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INDIAN ARTIFACTS OF TALLAHATTA QUARTZITE FROM TALLAHATTA CREEK SITE 22-LD-645, EAST-CENTRAL MISSISSIPPI

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INTRODUCTION

Hard silicic rock was the "industrial" material of Mississippi's native Indian population before the advent of European settlers and metal implements. The Indians sought rocks of rigid specifications to be used in the knapping (chipping) of stone tools and projectile points. These specifications included a conchoidal fracture for knapping, a hard and durable stone that could maintain a sharp point and cutting surface, and sufficient size to provide a core from which preforms could be cleaved. Such rock was especially prized in the Gulf Coastal Plain Province of Louisiana, southern Arkansas, Mississippi, and southern Alabama where the surface consisted largely of unlithified Tertiary and Cretaceous sediments. In Mississippi, Indians generally sought these rocks in the chert gravels of certain rivers and streams. An exception to this was an industry that developed between 9000 and 3000 years ago in east-central Mississippi where Indians quarried and worked quartzites from the Tallahatta Formation to make preforms, points, and other tools. These implements were widely traded and are readily recognizable as to their rock type and source. One site at which the Tallahatta quartzite was worked into implements,

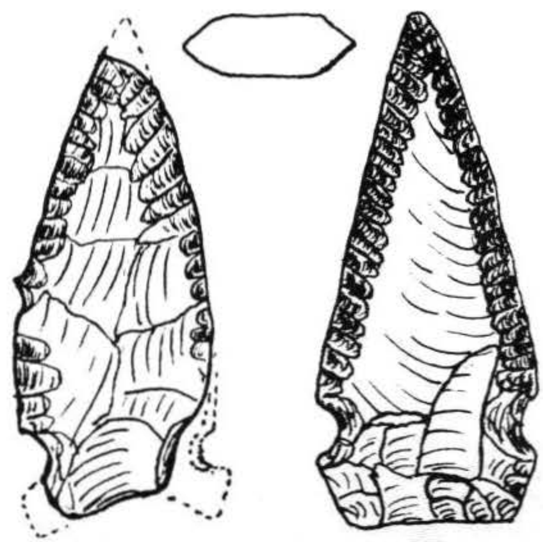

Figure 1. Early Archaic side-notched projectile points. Illustrated at actual size.

site 22-LD-645, was recently noted along Tallahatta Creek in Lauderdale County, Mississippi. The differing types of points found at this site suggest that it was an active work site between 9000 and 3000 years ago.

TALLAHATTA QUARTZITES

The name Tallahatta comes from an Indian term meaning white rock. This name is appropriate for the formation, which is light in color where it is exposed at the surface. Perhaps the most noted exposures of this formation are the off-white claystones seen in the vertical road cuts west of Meridian, Mississippi, on Interstate 20. Outcrops of erosion-resistant Tallahatta lithologies form a series of ridges and hills known as the Tallahatta cuesta. This cuesta extends from the formation's type locality in the Tallahatta Hills of southern Alabama northwestward through Lauderdale County and into north-central Mississippi. The Tallahatta Formation is Middle Eocene in age and consists of silicic claystones, sands, and sedimentary quartzites of marine origin. The quartzites contain quartz sand and some glauconite cemented together by silica. This cementation binds the grains together so strongly that when broken the fracture cuts through individual grains rather than around them as it would in a sandstone. Tallahatta quartzites have a characteristic gray to white sugary texture with scattered dark grains of glauconite. Along a broken surface, fracture surfaces of individual quartz sand grains are slightly inclined to that of the matrix. This gives fracture surfaces a sparkling appearance.

Tallahatta quartzites are unique among coastal plain rocks for their hardness and durability. Early settlers used these rocks for millstones. While quartzite ledges of a foot or less in thickness are common in the Tallahatta Formation, only a few are of the quality needed for knapping tools. For this reason, the Indians prospected for outcrops or stream beds with the high quality stone. Sites for this stone were discovered and rediscovered over a period of several thousand years by various Indian groups.

PREHISTORIC UTILIZATION OF TALLAHATTA QUARTZITE

The prehistoric utilization of Tallahatta quartzite is an interesting phenomenon to archaeologists for several reasons. Perhaps of greatest interest is the fact that this distinctive-looking stone became widely dispersed from the area where it naturally occurs in east-central Mississippi and adjacent parts of Alabama. How it came to be so widely dispersed is not known at present. It is generally assumed that it was traded from one group to another. It appears at least as far away as Louisiana and Arkansas.

Most of the flaked stone tools used by aboriginals in Mississippi were made from gravel chert which was abundant in many of the state's rivers and streams. This material was collected on gravel bars where it was tested, roughed out into blanks or preforms, and transported back to other locations where it was worked into finished tools or cached at strategic locations until it was needed. Although the gravel deposits contain minorities of workable quartzite, it is invariably stained brown, tan, or yellow as is most of the chert and is not to be confused with Tallahatta quartzite.

The concentration of large amounts of flakable stone in a fairly restricted area has resulted in some interesting archaeological situations. In some locations along the Tallahatta quartzite outcrops, massive mining operations were undertaken at least as early as the Middle Archaic Period (ca. 8000-5000 years ago). Great slabs or boulders of quartzite were reduced on the spot (for instance at sites 22-LD-550 and 22-LD-552) into flakes of various sizes and transported in bulk to more permanent sites (such as 22-LD-521) where they were further reduced into blanks or preforms for ultimate transportation to distant sources, cached locally, or worked into finished tools on the spot (O'Hear and Lehmann, 1983, p. 2-5). The quarry and workshop sites of this industry exhibit much greater lithic debris than any sites where gravel chert was worked.

Two interesting caches of Tallahatta quartzite have been reported to the Department of Archives and History. Each consisted of between two and three dozen artifacts. One cache, discovered in Simpson County, was composed of large blanks that were actually flakes of quartzite that had been trimmed on one or both sides into roughly triangular pieces about 4-5 inches long, 3-4 inches wide, and as thick as one inch (Figure 4A is a similar specimen). The other cache, found near Hattiesburg in Forrest County, contained what are termed advanced stage preforms. In other words, these were almost completed tools, which in this case were probably intended as projectile point/knives. The finished tools may have been Shumla or similar projectile points probably dating between 4000 and 2500 years ago.

Large Tallahatta quartzite tools of the Middle Archaic Period are commonly found cached with blue-gray Fort Payne chert tools in the upper reaches of the Tombigbee River watershed and in one site in Lauderdale County. Tallahatta quartzite blanks or preforms at the latter site were being prepared presumably for trade. Here several completed Middle Archaic projectile points of blue-gray Fort Payne chert were discovered (site 22-LD-521). The chert probably came from the Tennessee River area of northern Alabama. Commodities other than stone could well have been traded, but evidence of that trade, such as food and basketry, decomposed with time.

Tallahatta quartzite was used throughout all of the cultural periods recognized by archaeologists. There are Paleo-Indian (ca. 12,000-10,000 years ago) and Early Archaic (ca. 10,000-8000 years ago) tools of this material. The Paleo-Indian tools are very rare and apparently the potential of the concentrated quantities of material was not recognized during that period. Subsequent periods saw rapid increases in its utilization. Most of the artifacts of Tallahatta quartzite found great distances from the outcrop areas are Middle Archaic with representation remaining strong in the Late Archaic Period (ca. 5000-2500 years ago). Trade apparently diminished considerably after that time although tools of the later periods are occasionally found at great distances from the source area.

