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A NEW LATE EOCENE MICROSPHERULE LAYER IN CENTRAL MISSISSIPPI

Gary R. Byerly
Joseph E. Hazel
Charles McCabe

Department of Geology and Geophysics
Louisiana State University
Baton Rouge, Louisiana

INTRODUCTION

Tektites are small, macroscopic bodies of silicate glass that are thought to be of extraterrestrial origin. Most workers believe they are the dispersed, predominantly terrestrial rock resulting from meteorite or comet impacts on Earth (e.g., King, 1977). In North America they have been found on land in Texas and Georgia. The former are termed bediasites and the latter georgiaites. Microspherules, which include microscopic tektites and other microscopic spherules that are crystal-bearing, are materials that have been

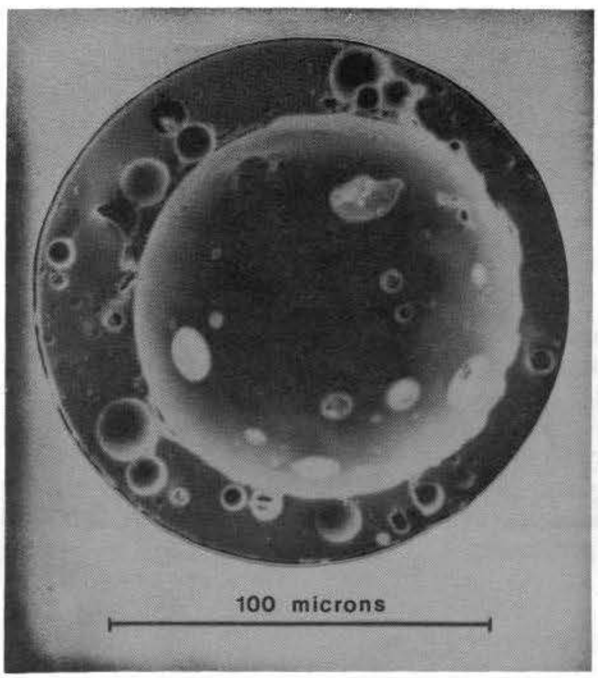

Figure 1. Microspherule polished section. SEM (Scanning Electron Microscope) image of typical Cynthia microspherule with large central cavity and numerous smaller vesicles. Glass is very homogeneous, high Al and Ca composition, with no hydration or other obvious effects of alteration.

found particularly in deep sea cores (e.g., Keller et al., 1987) and are also thought to be the result of extraterrestrial impacts. Recently, for the first time, tektites and microspherules have been found together (Thein, 1987).

Sixteen localities are known where microspherules have been found in rocks of late Eocene age (Keller et al., 1987), which is also the probable age of the bediasites and georgiaites. It is being debated in the literature whether the microspherules are the result of two or three impact events (Keller et al., 1987; Glass and Burns, 1987). There are supposedly one or two events that caused the formation of a layer or layers dominated by crystal-bearing microspherules (the cpx layer), and a younger event that resulted in the formation of a layer dominated by microtektites. In this report we document the occurrence of microspherules in the late Eocene in Mississippi that are younger than any of the other Eocene microspherules.

MICROSPHERULES AT THE CYNTHIA PIT

About ninety-five feet (the thickness changes as the pit is worked) of the Yazoo Formation of the Jackson Group are exposed in a large open pit mine at Cynthia in Hinds County, central Mississippi (Dockery and

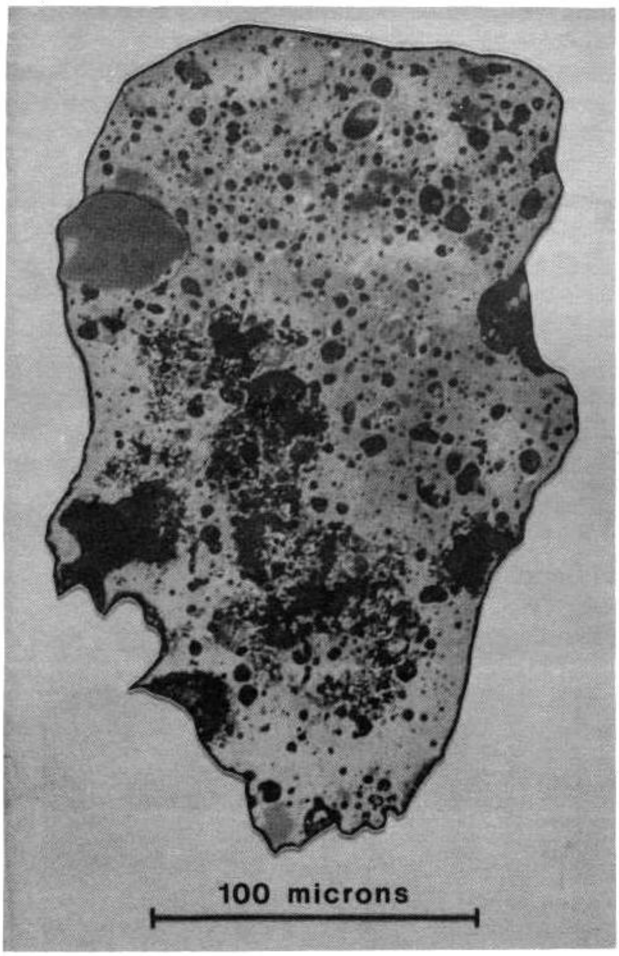

Figure 2. Irregular impact glass polished section. BSE (Back Scatter Electron) image of irregular glassy fragment. Glass is very heterogeneous with abundant lechatelierite (for example the light gray, 30x40 micron ovoid on left side of grain), in places partially mixed with the other glass. Several partially melted mineral grains are found in this fragment along with quench crystallites of pyroxene.

