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MISSISSIPPI LIGNITE - ENERGY FOR THE FUTURE

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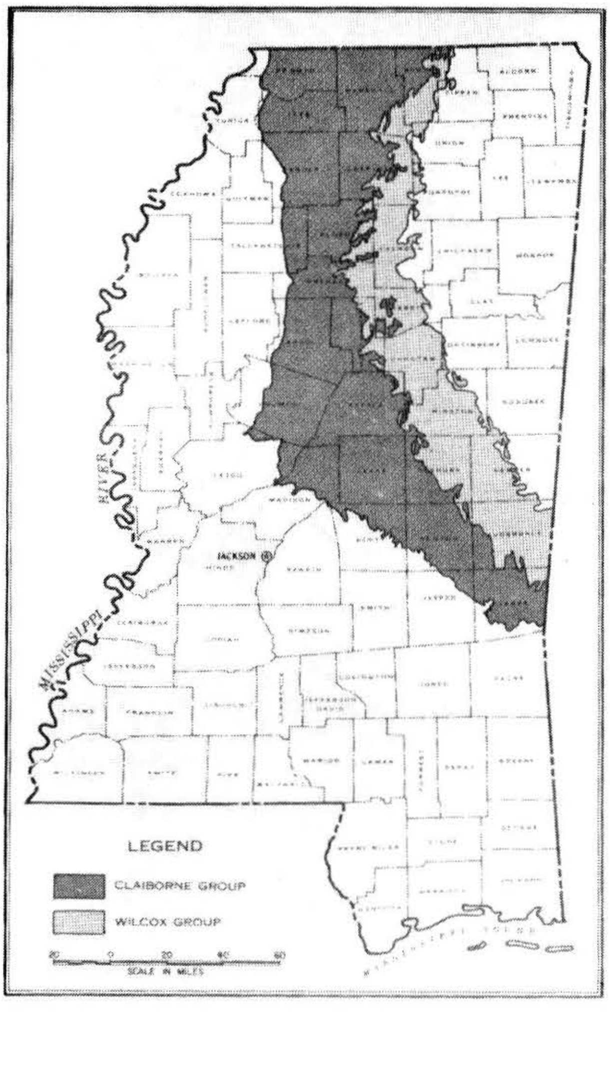

Sometime in the near future a new industry could move into Mississippi. It could employ hundreds of people, provide many millions of dollars in wages, and call for a capital investment of hundreds of millions of dollars. This new industry would be mining Mississippi lignite - a low grade form of coal. Lignite is brownish-black in color, generally high in moisture content and volatile matter, and relatively low in heat content.

Lignite is very abundant in the Gulf Coast region where about 23 billion tons of recoverable lignite are believed to exist. It has been estimated that Mississippi has approximately 5 billion tons of mineable lignite which is equivalent to 10 billion barrels of oil. This places Mississippi second to Texas in the Gulf Coast region in the extent of mineable lignite reserves.

The most significant use of lignite has been as a boiler fuel for utilities and industries. Texas has used lignite as a fuel for producing electric power since the 1920's. The heating value of Mississippi lignites averages about 6,000 BTU/lb as compared to 6,500 BTU/lb for the Gulf Coast region. However, Mississippi lignites should also do well as boiler fuel.

There are currently several sites in Mississippi being studied by coal companies through extensive exploration programs. The most extensive study to date has been carried out by Phillips Coal Company for the proposed Delta Star mine near Sledge in Quitman County. As conceived, the mine is expected to produce about 9 million tons of lignite per year. Over the 30-year expected life of the mine it should produce about 270 million tons of lignite from a 10,000 acre area. A virtual moving hole, the mine will move about a quarter of a mile per year, be about 9,200 feet long and 2,000 feet wide at the surface, and occupy about 420 acres at any given time. The Delta Star mine is proposed to begin operations in the late 1980's.

Because of the geologic and climatic setting of Mississippi's lignite, the mining and subsequent reclamation can be easily accomplished. The material overlying the lignite generally consists of unconsolidated sands and clays which are free of rock. The most extensive lignite deposits are located in the Wilcox and Claiborne groups (Fig. 1). Mississippi's high annual rainfall will help revegetation during the reclamation stage. As mining proceeds, reclamation will be kept concurrent with mining. The overburden will be removed and the lignite excavated; then the overburden will be replaced, leveled, fertilized, and replanted. Land which was farmland, pastureland, or forestland before mining may be returned to its former use.

