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THE FIRST EARLY EOCENE MAMMAL FROM EASTERN NORTH AMERICA:AN OMOMYID PRIMATE FROM THE BASHI FORMATION,LAUDERDALE COUNTY, MISSISSIPPI

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ABSTRACT

An omomyid primate recovered from the earliest Eocene Bashi Formation, Lauderdale County, Mississippi, is both the first fossil primate and the first early Eocene mammal to be recorded from eastern North America. On the basis of this new occurrence, the Wasatchian Land Mammal Age can be correlated directly with calcareous nannoplankton Zone NP10, planktonic foraminiferal Zone P6b, and the lower part of the Ypresian Stage for the first time.

INTRODUCTION

Fossil primates are poorly represented in North American Cenozoic strata east of the intermontane basins of the Rocky Mountain Region. Stratigraphically and geographically sporadic records are known from the Great Plains (see review by Storer, 1990) and from as far southeast as the Texas Gulf Coastal Plain (Westgate, 1990), but fossil primates have not previously been recovered from east of the Mississippi River. However, because of the rarity of mammal-bearing early Cenozoic localities in the southeastern United States [the few exceptions are discussed by Schiebout (1979), Schoch (1985), and Westgate (1986, 1990)], many workers have assumed that primates ranged over this region at this time, despite the absence of a fossil record to support such speculation. Indeed, this region has been cited as a potential geographic center of origin for Primates and other higher-level mammalian taxa that first appear at the beginning of the Wasatchian Land Mammal Age in the western interior of North America (Schiebout, 1979, 1981; but see critique by Krause and Maas, 1990).

In light of these considerations, the recovery of an omomyid primate from the lower Eocene Bashi Formation in Lauderdale County, Mississippi, significantly extends our knowledge of the spatiotemporal distribution of early Cenozoic primates in North America. This specimen, YPM-PU 23984, is both the first fossil primate and the first early Eocene mammal to be reported from eastern

North America. It is also the only fossil mammal currently known from the Bashi Formation, although we hope that ongoing field work will yield further mammalian specimens from this unit.

HISTORY OF DISCOVERY AND PROVENANCE

The omomyid jaw fragment was collected by Gerard R. Case while screen-washing matrix from the Bashi Formation for fossil marine vertebrates. The specimen was derived from the well known outcrop of the Bashi Formation exposed behind the Red Hot Truck Stop in NW 1/4, NW 1/4, NE 1/4, Sec. 20, T. 6 N., R. 16 E., Meridian, Lauderdale County, Mississippi. This locality corresponds to Mississippi Office of Geology locality MGS 19 (see Dockery, 1980) and to Carnegie Museum of Natural History (CM) fossil vertebrate locality 518. Macroinvertebrate fossils from this locality have been described by Dockery (1980). Case (1986) has briefly discussed the fossil teleosts.

Both the Tuscahoma and Bashi formations are exposed behind the Red Hot Truck Stop, where each has produced fossil vertebrates, including mammals. Unfortunately, there has been some confusion regarding the exact provenance of some vertebrate specimens from these two units. In particular, Holman (1982) reported the snake *Palaeophis casei* from the Bashi Formation, but the specimens he described were actually collected from the upper part of the Tuscahoma Formation at what is now CM locality 517 (see Case, 1986; Parmley and Case, 1988), stratigraphically about 10 feet below the Tuscahoma-Bashi contact. This locality is also in NW 1/4, NW 1/4, NE 1/4, Sec. 20, T. 6 N., R. 16 E., not in Sec. 6, T. 6 N., R. 16 E., as reported by Parmley and Case (1988).

Despite the problems discussed above, two factors demonstrate that YPM-PU 23984 was collected from the Bashi Formation rather than from the Tuscahoma Formation. First, a small amount of yellow sandy matrix, which corresponds to that from the Bashi Formation but which differs strikingly from the green sandy matrix of the Tuscahoma Formation, still adheres to the specimen. Additionally, Case's original field notes record that the specimen was derived from the "Boulder Zone" of the Bashi Formation (see also Case, 1986), a distinctive lithologic unit that is easily distinguished from the clays, sands, and glauconitic marls of the underlying Tuscahoma Formation (Dockery, 1980, 1986).

DESCRIPTION

YPM-PU 23984 is a left dentary fragment of an omomyid primate preserving the crown of m3 together with the posterior root and part of the anterior alveolus for m2 (Figure 1). The preserved part of the dentary itself reveals that the bone was robust mediolaterally, measuring 2.35 mm in this dimension at the level of the posterior root of m2. The inferior border of the dentary has been eroded away, so that the depth of the lower jaw cannot be determined. Posteriorly, only small parts of the coronoid process and masseteric fossa remain.

The m3 measures 2.50 mm (maximum mesiodistal length) X 1.75 mm (maximum buccolingual width of trigonid) X 1.50 mm (maximum buccolingual width of talonid). The principal cusps, particularly those of the trigonid, show a moderate degree of basal inflation, similar to that found in the anaptomorphine genera *Tetonius*, *Pseudotetonius* and *Absarokius* (see Szalay, 1976; Bown and Rose, 1987). The metaconid is the largest of the three trigonid cusps, but it is only slightly larger than the protoconid. The paraconid, which is reduced in comparison to the former cusps, is closely appressed to the mesiobuccal base of the metaconid, from which it is separated by a distinct valley. The paraconid is connected to the apex of the protoconid by an arcuate paracristid which forms the mesiobuccal border of the trigonid. The rounded, internal sides of the three trigonid cusps meet near the center of the trigonid, resulting in the isolation of two diminutive trigonid foveae mesially and distally. A moderately developed ectocingulid occurs on the mesiobuccal aspect of the trigonid. The buccal surface of the trigonid slopes more gradually than does the lingual surface, and the crown is moderately exodaenodont as a result. The talonid is narrower than the trigonid. The cristid obliqua runs mesiolingually from the hypoconid to join the postvallid near the base of the protoconid, yielding a shallow hypoflexid. The region surrounding the entoconid is unusual in that a distinct crest runs distobuccally from the apex of the entoconid toward the modest hypoconulid lobe. A second, mesiolingually trending crest runs, in turn, from the hypoconulid to the base of the entoconid. The distolingual margin of the m3 talonid is thus characterized by dual crests separated by a distinct valley.