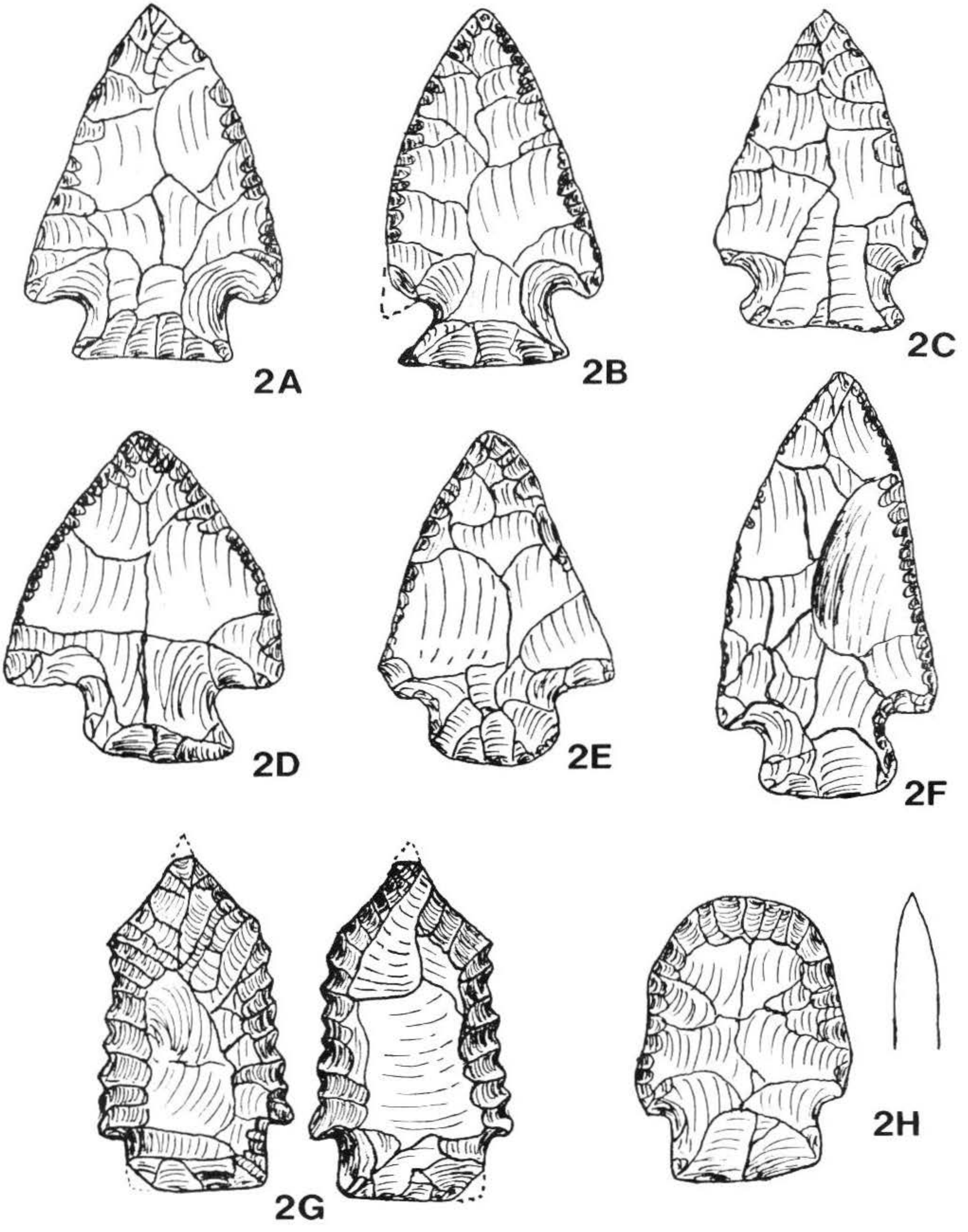

Figure 2. Middle Archaic projectile points and/or knives. Illustrated at actual size.

SITE 22-LD-645

The discovery of site 22-LD-645 expands our knowledge of Tallahatta quartzite procurement and processing. The site is confined to a rock and sand bar in Tallahatta Creek. A considerable portion of it is covered by a sand deposit of comparatively recent origin. Artifacts are most abundant at the edge of the deposit and may be concentrated beneath it. No measurements of the rock bar were taken, but the portion of it which was exposed at the time of our visit (April 3, 1992) was probably no more than 60-70 feet long by 20-30 feet wide. There were considerable quantities of workable quartzite visible. On close examination (most of it was covered by shallow running water), we collected 3 projectile point/knives (one Middle Archaic and two Late Archaic in age), 3 final stage preforms, 5 early stage preforms, 3 unifacial blanks, 15 biface thinning flakes, and 84 flakes. Other collections from the site were examined and recorded. Blanks, preforms and finished tools from the combined collections are illustrated in figures 1-4.

The earliest material recorded consists of two side-notched projectile points (Figure 1A and B), which most closely fit the type description of Big Sandy points. These points should be 9000+ years old (Cambron and Hulse, 1975).

The Middle Archaic Period is represented by the specimens illustrated in Figure 2. Of special interest among these specimens is Figure 2G. This form has been named Kirk, variety St. Tammany by Gagliano (1967, p. 3). The type has rarely been recorded outside of southwestern Mississippi and the adjacent Florida Parishes of Louisiana. Its occurrence in east-central Mississippi suggests that the predominantly heavily wooded areas of eastern Mississippi may hold many more surprises. The typology of the other specimens in Figure 2 is not as easily identified, but this is not essential for purposes of this paper. Suffice it to say that on a technological basis, they are Middle Archaic, having the typical broad stems of that period. Specimen 2H is interesting in that it exhibits a typical Middle Archaic modification of the distal end. It has been bifacially reworked, apparently into a knife form, which was intended to cut with the distal end instead of the blade edges.

The Late Archaic Period is represented by the specimens in Figure 3. The named types are: Pickwick - specimens A, B, C, I, and K (Cambron and Hulse, 1975, p. 103), Flint Creek - specimens F and G (Cambron and Hulse, 1975, p. 51), Shumla - specimen E (Bell, 1960, p. 86), and Gary - specimen H (Bell, 1958, p. 28). Specimen D is unidentified, but on the basis of shape and stem width is Late Archaic.

Figure 4 represents earlier stages in the reduction sequence. Specimen A, which is 24 mm thick, closely resembles items included in the previously mentioned Simpson County cache. This specimen would probably have been further reduced into a projectile point or knife such as specimen 2F. Specimen 3J would appear to be the final preform of the Pickwick points illustrated in Figure 3. Specimen 4C had apparently had one notch completed and another started when it broke and was discarded. Specimen 4E is of the same general size and degree of completion as the previously mentioned cache from the Hattiesburg vicinity.

CONCLUSIONS

The nature of site 22-LD-645, if indeed it is a site in the usual sense of the term, is not adequately understood at this time. What is obvious is that it is a mixed deposit with material from many different prehistoric periods. It is also obvious that there was a considerable quartzite reduction industry nearby, and possibly in the stream bed itself. Several knappable pieces of unaltered quartzite were observed in the stream bed. The availability of workable quantities of quartzite in the stream bed has not been assessed at this point. There are several possible explanations for the occurrence of so much cultural material in the stream bed:

1. Raw quartzite was abundant in the stream bed for thousands of years and was processed there with many of the tools being completed there.
2. Raw quartzite was processed in the stream bed, which accounts for the cores, blanks, and preforms, and in addition other tasks were performed in the stream bed, which necessitated the presence of projectile point/knives.
3. Most or all of the cultural material has arrived at this site because of stream action and was originally deposited at other sites upstream on or near the stream banks.

It seems likely that all of the alternatives listed above contributed to the situation in the stream bed today. Obviously there were many resources in the steam and contiguous to it in prehistoric times. The flora and fauna were surely exploited, and stone tools were essential in killing and processing game, in manufacturing tools of their bones and antlers, and in cutting and processing plants into food, containers, and utensils.

Given the tremendous quantities of quartzite available in the uplands of this area, it seems likely that much of it found its way into stream beds through natural geological processes. It would certainly make sense to take advantage of easily accessible raw material such as this before pursuing it in a quarrying or mining operation, which surely consumed vast amounts of energy.

A present day analogue of Mississippi's prehistoric quartzite industry may be that observed by Toth et al. (1992) at the village of Langda in New Guinea. In their article "The Last Stone Ax Makers," these authors observed the stone ax industry of a modern stone age society living on the cloud-shrouded southern slopes of western New Guinea's central cordillera in Irian Jaya. Villagers of this society hiked to the valleys where they knapped preforms from boulder and cobble cores found in the stream beds. Preforms were carried back to the village and finished into axheads.

There is no doubt that cultural material such as that recovered from Site 22-LD-645 often found its way into stream beds through the erosion of sites near the stream. Most permanent or semi-permanent aboriginal settlements were not too far removed from a dependable water supply. However, the evidence gathered so far suggests that most of the material is from a quartzite procurement and reduction