Due to the probability of future lignite mining in Mississippi, the Mississippi Legislature in 1979 passed the Mississippi Surface Coal Mining and Reclamation Act to insure that this important energy source is developed in an environmentally sound manner. Subsequently, regulations were written by the Bureau of Geology to enforce the new law. In 1980 Mississippi became the third state to have its regulatory program approved by the Office of Surface Mining, Department of the Interior.

Now that regulations are in place and exploration is better defining our lignite resources, all that is necessary is an energy demand to bring Mississippi's first lignite mine to life. For the future, conditions appear good for lignite to provide an alternative source of energy for a growing Mississippi.

Suggested Reading

Cleaves, Arthur W., 1980, Depositional systems and lignite prospecting models: Wilcox Group and Meridian sandstone of northern Mississippi: Gulf Coast Assoc. Geol. Soc. Trans., Vol. 30, p. 283-307.

Haynes, H. W., Jr., and D. Cornell, 1981, Identification of current lignite research projects in the United States and applicability to future research in Mississippi: University, Mississippi, Mississippi Mineral Resources Institute, Rept. of Invest. No. 79-19, 11 p.

Hollman, K., S. C. Shull, and R. S. Herren, 1980, Estimated economic impact of the proposed Delta Star Mine: University, Mississippi, Mississippi Mineral Resources Institute, Rept. of Invest. No. 801, 68 p.

Self, D. M., and D. R. Williamson, 1977, Occurrence and characteristics of Midway and Wilcox lignites in Mississippi and Alabama, *in* Campbell, M. D., ed., Geology of alternate energy resources in the south-central United States: Houston Geol. Soc., Houston, Tx., p. 161-177.

Williamson, D. R., 1976, An investigation of the Tertiary lignites of Mississippi: Mississippi Geological Survey, Info. Series MGS-74-1, 147 p.

THE LOBSTER *LINUPARUS* PRESERVED AS AN ATTACHMENT SCAR ON THE OYSTER *EXOGYRA COSTATA*, RIPLEY FORMATION (LATE CRETACEOUS), UNION COUNTY, MISSISSIPPI

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ABSTRACT----A specimen of *Exogyra costata* Say was collected from the Coon Creek facies of the Ripley Formation near Blue Springs, Union County, Mississippi. The articulated specimen preserved a 46 by 63 mm attachment scar near the umbo of the left valve. The attachment scar proved to be an external mold of the lateral margin of the carapace of a linuparid lobster. If the lobster were dead (a corpse or molt) at the time of the colonization by the *Exogyra* and if the first major break in oyster shell growth represents a seasonal break, the longevity of chitinous decapod exoskeleton in the Cretaceous Mississippi Embayment might have been as long as a year.

Introduction

While collecting fossil crabs and lobsters from the Blue Springs locality (GAB 37) in Union County, Mississippi, I collected an interesting oyster, *Exogyra costata* Say, from the lower part of the Ripley Formation (Coon Creek facies). The specimen (GAB 37-1111) is an articulated specimen, 13.2 by 12.2 cm in size, which exhibits a very interesting attachment scar formed by attachment to a linuparid lobster.

Previous Investigations

Exogyra is a common Coastal Plain Cretaceous oyster which has been extensively studied and utilized for biostratigraphic and paleoecologic purposes. The oyster has a highly convex left valve and a flat, lid-like right valve.

The shell is laterally coiled and ornamented by a rough rugose exterior, by radially spiraled costae, by concentric undulatory ridges, or if both are present, a cancellate interference structure which has resulted in naming of various species based on ornamentation (Stephenson, 1941).

The heavy bivalved shells of the Exogyras are usually composed of easily preserved low magnesium calcite resulting in excellent preservation. The larval stage of the Exogyras is one of a planktonic or nectonic existence. The larvae are easily distributed by oceanic currents which results in a widespread distribution and usefulness of this easily preserved bivalve mollusc in biostratigraphic zonation (Kauffman, 1975). At the end of the larval stage these oysters must attach their left valve to a hard substrate or perish (Stenzel, 1971). The only available site of attachment in soft-bottomed habitats often is the exposed exoskeletons of other invertebrates. The oyster grows attached to its substrate for an interval of time. At some point the oyster becomes too heavy to be supported by its substrate and the oyster topples over and assumes a free-living, reclining mode of life (Stenzel, 1971, p. 1074). If the substrate is chemically less stable than calcite, the substrate will eventually dissolve away leaving behind an external mold (negative imprint) of the substrate. These external molds may form very accurate imprints of the morphological features of shells of invertebrates available as settlement sites on the sea bottom (Stenzel, 1971, p. 997; Lewy, 1972, p. 348; Lawrence, 1968). In many cases these invertebrate attachment scars, or resulting xenomorphic structures on the oyster's right valves, may be the only preserved evidence of the presence of chemically less stable taxa (R. L. Priestley, 1979, personal communication).