Overall, the m3 preserved in YPM-PU 23984 possesses a combination of features that is not exactly matched in the corresponding tooth of any known omomyid. For this reason, and because of the isolated provenance of the fossil, we consider it likely that YPM-PU 23984 represents a previously undescribed omomyid taxon. However, the material at hand is too fragmentary to serve as the basis for a new species, and we therefore refrain from naming one here. YPM-PU 23984 most closely resembles relatively primitive omomyid genera such as *Teilhardina*, *Tetonius*, *Absarokius* and *Jemezius* in its preserved morphology (see Bown and Rose, 1987; Beard, 1987). Based on the morphologic similarity between YPM-PU 23984 and other relatively primitive omomyids, together with the general consensus based on marine biochronologies that the Bashi Formation is

Figure 1. The YPM-PU 23984 omomyid primate specimen from the Bashi Formation. Views are: occlusal (top), buccal (middle) and lingual (bottom). Scale equals 3 mm.

earliest Eocene in age (see below), we conclude that the Bashi Formation is temporally equivalent to part of the Wasatchian North American Land Mammal Age (NALMA) as it is defined in the western interior (Wood et al., 1941; Krishtalka et al., 1987).

CORRELATION BETWEEN WASATCHIAN NALMA AND MARINE BIOCHRONOLOGIES

The succession of land mammal faunas in the North American Paleogene is becoming increasingly well documented, but only in a few cases has it been possible to correlate directly between these terrestrial biochronologies and the marine realm. This problem is particularly vexing for those who are interested in reconstructing patterns of mammalian biogeography and dispersal on an intercontinental scale, because it has rarely been possible to assess the relative ages of taxonomically similar mammalian faunas on different continents by a means other than biostratigraphic correlation based on the mammals themselves (Wing, 1984). This type of correlation logically denies the possibility that, for example, a mammalian fauna from Europe is older than a compositionally similar fauna known from North America.

One of the most important biogeographic events in the early Cenozoic history of North America occurred at the base of the Wasatchian NALMA, at which time several higher-level mammalian taxa, including the orders Perissodactyla, Artiodactyla and Primates and the creodont family Hyaenodontidae, immigrated to the continent from a geographic source that is the subject of dispute (Godinot, 1982; Gingerich, 1986, 1989; Krause and Maas, 1990). Correlation of the base of the Wasatchian NALMA with marine biochronologies would help resolve this issue by providing an independent means of assessing the relative ages of the first appearance of these taxa on different continents, thereby constraining models of mammalian dispersal at this time. Although we are not currently able to correlate the base of the Wasatchian NALMA directly with marine biochronologies, the new occurrence reported here does place new limits on this correlation.

The Bashi Formation has been regarded as earliest Eocene in age based on calcareous nannoplankton (Bybell, 1980; Gibson and Bybell, 1981), planktonic foraminifera (Oliver and Mancini, 1980; Mancini, 1981), and palynomorphs (Frederiksen, 1979, 1980; Frederiksen et al., 1982). Bybell (1980) and Gibson and Bybell (1981) assigned calcareous nannofossils from the Bashi Formation to the lower part of Zone NP10 of Martini (1971). This assignment is based on the co-occurrence of *Tribrachiatus bramlettei*, which is restricted to Zone NP10, with *Transversopontis pulcher*, *Discoaster binodosus*, and *Campylosphaera dela*, all of which first appear at or near the base of Zone NP10 (Gibson and Bybell, 1981). The boundary between Zones NP9 and NP10 is generally accepted as the Paleocene-Eocene boundary (see Berggren et al., 1985).

Planktonic foraminifera collected from the Bashi Formation have been assigned by Oliver and Mancini (1980) and Mancini (1981) to the lower part of the *Morozovella subbotinae* Interval Zone of Bolli (1957, 1966), which is equivalent to the lower part of Zone P6b of Berggren (1969). This assignment is based on the co-occurrence of *Morozovella subbotinae, M. acuta, M. aequa, Acarinina wilcoxensis, Subbotina velascoensis* and *Pseudohastigerina velascoensis*, as well as the absence of *Morozovella velascoensis* and *M. occlusa*, which last appear in the preceding *Morozovella velascoensis* Interval Zone (see Stainforth et al., 1975).

Frederiksen et al. (1982) assigned an early Eocene age to the Bashi Formation on the basis of an abrupt change in the composition of palynomorph assemblages across the Tuscahoma-Bashi formational boundary in eastern Alabama and western Georgia. This change in palynomorph assemblages is equated with the Paleocene-Eocene (NP9-NP10) boundary. Assemblages from the Bashi Formation include *Platycarya* sp. and nine other taxa that are otherwise restricted to Zone NP10 and later intervals. Wing (1984) correlated the first appearance of *Platycarya* pollen in the abundantly fossiliferous Willwood Formation, Bighorn Basin, Wyoming, with the NP9-NP10 boundary, thus arguing that the Paleocene-Eocene boundary lies within the early part of the Wasatchian NALMA.

As noted previously, omomyid primates are among the taxa that first appear in North America near the beginning of the Wasatchian NALMA (Krishtalka et al., 1987). The recovery of an omomyid from the Bashi Formation thus allows us to make the first direct correlation between the Wasatchian NALMA and calcareous nannoplankton Zone NP10, planktonic foraminiferal Zone P6b, and the lower part of the Ypresian Stage. A more diverse but somewhat younger Wasatchian mammal fauna from Baja California Norte, Mexico, occurs in beds that intertongue with marine strata assigned to the "Capay" Stage on the basis of marine macroinvertebrates, benthic foraminifera, and ostracodes (Novacek et al., 1987; Flynn et al., 1989). The "Capay" Stage correlates in turn with planktonic foraminiferal Zones P7-P8, calcareous nannoplankton Zones NP11-NP13, and the middle part of the Ypresian Stage (Flynn et al., 1989). Hence, correlations of the Wasatchian NALMA with marine biochronologies of the Gulf and Pacific coasts are mutually consistent and together indicate a broad correlation between the Wasatchian NALMA and the Ypresian Stage. Direct correlation of the base of the

Wasatchian NALMA with marine biochronologies must rely on older mammalian fossils than those from either the Bashi Formation or those currently known from Baja California Norte, Mexico.