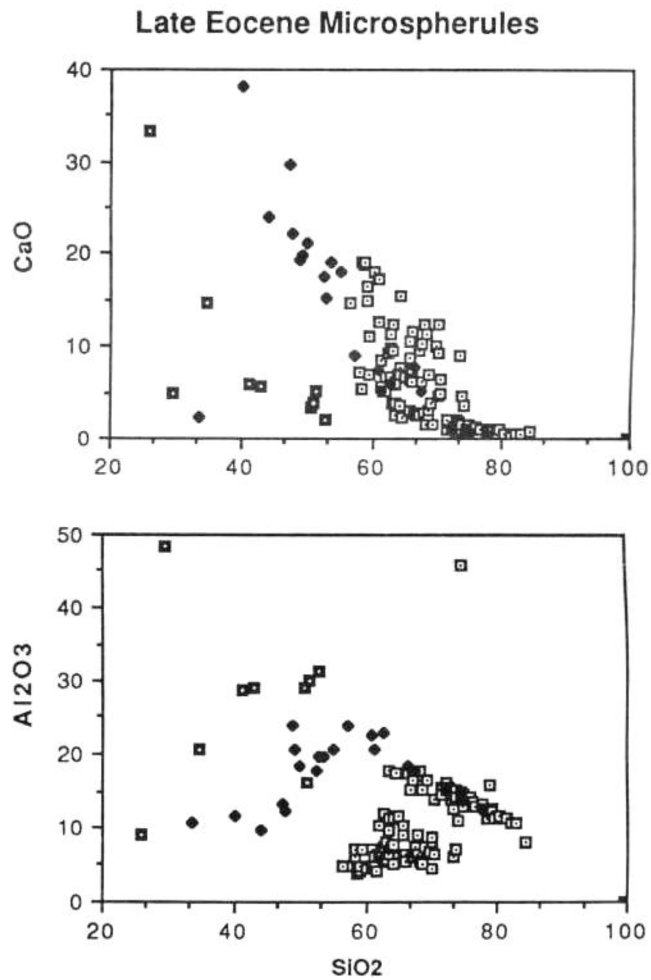

Figure 3. Compositional variation in the Cynthia glasses and other late Eocene impact glasses. The Cynthia glasses form a coherent suite distinct from other late Eocene impact glasses and were likely produced by impact-melting of a target that was a mixed clay-carbonate lithology. Cynthia glasses=diamonds; Spanish glasses=filled squares (data from D'Hondt et al., 1987); other late Eocene glasses=open squares (D'Hondt et al., 1987).

Siesser, 1984). Keller (1986) reported a few microspherules from a sample (C of Keller, 1985, fig. 14) collected at the pit by one of us (JEH) in 1979. The microspherule layer is in the lower part of the Yazoo at the pit in the middle of stratigraphic unit 1 of Dockery and Siesser (1984).

Subsequently, from another 10 gram cut of the same sample, we have found over 60 microspherules and irregularly shaped impact glasses. The microspherules range in size from about 250 to 75 microns. Washing the clays from the sample over a $<$ 63 micron screen caused the loss of most smaller spherules. However, several microspherules 5-10 microns in diameter were recovered because they were welded to much larger spherules. Irregular impact glasses range in size from 75 up to 400 microns. All but the smallest microspherules are highly vesicular. The larger microspherules typically have a large central cavity (Figure 1). The microspherules are generally holohyaline, but the more irregular grains have abundant inclusions of lechatelierite, a fused amorphous silica (Figure 2), rare partially melted zircon and ilmenite, and quench microlites of several phases. One of the quench microlites is identified as the calcium- and aluminum-rich pyroxene fassaite.

Preliminary EDS (Energy Dispersive System) analyses were obtained on polished sections of twelve specimens. The Cynthia glasses generally fall on a mixing line that has a low Al_2O_3-high CaO end member and a high Al_2O_3-low CaO end member. These glasses are compositionally unlike those from other late Eocene localities (Figure 3), though similar in some respects to the late Eocene Spanish microspherules (D'Hondt et al., 1987). Both the Spanish and Cynthia glasses suggest impact targets that were dominated by clays and carbonate. By contrast the main North American tektite layer glasses were likely derived from a quartz-rich sandstone target, and the glasses of the cpx layers from

TABLE 1
CHRONOSTRATIGRAPHY of UPPER EOCENE MICROSPHERULE LAYERS

General Area	Locality Name	Suggested Cu	Age Ma	Chronozones FP1/FP2/NN
Mississippi	Cynthia Pit	161.13	36.971	16/Tc/19-20
* E. Gulf Mexico	E67-128	158.23	37.558	16/Tc/19-20
* W. Pacific	DSDP 292	158.12	37.580	16/Tc/19-20
* W. Pacific	DSDP 292	157.41	37.724	16/Tc/19-20
Spain	Mol. de Cobo	156.28	37.952	16/Gs/19-20
C. Gulf Mexico	DSDP 94	156.08	37.993	16/Gs/19-20
Barbados	Bath Cliff	155.96	38.017	16/Gs/19-20
Barbados	Bath Cliff	155.93	38.023	16/Gs/19-20
C. Gulf Mexico	DSDP 94	155.59	38.092	16/Gs/19-20
Venezuela Basin	DSDP 149	155.58	38.094	16/Gs/19-20
C. Pacific	DSDP 167	154.66	38.280	16/Gs/19-20
C. Pacific	DSDP 166	154.66	38.280	16/Gs/19-20
W. Pacific	DSDP 462	154.54	38.305	16/Gs/19-20
Indian Ocean	DSDP 216	153.30	38.556	16/Gs/19-20
W. Pacific	DSDP 292	153.29	38.558	16/Gs/19-20
C. Pacific	DSDP 167	153.10	38.596	16/Gs/19-20
W. N. Atlantic	DSDP 612	151.40	38.940	16/Gs/19-20
* E. Gulf Mexico	E67-128	151.39	38.942	16/Gs/19-20

* possibly the result of contamination

Table 1. Position of the Cynthia microspherule layer and other late Eocene microspherule layers in a chronostratigraphic framework model (Cu column) and time (Ma column). Under the Chronozones column, 16=Zone P16 of Blow (1979); Tc=*Turborotalia cerroazulensis* Zone of Toumarkine and Luterbacher (1985); Gs=*Globigerinatheka semiinvoluta* Zone of Toumarkine and Luterbacher (1985); 19-20=Zones NP19 and 20 of Martini (1971). The map locations of the microspherule localities are given in Keller et al. (1987).

a more mafic target (Glass et al., 1985; Glass and Burns, 1987).