Methods

In a study of the attachment scars (and xenomorphs) exhibited by a suite of oysters from the Demopolis Chalk at Belden (Lee County, Mississippi), R. L. Priestley and I developed a technique of making wax impressions of the attachment scars of the oysters to obtain a positive replica (cast) of the attachment substrate. The replicating material used is a red dental impression material manufactured by Kerr Manufacturing Co. of Romulus, Michigan; it is used because of its availability in a local educational surplus warehouse. This material is a brittle solid at room temperature but becomes a viscous plastic when immersed in hot tap water. The impression is made by pushing the hot, viscous, plastic material onto the attachment areas of the oysters. The solid material is removed easily after it has cooled. The red impression of the substrate is then coated with a magnesium oxide whitening powder by burning magnesium ribbon under an inverted funnel and holding the replica in the rising magnesium oxide "smoke" above the funnel tip. The specimen and attachment impression were photographed on a Galvin-Bishop, 2 1/4 by 3 1/4 inch, macrofossil camera system.

Description

The specimen of *Exogyra costata* is a moderately-sized individual represented by both right and left valves. The lid-like right valve is pushed somewhat into the left valve and mostly covered with sediment. The left valve (fig. 1A) is 13.2 cm high and 12.2 cm wide, very convex, laterally spiraled with a large (bi-faceted) attachment scar which measures 63 by 46 mm. The surface of the left valve is ornamented by numerous radial costae which are crossed by a concentric ornament consisting of thin growth lines and 8-9 wider bands which form a somewhat undulatory surface. Two small *Exogyra* left valves are attached near the posterior commisure of the large specimen. The entire left valve is perforated by small holes, the gallery borings of clinoid sponges.

The attachment scar (fig. 1B) is large and composed of two more or less flat facets which form a dihedral angle of 110 ^{o} to 120^{o}. The larger facet is convex on the oyster and the smaller is concave on the oyster. The surface of the larger facet is composed of an anastomosing pattern of swirls and circles (fig. 1C).

The impression of the attachment scar is a cast (impression or positive replica) of the substrate to which the oyster attached (fig. 1D). The substrate was obviously the branchial region of the carapace of a lobster belonging to the genus *Linuparus* (such as fig. 1F). One of the elements of the Blue Springs decapod assemblage is the linuparid lobster, *Linuparus canadensis* (fig. 1E). Two oyster spat (?) are present near the middle of the attachment scar. The surface also exhibits numerous bumps (which are impressions of the sponge borings).

Conclusions

The attachment of oysters to the exoskeleton of crabs or lobsters has rarely been described. One instance on record is that of a hermit crab claw carrying a small oyster (Glen Rose Limestone) described by Bishop (In Press).

In the instance described from the Ripley Formation the condition of the lobster at the time of attachment and growth of the oyster cannot be determined with certainty. Because lobsters groom themselves, it is unlikely that the lobster was alive at the time of colonization by the *Exogyra*. The presence of two other spat preserved on the lobster's back reinforces this hypothesis.

The length of time the chitinous exoskeleton was able to survive the ravages of decomposition in the Cretaceous Seawater at least is as long as the interval of time it took the oyster to grow to a size where it overlapped the edge of the lobster carapace. There is a major growth imbrication just beyond the point where the lobster carapace was overlapped by oyster shell growth. Stenzel (1971, p. 1014) ascribed these laminations to seasonal or meteoro-