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FINDS OF FOSSIL WOOD FROM UPPER CRETACEOUS SEDIMENTS, NORTHEASTERN MISSISSIPPI

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LIGNITIZED WOOD FROM THE TOMBIGBEE SAND

Introduction: The main purpose of this article is to report the investigation of two lignitized log segments found in the upper part of the Tombigbee Sand Member of the Eutaw Formation, Upper Cretaceous, in Monroe County near Aberdeen, Mississippi (see Stephenson and Monroe, 1940, for a description of Upper Cretaceous deposits in Mississippi). The fossil logs were obtained at different times by staff of the Office of Geology of the Mississippi Department of Environmental Quality, but came from the same concretionary layer within the Tombigbee Sand. The lignitic material came from open pits for the mining of bentonite, a kind of clay used by industry in bleaching (oil clarification) and in drilling for oil (Mellen, 1959; Anonymous, 1988). The commercial bentonite layer is in the lower part of the Tombigbee Sand. The fossil logs discussed come, however, from the upper of three indurated (sandstone/concretion) layers of the Tombigbee Sand, occurring within a sand sequence above the bentonite layer. A discussion of bentonite, its volcanic/seawater origin, and the bentonite excavations south of Aberdeen, Mississippi, may be found in Merrill's work (1981, 1983). Merrill's master's thesis (1981) contains a good discussion of the Tombigbee Sand in general and a measured section of an excavation showing the location of the bentonite layer and the concretionary layers above. Marine invertebrate fossils are seen to become more abundant as the upper of the three calcareous sandstone layers is approached. The lignitized logs each came from within calcareous sandstone concretions of the uppermost concretionary layer, and are not mentioned per se in Merrill's work.

The Eutaw Group of sediments (see Dockery, 1981; Merrill and others, 1988) consists of the McShan Formation and the Eutaw Formation; the Eutaw Formation is in turn subdivided into the Lower Eutaw Member (or "Eutaw per se") and an upper portion known as the Tombigbee Sand Member. The Eutaw Group is in general the product of shallow marine deposition. The beginning of Eutaw deposition represents a return (transgression) of the Cretaceous sea into what is now northeastern Mississippi and northwestern Alabama; the underlying Tuscaloosa Formation is, by contrast, mostly a consequence of fluvial (nonmarine) deposition (Dunbar and Waage, 1969). The Lower Eutaw Member shows cross-bedding (Parks, 1960; Merrill and others, 1988), a feature indicative of near-shore deposition. The Tombigbee Sand Member constitutes perhaps a slightly deeper marine facies than the lower part of the Eutaw, in that bedding structure is generally lacking and the sediment is strongly bioturbated (Merrill, 1981). During Tombigbee time, the sea (Gulf) received large amounts of sand from the discharge of rivers and streams. Much of this sand was deposited seaward below the wave base--and hence the lack of preservation of evidence of disturbance, turbulence, or cross-bedding, cf. Merrill (1981). Logs, and driftwood in general, were no doubt rafted out to sea from their terrigenous points of origin, and buried (cf. Mellen, 1958, p. 8, in reference to lignite flotsam). It seems reasonable to speculate that some of these trunk segments may have provided a nucleus around which calcareous sandy masses became cemented, helping in effect to preserve the trees. The above would clearly explain the occurrence of fossil trees with what is a fundamentally marine fauna, e.g., as with the oyster, *Exogyra ponderosa* (cf. Vestal, 1943). Lignitized logs present in the Tombigbee Sand were probably growing on land situated along or near the coastline. Both fossil logs in the study were bored by the marine pelecypod, *Teredo*, a wood-boring clam present in shallow Cretaceous seas (cf. Mellen, 1958). Although extensively bored, i.e., in spite of abundant calcareous *Teredo* tubes, sufficient wood structure was preserved to permit determination. In one of the logs (labelled TBS-1 in this study), abundant wood structure was preserved toward the interior of the log.

Materials and Methods: Wood samples from both logs were prepared for sectioning in the manner described by Blackwell and Marak (1989) for lignitized and mummified woods. In brief, cubes or other small segments of the wood were dehydrated in several changes of acetone. The acetone was subsequently replaced, stepwise, by Spurr's epoxy mixture, until the specimens were infiltrated with 100% epoxy resin. The specimens in epoxy were cured in small, cubical plastic molds. The cubes of solid plastic (epoxy)-embedded wood obtained were attached to (i.e., mounted on) slides with another type of epoxy (of suitable optical property), and then thin-sectioned by standard petrographic techniques. Cross, radial-longitudinal, and tangential-longitudinal sections were made of wood specimens of each of the two logs. Coverslips were applied to the finished, polished slides with the same epoxy used to attach the epoxy cubes to the slides. Upon curing of the epoxy used to mount the coverslips, the slides (thin-sections) were then ready for viewing with and photography through a light microscope. Views of microscopic thin-sections of the wood of two fossil logs are illustrated in Plates 1 and 2.

Results: Plate 1 (Figures 1-7) illustrates the wood structure of the first log obtained by the Office of Geology from the bentonite pit; it is labelled TBS-2 (Tombigbee Sand #2) in this study because it was the second of the two logs to be sectioned for microscopic examination. This lignitized log is one foot in diameter and 2.5 feet long, and is held together by a sandstone rind and a dense interior network of calcite-filled *Teredo* borings. It was collected by Cragin Knox and is stored at the Mississippi Office of Geology. Resin ducts are present in specimen TBS-2 as is evident in the cross and tangential sections of Figures 1-2 and 6. Higher magnification of a resin duct in cross-section, as in Figure 2, illustrates the lack of a definitive (i.e., thick-walled) epithelium lining the inner surface of the resin duct. This suggests the wood of a pine (*Pinus*), cf. Phillips (1948). The lack of dentate ray tracheids, the apparently gradual transition (in the faint growth rings seen) from earlywood to latewood (Figure 1), and the presence of window-like or lenticular cross-field pits (between tracheids and ray parenchyma) are all features indicative of the soft or white pine group within the genus *Pinus*, as opposed to hard or yellow pines (see Panshin and de Zeeuw, 1980). Certain features of the wood, such as the particular nature of the cross-field pitting (Figure 4), are suggestive of both (i.e., are intermediate between) eastern and western North American white pines--respectively, *Pinus strobus* and *Pinus monticola*. However, statements such as the preceding are not to be taken as an assertion of actual identification, but rather as a suggestion (mere comparison) of resemblance of woods in this study to those of extant woods. Difficulty of precise identification of Cretaceous pine wood to species is consistent with that encountered by Blackwell (1984). Pertinent is the assertion by Jeffrey and Chrysler (1906) that, whereas pine was distinct as a genus during the Cretaceous (and probably even by the beginning of the Lower Cretaceous, cf. Mirov, 1967; Stewart, 1983; Axelrod, 1984), certain specific and even subgeneric distinctions within the genus *Pinus* did not clearly differentiate until the early Tertiary. In one wood slide-section prepared, TBS-2-R2 (i.e., radial section 2), a pattern of spiral-checking/spiral-banding was observed in tracheids (water conducting cells) of one portion of the wood (Figure 5). This rather small surface area of the slide showing spiral pattern is interpreted not as a "genetic" feature of the wood, as might be found throughout the wood of yews (*Taxus*), but rather as a local area of "compression wood" within the stem. "Compression wood" can be produced by tension on a tree trunk induced perhaps by leaning (cf. Jane, 1970) prior to uprooting and/or breakage.