AGE OF THE MICROSPHERULES

The Cynthia pit is in the upper part of the undifferentiated Yazoo Formation and Dockery and Siesser (1984) considered the exposure in the pit to correlate with the Shubuta Member of the Yazoo of eastern Mississippi. Based on recent and as yet unpublished studies of the Shubuta by one of us (JEH) using the Graphic Correlation chronostratigraphic modelling technique (see Edwards, 1984) using five microfossil groups, this member falls between 159.30 and 162.65 model or composite units (Cu). Because it can be shown that the model is linear with time, the composite units of the model can be converted to mega-annums (Ma). The Shubuta ranges in age from 37.34 Ma to 36.66 Ma.

Siesser found only a single specimen, considered reworked, of the nannofossil *Discoaster barbadiensis* and no *D. saipanensis* in his samples from the pit. These species become extinct late in the late Eocene, and Dockery and Siesser placed the Yazoo at the pit in nannoplankton zone NP21. However, empirically, in the Gulf Coastal Plain these *Discoaster* species become very rare toward the end of their range. A more important nannofossil event, however, for dating this section probably is the last occurrence of the nannofossil *Pemma papillatum*, which in eastern Mississippi last occurs in the middle Shubuta (Bybell, 1982). The apparent LAD (Last Appearance Datum) of this taxon has a value of 161.39 Cu (36.92 Ma), which is shortly before the LADs of the discoasters and virtually at the same time as the LAD of the foraminifer *Cribrohantkenina inflata*. *Pemma papillatum* occurs in the pit above the microspherule-bearing sample (Dockery and Siesser, 1984).

The ostracodes *Actinocythereis boldi*, *A. gibsonensis*, and *Haplocytheridea ehlersi* occur in the samples from the Cynthia pit above the microspherule sample. These typical Jackson Group species occur in the Shubuta, but disappear in the middle of that unit (Howe and Howe, 1973). The important benthic foraminifer species *Marginulina cocoaensis*, which is restricted to the upper part of the upper Eocene (e.g., Bandy, 1949), was found in a sample from the pit at virtually the same stratigraphic level as the microspherule layer. This species has a range of 158.33 to 161.40 Cu (37.54-36.92 Ma) in the model.

Fortuitously or not, the sample with the microspherules correlates with at least a regional decrease in the percentage abundance of *Globigerina ouachitaensis* in the Gulf Basin (see abundance curves in Keller, 1985), which, based on graphic correlation analysis, took place at about 161.13 Cu (36.97 Ma).

These fossil data suggest that the Yazoo at the pit is equivalent to the middle part of the Shubuta of eastern Mississippi and supports the correlation (but not the zonal placement) of Dockery and Siesser (1984). Preliminary paleomagnetic results from studies on a Yazoo sample from the lower part of the pit near the microspherule bed indicate reversed polarity. This supports the biostratigraphy, which suggests that the entire exposure in the pit should be in the reversed interval between the stratigraphic equivalent of sea floor anomalies 13 and 15 (there is no 14). This makes the Cynthia microspherules the youngest Eocene layer yet found. All the other microspherule layers predate the Shubuta.

Table 1 gives the age of the Cynthia microspherules and compares this to the ages of the microspherule layers at other localities derived from graphic correlation analysis of those sections. These studies show that there are several more late Eocene microspherule layers in upper Eocene rocks than had been thought.

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DEPOSITIONAL ENVIRONMENTS AND STRATIGRAPHY OF THE CATAHOULA FORMATION SANDSTONES OF SOUTHEASTERN MISSISSIPPI

Lee Day
Alacore, Inc.
Laurel, Mississippi

ABSTRACT

The Catahoula Formation (lower Miocene?) in southeastern Mississippi consists of non-marine sands, silts, and clays. In the subsurface, the Catahoula Formation can be divided into three distinct members: 1) an upper, sandy sequence; 2) a middle unit composed mainly of silts and clays (with occasional, discontinuous sand bodies); and 3) a lower sequence comprised of thin sands interbedded with finer sediments.

Catahoula Formation sediments were deposited by coalescing fluvial systems, which spread across the entire Gulf Coastal Plain. Specific depositional environments consist of abandoned channel deposits (silt, clay), point bar deposits (sand), overbank deposits (sand, silt, clay), crevasse splay deposits (sand, silt), and channel fill deposits (gravel). The lower member also has distributary bay or bar deposits (sand, silt, clay).

The stratigraphic boundaries for the Catahoula Formation are here redefined in part. The lower boundary exists as a disconformable contact between the Catahoula and Bucatunna formations, which indicates a period of nondeposition and/or erosion. This contact exists at the outcrop and is consistent in the subsurface throughout the study area. The upper boundary is found to be the contact between the upper sand and the finer-grained sediments of the Hattiesburg Formation. This contact is prominent in the subsurface. Updip what is currently mapped as "Citronelle" is actually the upper sand member exposed. This misinterpretation is due to formational classification by using sediment color and textural shifts as primary criteria. This is contradictory to the fundamental criteria used to define rock stratigraphic units at the "formational" level.

INTRODUCTION

The "Catahoula sandstone" was the term given by A. C. Veatch (1905) for exposures of non-marine sands, silts, and clays in Catahoula Parish, Louisiana. The Catahoula Formation is generally assigned to the Miocene in Mississippi and Louisiana (Williamson, 1959). The Catahoula Formation of Mississippi is correlated in Alabama with the Paynes Hammock Formation (Miocene) at the surface and the Tampa Limestone (Miocene) in the subsurface (Isphording, 1983). It is also time correlative (Figure 1) to the Oakville Formation (Miocene) of Texas (Rainwater, 1964a). The Neogene strata of Mississippi present problems concerning their lower boundary, their correlation both to west and east, interformational facies relationships, and in the determination of their depositional environments.

