold tooth may be washed downstream and end up as a "nugget" in a gravel bar in a river. A gold nugget found far to the north and brought here as a trade item by native Americans may have become lost and buried in the soil near the village as a result of some calamity. These speculative scenarios would not qualify as naturally-occurring gold.

At this point it is necessary to further qualify our question. Are there *economically minable*, naturally occurring deposits of gold in Mississippi? Is there a chance of locating a gold mine in the state? This time the answer is "No."

The Office of Geology is often asked about gold in

Mississippi, a question that has been asked since the agency was created in 1850 as the Mississippi Geological Survey. In his 1857 report, State Geologist Lewis Harper reported being sent pieces of fool's gold "more frequently than once in a month." Are there any deposits of placer gold in Mississippi that might be economically feasible to mine? Where would be a good place to go panning for gold in this state? Harper responded to the interest as follows. He noted that the people in an area of northeastern Mississippi with depleted soils refused to leave, and "hoped for the discovery of small mines of precious metals," and that "the desire of having such mines has created many groundless rumors about gold, silver, copper, lead, and other valuable metals; but such mines have not been, and never will be discovered." As of 1994, Harper is still correct about mines for precious metals in Mississippi. Fred Mellen wrote a similar statement in his 1959 report on the mineral resources of Mississippi: "The valuable metals, gold, silver, lead and even zinc have been widely reported over the State, seemingly always in a legendary fashion. None of these metals is known authoritatively to be indigenous to the rocks of the State, but erratic specimens of their ores are sometimes found." Recently these metals have been detected in deep-basin brines in Mississippi in small, but interesting, amounts.

From time to time, people come to the Office of Geology reporting to have found gold nuggets or ore. Our geologists also encounter such "finds" as they do field work throughout the state. These claims have never been substantiated, no matter how hard we try. "Joe's brother has a nugget from Claiborne County in the bank vault." The nugget cannot be found, even if Joe's brother is. "I have collected a jar full of gold nuggets in northeastern Mississippi." Would you show them to us, or even one, so we can tell if they are indeed gold? "No." We must often disappoint people by identifying their treasures as pyrite, mica flakes, or even yellow paint.

Harper's 1857 book contains interesting stories collected by himself and his colleague Dr. Eugene Hilgard relating to precious metals in Mississippi. He tells of some miners who had tunnelled into a hillside at a place where they had mistaken iron ore for copper ore, a form of quartz for gold, and mica for silver. The owner insisted that he had melted malleable copper from the ore. The mystery was solved when Dr. Hilgard determined that the man had used blue vitriol as a flux; the latter, being a sulphate of copper, was the source of the metal. At another place in northeastern Mississippi they investigated a supposed silver mine. "It was afterwards ascertained that the former owner of the place desired to sell it; in order to increase its value, he loaded small grains of silver in his gun, and shot in the sand, on the bank of the river; he asserted then, that this sand was argentiferous (silver-bearing); but as he, nevertheless, did not succeed by this ingenious trick to sell it, he ... vamosed into Texas." Harper also found some young miners sinking a shaft for copper ore on the strength of having found some iron pyrite in a place they claimed resembled Ducktown, Tennessee, where copper is mined; he could not convince them of their folly. When Hilgard visited the site more than a year later, he found the shaft "sunk to a depth of more than 60 feet in the tertiary rocks, and the young miners still on the place, pretending steadfastly: 'The treasure was there, if a fellow only knew how to find it!'"

The statement that Mississippi cannot have a gold mine, as any absolute statement in geology, needs clarification. It is conceivable that someone could perfect a process to extract gold profitably from seawater and set up on the Coast. A process to economically extract gold and other precious metals from deep-basin brines may be developed. Deep drilling at one of the buried igneous intrusions in Mississippi could find ore at a depth shallow enough to exploit with a deep underground mine. Any such project would be dependent upon the economics of the process, considering the price of gold and the cost of obtaining it. Few people would be satisfied with gathering ten dollar's worth of gold at the expense of investing thousands of dollars and a lot of labor. I remember learning many years ago from Dr. Donald M. Keady of Mississippi State University that it is better to have a good gravel pit than a bad gold mine.

Is there gold in Mississippi? Yes. Will a prospector or gold panner find naturally occurring gold in Mississippi in minable quantities? No.

REFERENCES CITED

Harper, Lewis, 1857, Preliminary report on the geology and agriculture of the State of Mississippi: Jackson, E. Barksdale, State Printer, 351 p.

Krauskopf, K. B., 1979, Introduction to geochemistry: New York, McGraw-Hill Book Company, p. 544-545.

Lucas, J. M., 1985, Gold, *in* Mineral Facts and Problems, 1985 Edition: U. S. Bureau of Mines, Bulletin 675, p. 323-338.

Mellen, F. F., 1959, Mississippi mineral resources: Mississippi Geological Survey, Bulletin 86, p. 87.

Saunders, James A., 1993, Hydrothermal alteration and mineralization at the Jackson Dome volcanic complex, Mississippi: Southeastern Geology, v. 33, no. 2, p. 71-79.

Simpson, T. A., and T. L. Neathery, 1980, Alabama gold: Geological Survey of Alabama, Circular 104, 169 p.

OSTRACODE BIOSTRATIGRAPHY OF THE DEMOPOLIS CHALK (CAMPANIAN AND MAASTRICHTIAN) IN EASTERN MISSISSIPPI

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INTRODUCTION

Ostracodes of the Cretaceous of the North American Gulf Coastal Plain have, in comparison with other fossil groups, been studied relatively little, with the first descriptions being published in this century (Berry, 1925). Since that time, a number of taxonomic works have been published, yet knowledge of Cretaceous ostracodes of North America has not progressed much beyond alpha taxonomy, i.e., putting names on species. Indeed, in many cases, several species are still placed in catch-all genera (e.g., *Cythereis*), even though they are known not to be members of those taxa. Further, there are no published investigations of the phylogenetic relationships of any Late Cretaceous ostracode groups of North America. There are also no published studies of the paleoecology of these ostracodes. Studies of ostracodes of the Cretaceous of Europe have, in contrast, been progressing for nearly 150 years, and the taxonomy, evolution, biostratigraphy and paleoecology of the Cretaceous ostracodes are often well known and are used routinely in solving geological problems.

Major works on the taxonomy of Cretaceous ostracodes of the Gulf Coast include those by Alexander (1929), Israelsky (1929), Schmidt (1948), Swain (1952), Butler and Jones (1957), Brown (1957, 1958), Howe and Laurencich (1958), Benson and Tatro (1964), Hazel and Paulson (1964), Swain and Brown (1964), Crane (1965), Brouwers and Hazel (1978), and Smith (1978). The only biostratigraphic and chronostratigraphic work to be published on the Upper Cretaceous ostracodes of North America is that of Hazel and Brouwers (1982). This work greatly contributed to our understanding of the chronostratigraphic distribution of North American Cretaceous ostracodes. In addition, much information was summarized on the state-of-the-art of generic assignments of these ostracodes. The biostratigraphic scheme of Hazel and Brouwers has been applied to Cretaceous units in Texas (Ross and Maddocks, 1983; Chimene and Maddocks, 1984), but has not been applied to those of Mississippi and Alabama.

The purpose of this paper is to show the stratigraphic distribution of ostracodes in the Demopolis Chalk of eastern Mississippi, and to assess the usefulness of the biostratigraphic scheme of Hazel and Brouwers (1982) as applied to the relatively deep-water deposits of the Demopolis Chalk.

METHODS

Sections were measured using standard field techniques. A structure contour map was constructed on the top of the Arcola Limestone Member of the underlying Mooreville Chalk, and the individual sections were projected onto this contour map. Measured sections and stratigraphic occurrence of samples, in addition to the ranges of selected taxa of ostracodes, are shown on Figure 1.

The samples were originally collected for paleoecological analyses of ostracodes in the Demopolis, and each sample has a representative slide of 300 specimens. Most samples were then scanned extensively for selected taxa, as the great majority of the ostracodes are represented by only a few taxa and the more useful taxa for biostratigraphy are typically rare. The ranges of the ostracodes were then plotted on the stratigraphic chart.

OSTRACODE BIOSTRATIGRAPHY

This section discusses briefly the ostracode biozones of Hazel and Brouwers (1982) in that part of the Upper Cretaceous represented by the Demopolis Chalk.

The *Ascetoleberis plummeri* Zone

The *Ascetoleberis plummeri* Zone is defined as the interval between the first appearance datum (FAD) of *A. plummeri* (Israelsky, 1929) and the FAD of *Limburgina verricula* (Butler and Jones, 1957). This interval zone was interpreted to range from about middle lower Campanian through about middle middle Campanian. Other members of the distinctive genus *Ascetoleberis* also first appear at or near the FAD of *A. plummeri*, including *A. crassicarinata* (Hazel and Paulson, 1964) and *A. rugosissima* (Alexander, 1929). Other taxa that first occur at or near the bottom of this zone include *Antibythocypris gooberi* (Jennings, 1936), *A. fabaformis* (Berry, 1925), *Haplocytheridea bruceclarki* (Israelsky, 1929) and, a little higher in the section, *H. insolita* (Alexander and Alexander, 1933). The last appearance datum (LAD) of *Veenia ozanana* (Israelsky, 1929), the "*Cythereis*" *bicornis* complex of species (including "*C.*" *bicornis* (Israelsky, 1929), "*C.*" *polita* Crane, 1965, "*C.*" *nodilinea* Crane, 1965, and

"C." levis Crane, 1965), *Brachycythere pyriforma* Hazel and Paulson, 1964, *Schizoptocythere compressa* (Hazel and Paulson, 1964), *Haplocytheridea dibulla* Crane, 1965, and *Schuleridea travisensis* Hazel and Paulson, 1964, are in the middle and upper part of the zone. In the upper part of the zone, *"Hazelina" cupiossata*(Crane, 1965), *Phacorhabdotus texanus* Howe and Laurencich, 1958, *P. venodus* Crane, 1965, *P. bicostilimus* Crane, 1965, and *Sphaeroleberis pseudoconcentrica* (Butler and Jones, 1957) make their first appearance.