Plate 2 (Figures 8-14) illustrates the second log obtained from the uppermost indurated layer of the bentonite pit (labelled TBS-1 in this study since it was the first log to be sectioned for microscopy). This specimen was collected in pieces from the interior of a large sandstone concretion by Bograd and Dockery on June 28, 1989. It does not exhibit resin ducts in microscopic (or macroscopic) section (e.g., Figures 8 and 14) and so does not show the larger "holes" in cross section present in TBS-2, except perhaps as one might encounter a minor point of injury or decay. Lacking resin ducts, as does this specimen, such coniferous trees as pines, spruces, douglas-firs, and larches may be eliminated from consideration (cf. Stover, 1951; Esau, 1960; Jane, 1970). Nonetheless, stringers of amber (i.e., fossil coniferous resin) are visible macroscopically in this trunk segment. The wood of this specimen (TBS-1) is remarkably well preserved, and exhibits good microscopic detail. The majority of the wood cells seen in

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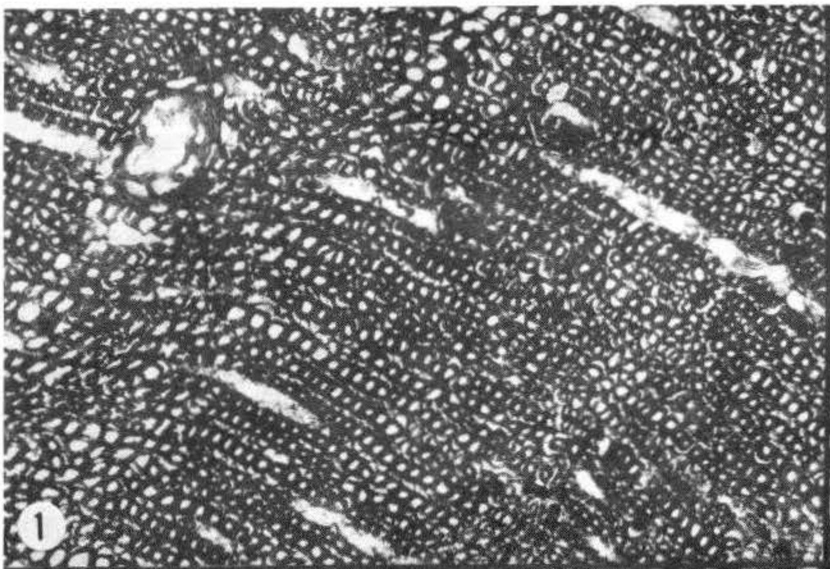
PLATE 1