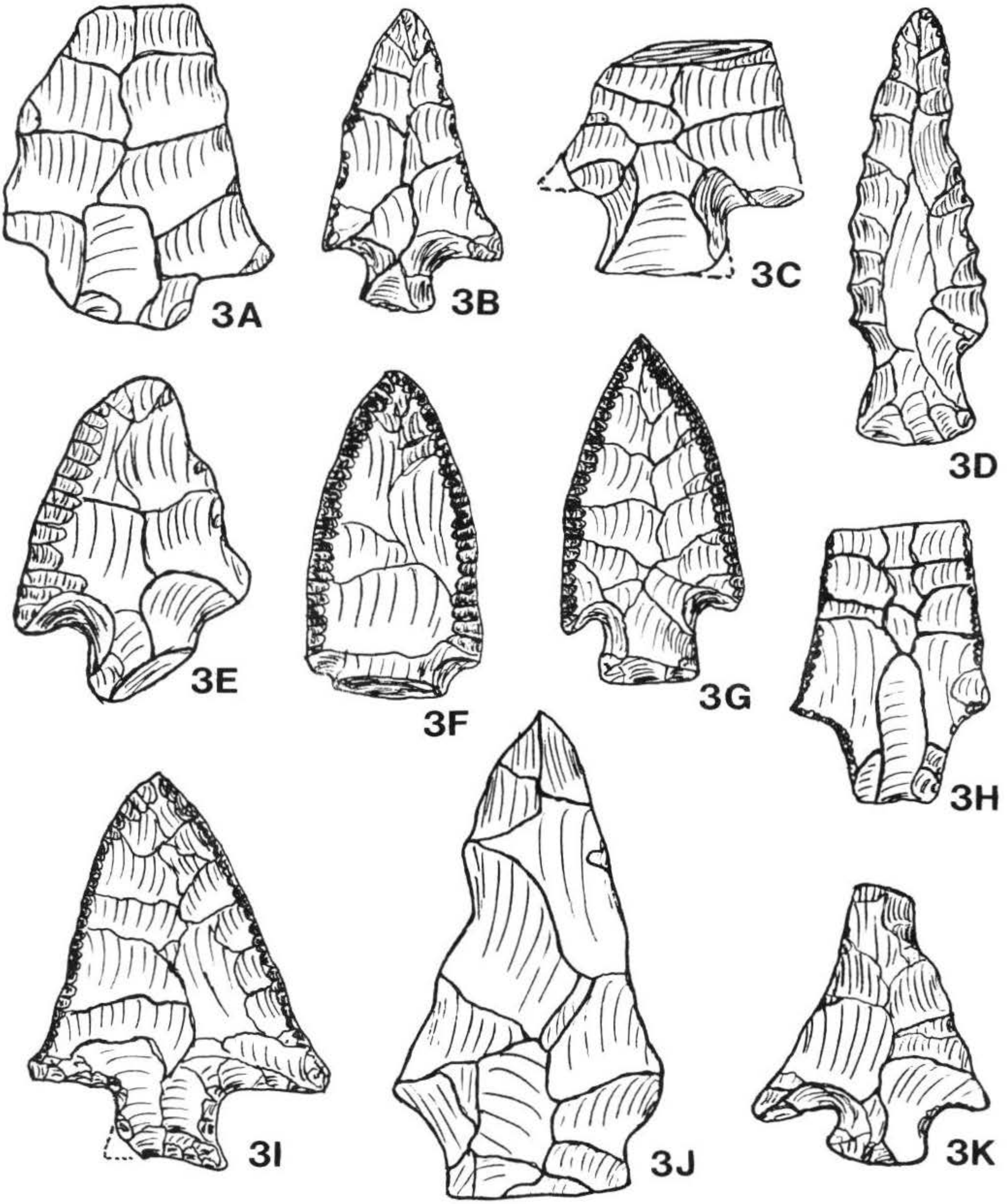

Figure 3. Late Archaic point types including Pickwick (B, C, I, and K), Gary (H), Shumla (E), and Flint Creek (F and G). D is unidentified but is placed as Late Archaic based on shape and stem width. Specimens 3A and 3J are Pickwick preforms. Illustrated at actual size.

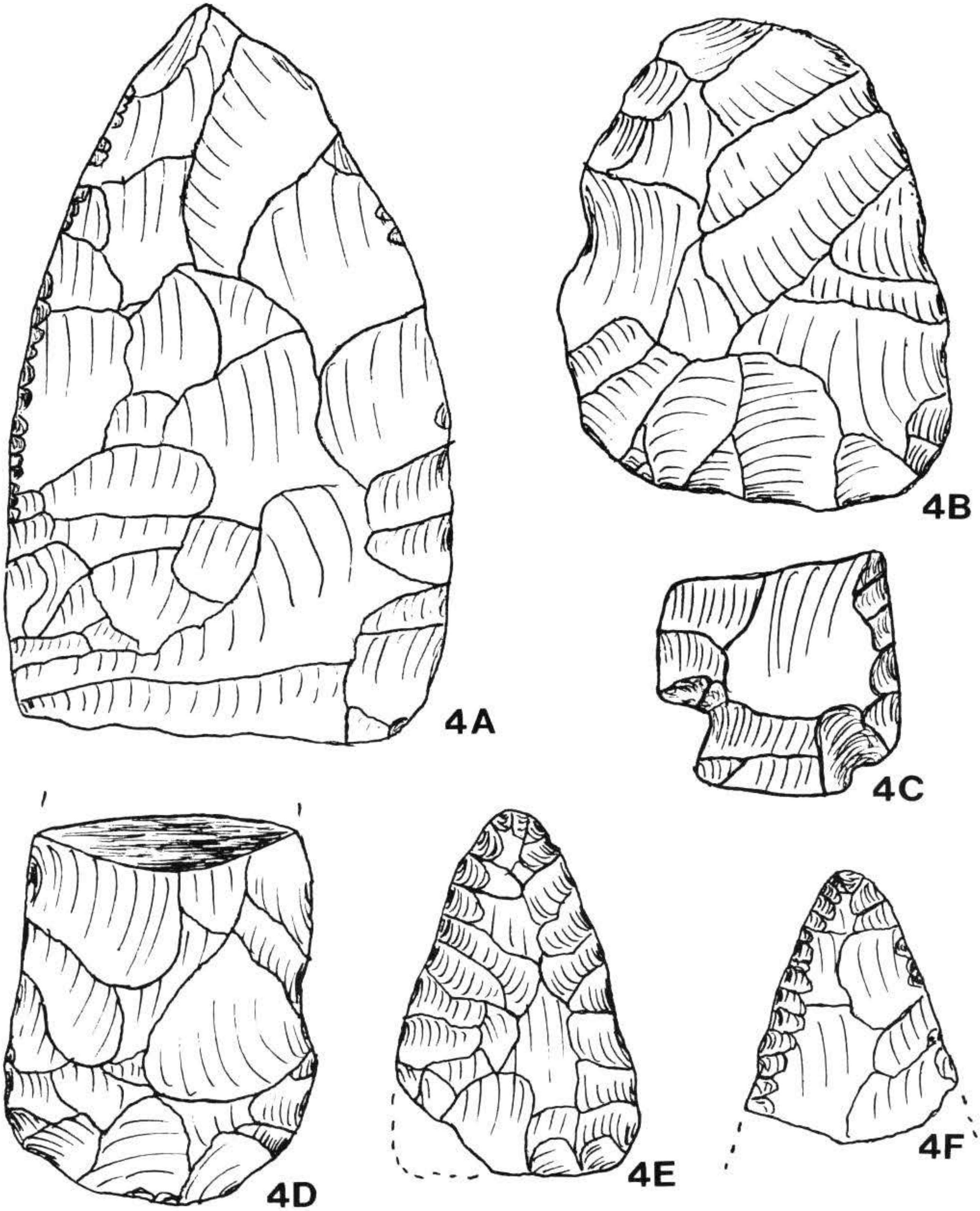

Figure 4. Blanks and preforms. Illustrated at actual size.

industry that was conducted at the site. Careful inspection of gravel-bearing streams will usually reveal prehistoric cultural material and an occasional finished tool, but the vast majority of the worked stone is of tested pebbles and cobbles and blanks and preforms. Keeping in mind that most of the material illustrated in this report was selected in favor of whole, finished projectile points and/or knives, we are left with the fact that most of the worked lithics at site 22-LD-645 are from the process of quartzite reduction prior to the completion of the tools. What differs at this site from the situation in most gravel-bottomed streams is the concentrated quantity of workable material present. Further field work should be done in the area to determine if in fact most streams near quartzite deposits exhibit a similar pattern of artifacts.

ACKNOWLEGMENTS

The writers thank James D. Dubuisson for pointing out the site and for the use of his artifacts in the figure illustrations.

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THE GEOLOGY OF THANKSGIVING FIELD

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Mississippi Office of Geology

INTRODUCTION

Thanksgiving Field is located in Township 2 North, Range 2 East, in Amite County, Mississippi (Figure 1). It was discovered in December 1987 by Oxy USA, Inc., through the use of stratigraphic seismic exploration. The discovery well, the Jackson A No. 1, was perforated from the interval of 12,042 - 12,052 feet. The well tested at 501 barrels of oil per day (BOPD) and 1.9 million cubic feet of gas (MMCF) on a 16/64" choke, gauged at a flowing tubing pressure of 3055 psi, with a gas to oil ratio of 3750/1. By the end of 1990, the field had produced 1,318,549 BO and 7,247,308 MCF from 15 wells out of the Tuscaloosa Group, 152,134 MCF of Frio gas from 4 wells (9-13-89, New Pool Discovery), and 51,774 BO and 16,150 MCF from one Wilcox well (10-21-88, New Pool Discovery). Since 1987, nine additional Tuscaloosa fields have been found in Amite and Wilkinson counties.

STRATIGRAPHY

The Tuscaloosa Group, which is stratigraphically above the Lower Cretaceous unconformity and beneath the Eutaw Formation, consists of three formations: Lower Tuscaloosa, Middle Marine Shale, and Upper Tuscaloosa (Gruebel, 1985).

* The Lower Tuscaloosa trend has been an exploration target since the 1940's. Current drilling activity and recent wildcat successes illustrate that southwestern Mississippi still has attractive potential.