The *Limburgina verricula* Interval Zone

The lower boundary of the *Limburgina verricula* Interval Zone is defined by the FAD of *Limburgina verricula* and the upper boundary is defined by the FAD of *Escharacytheridea pinochii* (Jennings, 1936). The FAD of *Planileberis costatana* (Israelsky, 1929), *Fissocarinocythere pidgeoni* (Berry, 1925), and *Antibythocypris elongata* (Brouwers and Hazel, 1978) occur within the lower half of this zone. The LAD of *Mosaeleberis sagena* (Crane, 1965), *Hazelina cupiossata*, *Fissocarinocythere gapensis* (Alexander, 1929), *Ascetoleberis plummeri*, and *Haplocytheridea insolita* (Alexander and Alexander, 1933) is near the upper boundary of this zone.

The *Escharacytheridea pinochii* Interval Zone

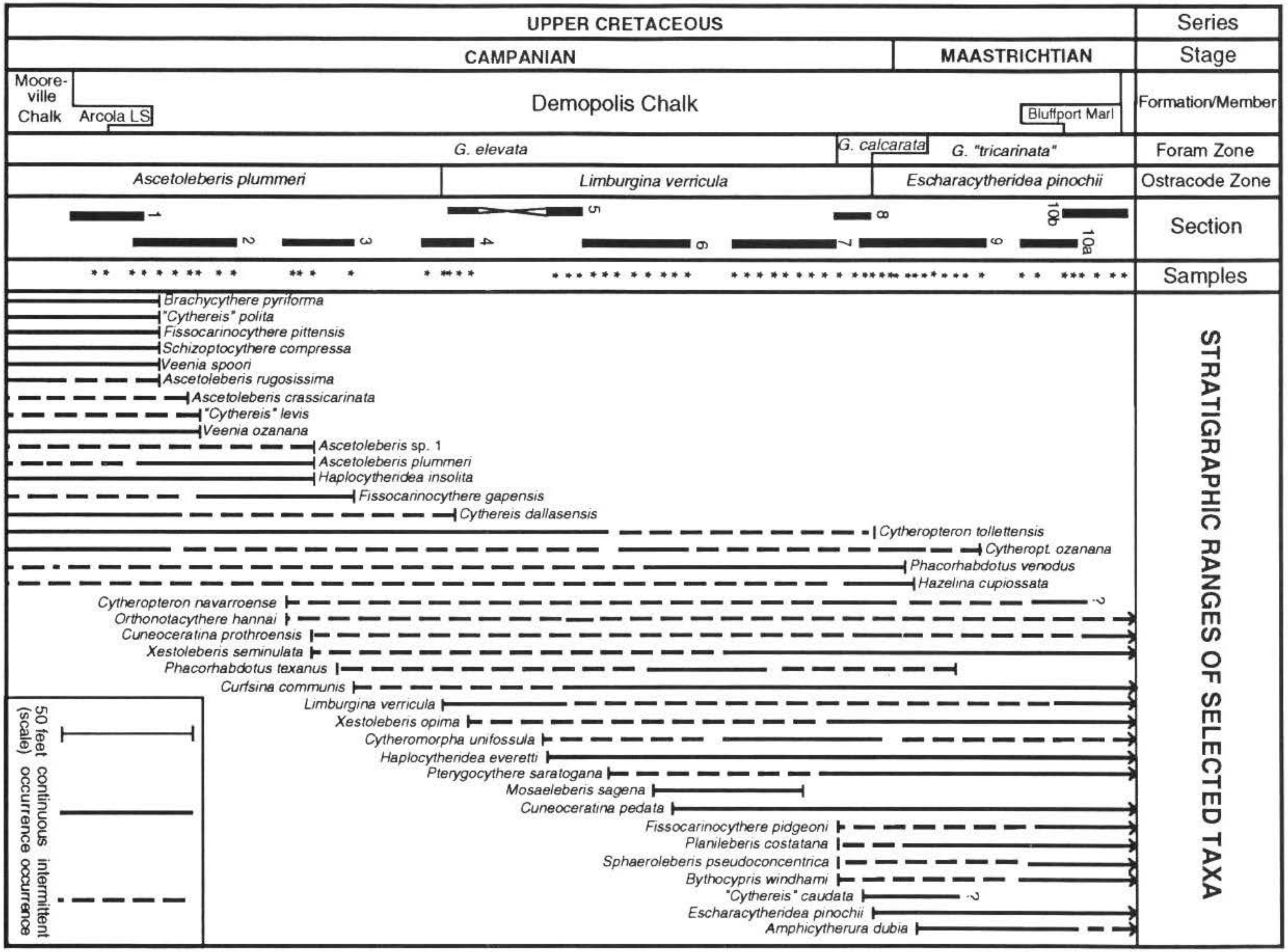
The lower boundary of this zone is defined by the FAD of *Escharacytheridea pinochii*, and the upper boundary is defined by the FAD of *"Cythereis" lixula* Crane, 1965. The FAD of *Brachycythere ledaforma* (Israelsky, 1929) is near the base of this zone. The FAD of the distinctive species *Ascetoleberis hazardi* (Israelsky, 1929) occurs in the middle part of this zone. Finally, the LAD of *Sphaeroleberis pseudoconcentrica*, *Veenia ponderosana* (Israelsky, 1929), and *Limburgina verricula* occur near the top of this zone.

RESULTS

General Remarks

A total of almost 20,000 ostracode shells was collected from the Demopolis Chalk for paleoecological analysis, which was supplemented by many more specimens selectively picked for biostratigraphic analysis. In all, 80 species were identified from the Demopolis Chalk. About half of the species ranged throughout the formation, or were too rare to be of any use biostratigraphically, and were not plotted on Figure 1. In addition, all species of the nondescript genus *Cytherella* were grouped together as *Cytherella* spp. and treated as a single

Figure 1. Stratigraphy, planktonic foraminiferal zones, measured section, locations of samples, and ranges of selected ostracode species within the Demopolis Chalk in eastern Mississippi. Placement of planktonic foraminiferal zones taken after Taylor (1985) and unpublished data. All sections were measured on West Point 7.5-minute topographic quadrangle except the "Rock Hill" section, which is on the Cedar Creek 7.5-minute topographic quadrangle. Section 1 is "Tibbee Creek" section on north-facing slope of Tibbee Creek just west of railroad bridge over Tibbee Creek in W/2 sec. 4 (irregular section), T. 19 N., R. 16 E., Clay Co., Miss. Section 2 is "Tibbee Creek II" section, on north-facing slope of Tibbee Creek just east of southernmost bend in Tibbee Creek, in E/2 sec. 5 (irregular section), T. 19 N., R. 16 E., Clay County. Section 3 is "Tibbee Creek III" section, on north-facing ridge of cut bank south of Tibbee Creek, about 300 yards east of Mississippi State Highway 45, near center of E/2 sec. 6, T. 19 N., R. 16 E., Clay County. Section 4 is "Line Creek II" section, on north-northwest-facing slope of Line Creek, near eastern terminus of north-facing slope, in NW/4 sec. 35, T. 20 N., R. 6 E., Oktibbeha County. Section 5 is "Line Creek" section, just east of sharp bend in creek, on north-facing slope, in extreme northwest sec. 35, T. 20 N., R. 6 E., Oktibbeha County. Section 6 is "Muldrow" section, starts on south side of dirt road and extends north down gullies on cow pasture, in E/2 NE/4 sec. 3, T. 19 N., R. 15 E., extreme NE Oktibbeha County. Section 7 is "Alexander Schoolhouse North" section, which extends west-northwest across gullied area about 300 yards west of dirt road, in SW/4 SW/4 sec. 33, T. 20 N., R. 15 E., Oktibbeha County. Section 8 is "Rap Road" section, which extends from base of hill on east side of road to top of hill about 50 feet west of dirt road in NW/4 sec. 4, T. 19 N., R. 15 E., Oktibbeha County. Section 9 is "Alexander Schoolhouse" section, on east-facing side of Alexander Schoolhouse road, extending from northwest side of intersection with east-west road, south to top of hill, along border between NE/4 sec. 8 and NW/4 sec. 9, and SE/4 sec. 5 and SW/4 sec. 4, T. 19 N., R. 15 E., Oktibbeha County. Section 10 is "Rock Hill" section, measured in two parts, (a) upper, pure chalk interval of lower unnamed member of the Demopolis measured in gulley on north-facing slope just west of creek, about 50 yards north of dirt road, and (b) Bluffport Marl Member of Demopolis measured on north-facing slope near western terminus of north-northwesterly-projecting spur of ridge, in NC and NW/4 of sec. 2, T. 20 N., R. 14 E., Oktibbeha County.


STRATIGRAPHIC RANGES OF SELECTED TAXA
Series
Stage
Formation/Member
Foram Zone
Ostracode Zone
Section
Samples
UPPER CRETACEOUS
CAMPANIAN
MAASTRICHTIAN
Mooreville Chalk
Arcola LS
Demopolis Chalk
Bluffport Marl
G. elevata
G. calcarata
G. "tricarinata"
Ascetoleberis plummeri
Limburgina verricula
Escharacytheridea pinochii
1
2
3
4
5
6
7
8
9
10a
10b
Brachycythere pyriforma
"Cythereis" polita
Fissocarinocythere pittensis
Schizoptocythere compressa
Veenia spoori
Ascetoleberis rugosissima
Ascetoleberis crassicarinata
"Cythereis" levis
Veenia ozanana
Ascetoleberis sp. 1
Ascetoleberis plummeri
Haplocytheridea insolita
Fissocarinocythere gapensis
Cythereis dallasensis
Cytheropteron tollettensis
Cytheropt. ozanana
Phacorhabdotus venodus
Hazelina cupiossata
Cytheropteron navarroense
Orthonotacythere hannai
Cuneoceratina prothroensis
Xestoleberis seminulata
Phacorhabdotus texanus
Curfsina communis
Limburgina verricula
Xestoleberis opima
Cytheromorpha unifossula
Haplocytheridea everetti
Pterygocythere saratogana
Mosaeleberis sagena
Cuneoceratina pedata
Fissocarinocythere pidgeoni
Planileberis costatana
Sphaeroleberis pseudoconcentrica
Bythocypris windhami
"Cythereis" caudata
Escharacytheridea pinochii
Amphicytherura dubia
50 feet (scale)
continuous occurrence
intermittent occurrence

taxon, as characters of the species of this genus are few and the systematics have not been clearly defined. Species of *Cytherella* ranged throughout the formation and were typically the most dominant taxon, often accounting for nearly three-quarters of the total fauna.