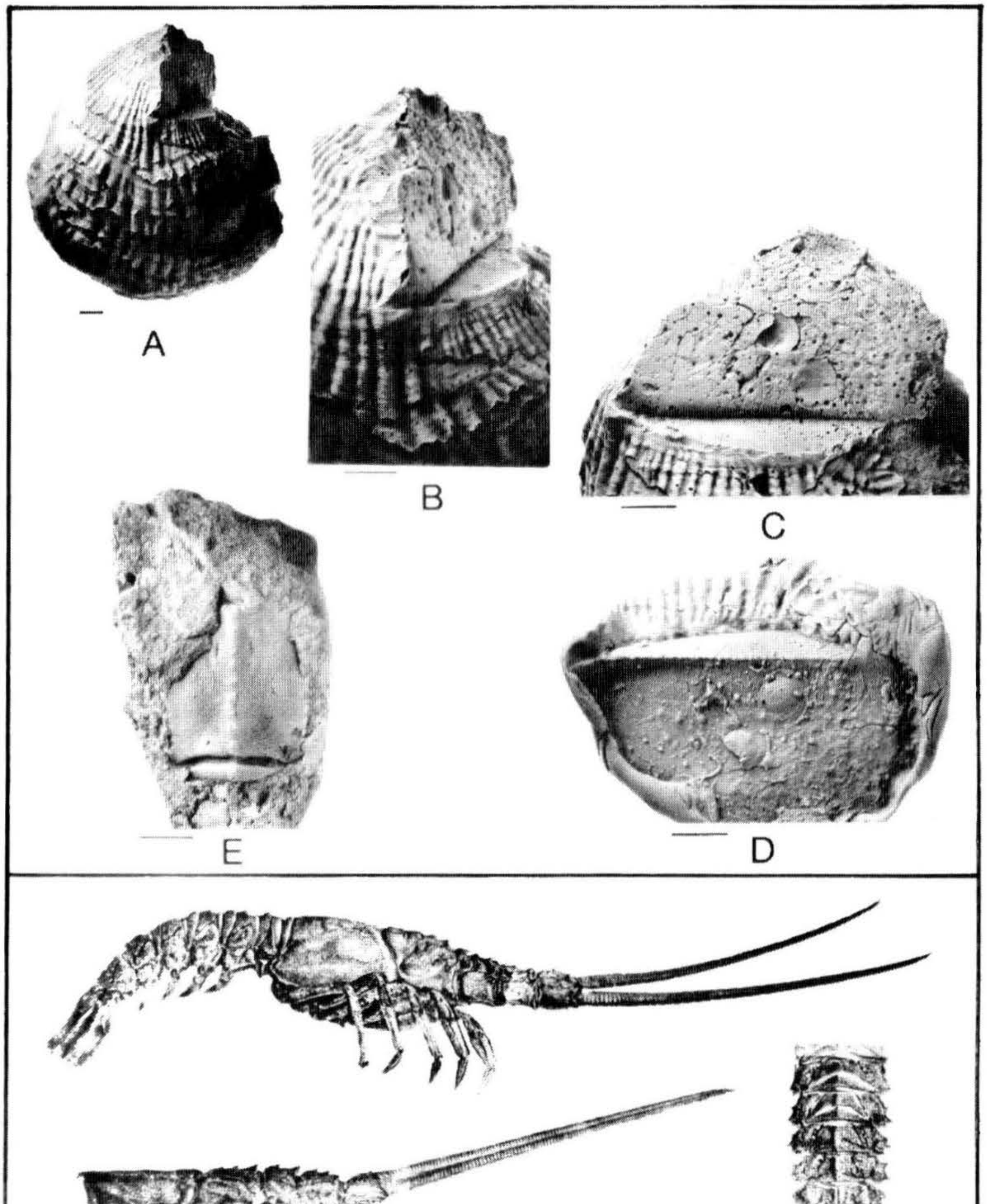

Figure 1. *Exogyra costata* (A-D) with attachment scar of the lobster *Linuparus* (D-F). The left valve (A and B) showing the large, planar attachment scar (C) and its wax replicate (D). The wax replicate is the edge of the carapace of *Linuparus canadensis* (Whiteaves, 1885) (E). Illustrations of *Linuparus (L.) trigonus* de Haan (F) (from Mertin, 1941, p. 214) relate the carapace fragment (D and E) to the whole organism. Bar scale = 1 cm.

logical changes in the oyster's habitat. They may be used (with some uncertainty) as marking annual growth. The evidence available indicates that the lobster carapace existed from the time of settlement almost to the end of the first growing season (marked by the first imbrication). This interval of time should not have exceeded one year; therefore the chitinous exoskeleton is thought to have lasted a major part of a year. This longevity far exceeds the four weeks cited by Wilhelm Schäfer (1972, p. 140) for decapod cuticle in the North Sea to lose its strength. If the assumptions of this lobster being a corpse (or molt) at the time of colonization and the major break in shell growth being a seasonal break are valid, the conclusion must be drawn that in some cases chitinous exoskeleton of decapod crustaceans is quite resistant to decomposition in seawater.