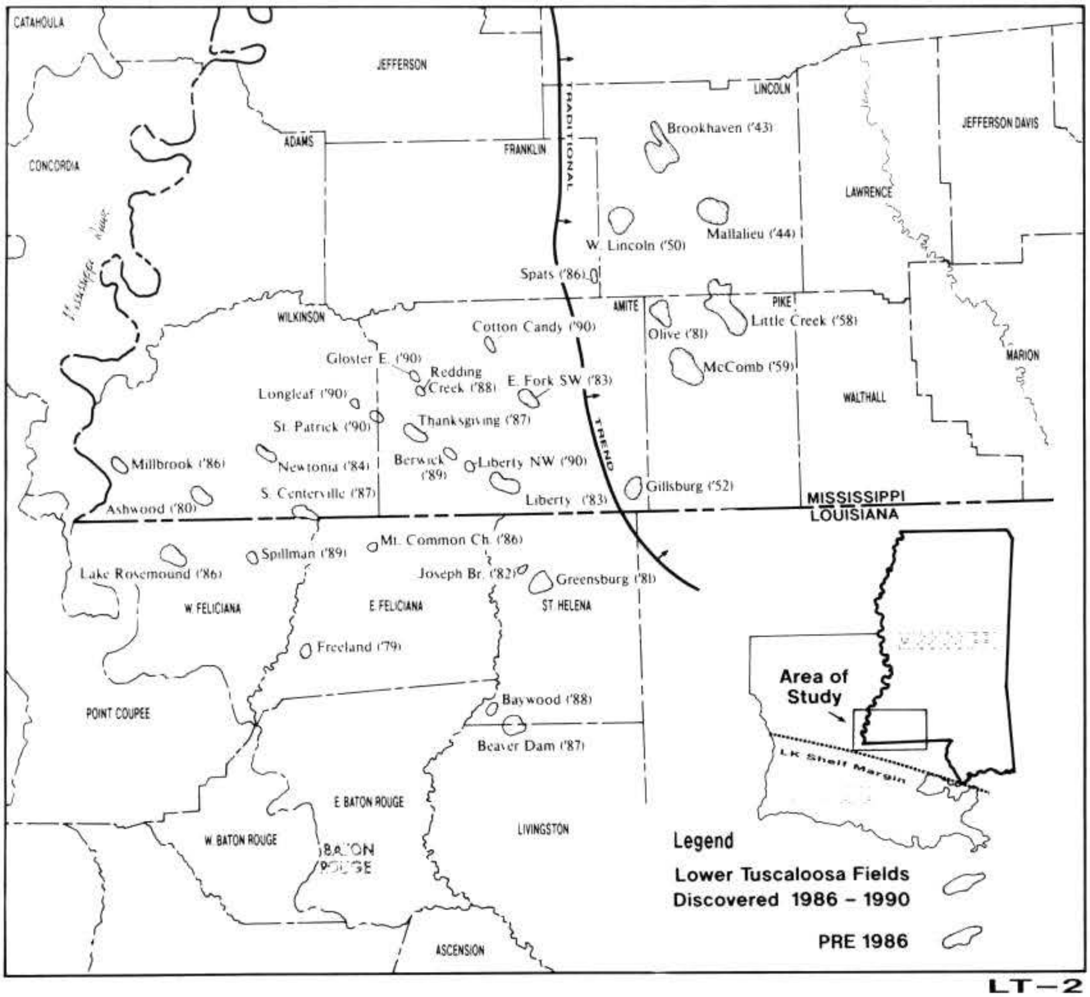
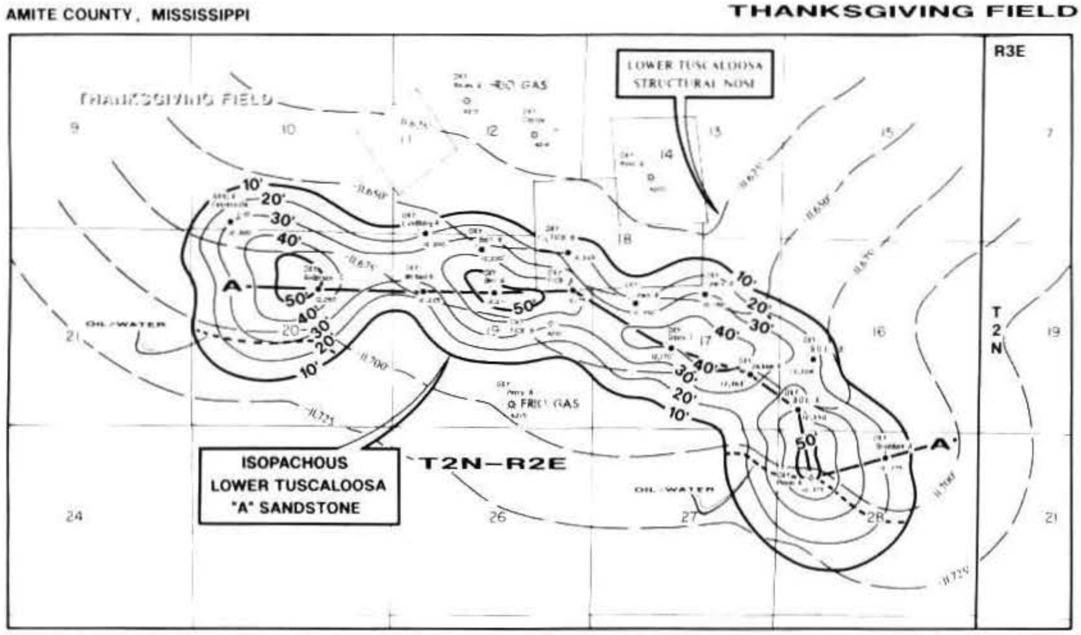


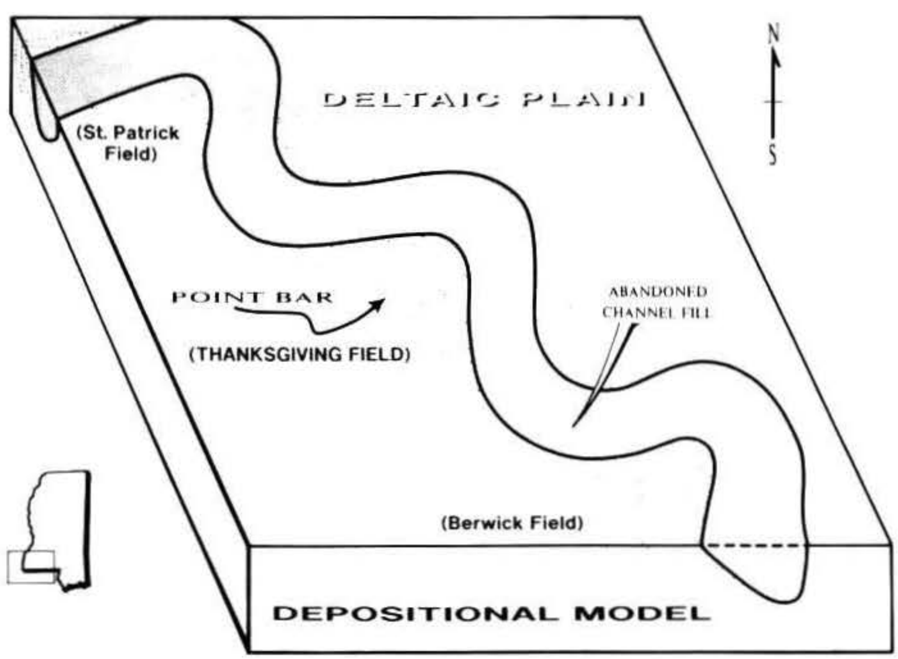
Figure 1.



* Thanksgiving Field is a classic example of a shaleout in three directions against regional dip. The sand pinches out into an abandoned shale-filled channel. This channel plug provides the lateral seal when located on the updip side north of the point-bar sand.

LT–5

Figure 2.



* The Stringer Member of Lower Tuscaloosa primarily consists of fluvial point-bar deposits. Deltaic and marginal marine facies are also present in this region.

LT–4

Figure 3.