Taxa occurring fairly commonly to abundantly throughout the formation include *Cytherella* spp., *Bairdioppilata* sp., *Veenia ponderosana*, *Argilloecia taylorensis* Alexander, 1935, and *Krithe cushmani* Alexander, 1929. Other species found in fewer numbers, occurring sporadically, or are known to range below the base of the formation include, in alphabetical order, *Alatacythere nadeauae* (Hill, 1954), *A. ponderosana* (Israelsky, 1929), *A. serrata* (Bonnema, 1940), *Brachycythere ovata* (Berry, 1925), *B. rhomboidalis* (Berry, 1925), *Cytherelloidea crafti* Sexton, 1951, *Haplocytheridea bruceclarki*, *H. renfroensis* Crane, 1965, *Orthonotacythere hannai* (Israelsky, 1929), and *Paracypris tenuicula* Alexander, 1929.

Ostracode Zones in the Demopolis Chalk

The FAD of *Limburgina verricula* is about 130 feet above the top of the Arcola Limestone and would suggest placement of the lower 130 feet of the Demopolis in the *Ascetoleberis plummeri* Interval Zone of Brouwers and Hazel (1982), although the LAD of *A. plummeri* is at about 80 feet above the Arcola, some 50 feet below the FAD of *L. verricula*. Hazel and Brouwers (1982) reported the LAD of *A. plummeri* to be near the top of the *L. verricula* Zone. The LAD of *Veenia ozanana*, *Brachycythere pyriforma*, the *"Cythereis" bicornis* complex of species, and *Schizoptocythere compressa* occur at nearly the same horizon, about 20 feet above the top of the Arcola, which is about 60 feet below the LAD of *A. plummeri* and about 110 feet below the FAD of *L. verricula*. These last occurrences also suggest that the lower part of the Demopolis is in the upper part of the *Ascetoleberis plummeri* Interval Zone.

Although *Limburgina verricula* occurs through the top of the Demopolis, it is not found in a fairly thick stratigraphic interval ranging from about 180 feet to about 370 feet above the top of the Arcola, which is in the purest chalk interval of the Demopolis.

The lowest occurrence of *E. pinochii* is about 290 feet above the Arcola, and thus the base of the *Escharacytheridea pinochii* Zone is placed at this level. This horizon is also coincident with the highest occurrence of the planktonic foraminifer *Globotruncanita calcarata* (Cushman, 1927), which is generally considered to mark the Campanian/Maastrichtian stage boundary. The LAD of taxa associated with the upper boundary of the *Limburgina verricula* Zone, in addition, occur in the upper part of the lower unnamed member of the Demopolis. The LAD of *Mosaeleberis sagena* occurs about 270 feet above the top of the Arcola, and the LAD of *Hazelina cupiossata* occurs about 315 feet above the top of the Arcola, supporting the interpretation that the base of the *E. pinochii* Zone is near this level. The FAD of several species is at or very close to the LAD of *Globotruncanita calcarata*, including *Planileberis costatana*, *Fissocarinocythere pidgeoni*, *Sphaeroleberis pseudoconcentrica*, and *Bythocypris windhami* Butler and Jones, 1957. *Globotruncanita calcarata* is often extremely rare, and the aforementioned species are good substitute markers for this chronostratigraphic horizon.

SUMMARY

Ostracodes are found throughout the Demopolis Chalk, and the distributions of biostratigraphically useful species have been plotted relative to an excellent regional marker bed, the top of the underlying Arcola Limestone Member of the Mooreville Chalk. The ranges of the ostracode species presented on Figure 1 and reported herein are applicable to the Oktibbeha and Clay counties area and at least to the Mississippi/Alabama border, where the base of the Demopolis Chalk is defined by the top of the Arcola Limestone. Analysis and comparison of the distribution of ostracodes in the Demopolis with the proposed biostratigraphic zones of Hazel and Brouwers (1982) suggest that the lower 130 feet of the Demopolis lie within the *Ascetoleberis plummeri* Zone, the interval from 130 to about 250 feet lies within the *Limburgina verricula* Zone, and the interval above about 250 feet lies within the *Escharacytheridea pinochii* Zone. There are some differences in the stratigraphic distributions of some species in the Demopolis compared to those given by Hazel and Brouwers (1982), however. The LAD of *Ascetoleberis plummeri*, for example, is well below the FAD of *Limburgina verricula*, although this species was described as occurring to nearly the top of the *L. verricula* Zone. These differences in chronostratigraphic range are herein suggested to result from the paleoenvironmental limitations of several of the key taxa used by Hazel and Brouwers (1982).

REFERENCES

Alexander, C. I., 1929, Ostracoda of the Cretaceous of north Texas: University of Texas Bulletin 2907, 114 p., 10 pls.

Alexander, C. I., 1935, Ostracoda of the genus *Argilloecia* from the Cretaceous of Texas: Journal of Paleontology, v. 9, p. 356-357.

Alexander, C. I., and C. W. Alexander, 1933, Reversal of valve size and hinge structure in a species of the genus *Cytheridea*: American Midland Naturalist, v. 14, p. 280-283.

Benson, R. H., and J. O. Tatro, 1964, Faunal description of the Marlbrook Marl (Campanian), Arkansas: University of Kansas Paleontological Contributions, Arthropoda 7, 32 p., 6 pls.

Berry, E. W., 1925, Upper Cretaceous Ostracoda from Maryland: American Journal of Science, v. 9, p. 481-487.

Bonnema, J. H., 1940, Ostracoden aus der Kreide des Untergrundes der nordostlichen Niederlande: Natuurhistorisch Maandblad, v. 27, p. 129-132, pl. 4.

Brouwers, E. M., and J. E. Hazel, 1978, Ostracoda and correlation of the Severn Formation (Navarroan; Maestrichtian) of Maryland: Society of Economic Paleontologists and Mineralogists, Paleontological Monograph 1, 52 p., 11 pls.

Brown, P. M., 1957, Upper Cretaceous Ostracoda from North Carolina: North Carolina Department of Conservation and Development, Division of Mineral Resources, Bulletin 70, 27 p., 7 pls.

Brown, P. M., 1958, Well logs from the Coastal Plain of North Carolina: North Carolina Department of Conservation and Development, Division of Mineral Resources, Bulletin 72, 68 p., 8 pls.

Butler, E. A., and D. E. Jones, 1957, Cretaceous Ostracoda of the Prothro and Rayburns salt domes, Bienville Parish, Louisiana: Louisiana Geological Survey, Bulletin 32, 65 p., 6 pls.

Chimene, J. B., II, and R. F. Maddocks, 1984, Ostracode biostratigraphy and paleoecology of the upper Taylor Group (Campanian, Upper Cretaceous) in central Texas: Gulf Coast Association of Geological Societies, Transactions, v. 34, p. 311-320.

Crane, M. J., 1965, Upper Cretaceous ostracodes of the Gulf Coast area: Micropaleontology, v. 11, no. 2, p. 191-254, 9 pls.

Hazel, J. E., 1968, Ostracodes from the Brightseat Formation (Danian) of Maryland: Journal of Paleontology, v. 42, no. 1, p. 100-142, pls. 21-26.

Hazel, J. E., and E. M. Brouwers, 1982, Biostratigraphic and chronostratigraphic distribution of ostracodes in the Coniacian-Maastrichtian (Austinian-Navarroan) in the Atlantic and Gulf Coastal Province, *in* R. F. Maddocks, ed., Texas Ostracoda: Guidebook of excursions and related papers for the Eighth International Symposium on Ostracoda, University of Houston, Houston, Texas, p. 166-198, 6 pls.

Hazel, J. E., and O. L. Paulson, 1964, Some new ostracode species from the Austinian and Tayloran (Coniacian and Campanian) rocks of the East Texas Embayment: Journal of Paleontology, v. 38, no. 6, p. 1047-1064, pls. 157-159.

Hill, B. L., 1954, Reclassification of winged *Cythereis* and winged *Brachycythere*: Journal of Paleontology, v. 28, no. 6, p. 804-826, pls. 97-100.

Howe, H. V., and L. Laurencich, 1958, Introduction to the study of Cretaceous Ostracoda: Louisiana State University Press, 536 p.

Israelsky, M., 1929, Upper Cretaceous Ostracoda of Arkansas, *in* W. C. Spooner and others, Stratigraphy and structure of the Gulf Coastal Plain of Arkansas: Arkansas Geological Survey, Bulletin 2, p. 3-20, 4 pls.

Jennings, P. H., 1936, A microfauna from the Monmouth and basal Rancocas Groups from New Jersey: Bulletins of American Paleontology, v. 23, no. 78, p. 161-235.

Ross, J. E., and R. F. Maddocks, 1983, Recurrent species associations and species diversity of cytheracean ostracodes in the upper Austin and lower Taylor Groups (Campanian, Upper Cretaceous) of Travis County, Texas: Gulf Coast Association of Geological Societies, Transactions, v. 33, p. 397-406.

Schmidt, R. A. M., 1948, Ostracoda from the Upper Cretaceous and lower Eocene of Maryland, Delaware, and Virginia: Journal of Paleontology, v. 22, p. 389-431, pls. 61-64.

Sexton, J. V., 1951, The ostracode *Cytherelloidea* in North America: Journal of Paleontology, v. 25, no. 6, p. 808-816, pls. 115-117.

Smith, J. K., 1978, Ostracoda of the Prairie Bluff Chalk, Upper Cretaceous (Maestrichtian), and the Pine Barren Member of the Clayton Formation, Lower Paleocene (Danian) from exposures along Alabama State Highway 263 in Lowndes County, Alabama: Gulf Coast Association of Geological Societies, Transactions, v. 28, p. 539-579, 8 pls.

Swain, F. M., 1952, Ostracoda from wells in North Carolina: U. S. Geological Survey, Professional Paper 234-B, p. 59-93, pls. 8-9.

Swain, F. M., and P. M. Brown, 1964, Cretaceous Ostracoda from wells in the Southeastern United States: North Carolina Department of Conservation and Development, Division of Mineral Resources, Bulletin 78, 55 p., 5 pls.

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., 10 pls.