Most authors (e.g., Rainwater, 1964b) propose that sediments of the Catahoula Formation were deposited by coalescing fluvial systems in the area across the Gulf Coastal Plain from Texas to Mississippi. May (1980) considered the Catahoula Formation of south-central Mississippi to be a product of sedimentation by fluvial and deltaic systems but provided few details on specific depositional environments.

The area studied includes Simpson, Smith, Jones, Covington, Jasper, Jefferson Davis, and parts of Rankin and Lawrence counties (Figure 2).

GEOLOGIC SETTING

The Catahoula Formation in Mississippi is sporadically exposed at the surface in an east-west belt approximately 30 to 60 miles wide (Figure 3). The strike of these beds is generally NW-SE, with a dip of 10 feet per mile toward the Gulf of Mexico (May, 1980). The Catahoula Formation in most of onshore Mississippi is composed of mainly nonfossiliferous sediments, and lacks a diagnostic faunal assemblage necessary for regional correlation. As a consequence, both the age of the formation (and overlying units) as well as the time involved in their deposition are far from clear.

The Miocene epoch in the Gulf Coast was highlighted by a general marine regression punctuated by transgressive cycles in southern and offshore portions of Louisiana and Mississippi. As a result, the updip section (the study area) is dominantly a regressive sequence, whereas the downdip sediments (present-day coastal Mississippi and Louisiana) were deposited in nearshore marine and marine environments. These downdip sediments thicken dramatically (Williamson, 1959).

The lower Miocene boundary in Mississippi and Louisiana is invariably placed at the base of the Catahoula Formation sands and clays. Since the contact with the underlying Bucatunna Formation is probably disconformable, based on the contrast in lithology between the two units (Wojna, 1985), and the Catahoula sediments are nonfossiliferous, the assignment of an "age" to this contact cannot be justified.

The upper boundary of the Catahoula Formation is even more questionable. This is due to the lack of a mappable contact updip at the surface and a somewhat disputable upper contact in the subsurface downdip. Most workers have placed the contact at the highest appearance of a fine- to medium-grained, buff sand underlying the mottled clays of what is supposed to be the Hattiesburg Formation.

The Hattiesburg Formation, when unweathered, is composed of greenish gray, silty to sandy clay and clayey siltstone. It may weather locally to a ferruginous, reddish-purple, nodular clay (Luper, 1972). The Catahoula Formation is thought to be overlain unconformably by sands and gravels of the Citronelle Formation (age undetermined) where the Hattiesburg Formation is missing through erosion or non-deposition. However, in the updip section it is almost impossible to distinguish between sands and gravels of the Citronelle Formation and those of the upper sand member of the Catahoula Formation.

The geology of the study area is influenced by several regional structural features. The study area is located along the eastern side of the southward-plunging synclinal Mississippi Embayment. To the northwest is the Jackson Uplift, and to the northeast is the Pickens-Gilbertown Fault System. To the south is the Wiggins Anticline (or "Arch"). Dip in the study area is generally uniform except where influenced by regional and local structural features such as the Jackson Uplift and various salt domes (e.g., D'Lo Dome).

PROCEDURE

Outcrops of the Catahoula Formation occur sporadically throughout the study area. For this investigation, only the nine largest outcrops were selected for

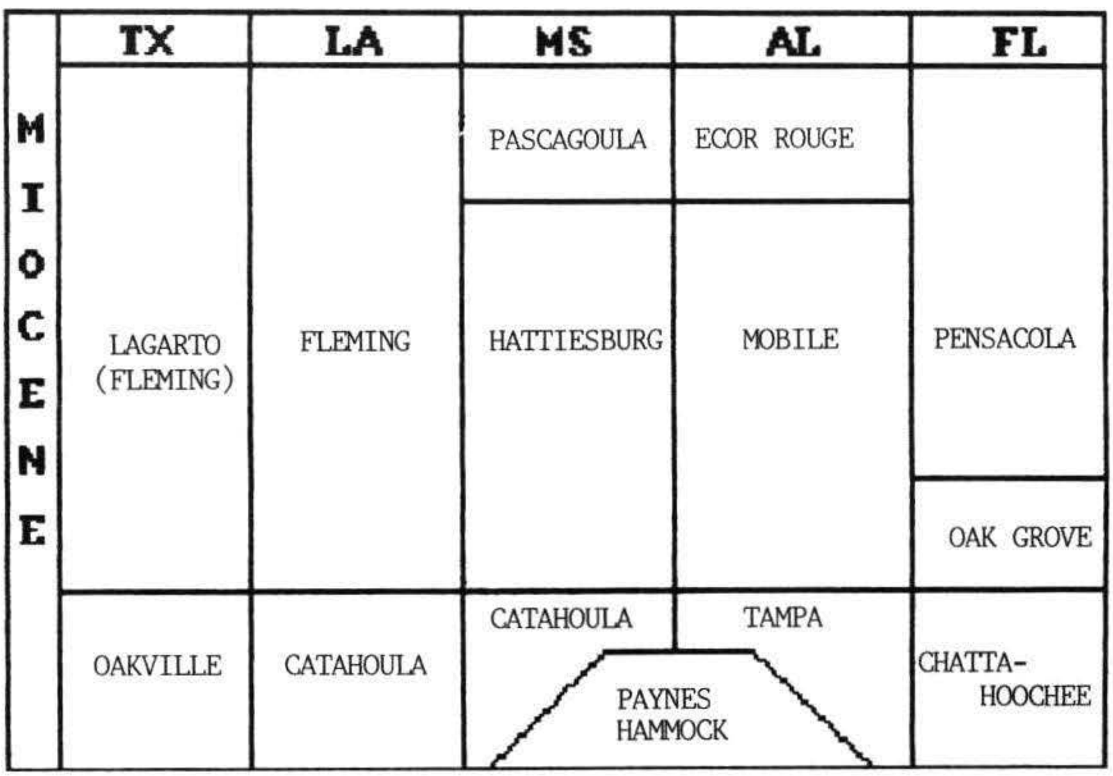

Figure 1. Generalized correlation chart for Gulf Coast Miocene sediments. Modified from Isphording (1983) and Rainwater (1964a).