Figures 1-7, photomicrographs of specimen TBS-2, fossil pine-like wood from the Tombigbee Sand: (1) Cross section; resin duct toward upper left; X 100. (2) Resin duct, center of photo, X 200. (3) Radial-longitudinal section; tracheids with uniseriate, intertracheal pits evident; X 400. (4) Similar to 3 but showing traversing ray with cross-field pitting, X 400; crack-like mark in lower right and in several other photos is due to natural splitting of the wood due to drying. (5) Radial section through what is apparently a zone of compression wood; note spiral-like markings throughout photo; X 400. (6) Tangential-longitudinal section showing ray containing a resin duct transected, center, X 400. (7) Lower magnification of tangential section, showing uniseriate rays transected, e.g. arrow, X 200.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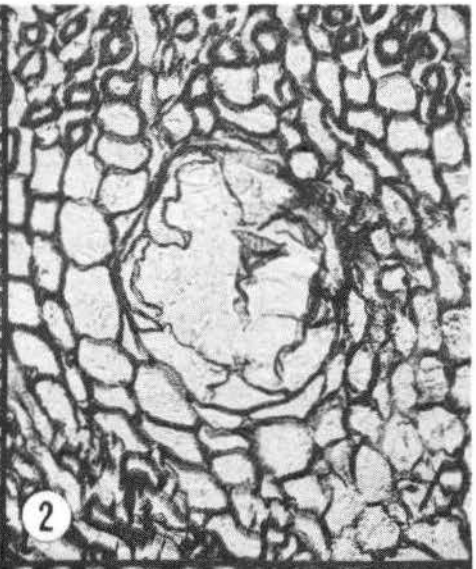
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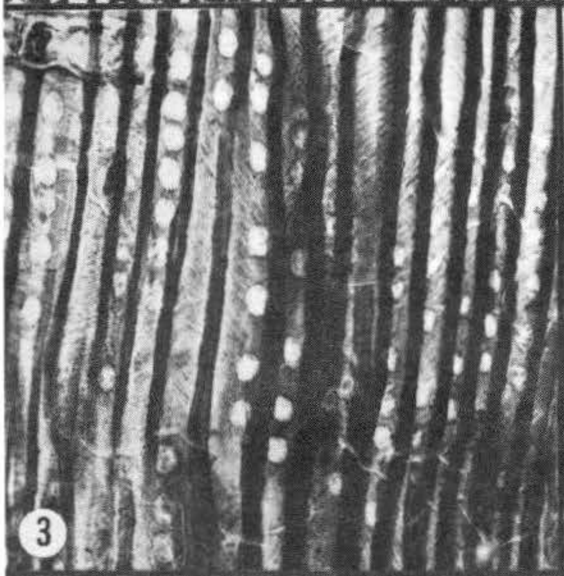
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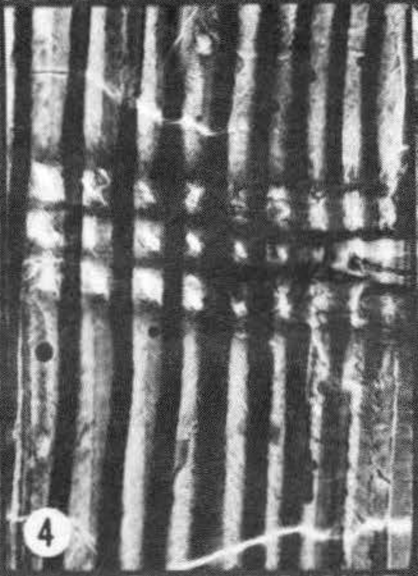
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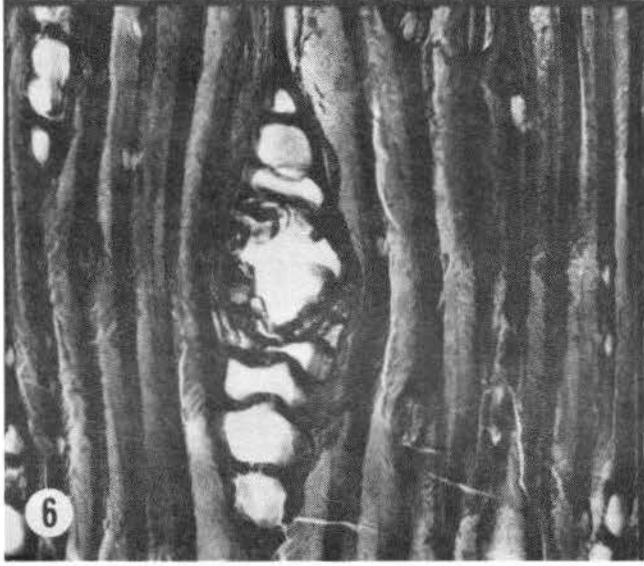
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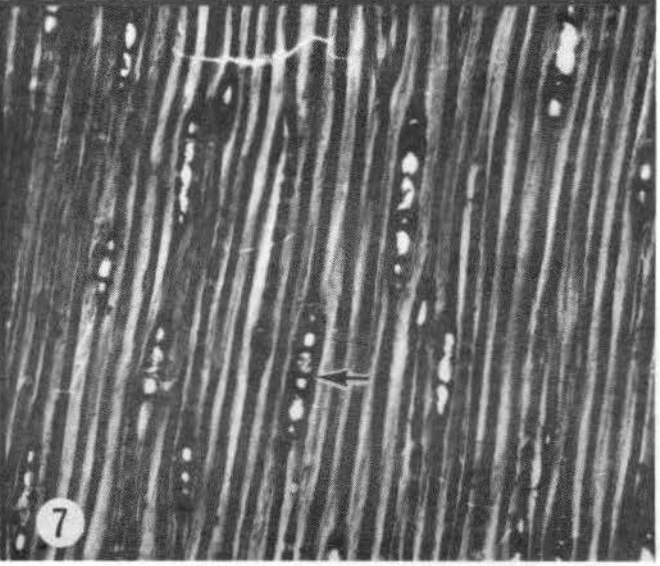
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Plate 2, as in the case of Plate 1, are tracheids--the standard coniferous water-conducting cells. A somewhat unusual feature of this wood is the presence of strand tracheids (parenchyma cells transformed into tracheids) in some of the sections. While not possessing resin ducts, the wood specimen in Plate 2 (TBS-1) does, however, possess what are apparently distinct resin (parenchyma) cells (Figures 9 and 10). These cells are found occasionally among the tracheids and sometimes occur adjacent to each other (Figure 10) in "bands." They could indeed account for the presence of lines of amber in the wood. The intertracheal pitting, present in a single vertical row (Figure 11), as well as the nature of the cross-field pitting (Figure 13), i.e. cupressoid, not taxodioid, would tend to rule out *Sequoia* (redwood, bigtree, etc.) as a possibility in identification. The fact that the end-walls of both longitudinal and ray parenchyma are smooth (Figure 12), and not nodular or bumpy, would seem to eliminate from further consideration the *Juniperus* group of cedars, such as eastern red cedar. In terms of "keying out" the wood illustrated in Plate 2 (as in Panshin and de Zeeuw, 1980), the closest fit would appear to be the wood of Atlantic white-cedar, *Chamaecyparis thyoides*. Again, the preceding constitutes a suggestion of overall wood similarity, and not a firm identification. As a final descriptive point, TBS-1 possesses distinct growth rings (Figures 8-9), a fact that will be further dealt with in the discussion.

OTHER UPPER CRETACEOUS WOOD SAMPLES FROM MISSISSIPPI

(1) Other fossil wood material located by the Office of Geology includes a lignitized specimen, associated with amber, collected from the McShan Formation (lower Eutaw Group) during the construction of the Aberdeen Lock and Dam on the Tennessee-Tombigbee Waterway. Upon sectioning, this specimen did not possess the excellent preservation of wood features observed in the two specimens above. Nonetheless its wood structure was suggestive of the "cedar-like" wood illustrated by TBS-1.

(2) In 1984, Blackwell (see references cited) described silicified pine wood of the yellow or hard pine type--bearing resemblance to both the ponderosa (*Ponderosa*) and loblolly (*Taeda*) sections within the genus *Pinus*--from the lower part of the Eutaw Formation, just above the contact with the McShan Formation. This fossil pine collection (labelled Blackwell PC-1 through PC-5) was found at the precise locality of a large, silicified log reported by Parks (1960), and may indeed represent a portion of this log that had been broken off. Growth rings were not observed in this specimen.

(3) A fragmentary, lignitized specimen was collected by the Office of Geology from the Tupelo Tongue of the Coffee Sand Formation in northern Lee County, Mississippi. The Coffee Sand and the underlying Mooreville Formation are the lower units of the Selma Group. In Lee County the Mooreville Formation is immediately above the Tombigbee Sand. Mellen (1958) alluded to the presence of lignitic fragments in the Coffee Sand, the specimen in hand seeming to fit this description. Dockery and Jennings (1988) made mention of the poor state of preservation of certain fossils from the Coffee Sand. Indeed, the superficially sheath-like or lamina-like specimen discussed here is not particularly well-preserved; yet, enough can be seen of its structure to state that it is the remains of a coniferous wood, at least superficially resembling the wood in Plate 2 (TBS-1) and that of the lignitized specimen from the Aberdeen Lock and Dam; that is, it is "cedar-like" in microscopic appearance.