THE MOBIL - MISSISSIPPI OFFICE OF GEOLOGY CORE-HOLE PROJECT

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INTRODUCTION

A cooperative drilling program between Mobil Exploration and Producing Technical Center and the Mississippi Office of Geology was undertaken to study the sequence stratigraphy of late Paleogene units in Wayne County, Mississippi. The Office of Geology provided the drill rig, drillers, and geologists, and Mobil covered the daily drilling cost. Three core holes were drilled along a north-south dip section including (from north to south) the #1 Ketler, #1 Wayne County Lime Company, and #1 Young (figures 1-2). The #1 Ketler was drilled and abandoned between September 27 and October 6, 1993. It spudded in thin terrace deposits above the Red Bluff Formation and reached a total depth of 340 feet in the Gordon Creek Shale Member of the Cook Mountain Formation. The cored interval was 10 to 340 feet. The #1 Wayne County Lime Company was drilled on October 6-7, 1993. It spudded in the Marianna Limestone as exposed in the middle of the quarry and reached total depth at 200 feet in the Shubuta Clay Member of the Yazoo Formation. The cored interval was 20 to 200 feet. The #1 Young was drilled and abandoned between October 12 and November 11, 1993, with no activity the week of October 17-23. It spudded in the Catahoula Formation and reached total depth at 620 feet in the Gordon Creek Shale Member of the Cook Mountain Formation. Coring began in the Marianna Limestone at 180 feet and continued to 620 feet.

The core holes were drilled with the Office's Failing 1500 rig and ten-foot core barrel (see Dockery et al., 1991). Thus, coring trips were made every ten feet. Drill stems were broken in sets of twenties (two ten-foot sections) and stacked against the monkey board during trips. Each trip involved coring, tripping out, unscrewing the bit, extruding the core hydraulically, cleaning and replacing the bit, tripping down, and adding a ten-foot section of drill stem. For difficult intervals, such as the North Twistwood Creek Clay Member of the Yazoo Formation, a trip might include several unsuccessful attempts to extrude the core (repeatedly blowing out the pop-off valve of the mud pump) and finally unscrewing the inner core barrel and digging parts of the core out from each end. Under ideal conditions, trip cycles took an hour or more below 200 feet and were labor intensive.

Cores were extruded onto a longitudinally-halved PVC pipe, described (color determined from GSA Rock-Color Chart), cut into two-foot sections, wrapped in clear plastic, and boxed with five two-foot trays per box. The core boxes were shipped to Mobil in Dallas, Texas, and later transported to ARCO's lab in Plano, Texas, for examination and sampling. Here the cores were split in half and photographed (on January 27-28, 1994), and a second description was made of the #1 Young and the upper part of the #1 Ketler.

The Mobil - Office of Geology cores will be examined for microfossils, strontium isotopes, and paleomagnetism by Mobil and Arco scientists. Rick Fleugeman of Ball State University is studying bit samples taken every ten feet for benthic and planktic Foraminifera.

DESCRIPTION OF CORES

#1 Ketler

0'-13' **Terrace deposit**: Sand, clay, and gravel; lower contact erosional with gravel.

13'-36.7' **Red Bluff Formation**: Clay, light olive gray to olive gray, fossiliferous with lenses of grayish olive green clay and glauconitic, fossiliferous sand; lower contact sharp and burrowed.

36.7'-97' **Shubuta Clay Member**: Clay, dusky yellow green, with chalky shells and speckled with uvigerinids at 50'-60' and 70'-72'; lower contact gradational.

97'-125' **Pachuta Marl Member**: Clay, grayish green, with grayish yellow green marl beds at 97'-97.5', 100'-100.5', 103'-103.5', 106'-106.5', 111'-112', 114'-115', and 116'-120'; lower 15 feet sandy; lower contact determined by increase in drilling speed as only 1.5' of Pachuta and 1.5' of Cocoa were recovered from the 120'-130' cored interval.

125'-137' **Cocoa Sand Member**: Sand, light gray, clayey; lower contact gradational.

137'-203' **North Twistwood Creek Clay Member**: Clay, light to medium gray, with chalky shells and sandy in the upper 7 feet; lower contact sharp; when split the core was mottled with oxidized? zones appearing light olive gray to dusky yellow.

203'-215.7' **Moodys Branch Formation**: Sand, medium dark gray to grayish black, very fossiliferous, glauconitic; lower contact sharp.

215.7'-230' **Creola Member**: Sand, brownish gray to brownish black; moderately to sparsely fossiliferous; lower contact gradational.

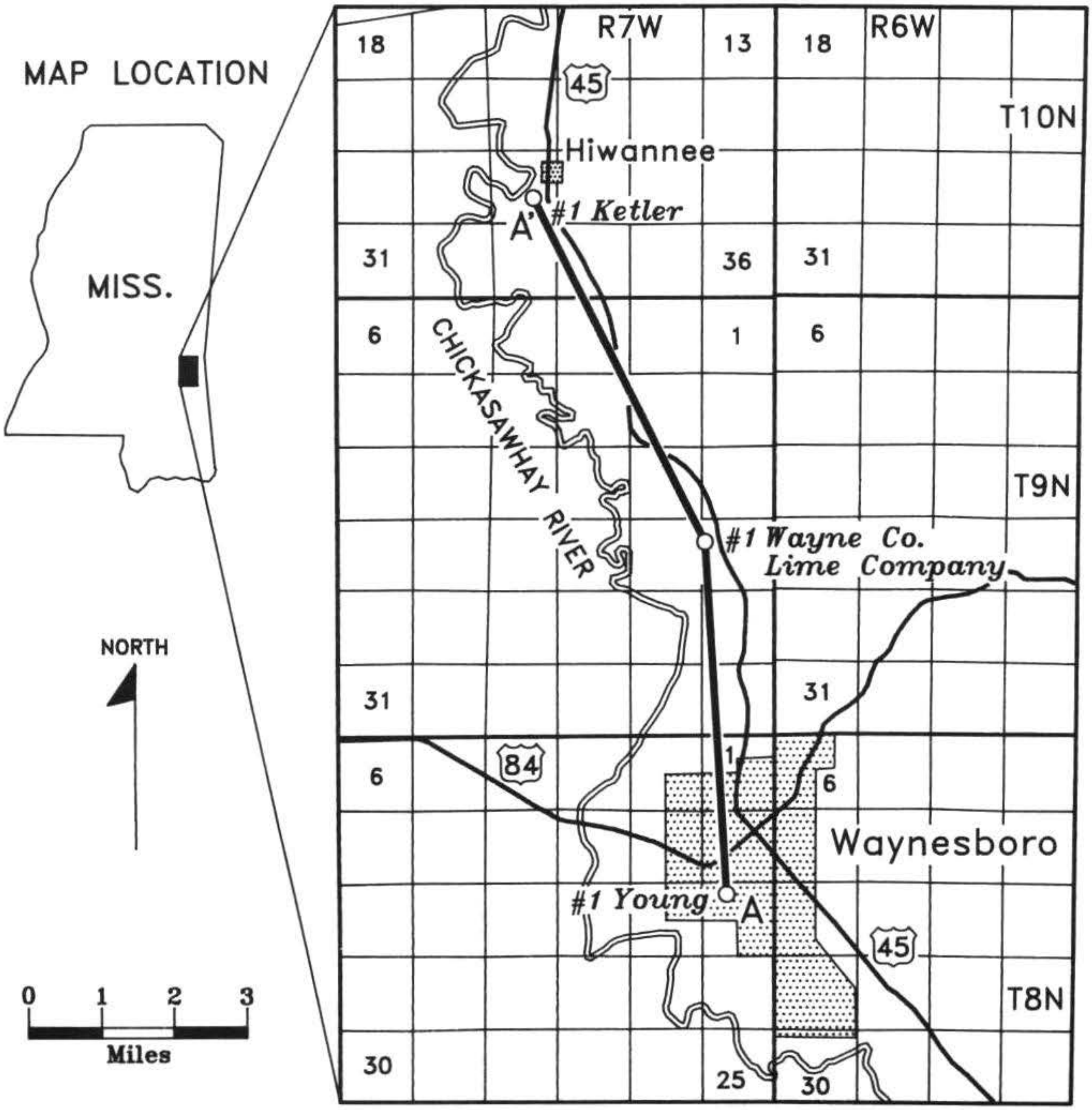
MAP LOCATION
MISS.
NORTH
0 1 2 3
Miles
R7W
R6W
T10N
T9N
T8N
18
13
18
45
Hiwannee
#1 Ketler
A'
31
36
31
6
1
6
CHICKASAWHAY RIVER
#1 Wayne Co.
Lime Company
31
31
84
1
6
Waynesboro
#1 Young
A
45
30
25
30

Figure 1.

230'-300' **Cockfield Formation**: Sand, dark gray, fossiliferous from 254'-300' with concentrations of molluscan fossils at 254'-256.4', 260'-261', and 291.6'-292'; lower contact disconformable with lag of green (with glauconite), worn, shell fragments.

300'-340' **Gordon Creek Shale Member**: Clay, gray, with light gray silt lenses.

#1 Wayne County Lime Company

0-28' **Marianna Limestone**: Calcarenite and packstone, very light gray, with hard ledge in basal 1 foot; lower contact sharp but conformable.

28'-30' **Mint Spring Formation**: Sand, gray with aragonitic shells including *Dentalium*; lower contact disconformable with pavement of lithified clay clasts and burrows.

30'-57' **Forest Hill Formation**: Sand (no recovery) with a grayclay interval recovered at 30'-32'.

57'-176' **Forest Hill Formation**: Clay, gray with light gray silty partings and a fossiliferous silt at 92'-94'; lower contact gradational.

176'-189' **Red Bluff Formation**: Clay, gray, with limy, fossiliferous, glauconitic sand lenses; lower contact sharp and burrowed.

189'-200' **Shubuta Clay Member**: Clay, dusky yellow green.

#1 Young

0-17' **Catahoula Formation**: 0-6' Clay, gray; 6'-17' sand.

17'-44' **Paynes Hammock Formation**: Clay, blue gray, fossiliferous with some pea gravel at 30'-40' and limestone at 40'-44' containing sand lenses and oyster shell fragments.

44'-60' **Chickasawhay Limestone**: Clay with limestone layers at 54'-56' and 57'-59'.

60'-137' **Waynesboro Sand**: Sand, fine- to medium-grained, withsilty clay at 130'-137'; sand remained in suspension during drilling of this interval; lithologies determined by drilling rate (sand settled out during drilling of lower units).