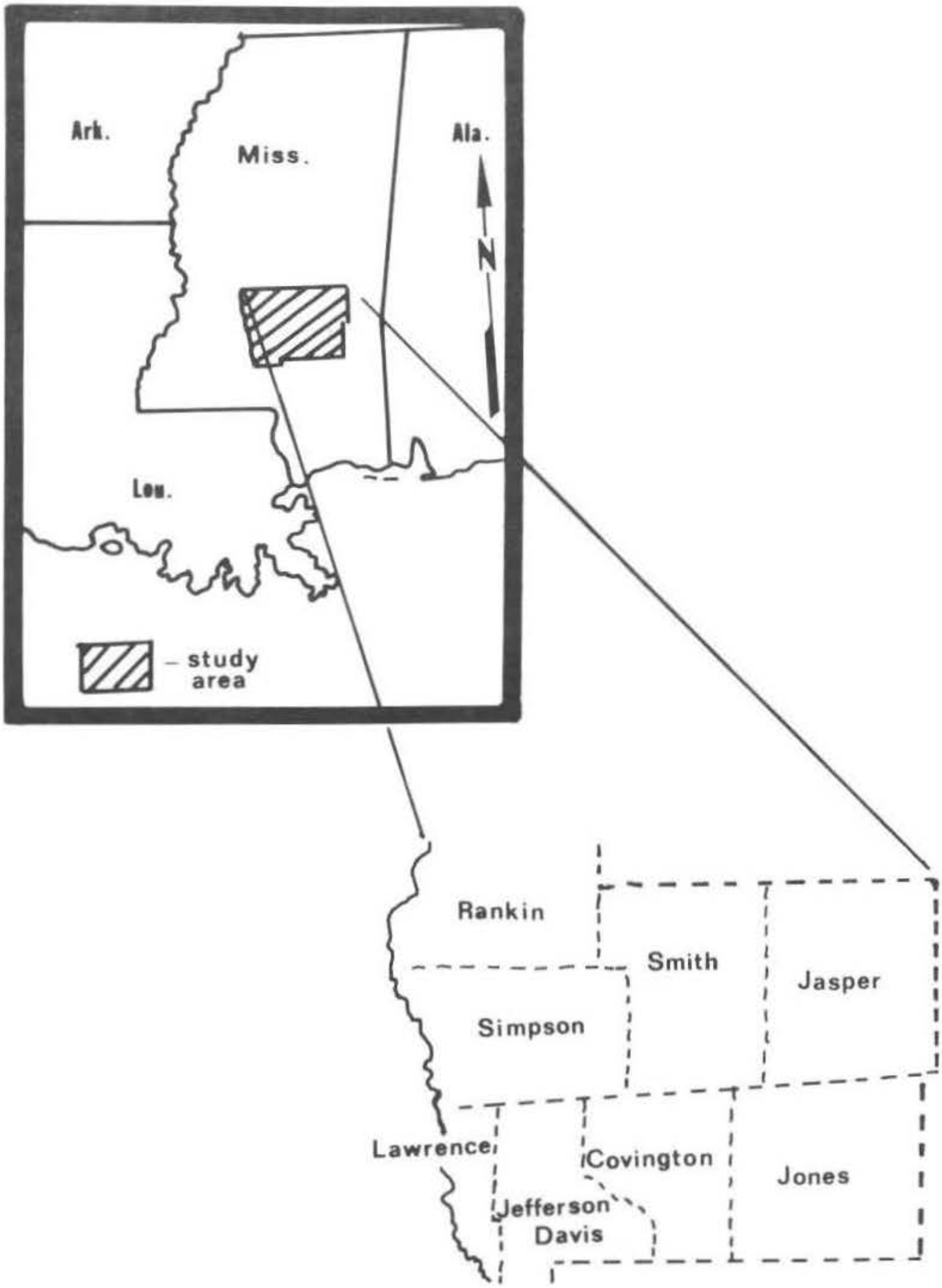

Figure 2. Location of the study area.

study. These outcrops are located in Simpson and Smith counties (Figure 4). No one location found within the study area contains a "complete" section of the Catahoula Formation; exposures are quite limited both laterally and vertically. The limited nature of the exposures causes difficulties with respect to interpretations of facies relationships and depositional environments. The outcrops were first described and then, on the basis of elevation, fitted into subsurface cross-sections that were constructed on the basis of well information and electric logs.

RESULTS

The Catahoula Formation in the study area occurs at the outcrop as a unit with an average composition of medium- to very fine-grained sandstone (69%), with clay (17%), and siltstone (14%). The lower contact with the Bucatunna Formation was observed in the field, but the upper contact with fine sediments assigned to the Hattiesburg Formation was not seen at the outcrop.

What is currently designated as the "Hattiesburg" appears to pinch out updip within the study area due to non-deposition and/or erosional processes associated with the fluvial systems that deposited overlying Citronelle sands and gravels. As previously mentioned, the coarse sediments seen at the outcrop may belong to the Citronelle Formation or the Catahoula Formation. The main problem with the current classification at the outcrop has to do with the overuse of color as a mapping criterion (James May, U.S. Army Corps of Engineers, Waterways Experiment Station, 1986, personal communication). Color has traditionally been used as a key criterion to identify the "Citronelle". It has been observed by the author at the outcrop that the Catahoula Formation sands and gravels may exhibit the same coloration as the "Citronelle". This coloration is due to the percolation of iron-rich waters throughout the pore spaces of sands. Thus, Catahoula Formation sands that have been exposed at the surface for an extended period of time will take on this coloration, while freshly exposed sands retain their original grayish-white color.