Acknowledgments

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References Cited

Bishop, G. A., In Press, Fossil decapod crustaceans from the Early Cretaceous Glen Rose Limestone of Central Texas.

Kauffman, E. G., 1975, Dispersal and biostratigraphic potential of Cretaceous benthonic Bivalvia in the Western Interior, *in* W.G.E. Caldwell, ed., The Cretaceous System in the Western Interior of North America: Geol. Assoc. Canada, Spec. Paper No. 13, p. 163-194.

Lawrence, D. R., 1968, Taphonomy and information losses in fossil communities: Bull. Geol. Soc. Am., v. 79, p. 1315-1330, 4 figs.

Lewy, Zeev, 1972, Xenomorphic growth in ostreids: Lethaia, v. 5(4), p. 347-351, 2 figs.

Mertin, Hans, 1941, Decapode Krebse aus dem subhercynen und Braunschweiger Emscher and Untersenon, sowie Bemerkungen über winige verwandte Formen in der Oberkreide: Same (Abhandl. Kaiserl. Leopold.-Carolin. Deutsch. Akad. Naturforsch.), new ser., v. 10, no. 68, p. 152-257, 8 pl., 30 text figs.

Priestley, R. L., 1979, Attachment areas and xenomorphs of Cretaceous oysters as to associated fauna in the Demopolis Chalk of Lee County, Mississippi: Senior Thesis, Georgia Southern College.

Schäfer, Wilhelm, 1972, Ecology and Palaeoecology of Marine Environments (ed. by G. V. Craig, transl. by I. Oertel): Univ. Chicago Press, 568 p.

Stenzel, H. B., 1971, Oysters, *in* R. C. Moore, ed., Treatise on Invertebrate Paleontology, Part N, v. 3, p. 953-1224.

Stephenson, L. W., 1941, The larger invertebrate fossils of the Navarro Group of Texas (exclusive of corals and crustaceans and exclusive of the fauna of the Escondido Formation): Univ. Texas, Pub. 4101, p. 641, pl. 95, 6 tbls.

CALENDAR OF EVENTS

1981 October - December

October 12-16 - Society of Exploration Geophysicists, ann. mtg., Los Angeles, California. (John Hyden, SExG Headquarters, Box 3098, Tulsa, Oklahoma 74101)

October 13-15 - Fifth Conference on Geopressured-Geothermal Energy, U. S. Gulf Coast, Louisiana State University, Baton Rouge, Louisiana; Conference Chairman: Don Bebout, Louisiana Geological Survey. Subject: Results of well tests of the Gulf Coast geopressured resource; results of research concerning geology, salinity determination from logs, controls on methane content, reservoir mechanics, technology, economics of development, legal, institutional and environmental issues. Sponsors: Louisiana Geological Survey, Department of Natural Resources; Energy Programs Office, Louisiana State University; U. S. Department of Energy. For further information contact Ann Bachman Conference Coordinator, Energy Programs Office, 105 Hill Memorial, Louisiana State University, Baton Rouge, Louisiana 70803; 504/388-6816. For pre-registration materials contact Short Courses and Conferences, Division of Continuing Education, Louisiana State University, Baton Rouge, Louisiana 70803; 504/388-6621.

October 20-23 - Gulf Coast Section, American Association of Petroleum Geologists, ann. mtg., Corpus Christi, Texas. (Wilson Humphrey, Border Exploration Co., 310 Meldo Park, Corpus Christi, Texas 78411; 512/883-1470)

November 2-5 - Geological Society of America, and associated societies, ann. mtg., Cincinnati. (GSA Headquarters, 3300 Penrose Place, Boulder, Colorado 80301)

MACROFOSSIL ASSEMBLAGES OF THE MOODYS BRANCH FORMATION (UPPER EOCENE), LOUISIANA AND MISSISSIPPI

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Introduction

The Moodys Branch Formation (Upper Eocene, Jackson Group) is a thin, fossiliferous, glauconitic sand which crops out parallel to the Mississippi Embayment. Its basal contact with the Cockfield Formation (Middle Eocene) is generally burrowed and erosional although in selected areas a transitional zone has been noted (Tschudy, 1973; Dockery, 1980). The upper contact is gradational with the Yazoo clay. The Moodys Branch Formation, which can be divided into a northern, nearshore facies and a southern, offshore facies (Dockery, 1976), has been described as a destructive-shelf sand deposited by a transgressing Upper Eocene sea. The transition from sandy to clayey sediments reflects the deepening conditions of this transgression.