137'-156' **Glendon Limestone**: Limestone and marl with hard layers at 137'-138', 138.5'-140', 140.2'-142', 145'-147', 148'-152', and 153'-156'.

156'-187' **Marianna Limestone**: Limestone, pale olive, soft, withhard layers at 165'-166' and 168'-169'; upper contact determined by increase in drilling rate, lower contact conformable.

187'-189.4' **Mint Spring Formation**: Limestone, pale olive, glauconitic, sandy, with olive gray glauconitic sand and clay at 189'-189.4'; lower contact disconformable.

189.4'-308.6' **Forest Hill Formation**: Clay, olive gray, with silty partings and with brownish gray mottled clay at top (189.4'-190') and a light olive gray fossiliferous limestone with drusy calcite veins at 216'-216.9' underlain by olive gray glauconitic fossiliferous sand at 216.9'-217.5'; lower contact gradational.

308.6'-319' **Red Bluff Formation**: Clay, olive gray to grayish green, fossiliferous, sandy, and grayish green, glauconitic, fossiliferous sand; lower contact sharp and burrowed.

319'-371' **Shubuta Clay Member**: Clay, grayish olive green to grayish olive, with chalky shells; clay intervals at 328'-330' and 353'-354' are speckled with large uvigerinids; lower contact gradational.

371'-396.2' **Pachuta Marl Member**: Clay, pale olive, calcareous, with hard marl layers at 380.4'-380.6' and 395.3'-396.2'; lower contact gradational.

396.2'-425.7' **Cocoa Sand Member**: Sand, light olive gray to greenish gray; lower contact gradational.

425.7'-483.9' **North Twistwood Creek Clay Member**: Clay, greenish gray, with chalky shells; lower contact conformable; when split the core was mottled with oxidized? zones appearing light olive gray to dusky yellow.

483.9'-504' **Moodys Branch Formation**: Sand, greenish black to greenish gray, glauconitic, fossiliferous, and light olive gray, clayey, fossiliferous, glauconitic sand; lower contact disconformable and burrowed.

504'-533' **Cockfield Formation**: Clay, brownish black (at top) to olive gray clay; lower contact gradational.

533'-600' **Gosport Sand**: Sand, blackish green to dusky blue green, glauconitic, very fossiliferous with shell coquina of *Callista aequorea* at 548.3'-549' and coarsening-downward shell hash at 568'-570'; lower contact disconformable and burrowed.

600'-620' **Gordon Creek Shale Member**: Clay, olive gray with a blackish green glauconitic sand at 617.6'-617.8'.

DISCUSSION

This study concerns the sequence stratigraphy of the upper Cook Mountain Formation to lower Marianna Limestone interval. Haq et al. (1987) placed this interval in their supercycle TA4. Baum and Vail (1988) labeled this supercycle Td and subdivided it into cycles TE3 and TO1 at the Mint Spring - Forest Hill contact. Cycle TE3 was subdivided into smaller cycles as follows: TE3.1 including the Gosport Sand and lower Moodys Branch Formation, TE3.2 including the upper Moodys Branch Formation and the North Twistwood Creek Clay Member of the Yazoo Formation, TE3.3 including the Late Eocene Cocoa Sand, Pachuta Marl, and Shubuta Clay members of the Yazoo Formation and the Early Oligocene Bumpnose Limestone, Red Bluff Formation, and Forest Hill Formation. Cycle TO1 was divided into TO1.1 including the Mint Spring Formation and Marianna Limestone and TO1.2 including the Glendon Limestone, Byram Formation, and Bucatunna Formation. The classic Jackson-Vicksburg unconformity was recognized as the condensed section of TE3.3.

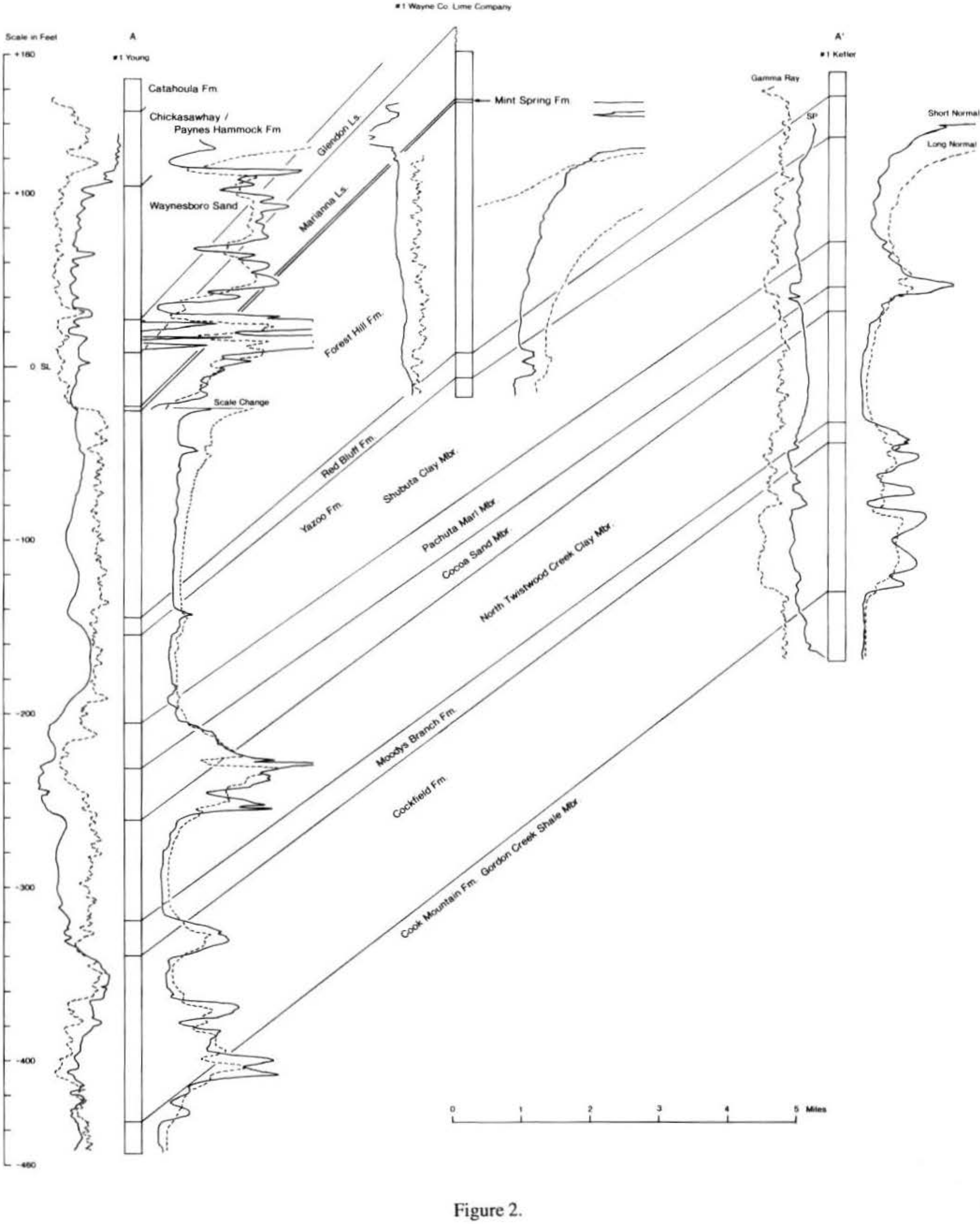
#1 Wayne Co. Lime Company
Scale in Feet
+180
+100
0 SL
-100
-200
-300
-400
-460
A
#1 Young
A'
#1 Kefler
Gamma Ray
SP
Short Normal
Long Normal
Catahoula Fm.
Chickasawhay / Paynes Hammock Fm.
Waynesboro Sand
Glendon Ls.
Marianna Ls.
Mint Spring Fm.
Forest Hill Fm.
Scale Change
Red Bluff Fm.
Yazoo Fm.
Shubuta Clay Mbr.
Pachuta Marl Mbr.
Cocoa Sand Mbr.
North Twistwood Creek Clay Mbr.
Moodys Branch Fm.
Cockfield Fm.
Cook Mountain Fm. Gordon Creek Shale Mbr.
0
1
2
3
4
5 Miles

Figure 2.

Mancini and Tew (1991, and in press) followed the Baum and Vail cycles with the exception of including the Moodys Branch Formation entirely in cycle TE3.2 and placing the Glendon Limestone at the top of cycle TO1.1. They also recognized the Jackson-Vicksburg hiatus as a condensed section. Dockery (1990 and 1992), Coleman and Galloway (1990), and Combes (1993) argued that a Type 1 sequence boundary representing a sea level lowstand was present at the base of the Vicksburg Group. This boundary would restrict Cycle TE3.3 to the Cocoa Sand - Shubuta interval and create a new cycle, TO1.1, to include the Red Bluff and Forest Hill formations. The old Cycle TO1.1 would be shifted to TO1.2, and the old TO1.2 to TO1.3.

Miller et al. (1993) reconciled opposing views in their interpretation of the Jackson-Vicksburg hiatus. This interpretation was based on a detailed study of core holes drilled at St. Stephens Quarry and Bay Minette, Alabama, that integrated strontium and oxygen isotopic, biostratigraphic, and magnetostratigraphic data from the upper Eocene-Oligocene sections. These core holes contain the same interval studied here. Miller et al. recognized an oxygen isotope increase across the Vicksburg-Jackson hiatus and placed the TA4.4 sequence boundary of Haq et al. (=TO1.1 of Baum and Vail) at the top of the Shubuta Clay Member. They recognized the unnamed blue clay above the Shubuta (Loutit et al., 1988) as the condensed section or early highstand deposits of the overlying sequence. This would require the transgressive systems tract to be thin or missing and the maximum flooding surface and sequence boundary to be close together or concatenated. Pasley and Hazel (1994) using organic petrology and graphic correlation of biostratigraphic data recognize the surface of maximum starvation (= maximum flooding surface) and the sequence boundary to be merged above the Shubuta at St. Stephens Quarry.

Analysis of the Mobil core holes will test sequence models for the upper Eocene and lower Oligocene of the northern Gulf. The following preliminary comments are based on drilling characteristics, core descriptions, and paleontology.