DISCUSSION

The Prentiss County Geology Bulletin (Parks, 1960) and the Tishomingo County Geology and Mineral Resources Bulletin (Merrill and others, 1988) both alluded to the occurrence of silicified (petrified) fossil wood in the lower part of the Eutaw Formation in Mississippi. The Bulletin for Monroe County (Vestal, 1943) reported the presence of "plant fragments and pieces of lignite" in the Eutaw. In light of these statements, it is not surprising to have found both lignitized and silicified woods in the

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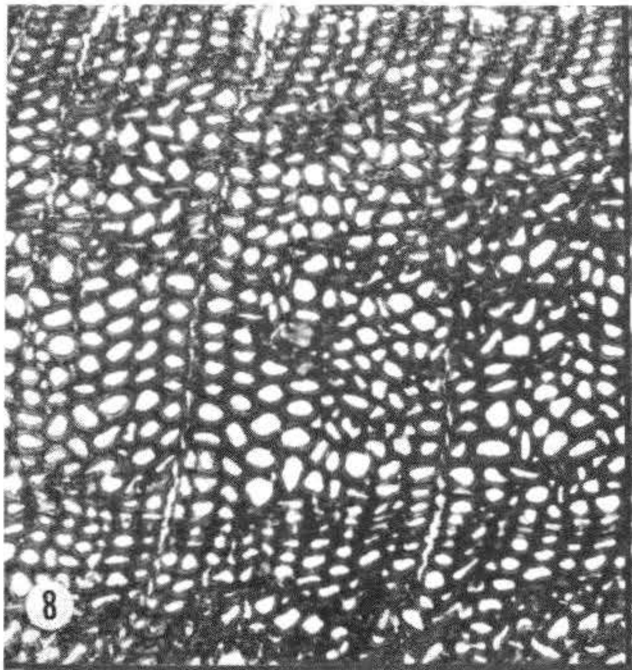
PLATE 2

Figures 8-14, photomicrographs of specimen TBS-1, fossil "cedar-like" wood from the Tombigbee Sand: (8) Cross-section; note distinct growth ring crossing lower part of photo; X 100. (9) Similar to photo 8 but higher magnification; occasional resin cells (seen better in next photo) are mixed among the tracheids; X 200. (10) Portion of earlywood showing resin cells (solid contents) among the tracheids, X 400. (11) Radial-longitudinal section; vertical row of uniseriate intertracheal pits, left center; X 400. (12) Radial section showing ray (middle two-thirds of vertical photo) traversing tracheids; note smooth (non-nodular) end-walls of ray cells, e.g. at arrow; X 400. (13) Ray cell at upper center, i.e., with dark contents, showing cross-field pits, X 400. (14) Tangential-longitudinal section, showing rays transected, e.g. at arrow, X 100.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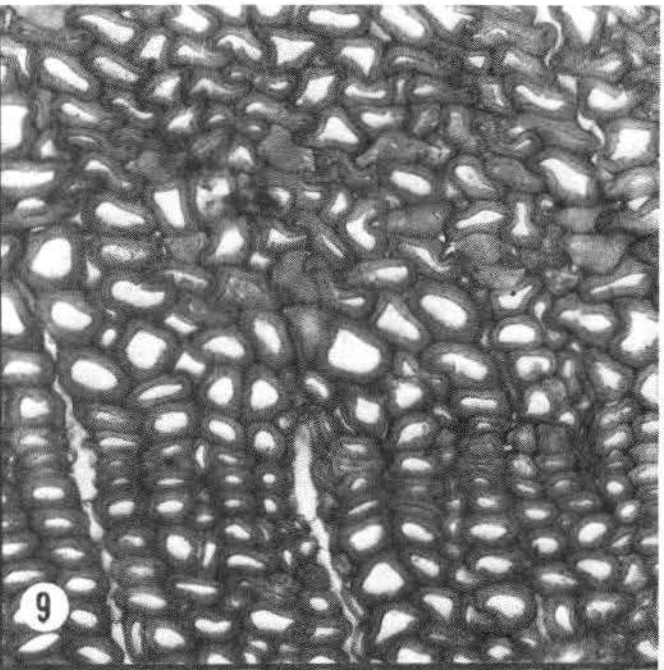
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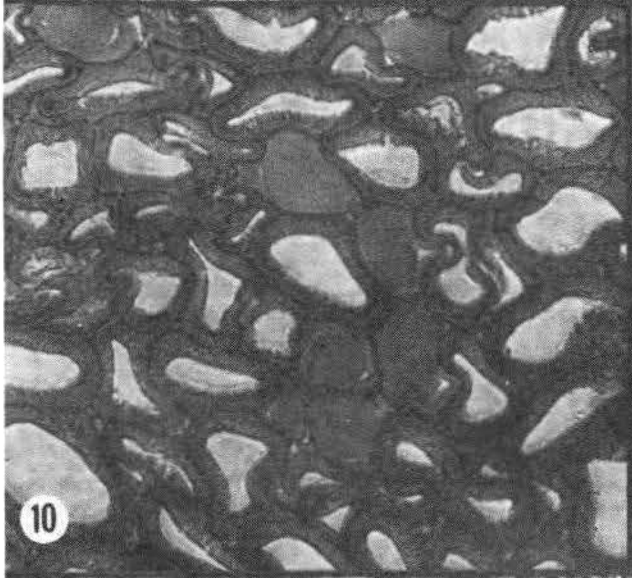
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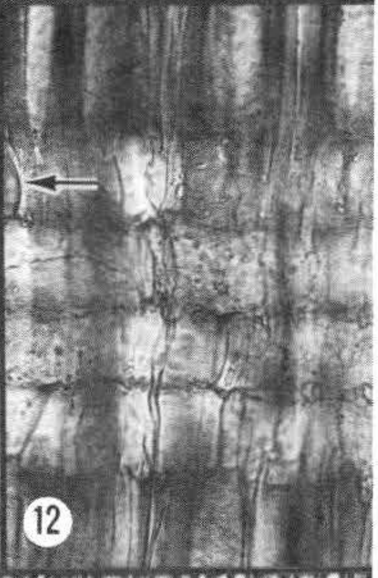
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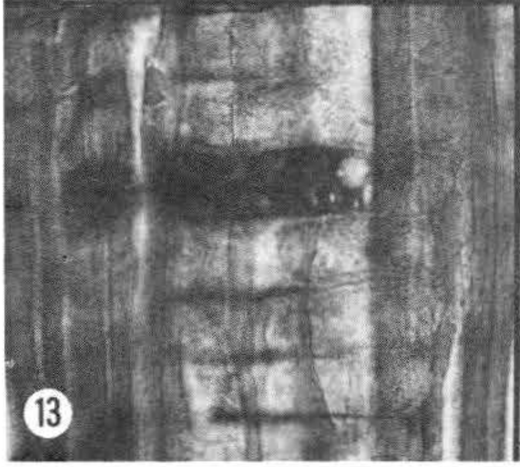
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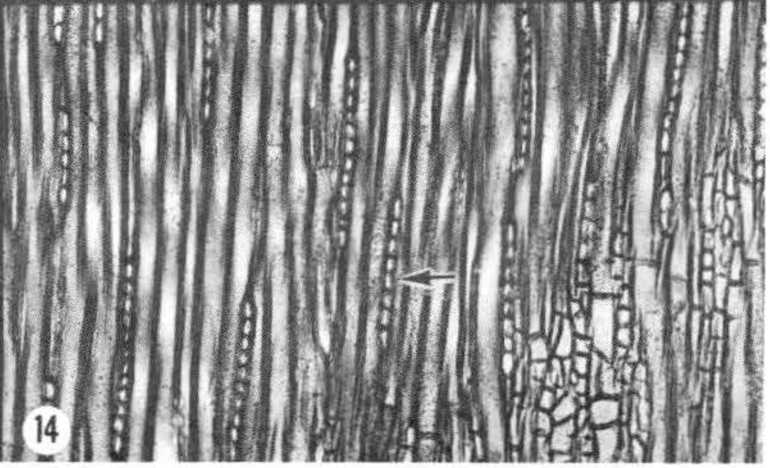
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Eutaw Group. Vestal (1943) reported "scattered lignitized logs" in the Tuscaloosa. And, as indicated, lignitized wood fragments from the Coffee Formation of the Selma Group are reported in this study. Hence, it seems that fossil wood, either lignitized or silicified, may be reasonably well represented throughout much of the sandy and/or clayey phases of the Upper Cretaceous in northeastern Mississippi.