The sands of the Catahoula Formation are generally pinkish-white to light gray or buff white, fine- to very fine-grained, subangular to subrounded, with moderate to poor sorting. Wojna (1985), whose study area is encompassed by the present study area, gave the detrital components of the sandstones as quartz 86.6%, rock fragments 8.1%, and feldspar 5.3%. He also indicated that the clay mineral percentages were kaolinite (66%), illite (24%), and smectite (10%); the smectite occurs only in the middle unit of the Catahoula Formation. These sand units vary in thickness from 2 to 15 feet. The domi-

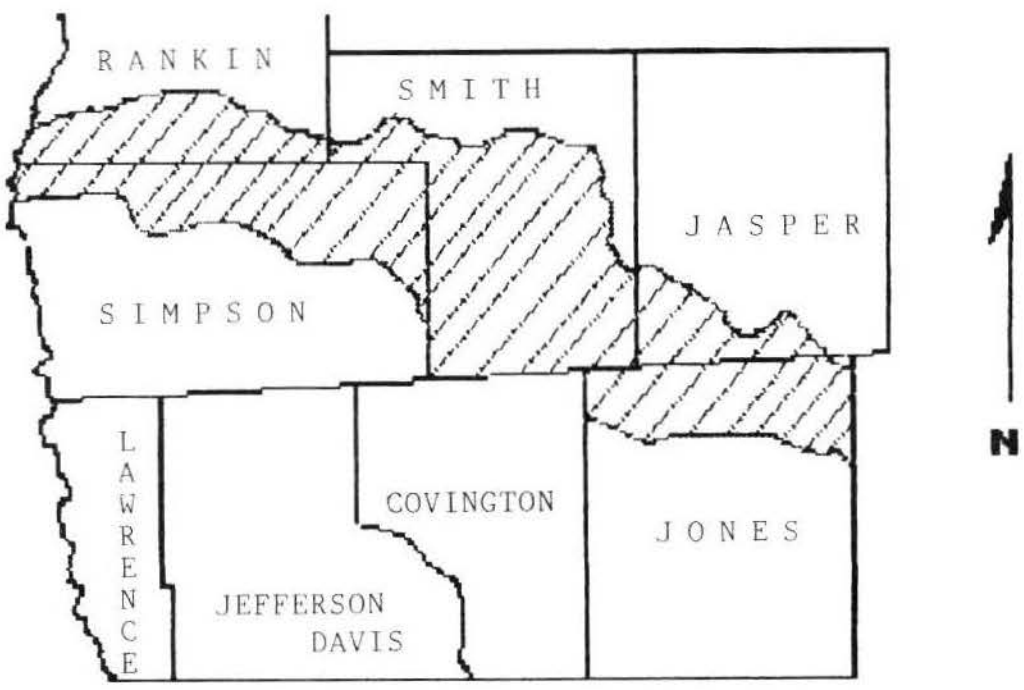

Figure 3. Outcrop belt (shaded) within the study area. Exposures within this area are very discontinuous and intermittent.

nant structures appear to be laminated bedding in the fine-grained sands, and small to medium cross-beds in the medium-grained sands. The siltstones are mostly gray to white, and clayey. They vary in thickness from 1 to 12 feet. The clays are gray to yellowish-gray, and a large number exhibit red or purplish mottling. A few are also silty and/or sandy. These clays range in thickness from less than 1 foot to 6 feet.

The Catahoula Formation's lower contact with the Bucatunna is unconformable. This opinion is based primarily upon observation of the sharp contact and abrupt change in lithologies. Also, the Bucatunna is carbonaceous and partly fossiliferous, aspects generally missing in the Catahoula. This contact is exposed at location F, where the dark gray Bucatunna Formation is in abrupt contact with a unit comprised of alternating mottled, light-gray clays and yellow-orange, fine- to very fine-grained sands.

An upper contact with a fine-grained unit ("Hattiesburg"?) is present in the subsurface except where a sand and possibly a gravel unit has cut through to the Catahoula Formation. The "Hattiesburg" appears above the upper Catahoula sand as a clayey section, variable in thickness from 50-120 feet, and containing sand lenses, which are no more than 20-30 feet in thickness and of limited lateral extent.

The Catahoula Formation in the subsurface of the study area may be divided into three distinct units (Figure 5). The upper sand unit has a thickness from 175 feet to 325 feet. It is persistent only in the subsurface of the southern part of the study area. This sand is the unit currently being called "Citronelle" updip. Next, there is a middle unit (250 to 350 feet thick), composed mainly of silt and clay, with recurrent sands. The outcrops in and around Mendenhall (locations C, D, and I), along with the easternmost outcrop (location A), appear to belong to this middle unit. These sands are fluvial channel (probably point bar) and associated floodplain deposits. A lower unit (75 to 140 feet thick) is made up of sand and finer sediments (silt and clay).