1. **The Cook Mountain - Cockfield Contact.** The Cook Mountain - Cockfield contact is conformable at MGS locality 55 in Clarke County, Mississippi. Here the sequence is best described as a progradational deltaic sequence grading upward from prodelta clays of the Gordon Creek Shale Member of the Cook Mountain Formation to the basal Cockfield sands. In the #1 Ketler core hole, this contact was encountered at 300 feet and indicated an erosional surface overlain by abraded, glauconite-stained shells. The abrupt contact is shown by the resistivity log. This contact was also erosional in the #1 Young, where fossiliferous sands of the Gosport are in sharp contact with nonfossiliferous, silty, gray clays of the Gordon Creek Shale. It appears nearly identical to the well-known Lisbon-Gosport contact at Little Stave Creek in Clarke County, Alabama. A correlation of units suggests that the nonfossiliferous clay of the upper Lisbon at Little Stave Creek is a Gordon Creek Shale equivalent.

2. **Gosport Sand.** Several thin, fossiliferous sands of the middle and lower Cockfield Formation in the #1 Ketler grade downdip into very fossiliferous, glauconitic sands of the Gosport Formation in the #1 Young. The Gosport in this core hole is 67 feet thick, thus indicating that the fossiliferous, marine, Gosport section is equivalent to all but the uppermost Cockfield.

Loose sand and shells in the Gosport made recovery difficult at certain intervals. The upper 6 feet of the core at 570'-580' consisted of a disturbed soupy mix of shells and sand. These sediments were sieved, and the following Gosport mollusks were identified:

GASTROPODA

Ancilla staminea (Conrad)
Architectonica meekana Gabb
Athleta petrosa (Conrad)
Buccitriton sagenum (Conrad)
Bullata semen (Lea)
Calyptraphorus velatus (Conrad)
Crepidula lirata Conrad
Eopleurotoma sayi (Lea)
Eosurcula moorei (Gabb)
Mesalia vetusta (Conrad)
Mitrella elevata (Lea)
Neverita limula (Conrad)
Penion bella (Conrad)
Retusa galba (Conrad)
Sinum bilix (Conrad)
Skaptotion nitens (Lea)
Turritella carinata Lea
Turritella ghigna de Gregorio

BIVALVES

Bathytormus protextus (Conrad)
Callista aequorea (Conrad)
Callista mortoni (Conrad)
Callista perovata (Conrad)
Diplodonta ungulina (Conrad)
Calorhadia bella (Conrad)
Caryocorbula alabamiensis (Lea)
Glycymeris trigonella (Conrad)
Glyptoactis alticostata (Conrad)
Linga pomilia (Conrad)
Nucula ovula Lea

SCAPHOPODA

Dentalium thalloides Conrad

3. **Creola Member.** The fossiliferous Creola Member of the Cockfield Formation was present in the #1 Ketler but not in the #1 Young, where the Moodys Branch Formation was thicker. This suggests a possibility that updip facies of the Creola Member might be equivalent to the lower Moodys Branch Formation downdip.

4. **Moodys Branch Formation.** The thickening of the

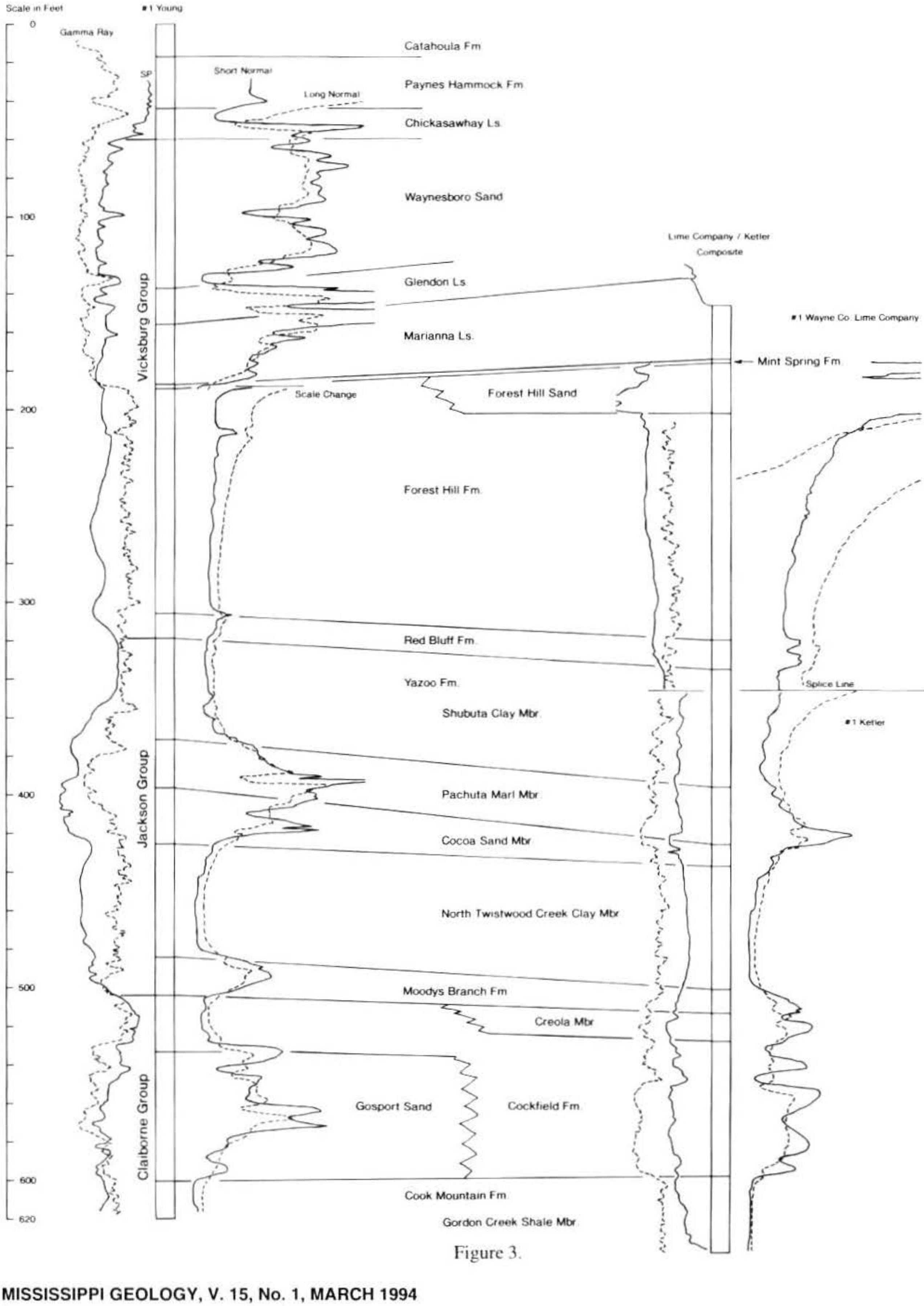
Scale in Feet
#1 Young
0
100
200
300
400
500
600
620
Gamma Ray
SP
Short Normal
Long Normal
Scale Change
Catahoula Fm
Paynes Hammock Fm
Chickasawhay Ls
Waynesboro Sand
Glendon Ls
Marianna Ls
Vicksburg Group
Lime Company / Ketler Composite
#1 Wayne Co. Lime Company
Mint Spring Fm
Forest Hill Sand
Forest Hill Fm
Red Bluff Fm
Yazoo Fm
Splice Line
Shubuta Clay Mbr
#1 Ketler
Jackson Group
Pachuta Marl Mbr
Cocoa Sand Mbr
North Twistwood Creek Clay Mbr
Moodys Branch Fm
Creola Mbr
Claiborne Group
Gosport Sand
Cockfield Fm
Cook Mountain Fm
Gordon Creek Shale Mbr

Figure 3.

Moodys Branch Formation downdip was a surprise. This formation is 9 feet thick at MGS locality 18 on the Chickasawhay River in Clarke County. It was 12.7 feet thick in the #1 Ketler and 20.1 feet thick in the #1 Young. This downdip thickening may explain the thick sand section attributed to the Moodys Branch Formation at Little Stave Creek in Alabama.

5. **Cocoa Sand Member.** The base of the Cocoa Sand Member of the Yazoo Formation is the TE3.3 sequence boundary of Baum and Vail (1988) and Mancini and Tew (1991). This contact was gradational in both the #1 Ketler and #1 Young, with sand continuing into the North Twistwood Creek Clay below and the Pachuta above. Mancini and Tew (1991) recognized the Cocoa Sand as a shelf margin sand. It is the only member of the Yazoo Formation found to thicken downdip in the cores, varying from 12 feet thick in the #1 Ketler to 29.5 feet thick in the #1 Young. The Cocoa thickens partly at the expense of the bounding units with the North Twistwood Creek Clay contributing the greater share.

6. **Pachuta Marl Member.** The Pachuta Marl Member of the Yazoo Formation has gradational upper and lower contacts and maintains a fairly uniform thickness varying between 25.2 and 27 feet thick. The upper contact is placed at the first lithified marl at the base of the Shubuta Clay Member. The basal unit of the Pachuta is a hard sandy limestone that produces a spike on resistivity logs in the #1 Ketler and #1 Young. This unit may represent the condensed section of cycle TE3.3 (see above).

7. **Shubuta Clay Member.** The Shubuta Clay Member of the Yazoo Formation contains the deepest water environments of the cored interval. This is indicated in part by the presence of the deep-water, benthic foraminifer *Uvigerina*. Large uvigerinids were so abundant at certain intervals (see core descriptions) that they speckled the clay.

8. **The Shubuta - Red Bluff Contact.** The Shubuta - Red Bluff contact is considered here to be the TA4.4 sequence boundary of Haq et al. (1987). The contact is marked by a color change and burrowed surface. Above is the glauconitic, sandy, fossiliferous, olive gray clay of the Red Bluff Formation, and below is the dusky yellow green to grayish olive Shubuta Clay. The color contrast across the contact is accentuated at outcrop exposures - the Red Bluff appearing more dark gray as if containing detrital organic material and the Shubuta a light blue-gray appearing as a deep-water lutite.

9. **Red Bluff Formation.** The Red Bluff Formation is the transgressive system tract for an unnamed sequence bounded by the Shubuta - Red Bluff disconformity below and the Forest Hill - Mint Spring disconformity above. It is distinguished from similarly colored clays in the overlying Forest Hill Formation by containing beds of glauconitic, fossiliferous sands and calcareous/ironstone nodules. These sands and nodular beds give the Red Bluff a higher resistivity than the bounding clay sections on geophysical logs and aid in the unit's correlation.