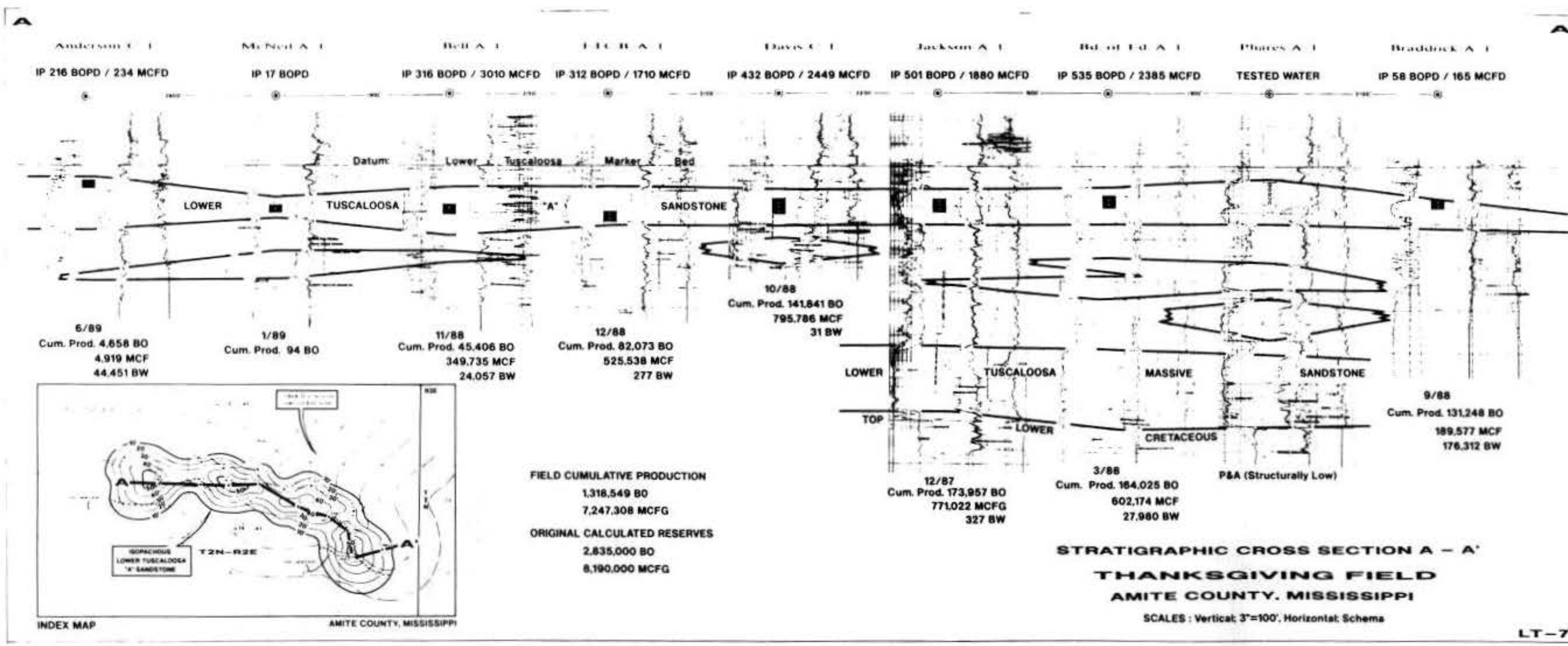

A
A'
IP 216 BOPD / 234 MCFD
IP 17 BOPD
IP 316 BOPD / 3010 MCFD
IP 312 BOPD / 1710 MCFD
IP 432 BOPD / 2449 MCFD
IP 501 BOPD / 1880 MCFD
IP 535 BOPD / 2385 MCFD
TESTED WATER
IP 58 BOPD / 165 MCFD
Datum: Lower Tuscaloosa Marker Bed
LOWER TUSCALOOSA "A" SANDSTONE
6/89
Cum. Prod. 4,658 BO
4,919 MCF
44,451 BW
1/89
Cum. Prod. 94 BO
11/88
Cum. Prod. 45,406 BO
349,735 MCF
24,057 BW
12/88
Cum. Prod. 82,073 BO
525,538 MCF
277 BW
10/88
Cum. Prod. 141,841 BO
795,786 MCF
31 BW
LOWER TUSCALOOSA MASSIVE SANDSTONE
TOP LOWER CRETACEOUS
12/87
Cum. Prod. 173,957 BO
771,022 MCFG
327 BW
3/88
Cum. Prod. 164,025 BO
602,174 MCF
27,980 BW
P&A (Structurally Low)
9/88
Cum. Prod. 131,248 BO
189,577 MCF
176,312 BW
FIELD CUMULATIVE PRODUCTION
1,318,549 BO
7,247,308 MCFG
ORIGINAL CALCULATED RESERVES
2,835,000 BO
8,190,000 MCFG
ISOPACHOUS LOWER TUSCALOOSA "A" SANDSTONE
T2N-R2E
INDEX MAP
AMITE COUNTY, MISSISSIPPI
STRATIGRAPHIC CROSS SECTION A – A'
THANKSGIVING FIELD
AMITE COUNTY, MISSISSIPPI
SCALES : Vertical: 3"=100', Horizontal: Schema
LT–7

Figure 4.

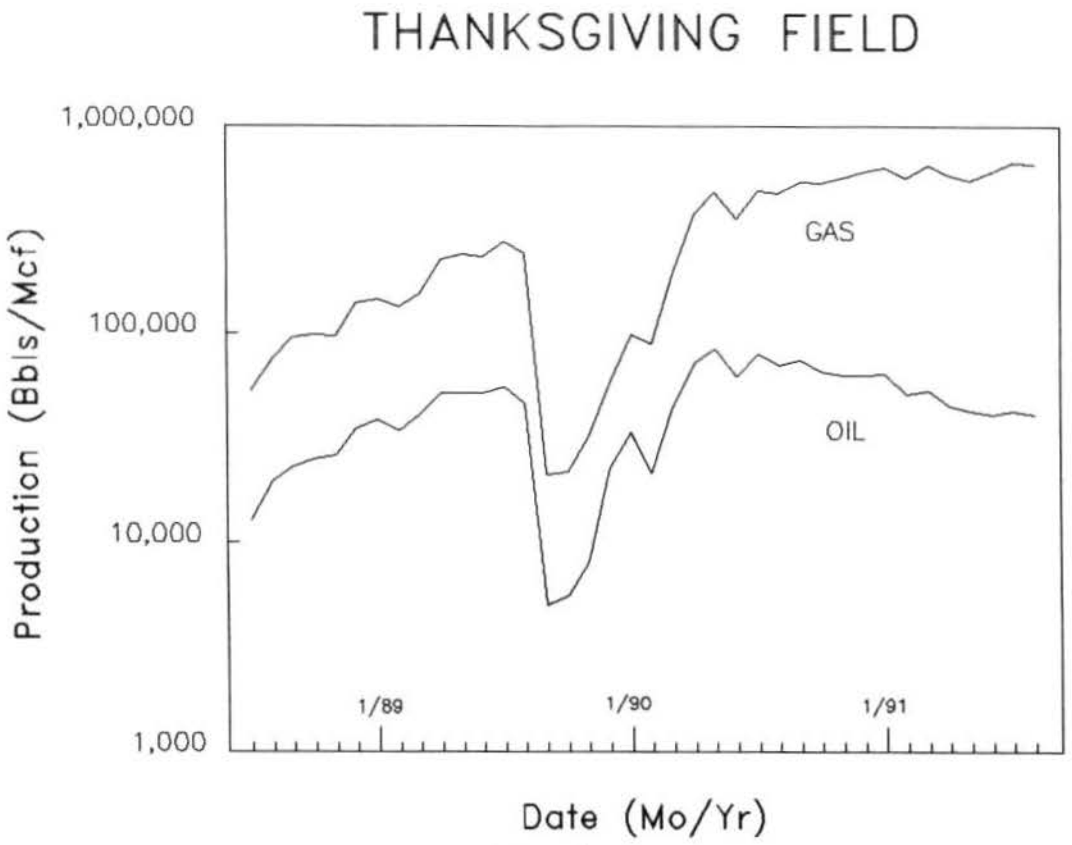


Figure 5.

The Lower Tuscaloosa is further divided into the Stringer Sand Member and the Massive Sand Member. The Lower Tuscaloosa contains good reservoir sands, with the Stringer Sand Member being the current primary objective.

TRAP AND RESERVOIR

The "A" Stringer Sand of the Lower Tuscaloosa formation is the producing zone at Thanksgiving Field. The present structural configuration is interpreted to consist of a gentle southward-plunging nose (Figure 2). The "A" sand was deposited in a fluvial-deltaic environment and occurs in a northwest-southeast trending meander belt that parallels structural strike (Figure 3). Thanksgiving Field exhibits a nearly ideal stratigraphic trap with sand shaling out in three directions against regional dip. The sand pinches out into an abandoned channel clay plug and flood-plain shales. This channel plug provides the lateral seal when oriented on the updip side to the north of the point-bar sands. The stratigraphic cross-section (Figure 4) shows the log correlations of these point bar sands. Log calculations can be misleading due to "bound water" clays which distort the resistivity values, reduce porosities, etc., making coring very helpful. In the producing zone, resistivities as low as 0.6 - 1.0 ohm are not uncommon and the production is water free. Conventional and sidewall cores in productive wells in southwestern Mississippi indicate porosities of 18-26%, permeabilities that range from 50-350 millidarcies, and water saturations of 45-70%. Gross sand thicknesses vary from 20 to 70 feet, with average net pay being 23 feet.

PRODUCTION

Prior to the implementation of a gas injection pressure maintenance program a decline curve analysis was run on twelve of the wells in Thanksgiving Field (source: Zorbalas, 1990). This analysis projected an ultimate primary recovery of 2,566,517 barrels of oil, assuming an average exponential decline of 25%. Using a 650 MCF/acre foot recovery, gas production should be over 8 billion cubic feet (BCF). The implementation of the pressure maintenance by gas injection should result in significantly higher recoverable oil reserves. The field is currently producing in excess of 40,000 BO/month (Figure 5).

CONCLUSION

A recent Tuscaloosa well of interest is a wildcat operated by Oxy USA, Inc. Oxy completed the No. 1 CMR "A" in Wilkinson County in August 1991; it tested 143 BO and 2674 MCF from perforations at 11,551 - 11,564 feet. The new field discovery, Freedom Field, is located five miles northwest of Longleaf Field, and is on strike with the Thanksgiving Field meander belt.