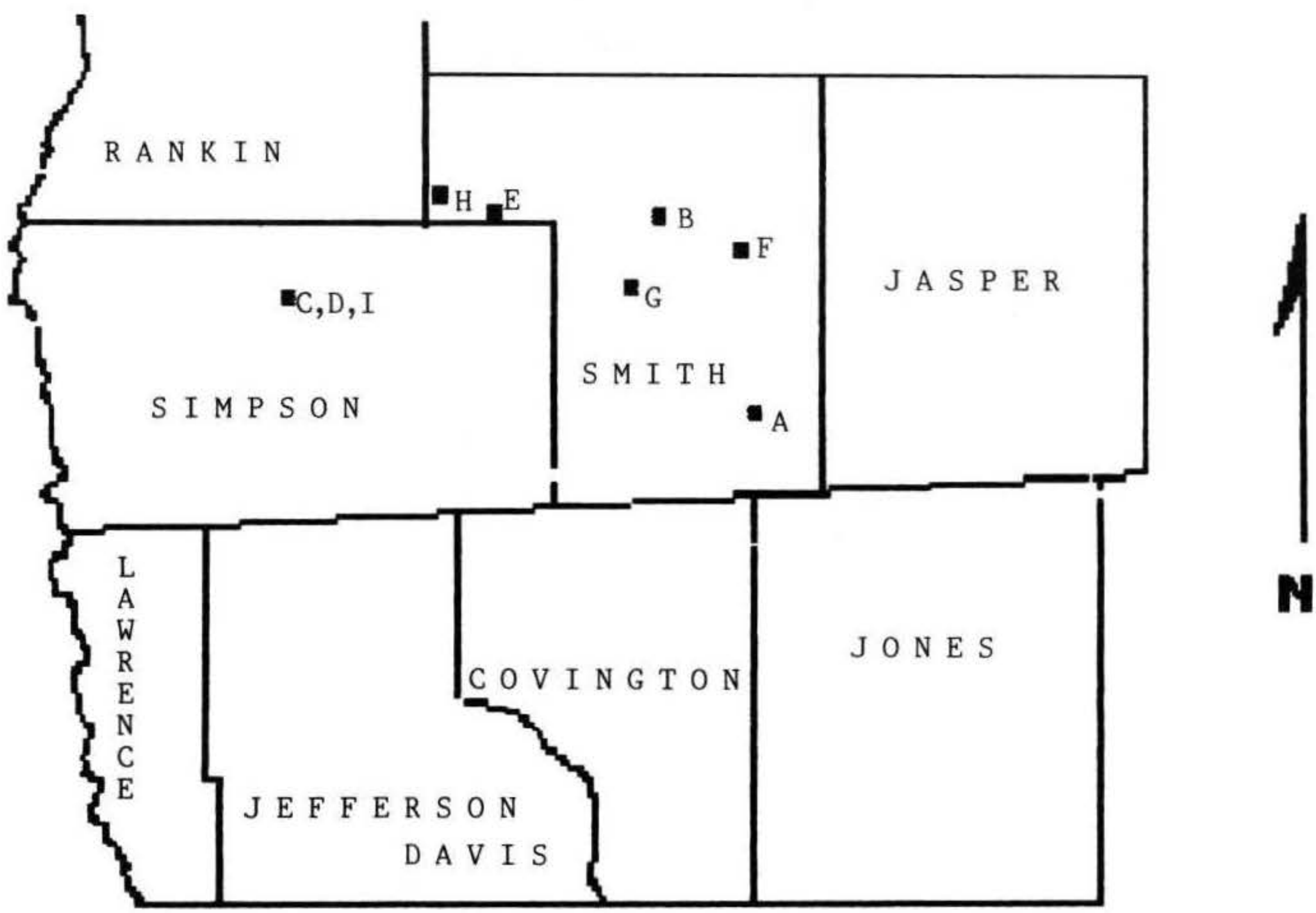

Figure 4. Location of outcrops within the study area.

The sands in this unit are relatively thin and lacking in areal extent, although they appear to be "stacked" in some areas, which is often indicative of deposition in incised fluvial channels. Part of this unit may be seen at outcrop location F, where it is in contact with the Bucatunna Formation. At location H the thin basal sands coarsen upward and exhibit characteristics of shorezone depositional environments.

DISCUSSION

Within the study area, the Catahoula Formation consists of non-marine sands, silts, and clays. This varied lithology, and the absence of marine facies, is indicative of a fluvial sequence. The majority of the sands present are interpreted as being either point bar sequences, other coarse-grained fluvial channel deposits, or overbank deposits (finer sands).

The point bar sequences are rarely complete, due to the upper fine-grained units being removed and reworked downstream. These units have the fining upward sequences and textural and sedimentary structure variations typical of fluvial channel sediments deposited by both braided and meandering stream systems. Location C best exemplifies a point bar sequence with finer sediments (silts and clays) deposited as either part of this point bar complex or as associated floodplain deposits.

A few test holes drilled by Luper (1972) in Smith County indicated the presence of some lignite (test hole AL-50) or other carbonaceous materials (test holes AL-60, AL-40, and AL-37). This material was described as being present with silts and clays, further indicating a floodplain depositional environment and/or accumulation in low-energy swales in the upper portions of the sand bars.

One surprising characteristic is the fact that there are few coarse-grained sediments (gravels) to be found in what is currently identified as the Catahoula Formation updip. Possible explanations for this are as follows:

1. The rivers and streams that carried these sediments did not have sufficient energy to do so.
2. In the source area, there were few coarse-grained sediments (pebbles, cobbles) available to be transported downstream.
3. These gravels (or coarser grained sediments) may have been reworked downdip.
4. At the outcrop, "Citronelle" sands and gravel are misinterpreted, and may be correlated with similar sediments (upper member of the Catahoula Formation) downdip.

The data and observations gained from this study point toward a combination of 3 and 4 from above. Gerald (1985) discovered the presence of gravels downdip within the Catahoula Formation. Similarly, the subsurface data developed by this study indicate that these gravels and coarse-grained sediments are represented updip by what is currently indentified as "Citronelle" sediments. In Simpson and Smith counties (updip), these coarser sediments are consolidated and form the large hills that make up the area. Since the deposition of these sands and gravels, rivers and streams have reworked part of these sediments and deposited them to the south.