10. **Forest Hill Formation.** The Forest Hill Formation represents highstand regressive deposits conformably overlying Red Bluff transgressive deposits. Updip this formation has a fluvial-deltaic component as seen in its upper sands in the #1 Wayne County Lime Company (Figure 3). These sands pinch out downdip and are not present in the #1 Young. Here a foot-thick limestone overlying a thin, glauconitic, fossiliferous sand was found in the upper Forest Hill.

11. **The Forest Hill - Mint Spring Unconformity.** The Forest Hill - Mint Spring unconformity is the most prominent contact noted in the cores. The Mint Spring Formation is a two-foot thick section of calcareous, glauconitic, fossiliferous sand grading upward into a soft limestone. It forms the base of a 52-foot thick carbonate section in the Vicksburg Group. Underlying it is over a hundred feet of sand and gray clays of the Forest Hill Formation. At surface exposures, the unconformity surface is marked by burrows and a pavement of rounded, lithified, bored, and encrusted clay clasts. Baum and Vail (1988) and Mancini and Tew (1991) recognize it as a Type 1 unconformity at the base of cycle TO1.1. One problem with this contact as a sequence boundary is that it is diachronous across Mississippi. The Mint Spring and Marianna of eastern Mississippi are in calcareous nannoplankton zone NP21, while the Mint Spring of western Mississippi is in NP22 (Siesser, 1983).

12. **Bentonites.** Several thin bentonites were noted in cores of the Yazoo and Forest Hill formations and two surface bentonites were sampled from the Moodys Branch Formation and North Twistwood Creek Clay Member. It was hoped that these samples would contain sanidine useful in determining a radiometric age. The Moodys Branch bentonite was sampled from MGS locality 18 on the Chickasawhay River in Clarke County. It consisted of a string of large, elongate, ovoid clasts located one foot above the formation's base. These clasts are believed to be the remains of a bed squeezed by soft-sediment deformation. On exposure, the clasts hardened to a flint-like texture and fracture.

The North Twistwood Creek Clay was sampled from an old clay pit two miles east of Matherville in northern Wayne County in which Ghosh (1972) obtained a radiometric age of 38.5 Ma (recalculated to 39.5 Ma, Obradovich, personal communication) from biotite layers. This pit has been back-filled with sand and is now occupied by the house of Mr. Thomas Donald. No biotite layers were seen, and the sample was taken from a partly weathered exposure in a ditch. When examined by John Obradovich of the U.S. Geological Survey Isotope Geology Branch, both the Moodys Branch and North Twistwood Creek bentonites contained angular quartz but lacked sanidine.

Three additional bentonites were examined from the cores. These included one from the #1 Ketler at 160 feet in North Twistwood Creek Clay and two from the #1 Young at 296.7 feet in the lower Forest Hill and at 411.5 feet in the Cocoa. Unfortunately, none of these bentonites contained sanidine.

ACKNOWLEDGMENTS

Many thanks to landowners Jeff M. Ketler and Stanford Young for permission to drill on their property and to Ronnie Morris for permission to drill in the Wayne County Lime Company quarry. Thanks are also due the Mississippi Office of Geology drill crew of Archie McKenzie, Christopher D. Woodward, and Kevin P. Benoit for a job well done and to John C. Marble and James C. Crellin for running the geophysical logs.

REFERENCES CITED

Baum, G. R., and P. R. Vail, 1988, Sequence stratigraphic concepts applied to Paleogene outcrops, Gulf and Atlantic basins: Society of Economic Paleontologists and Mineralogists, Special Publication No. 42, p. 309-327.

Coleman, J., and W. E. Galloway, 1990, Sequence stratigraphic analysis of the lower Oligocene Vicksburg Formation of Texas, p. 99-112, *in* B. F. Perkins, ed., Sequence Stratigraphy as an Exploration Tool, Concepts and Practices in the Gulf Coast: Eleventh Annual Research Conference, Gulf Coast Section, Society of Economic Paleontologists and Mineralogists Foundation, 409 p. (reprinted in 1991).

Combes, J. M. (=J. Coleman above), 1993, The Vicksburg Formation of Texas: depositional systems distribution, sequence stratigraphy, and petroleum geology: American Association of Petroleum Geologists Bulletin, v. 77, no. 11, p. 1942-1970.

Dockery, D. T., III, 1990, The Eocene-Oligocene boundary in the northern Gulf - a sequence boundary, p. 141-150, *in* B. F. Perkins, ed., Sequence Stratigraphy as an Exploration Tool, Concepts and Practices in the Gulf Coast: Eleventh Annual Research Conference, Gulf Coast Section, Society of Economic Paleontologists and Mineralogists Foundation, 409 p. (reprinted in 1991).

Dockery, D. T., III, 1992, The Eocene-Oligocene boundary in the northern Gulf Coastal Plain - a Type 1 sequence boundary: Geological Society of America, 26th Annual South-Central Section, 1992 Abstracts with Programs, v. 24, no. 1, p. 9.

Dockery, D. T., III, C. W. Stover, P. Weathersby, C. W. Stover, Jr., and S. L. Ingram, 1991, A continuous core through the undifferentiated Yazoo clay (Late Eocene, Jackson Group) of central Mississippi: Mississippi Geology, v. 12, no. 3-4, p. 21-27.

Ghosh, P. K., 1972, Use of bentonites and glauconites in potassium 40/argon 40 dating in Gulf Coast stratigraphy: Ph.D. thesis, Rice University, Houston, Texas, 136 p.

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

Loutit, T. S., J. Hardenbol, P. R. Vail, and G. R. Baum, 1988, Condensed section: The key to age determination and correlation of continental margin sequences: Society of Economic Paleontologists and Mineralogists, Special Publication 42, p. 183-213.

Mancini, E. A., and B. H. Tew, 1991, Relationships of Paleogene stage and planktonic foraminiferal zone boundaries to lithostratigraphic and allostratigraphic contacts in the Eastern Gulf Coastal Plain: Journal of Foraminiferal Research, v. 21, no. 1, p. 48-66.

Miller, K. G., P. R. Thompson, D. V. Kent, 1993, Integrated Late Eocene-Oligocene stratigraphy of the Alabama coastal plain: correlation of hiatuses and stratal surfaces to glacioeustatic lowerings: Paleoceanography, v. 8, no. 2, p. 313-331.

Pasley, M. A., and J. E. Hazel, 1994, Revised sequence stratigraphic interpretation of the Eocene-Oligocene boundary interval, Mississippi and Alabama, Gulf Coast Basin, U.S.A., in press.

Siesser, W. G., 1983, Paleogene calcareous nannoplankton biostratigraphy: Mississippi, Alabama and Tennessee: Mississippi Bureau of Geology, Bulletin 125, 61 p.

FELT REPORTS FROM NORTHERN MISSISSIPPI OF THE NOVEMBER 9, 1968, ILLINOIS EARTHQUAKE

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Mississippi Mineral Resources Institute

INTRODUCTION

The southern Illinois earthquake of November 9, 1968, occurred at 11:01:41 a.m. (central time) at latitude 37.96^{0}N and longitude 88.46^{0}W. The magnitude of the earthquake measured 5.5 on the Richter scale and the intensity was about VII on the Modified Mercalli scale (Heigold, 1968). Nuttli (1979) reported that this quake was felt in an area of 1,600,000 square kilometers. Focal depth was determined to be about 20 km (Stauder and Nuttli, 1970). Coffman and others (1982) reported that this quake was the largest in the region since 1895, and was felt as far south as northwestern Florida.

The objective of this investigation is to analyze a statement made by Otto W. Nuttli in a 1981 report to the Federal Emergency Management Agency. In this report Nuttli stated, in regard to the November 9, 1968, earthquake, "Students in tall buildings at the University of Mississippi (250 miles away) fled the dormitories in panic." Mr. James Wilkinson of the Mississippi Emergency Management Agency requested an effort be made to verify this statement by Nuttli. The importance of this statement is that if a 5.5 magnitude earthquake, with its epicenter in Illinois, is sufficient to cause dormitories at the University of Mississippi to sway to the extent to cause panic, then an earthquake of equal magnitude in the much closer southern portion of the New Madrid seismic area may cause significant damage in the University of Mississippi area.

FELT REPORTS

Primary sources of information regarding the quake in Mississippi have been newspaper articles from the area. Additional information was derived from interviews with people having experienced the quake. Coffman and Cloud (1970) reported that the earthquake was felt in Mississippi at intensity V at Tunica, and at intensity I-IV at Aberdeen, Ashland, Batesville, Booneville, Clarksdale, Cleveland, Coffeeville, Corinth, Greenwood, Hernando, Iuka, Marks, New Albany, Oxford, Port Gibson, Ripley, State College, Tupelo, and University.

The Daily Mississippian, the student newspaper at the University of Mississippi, reported the earthquake in its November 12, 1968, issue. This short article noted the earthquake was recorded at the University of Mississippi seismic station at 11:03 a.m., and its epicenter was located 375.6 miles away. Mr. Jack Lacey, working at the seismic station, stated the quake rocked his car. The article makes no mention of any panic generated by the quake on campus.

An article appeared in the *Oxford Eagle* (Oxford, Mississippi) on November 14, 1968. Dr. Kenneth McLaughlin, Chairman of the Department of Geology at the University of Mississippi, stated that the intensity of the quake was 3.5 at St. Louis, but "was not over two here." Dr. McLaughlin also noted that the 1966 earthquake at Belzoni, Mississippi, was more intensely felt than the 1968 quake; this comment probably refers to the 1967 Greenville earthquake.

In Tupelo, Mississippi, the November 11 issue of the *Daily Journal* stated that many of the residents of Tupelo reported feeling the tremor. The article reported that students at Mississippi State University noticed dormitory walls swaying during the tremor. The article also reported that at Corinth, Mississippi, the walls of WCMA radio station building "swayed and creaked." Swaying light fixtures and shaking windows were noted at a clothing factory at Red Bay, Alabama, but no damage to the building was reported.

The quake was felt in Greenville, Mississippi. The November 10 issue of the *Delta Democrat-Times* reported that floors rumbled during the quake at the *Greenwood Commonwealth* newspaper in Greenwood, Mississippi. This article also stated the tremor was felt as far away as Newnan, Georgia, by Bob Hustell of the WNEA radio station.