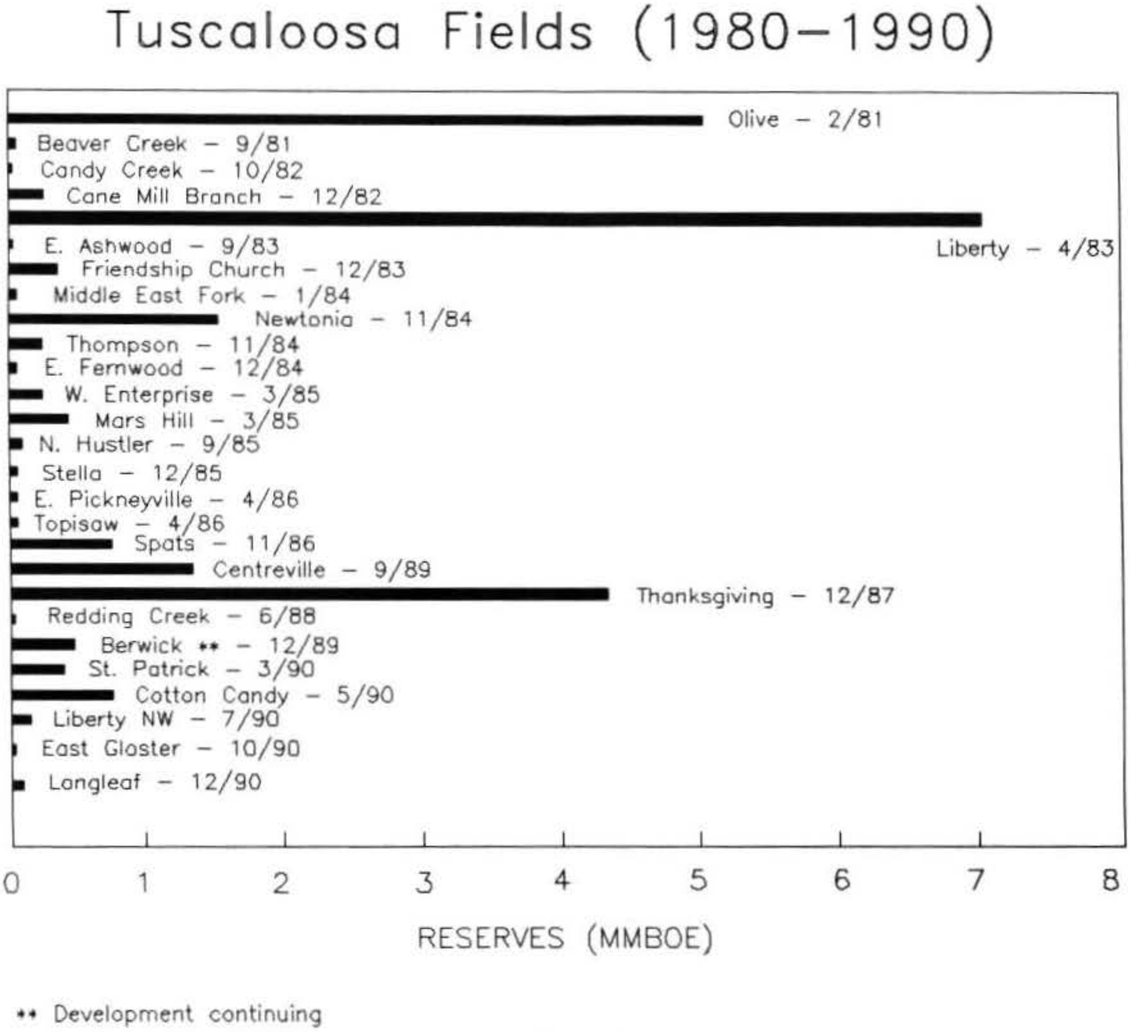


Figure 6.

Tuscaloosa trend activity will continue due to seismic stratigraphy and the reserve potential that remains. In the past ten years, major reserves have been found at Olive Field (1981), Liberty Field (1983), Thanksgiving Field (1987), and Berwick Field (1989) (see Figure 6). The success at Thanksgiving Field has shown there are still high quality prospects in the Tuscaloosa trend of southwestern Mississippi.

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ON THE OCCURRENCE OF THE TRACE FOSSIL *GASTROCHAENOLITES* AND ITS CAUSATIVE BIVALVE IN THE TALLAHATTA FORMATION (EOCENE) OF EAST-CENTRAL MISSISSIPPI

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ABSTRACT

A new, earliest occurrence of the ichnospecies *Gastrochaenolites ornatus*, together with its causative bivalve *Pholas* (*Monothyra*) sp. cf. *orientalis*, is described from the Middle Eocene, Tallahatta Formation of east-central Mississippi. The traces occur within transgressive, shallow marine sands that were colonized by a variety of ichnogenera in a three-stage process. The three stages involve the colonization of 1) a soft substrate, 2) a firmground, and 3) a post-omission surface.

INTRODUCTION

This paper presents a description of the boring ichnospecies *Gastrochaenolites ornatus* together with *in situ* steinkerns of its causative bivalve *Pholas* (*Monothyra*) sp. cf. *orientalis* from the Basic City Member of the Tallahatta Formation (Claiborne Group, Lutetian, Middle Eocene) in east-central Mississippi. This occurrence represents the earliest known record of *G. ornatus*. The borings of *G. ornatus* are described from a single road cut exposure (Figure 1), 16.5 km (10.3 miles) southeast of Philadelphia on Highway 19 in Neshoba County (S 1/2, NW 1/4, Sec 12, T9N, R12E, Deemer 7.5-minute quadrangle). Specimens from this outcrop have been deposited in the Paleontological Collections (accession number 3342) of the Dunn-Seiler Museum of Geology at Mississippi State University.

LITHOSTRATIGRAPHIC SETTING

The initial deposits of the Claiborne transgressive event in Mississippi include the Meridian Sand and the Basic City Shale Member of the Tallahatta Formation. The Meridian

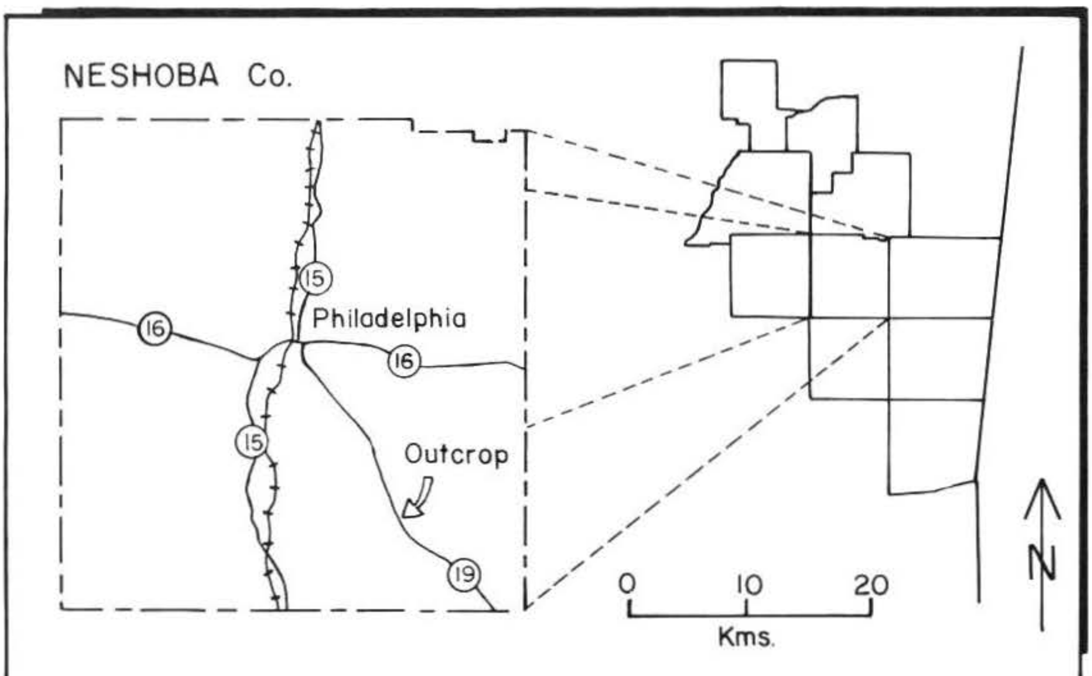

Figure 1. Location map of *Gastrochaenolites* outcrop.

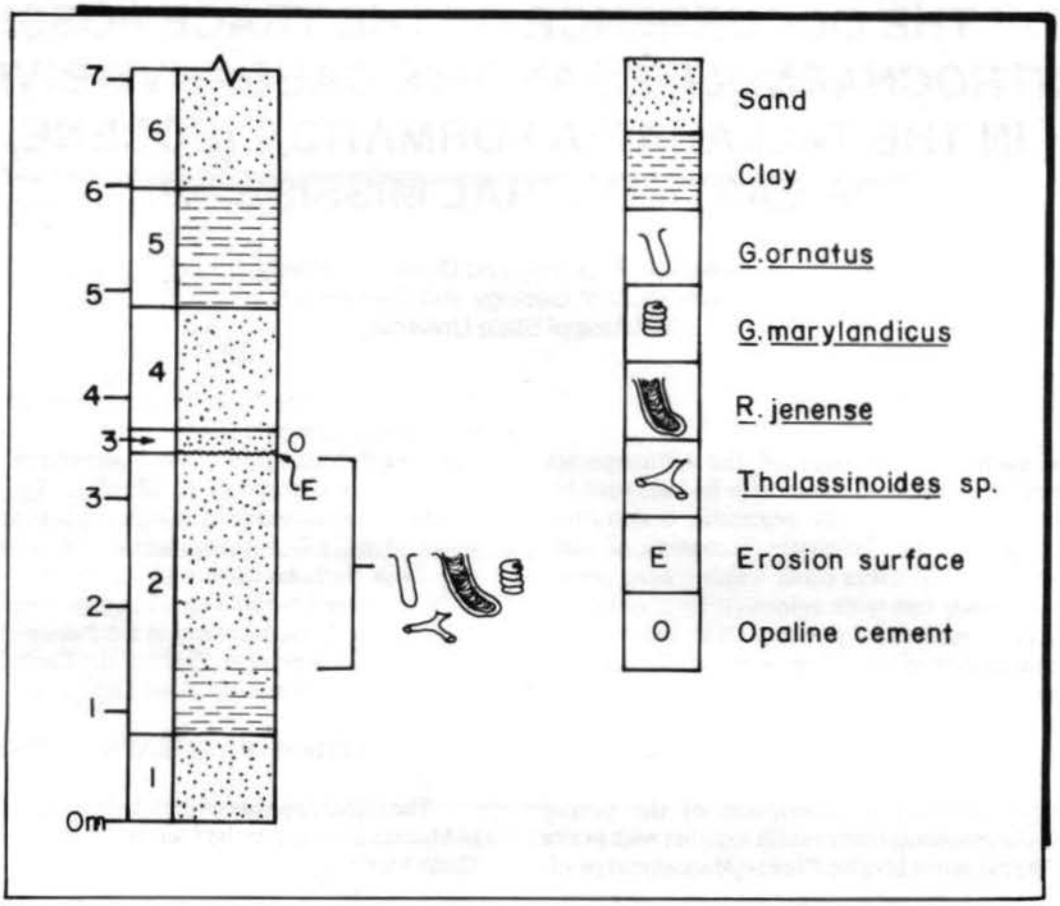

Figure 2. Stratigraphic section for outcrop on Highway 19, south of Philadelphia.