In areas where the rate of sea-level lowering outpaces local or regional rates of sediment accommodation, all or part of the exposed fluvial and/or nearshore marine sediments preserved during the waning stages of the last transgressive cycle will be stripped by erosion during deposition of the next offlapping facies (May, 1980). This seems to be the case in the study area, as several cross-sections indicate a thinning in

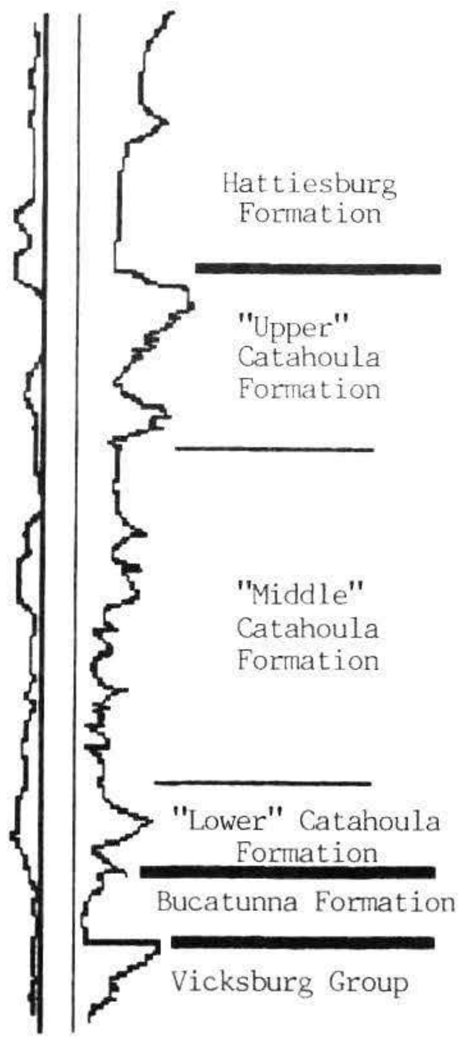

Figure 5. "Typical" log showing the three "members" of the Catahoula Formation.

the Bucatunna in several areas, which is probably due to erosion before the deposition of the lower Catahoula sediments. The lower Catahoula sands and associated facies are then interpreted as being predominantly of fluvial origin within the study area.

The middle Catahoula was deposited by rivers and streams that were similar to those that drain the study area today (Pearl River, Leaf River). The rivers and streams that transported the sediments deposited in this part of the formation were probably sinuous, and carried sediments ranging from medium-grained sand to silt and clay.

Sands of the upper part of the formation may have been deposited by larger streams than those that acted during deposition of the lower and middle members. This opinion is based on the thickness and continuity of the sand bodies of the upper member. A shift in sediment supply, hydraulic capacities or stream competence, and/or a change in rates of depo-center accommodation might also account for greater sand distribution in the upper member.

The stratigraphy of Miocene sediments of the Neogene section in this part of Mississippi is a complex problem. The cumulative results of this investigation reveal that the fundamentals for defining rock stratigraphic units at the "formational" level are absent with respect to the exposed ("updip") Mississippi Neogene succession.

Many questions remain as to which sediments belong to the Miocene and which sediments belong to a younger series, as the age and position of the Catahoula's upper boundary are debatable. The "Hattiesburg" unconformably overlies the Catahoula Formation in the southern part of the study area, and thins updip to a point where it is non-existent. The "Hattiesburg" is represented in the subsurface by a fine-grained interval approximately 50 to 120 feet thick. The top of the Catahoula Formation in the study area is picked as the top of a massive sand unit that is present throughout most of the subsurface. This upper sand member is currently mapped as "Citronelle" on the surface, and comprises the large hills present throughout Simpson and Smith counties.

The massive upper Catahoula sand was not found updip at the outcrop. The following alternatives are offered to explain this:

1. The upper sand was "faulted out". This alternative is not considered reasonable, since no such structural elements appear to cut the underlying Vicksburg rocks.
2. Non-deposition or erosion (reworking) of this upper sand. No evidence has been found to either deny or support this possibility.
3. A facies misinterpretation (updip) concerning the nomenclature of the Citronelle vs. the Catahoula formations. This alternative is favored because: a) dip sections show that the thick upper sands of the Catahoula Formation (overlain by "Hattiesburg") trend to the outcrop mapped as "Citronelle", and b) the original criteria used to distinguish "Citronelle" from "Catahoula" are non-diagnostic with respect to mapping at the formational level.

It should be noted that Gerald (1985) discovered the presence of gravels downdip within the Catahoula Formation and/or the Hattiesburg Formation. Thus it would appear that much of what is mapped at the outcrop as Citronelle in this area (especially in Smith County) is really oxidized sand and gravel of the Catahoula Formation. Collectively, the data and observations of this study suggest that the third alternative is the most attractive hypothesis. At the updip limit of the outcrop belt the fine-grained Hattiesburg Formation appears to wedge out and is often replaced by a sand unit. This sand unit appears to have cut down into fine-grained units of the Catahoula Formation and may be what is currently mapped as "Citronelle". Alternatively, this disconformable unit may represent a reworked Catahoula Formation sand cycle.

CONCLUSIONS

This study has identified some major problems and misconceptions regarding Neogene stratigraphy and existing geological maps in south-central Mississippi. Although the conclusions drawn here apply directly to the study area under consideration, they are also pertinent to immediately adjacent sectors to the east and west.

1. The fundamental criteria for defining rock stratigraphic units at the "formational" rank are absent with respect to the exposed ("updip") Neogene section in this part of Mississippi. The base of the section is reasonably well defined by its contact with the Bucatunna Formation (Oligocene Vicksburg Group). However, a mappable bounding sequence above the Catahoula-Bucatunna Formation contact does not crop out in the study area.
2. A fine-grained, bounding sequence (Hattiesburg Formation?) above the Catahoula Formation is recognizable in the subsurface of the study area. However, this overlying sequence appears to wedge-out before reaching the outcrop.
3. Differentiation between updip Catahoula gravels and similar facies of the Citronelle Formation is difficult (if not impossible) based on the results of the current study.
4. The Catahoula Formation is definable in the subsurface of the study area, and appears to be

made up of three (informal) members:

(a) A basal unit composed of sands with subordinate fine-grained facies.

(b) A relatively fine-grained middle unit composed of silts and clays with recurrent, discontinuous sand bodies.

(c) An upper unit composed largely of sands and gravels. Portions of this unit are mapped as "Citronelle" in updip portions of the study area, especially Smith County.

5. Most of the Catahoula Formation (as identified in this investigation) is represented by fluvial channel and associated floodplain facies.

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