In Memphis, Tennessee, the *Commercial Appeal* reported on November 11, 1968, that "window blinds rocked and open doors swung about an inch." This report was by Dr. Sherman H. Hoover, who was on the tenth floor of the Medical Center Plaza Building. The quake was also felt by personnel in the ten story Memphis Metropolitan Airport control tower. No damage was reported near Memphis.

The quake was reported in the *Clarion-Ledger*, in Jackson, Mississippi, on November 10, 1968. The news article recapped other stories, and did not mention any felt reports from the Jackson area.

DISCUSSION

None of the newspaper articles reviewed in this investigation indicated that any panic, such as was stated by Nuttli, was generated by the quake at the University of Mississippi. Dr. William Reynolds was with the Department of Geology and Geological Engineering at the University of Mississippi when the quake occurred and is referenced in the *Oxford Eagle* article. Dr. Reynolds does not recall that the quake generated any undue concern at the University. He recalls that the felt effects of the quake were relatively small. This statement concurs with the statement Dr. McLaughlin made in the 1968 *Oxford Eagle* article. A review of the University of Mississippi Physical Plant records indicated that in 1968 there were only two dormitories containing more than four stories. Stewart and Kincanon halls are both seven story structures and were constructed in 1963. The tallest dormitory on campus, Stockard-Martin Hall (consisting of eleven stories), was constructed after the 1968 quake. There is, therefore, no reason to believe that panic was generated by the earthquake at the University.

The *Daily Journal* article noted that walls swayed at Mississippi State University, at Starkville, Mississippi, and perhaps Nuttli had mistakenly substituted the University of Mississippi for Mississippi State University. Mr. Michael Bograd, of the Mississippi Office of Geology, was attending Mississippi State University at the time of the quake. He recalls that he noticed the quake, but others in the same room did not. He does not recall any panic generated on campus due to the quake. If the earthquake effects were so slight as to be felt by only certain individuals and not others, then it is doubtful, as Mr. Bograd states, that any panic was generated.

The distance from the epicenter to the University of Mississippi is stated by Nuttli as being 250 miles. The distance reported by Mr. Lacey of the University of Mississippi seismic station was 375.6 miles. Perhaps, because of the similarity in names, the University of Mississippi was substituted for the University of Missouri. The distance from the epicenter of the quake to Rolla, Missouri, which contains a campus of the University of Missouri, was estimated at 180 miles, much closer to the 250 mile figure used by Nuttli. The main campus at Columbia, Missouri, is north of Rolla, and would be even closer to the 250 mile figure. The University of Missouri is also close enough to the epicenter to have much stronger felt effects. Coffman and others (1982) report structural damage as close as St. Louis, Missouri, so swaying dormitories at Columbia or Rolla might be expected.

Review of newspaper articles in the northern Mississippi area and interviews with people who experienced the 1968 earthquake have failed to verify the statement of Nuttli (1981). It is probable that the University of Mississippi's name was inadvertently substituted for the University of Missouri. Since Dr. Nuttli died some years ago, it will probably be difficult to reach a definitive conclusion, and the case for substitution of names must remain speculative.

REFERENCES CITED

Coffman, J. L., and W. K. Cloud, 1970, United States earthquakes, 1968: U. S. Department of Commerce, Coast and Geodetic Survey, p. 16-29, 67.

Coffman, J. L., C. A. von Hake, and C. W. Stover, 1982, Earthquake history of the United States: U. S. Department of Commerce, Publication 41-1, 208 p.

Heigold, P. C., 1968, Notes on the earthquake of November 9, 1968, in southern Illinois: Illinois State Geological Survey, Environmental Geology Notes, No. 24, 17 p.

Nuttli, O. W., 1979, The seismicity of the central United States, *in* Geology in the siting of nuclear power plants: Geological Society of America, Reviews in Engineering Geology, v. 4, p. 67-93.

Nuttli, O. W., 1981, Evaluation of past studies and identification of needed studies of the effects of major earthquakes occurring in the New Madrid Fault Zone: Federal Emergency Management Agency, CUSEPP Report Number 81-1, 29 p.

Stauder, W., and O. W. Nuttli, 1970, Seismic studies: South central Illinois earthquake of November 9, 1968: Seismological Society of America Bulletin, v. 60, p. 973-981.

1993 Open-File Reports Available From The Mississippi Mineral Resources Institute

The following open-file reports, for the year 1993, are presently available. To purchase these reports, please send the publication number, publication title, and prepayment in the form of a check or money order made payable to the University of Mississippi. A list of older reports is available upon request. All orders and/or correspondence should be addressed to The Mississippi Mineral Resources Institute, 220 Old Chemistry Building, University, Mississippi 38677.

93-1F **Subsurface Structure and Hydrocarbon Occurrence, Maxie and Pistol Ridge Fields, Southeast Mississippi**; Songqiao Luo and Maurice A. Meylan; June, 1993; 91 pgs., $7.00.

93-2F **Lithostratigraphy and Petrology of Neogene and Quaternary Sediments, South-Central Mississippi;** Zebao Li and Maurice A. Meylan; August, 1993; 226 pgs., $10.00.

93-3F **Enhanced Recovery of Methane from Coalbeds;** Rudy E. Rogers and Vark Kalluri; July, 1993; 24 pgs., $2.00.

93-4F **Evaluation of Coalbed Methane Projects by Monte Carlo Simulation**; Rudy E. Rogers and Senthil Balasubramanian; July, 1993; 16 pgs., $2.00.

93-5F **Specific Gravity and Cation Exchange Capacity of Mississippi Clays**; Nolan B. Aughenbaugh; August, 1993; 26 pgs., $3.00.

93-6F **Development of Techniques to Integrate Subsurface and Surface Models into a Geographic Information System**; Liu Lei, Sridhar Katragadda, Douglas Lockhart, and Charles Swann; September, 1993; 152 pgs., $10.00.

93-7F **Integration of North Mississippi Clay Data Bases for Use in Production Models and Landfill Siting**; Fazlay Faruque, Charles Swann, and Douglas Lockhart; September, 1993; 40 pgs., $3.00.

HIGH-ACCURACY GPS SURVEY COMPLETED IN MISSISSIPPI

A joint project involving the National Geodetic Survey Division (NGSD), the Stennis Space Center of the National Aeronautics and Space Administration (NASA-SSC), and others has developed the Global Positioning System (GPS) High Accuracy Reference Network (HARN) in Mississippi. The objectives of this survey are (1) extend the HARN throughout the State of Mississippi with control points spaced approximately 50 km apart, with more dense spacing in the gulf coast region in and around the NASA-SSC facility, (2) improve the model of the geoid (the equipotential surface approximating mean sea level) in Mississippi using NGSD vertical control surveys that would establish precise height values for a subset of HARN control points, and (3) coordinate research on the use of a GPS Continuously Operating Reference Station (CORS) located at the NASA-SSC facility. Other organizations involved in the project's survey operations were Mississippi's Departments of Transportation and Environmental Quality, Mississippi State University, Louisiana Department of Transportation, Louisiana State University, the U. S. Geological Survey, the Army Corps of Engineers and Naval Oceanographic Office, as well as EMC, Inc., Navigation Electronics, Inc., and Western Geophysical Company.

Ninety-nine new and existing control points were observed during the project. Sixty-three of these stations are now identified as HARN stations in Mississippi. The observations recorded during this project also were coordinated with satellite observations at selected North American stations of the Cooperative International Global Positioning System Network (CIGNET).

GPS CORS data can be made available to users after computer processing. These data enable surveyors to perform field surveys with fewer GPS receivers because a highly accurate initial reference point (the CORS) is already provided. Furthermore, a computer also could be connected to the GPS-CORS receiver, permitting real-time quality control checking of observational data and monitoring data availability to GPS user.

Inquiries: John Love, (301) 713-3205

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MISSISSIPPI OFFICE OF GEOLOGY

MEMORANDUM

March 18, 1994

Re: DEQ GPS Base Station Network

The Mississippi Deptartment of Environmental Quality GPS Base Station Network is now operational. Three Trimble Pathfinder Community Base Stations have been installed and tested by the staff of the Office of Geology. The stations are located in Oxford (north), Jackson (central), and Biloxi (south). This arrangement provides for a maximum base line correction distance of less than 125 miles for any location in the state. GPS differential corrections should be made using the closest base station to your field data collection point. The stations at Oxford and Biloxi are subject to power interruptions due to storms or equipment failure. The station in Jackson is on a 24-hour Uninterrupted Power Source (UPS) at MARIS, and will always be up and operating should either of the other stations fail. The Jackson Station can be used for correction of data anywhere in the state if necessary with only a minor decrease in accuracy.

These stations record GPS C/A code correction data every 5 seconds for 12 hours each day starting at 6:00 am local time. The data will be compressed and stored in the *.ssf* Trimble file format, and compiled in hourly files in GPS Time (Greenwich meridian time). The data are downloaded each night to the GPS Bulletin Board located at DEQ headquarters in Jackson. Data will be archived for at least one month before being deleted. Access to the data will be by modem through the bulletin board (restricted to 9600 baud or faster). This is a single-line bulletin board, so please restrict your calls to the minimum required for file retrieval. At the present time there is no fee charged for access. The bulletin board shuts down for about 2 hours each night to download files from the stations, but is available at any other time.

The base stations are 12-channel units capable of tracking every possible satellite configuration. The elevation mask is set at 10°, so field elevation masks should be set to at least 15° such that no satellites will be picked up in the field which are not recorded by the base stations. These stations were included in the HARN Project for Mississippi, completed last year, and are located with an accuracy of 1:100,000. Differential correction of Pathfinder field data by each station over published benchmarks has yielded accuracies of less than 1/2 meter for an averaged corrected field position.

Should you have any questions about the base stations or the bulletin board you can contact Peter Hutchins, 961-5505, or Steve Oivanki, 961-5518, at the Office of Geology.

DEQ GPS Bulletin Board: 961-5290

An up-to-date index of *Mississippi Geology* is available from the Office of Geology. Open-File Report 15, "Current Index to *Mississippi Geology*," compiled by Michael B. E. Bograd, is available for $2.00 ($2.50 by mail) from the Office of Geology, P. O. Box 20307, Jackson, MS 39289.

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