Sand is a planar cross-bedded, fine- to medium-grained, yellow to yellow-gray, glauconitic sand. According to Keady and Lins (1979), the Meridian Sand represents a shallow marine, offshore shoal.

The Basic City Member of the Tallahatta Formation contains a finely micaceous, opaline claystone informally known as the "buhrstone" as well as opaline, fine- to medium-grained, yellow to white sands. The Basic City Member is generally considered to represent an offshore transgressive shelf deposit (Weaver and Wise, 1974; Dockery, 1986).

In terms of sequence stratigraphy, Ingram (1992) has suggested that the Meridian Sand and the Tallahatta Formation represent deposits of the TE2.1 Sequence Event. In this interpretation the Meridian Sand comprises the lowstand deposits, and the Tallahatta records the highstand deposits (Ingram, 1992).

LITHOLOGY AND PALEONTOLOGY

The outcrop on Highway 19, south of Philadelphia, contains sediments that are transitional between the Meridian Sand and the claystones of the Basic City Member of the Tallahatta Formation (Figure 2). The seven meter section was described by Yip (1981), but was remeasured for this study.

Most of the section consists of pale yellow-gray, fine- to medium-grained, glauconitic and opaline sand; however, there are two pale gray to yellow-gray clayey intervals in the exposure. The lowermost clay is part of a coarsening upward unit near the base of the section at about the one meter level and the uppermost clay is about one meter thick and occurs in the 4.8 to 5.9 m interval (Figure 2). The sediments are planar bedded, but the top of Unit 2 is marked by an erosional surface.

The only macroinvertebrate body fossils that occur in the outcrop are steinkerns of the pholadid bivalve *Pholas* (*Monothyra*) sp. cf. *orientalis* which are found only *in situ* within borings of *Gastrochaenolites ornatus*. Although there are few body fossils in the outcrop, abundant ichnological remains occur throughout Unit 2. Ichnospecies present include U-shaped spreiten of *Rhizocorallium jenense*, branched tunnel systems of *Thalassinoides* sp., and spirally coiled burrows of *Gyrolithes marylandicus*. In addition to the larger traces, there are also small (millimeter scale) burrows on, and

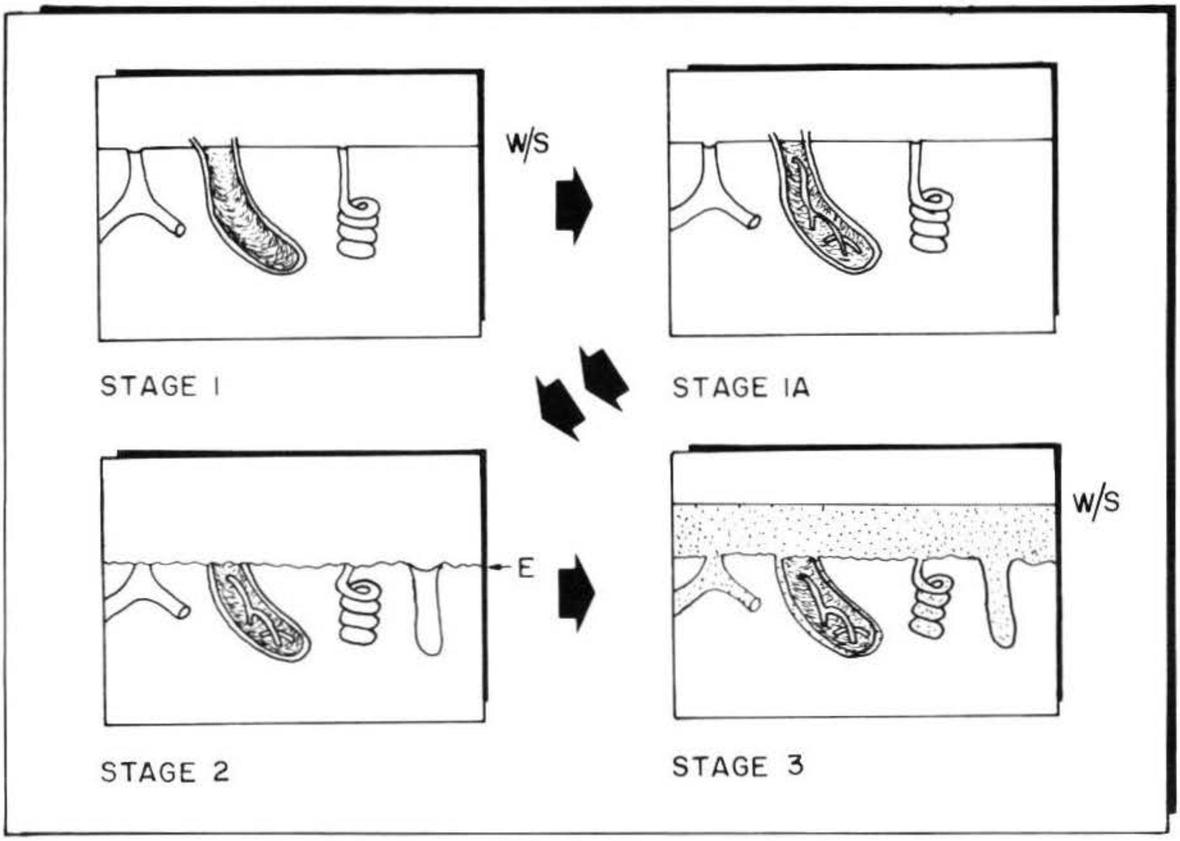

Figure 3. Colonization sequence of Unit 2. For explanation see text; for symbols see legend of Figure 2; W/S: water/sediment interface; E: erosional surface.

in, both the boring casts and the bivalve steinkerns. The distribution and occurrence of traces suggest that biological activity within Unit 2 occurred at different times and in distinct phases.

PALEOENVIRONMENTAL ANALYSIS

Although the lithologies present in the outcrop on Highway 19 are transitional between the glauconitic sand facies of the Meridian Sand and the opaline claystone facies of the Basic City Member of the Tallahatta Formation, the sedimentological evidence supports the contention that the paleoenvironment was a transgressive, shallow marine shoal and shelf (Keady and Lins, 1979; Dockery, 1986). Furthermore, the trace fossil associations suggest that the paleoenvironment may have been in the tidal to shallow subtidal range (Frey and Seilacher, 1980; Pemberton and Frey, 1985). Whether these data indicate a proximity to the true shoreline or an offshore shoal is impossible to say from the available evidence.

It is also clear from the sediments that an erosional surface marks the top of Unit 2, but the significance of this surface is apparent only when the three-stage colonization history of the unit is considered (Figure 3):

Stage 1: After the deposition of Unit 2, a soft, fairly competent and relatively inactive substrate was available for colonization. The suite of ichnospecies which characterizes Stage 1 colonization represents a pre-omission assemblage (*sensu* Bromley, 1975) that would be referable to the *Cruziana* Ichnofacies of Seilacher (1967). The two most important colonizers were callianassid shrimps which were responsible for the development of extensive, ramose, bedding-parallel, *Thalassinoides* galleries and a deposit feeder which was responsible for the meniscate, U-shaped spreiten of *Rhizocorallium jenense* (Yip, 1981). The *R. jenense* spreiten are normal to bedding in their upper portions but become oblique to bedding at the base of the U-shaped structure. Furthermore, the *R. jenense* traces are short and their upper ends are not protrusive at the top of Unit 2, which suggests that they may have been truncated by later erosion. A minor component of the Stage 1 assemblage is the vertically oriented, spiral burrows of *Gyrolithes marylandicus* (Yip, 1981).

Stage 1a: Indeterminate hollow tube-like traces occur throughout the menisci of *Rhizocorallium jenense* and therefore postdate the initial colonization event.

Stage 2: After some synsedimentary lithification of the sea floor to form a firmground, Unit 2 was colonized by the boring bivalve *Pholas* (*Monothyra*) sp. cf. *orientalis* which produced traces of *Gastrochaenolites ornatus*, during a period of non-deposition. The firmground colonization by bivalves can be related to the *Glossifungites* Ichnofacies (*sensu* Frey and Seilacher, 1980) and represents the omission suite of Bromley (1975). Since the borings of *G. ornatus* are relatively short, lack any kind of tapering neck and the bivalve steinkerns contained therein are very near the upper surface of Unit 2, it is likely that scouring of the surface took place prior to the onset of Stage 3.

Stage 3: The resumption of sedimentary activity was responsible for filling the galleries of *Thalassinoides* sp. and the spiral tubes of *G. marylandicus* described in Stage 1, as well as the borings and the bivalves described in Stage 2, with fine sand, and thereby providing a substrate for Stage 3 colonizers.