A search through the literature reveals plant remains (variously leaves, twigs, cones, wood) to be rather common in the Upper Cretaceous from the northern to the southern Atlantic states (i.e., from New York and New Jersey, south to South Carolina and Georgia) and in two of the eastern Gulf Coast states, Mississippi and Alabama (Berry, 1907, 1908a, 1908b, 1909, 1910a, 1910b, 1911, 1913, 1914, 1919; Hollick and Jeffrey, 1909; Jeffrey and Chrysler, 1906). The flora depicted by all of the finds and identifications of plant remains is that of a mixed temperate and/or subtropic vegetation, adapted to relatively warm, relatively moist conditions. Components of this flora included figs, magnolias, laurels, willows, and leguminous trees, with some cone-bearing trees mixed in with the finds. Berry (1911) likened the vegetation (in terms of physiognomy, not species composition) to that of the temperate rainforests of New Zealand. In reference to the Cretaceous coastal plain area of the southeastern United States, Berry (1907) had initially puzzled over the seeming dearth of gymnosperms (conifers) in an apparently angiosperm-dominated flora. At that time, Berry considered that gymnosperms were much more prevalent in the northern part of the Atlantic Coast Province than in the southern part. The prevalence of gymnosperms in the northern Atlantic Coast Province in the Upper Cretaceous was supported by the work of Jeffrey and Chrysler (1906) and Hollick and Jeffrey (1909). Berry subsequently (e.g., 1908a, 1910b, 1913, 1914, 1919) reported a number of fossil gymnosperms (coniferous remains) from the Southeast, reflecting a change in viewpoint. Regardless, the notion persisted, e.g. Dunbar and Waage (1969), that angiosperms were the prevalent form of plant life in the Upper Cretaceous landscape. Angiosperms were considered to have invaded (perhaps dominated) coastal lowlands in the Cretaceous under conditions of equable climate (Axelrod, 1970). Upchurch (1989) believed that late Cretaceous eastern North America (including the Gulf region) was generally covered by a broad-leaved, evergreen woodland in which angiosperms constituted perhaps 80% of the forest, dominating the canopy (considered to be an open canopy), with conifers (needle-foliaged, typically evergreen trees) present (to a lesser extent) as an "emergent stratum." While this notion of "angiosperm domination" may be generally correct, the present investigation of Upper Cretaceous wood in northeastern Mississippi points so far to a different picture. From bottom to top, formations such as the McShan, Eutaw, Tombigbee Sand, and the Coffee Sand all represent marine, but near-shore environments. The majority of woods buried within these sediments, although of course growing on land, were probably located relatively close to the shoreline (see Schuchert, 1955, for an account of shoreline position during the late Cretaceous). The fact that the landscape was probably a peneplain (Fenneman, 1938), with a deltaic-alluvial fan type of drainage, would mitigate against the notion of any long-range terrigenous transport. If the fossil woods in the present study are representative of trees growing near the shoreline during the late Cretaceous, then the coastal vegetation of the late Cretaceous of the Southeast, at least during Eutaw time, may have been predominantly a coniferous forest, physiognomically not unlike the open canopy "pine-savanna" or "piney woods" vegetation in southern Mississippi today. The findings in this study suit well Mellen's (1958) proposal of similarity of the environs of Cretaceous shelf deposition in northern Mississippi with that of southern Mississippi today. The presence of what seems to be white cedar, in addition to pines, is not at all surprising given its continued occurrence in portions of the coastal plain of the Carolinas in the twentieth century (Harper, 1910). The fossil plant described by Berry (1910a, 1910b) from the coastal plain of Maryland and North Carolina as *Moriconia americana* may represent foliage similar to that of a cedar such as *Chamaecyparis*, and is a plausible candidate for correlation with wood such as that of TBS-1 (i.e., Plate 2). The report by Berry (1919) of gymnosperms, *Androvettia* and *Sequoia*, at a Eutaw Formation locality near Iuka, Mississippi, (see Merrill and others, 1988) supports the concept of a coastal Cretaceous needleleaf-evergreen (coniferous) vegetation during portions of Eutaw time, and also indicates that the plant associations may have been more complex than revealed by the results of any single publication.

The presence of more or less distinct growth rings in the fossil wood from the Tombigbee Sand (especially in TBS-1) would seem to support Berry's (1937) notion that the Upper Cretaceous flora was in general, based in his studies on species composition, indicative of somewhat more temperate, subhumid climatic conditions than those suggested by the more moist-tropical Paleocene and Eocene floras which followed. Similarly, Upchurch (1989), in reference to southeastern North America, discussed a probable change from woodland (open canopy) vegetation of late Cretaceous time to a tropical rainforest vegetation in the Paleocene, indicating a shift to more humid conditions in the early Tertiary. If not indicative of an annual cold season, the growth rings, illustrated in Figures 8 and 9, would be suggestive perhaps of distinct wet/dry annual seasons during the late Cretaceous. In either case, the climatic picture emerging is not necessarily that of equable yearly climate during at least part of late Cretaceous time; this conclusion is in essence in agreement with that of Spicer and Parrish (1990) concerning late Cretaceous wood from Alaska. The climatic pattern may not have been a consistent one throughout late Cretaceous time, as indicated, for example, by the general lack of distinct growth rings in silicified material described by Blackwell (1984) from the lower part of the Eutaw. It should be noted, however, that the pine in the present study (Plate 1) does not possess strong growth rings (Figure 1), as compared with the cedar type wood (Plate 2, Figures 8, 9), suggesting perhaps some generic (genetic?) difference in Upper Cretaceous trees in their tendency to form annual rings. The formation, nature, and distribution of growth rings in Cretaceous trees have constituted focuses of at least two recent papers (Francis, 1986; Spicer and Parrish, 1990), and appear to be worthy subjects of study as possible indicators of paleoclimates, as well as generic or specific differences between trees. In particular, further investigation of growth rings of woods found in the Cretaceous sediments of Mississippi would seem to be a significant undertaking for the future.

Lignites are abundant in various portions of Mississippi (Brown, 1907) and now could be said to stand in need of reinvestigation for their "botanical content," that is the taxonomy of the trees (and perhaps other plant materials) producing the lignites, the presence or absence of growth rings, etc. The occurrence of amber in association with the lignitic specimen from the Aberdeen Lock and Dam (McShan Formation), the amber stringers found in the "cedar wood" (TBS-1) from the Tombigbee Sand, and the resin ducts of TBS-2 (pine wood from the Tombigbee) are all consistent with reports of amber associated with, or contained within, lignites (i.e., lignitized wood) from the Upper Cretaceous of New York (see Hollick, 1906; Hollick and Jeffrey, 1909; Jeffrey and Chrysler, 1906). Cretaceous amber is in fact known from various localities in North America, including sites in Canada and Alaska (Rice, 1980). If significant finds of amber are made in association with lignitic remains in the Upper Cretaceous of Mississippi, it will be interesting to further determine the identity and nature of the trees producing the amber. It will as well be interesting to determine whether insects and/or other animal remains might be preserved within the amber, as is the case with Upper Eocene/Lower Oligocene European (Baltic) deposits of amber (Rice, 1980). In short, the further deciphering of fossil "amber-bearing forests" in Mississippi, and elsewhere, would be a future activity of potentially considerable paleoecological significance, well worthy of pursuit.

ACKNOWLEDGMENTS

The Willard Sherman Turrell Herbarium Fund of Miami University, Oxford, Ohio, is gratefully acknowledged for partial support (grant number 103) of travel to the U.S. Forest Products Laboratory in Madison, Wisconsin, for the purpose of microscopic comparison of the fossil woods in this study with extant woods. Dr. Regis B. Miller was kind enough to provide assistance at the Center for Wood Anatomy Research (U.S. Forest Products Lab). Appreciation is also extended to the Office of Geology, Jackson, Mississippi, for providing, through field work, the majority of the fossil wood utilized in this study for microscopic sectioning and study.

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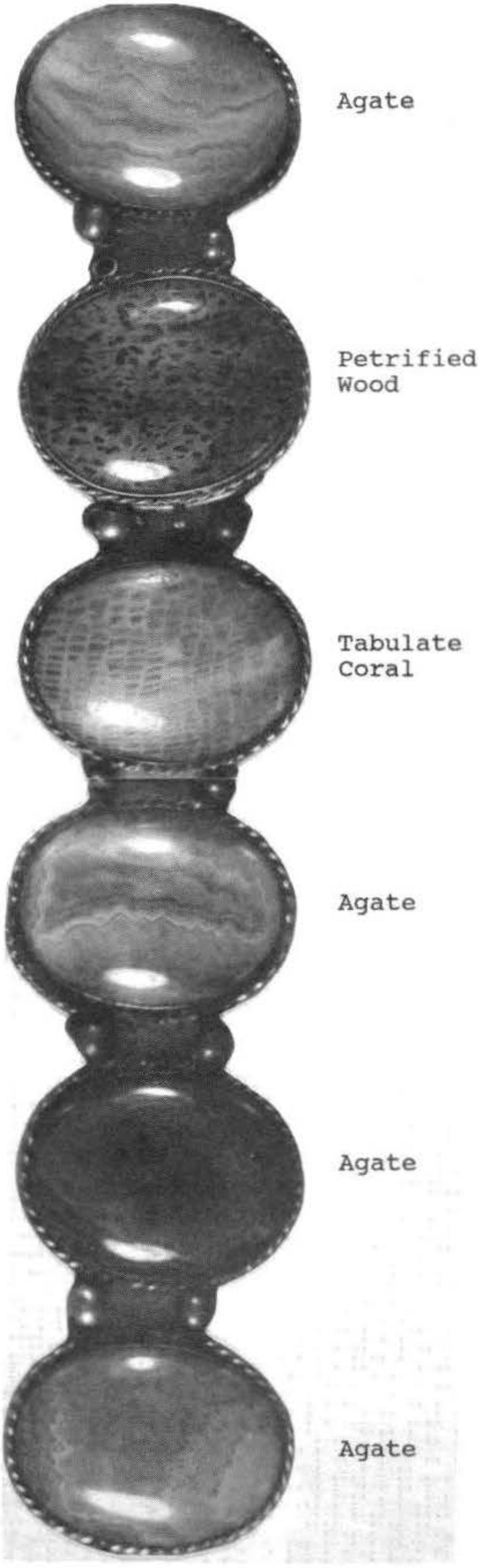
A BRACELET OF NATIVE STONES MADE BY B. L. C. WAILES

Michael B. E. Bograd and David T. Dockery III
Mississippi Office of Geology

Benjamin Leonard Covington Wailes (1797-1862) of Washington, near Natchez, was a planter, naturalist, teacher at Jefferson College, and first President of the Mississippi Historical Society. He was employed by the Mississippi Geological Survey soon after its creation. His publication in 1854 of Report on the Agriculture and Geology of Mississippi was the first report by the Survey on the geology of the state.

The bracelet illustrated here was made by B. L. C. Wailes from native stones. Agates, petrified wood, and silicified corals such as these can be found in stream gravels in southwestern Mississippi, where Wailes traveled extensively. The length of the bracelet is approximately six inches, with the stones being about one inch by three-quarters inch. This bracelet is owned by Mr. Segrest Wailes, the great-great-grandson of B. L. C. Wailes, and was kindly shown to the authors by his wife, Mrs. Jimmie Wailes.



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