Traces that are associated with Stage 3 occur only as post-omission features on, and within, the bivalve steinkerns and the sand-filled borings which contain them. Characteristically, both the steinkerns of the bivalves and the casts of the borings are traversed and invaded by small (millimeter scale), branched and unbranched burrows (Plate 1). The burrowing activity of Stage 3 was restricted to the steinkerns and the boring casts because the organic materials of the decaying bivalves would have provided a nutrient-rich environment inside and surrounding the shells while the sediment was soft and before the shells were dissolved away during later diagenetic activity. Fursich et al. (1981) suggest that similar types of traces at the Austin/Taylor (Upper Cretaceous) contact zone in Texas are the work of vermiform organisms which reworked the sediment inside the shells prior to cementation.

ICHNOFOSSIL DESCRIPTION

Traces referable to the genus *Gastrochaenolites* normally occur in lithic substrates ranging from Jurassic to Recent. A review of their taxonomic status is given in Kelly and Bromley (1984).

Specimens of *Gastrochaenolites* from the Tallahatta Formation are sand-filled casts of the original borings. The casts are about 7-8 cm long, clavate, circular in cross section with a diameter of about 2-3 cm and have five or six concentric grooves and ridges at the base of the structure. Previous descriptions of cylindrical traces in the Tallahatta (Copeland, 1966; Toulmin, 1977; Yip, 1981) either left them unidentified or referred them to the ichnogenus *Cylindricum* (Yip, 1981). The presence of the concentric ridges and grooves in the present material, however, (Plate 1, fig. 2) is diagnostic and indicates that the traces should be referred to *G. ornatus* Kelly and Bromley. Kelly and Bromley (1984) suggest that the concentric ornamentation at the base of *G. ornatus* borings represents a bioglyph formed by the rotary action of the anterior serrations on the causative bivalve as it enlarged its boring (see also ?Pliocene "burrow" of *Chaeceia ovoidea* in Kennedy, 1974, fig. 103).

According to Kelly and Bromley (1984), *G. ornatus* has a geologic range of Pleistocene to Recent. However, Warme and McHuron (1978) also figured clavate borings from Miocene mudstones of the Stetson Bank off the central Texas coast. Resin casts of the borings formed by *Jouannetia quillingi* (Warme and McHuron, 1978, p. 97, fig. 9b) possess concentric markings at their base, and appear to be identical to the borings referred to *G. ornatus* Kelly and Bromley (1984, p. 802, fig. 7a-d). The occurrence of clavate borings with concentrically grooved basal portions in the Tallahatta of Mississippi supports the extension of the range of *G. ornatus* from the Eocene to the Recent.

G. ornatus borings have been described as containing the remains of, or having been formed by, a variety of pholadid bivalves such as *Zirfaea crispata*, *Jouannetia quillingi*, *Barnea* and *Pholas* (Warme and McHuron, 1978; Roder, 1977; Kelly and Bromley, 1984). Specimens from the Tallahatta contain steinkerns of a pholadid bivalve with strong anterior serrations that would have been capable of producing the concentric bioglyph found at the base of the borings.

We suggest that the steinkerns represent specimens of *Pholas* (*Monothyra*) sp. cf. *orientalis*. Our taxonomic uncertainty stems from three observations: Firstly the lack of shell material in the Tallahatta specimens; secondly, although *Cyrtopleura* (*Scobinopholas*) *costata* is the most common pholadid in the Gulf Coast region (DuBar, 1958; Fallow and Wheeler, 1969; Kennedy, 1974) it only has a recorded range of Pliocene to Recent (Kennedy, 1974, p. 27-8); and thirdly the smooth posterior portion of the steinkerns is reminiscent of the Cretaceous to Recent ranging, Indo-Pacific subgenus *Pholas* (*Monothyra*) (type species *P.* (*M.*) *orientalis* - Recent, Singapore) described in Cox and others (1969, p. N707-8). In this regard it is important that during the Eocene there was free circulation from the Pacific into the Gulf of Mexico until development of the Panama Isthmus in the Pliocene (Keigwin, 1978).

DISCUSSION

The occurrence of *Gastrochaenolites ornatus* together with the causative bivalve *Pholas* (*Monothyra*) sp. cf. *orientalis* in the Tallahatta Formation of Mississippi is an important addition to the paleobiological knowledge of this unit for several reasons.

1) The causative bivalve is of Indo-Pacific affinity and further demonstrates the connection between the Pacific and Gulf of Mexico during the Eocene.

2) The causative bivalve also supports the idea that *G. ornatus* can be produced by a variety of pholadid bivalves which possess anterior serrations.

3) This report extends the lower range of *G. ornatus* from Pleistocene (Kelly and Bromley, 1984) down into the Eocene.

4) The sequence of substrate colonization indicates the presence of a previously unrecognized omission surface near the base of the Tallahatta Formation. From this statement it is clear that at least local, partial, sea floor lithification was occurring during periods of non-deposition as an integral part of the transgression process which marked the TE2.1 event.

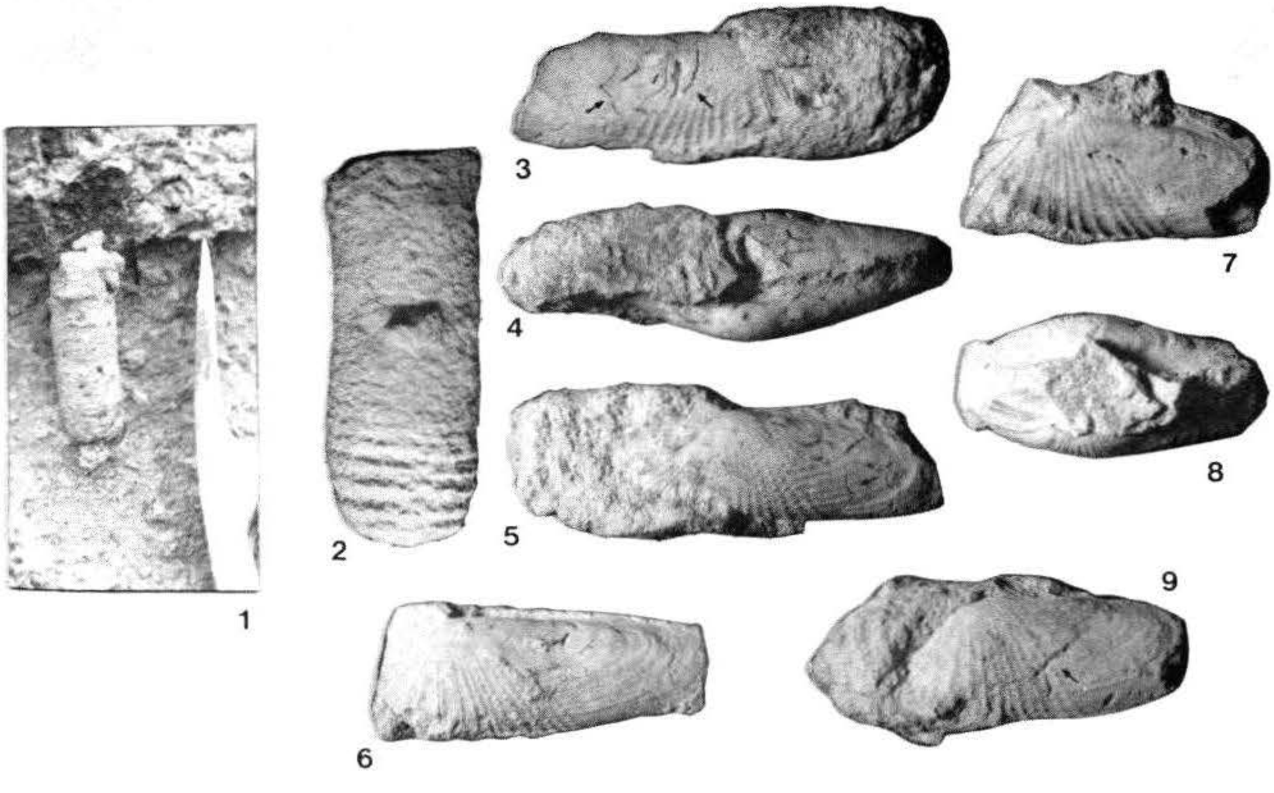

PLATE CAPTION

Figure 1. *Gastrochaenolites ornatus in situ*; hammer head for scale.
Figure 2. Cast of *Gastrochaenolites ornatus*, #3342-1, length 7.3 cm.
Figure 3. *Pholas (Monothyra)* sp. cf. *orientalis*, #3342-2, right aspect of steinkern. Length 7.4 cm. Note: arrows indicate vermiform burrows.
Figure 4. *Pholas (Monothyra)* sp. cf. *orientalis*, #3342-2, dorsal aspect of steinkern.
Figure 5. *Pholas (Monothyra)* sp. cf. *orientalis*, #3342-2, left aspect of steinkern. Note: arrow indicates vermiform burrows.
Figure 6. *Pholas (Monothyra)* sp. cf. *orientalis*, #3342-3, left aspect of steinkern. Length 5.7 cm.
Figure 7. *Pholas (Monothyra)* sp. cf. *orientalis*, #3342-4, left aspect of steinkern. Length 5.3 cm.
Figure 8. *Pholas (Monothyra)* sp. cf. *orientalis*, #3342-4, dorsal aspect of steinkern.
Figure 9. *Pholas (Monothyra)* sp. cf. *orientalis*, #3342-5, left aspect of steinkern. Length 6.4 cm. Note: arrow indicates vermiform burrows.

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