The fauna of the Jackson Group has been studied extensively since the 1850's when Conrad first described the fossils in Wailes' report on Mississippi geology. A recent monograph (Dockery, 1977) describes the molluscan fauna of the Moodys Branch Formation. Only recently have the depositional systems of the Moodys Branch Formation been studied (Anderson, 1971; Dockery, 1976). The purpose of this research is to combine the sedimentological and paleontological information in order to delineate the fossil assemblages and relate these assemblages to their paleoenvironments.

Methods

Bulk sediment samples were collected from eight sections of the Moodys Branch Formation across Louisiana and Mississippi. Samples were taken at vertical intervals of 1 to 2 feet; closer intervals were sampled in areas of higher fossil density. In the lab, subsamples weighing about 500 g were disaggregated and fossils larger than 1 mm were picked and counted. Whole gastropods and spires were counted as individuals. The total number of pelecypod valves and identifiable beaks was divided by two to determine the number of pelecypod individuals. Scaphopods and solitary corals were also included in the quantitative study. If new species were continually encountered additional subsamples were picked until no or very few new species were found. In general the rate of increase in diversity leveled off between 200 and 300 individuals per sample.

The species counts from each sample were entered into a computer and the Shannon-Weiner diversity index (H') and a rarefraction curve (a graphic method of plotting the expected number of species in a sample for a particular number of individuals) were determined for each sample. The samples were then subjected to cluster analysis, a computer technique that compares all the samples and groups them according to their species composition and proportions. The Bray Curtis distance coefficient and flexible sorting method were used for the cluster analysis.

Results

Cluster analysis of 33 stations produced the dendrogram in Figure 1. Immediately obvious are the two major clusters. The upper cluster, which includes the subclusters A, B, and C, is composed primarily of the stations with sandier sediments. All the stations in the northern facies and the sandy stations of the southern facies comprise this group. The more clayey stations of the western-most localities and the upper clayey sediments in the east make up the lower cluster. Therefore the two major clusters seem to reflect the substrate preference of the fauna. This may be indirectly related to water depths.

The dendrogram displays six (A - F) finer subdivisions. These represent recurring fossil assemblages which are themselves a result of recurring environmental conditions. Figures 2 and 3 display the stratigraphic and geographic extent of each cluster. It is easy to see the succession of fossil assemblages with increasing water depth. Fossil assemblage A is found at the northern-most localities and is overlain by fossil assemblage B, also found in the northern facies. The basal portion of the southern facies exhibits two assemblages, C in the east and D in the west. Fossil assemblage E overlies C and then both the east and west localities are capped by fossil assemblage F. The clusters have been labelled A - F in order of increasing distance from shore. Note the short range and limited geographic extent of cluster E. This is probably due to some local variation in the environment and may not accurately reflect the overall trend. The environments are interpreted as A) open bay or lagoon, B) nearshore (shoreface?) wave-influenced environment, C) eastern inner shelf, D) western, inner middle shelf, E) eastern, inner middle shelf, and F) outer middle shelf. Each environment has a distinct fossil assemblage.

Fossil Assemblages

Species composition between assemblages is often very

FOSSIL ASSEMBLAGE	INTER-PRETATION	SEDIMENTS	CHARACTERISTIC SPECIES	H'	S	DESCRIPTION
A	open bay	fine sand	*Spisula jacksonensis* *Yoldia mater* *Pyramidella meyeri*	2.7	39	-species diverse -infaunal -suspension/detritus/carnivores
B	nearshore, wave-influenced	medium- fine sand	*Glycymeris idoneus* *Diplodonta ungulina* *Spisula jacksonensis*	2.0	32	-species dominant (Spisula) -infaunal -suspension
C	inner shelf	clay-rich, fine sand	*Alveinus minutus* *Lucina curta* *Eburneopecten scintillatus*	2.0	43	-species dominant (Alveinus) -infaunal/epifaunal -suspension/detritus
D	inner middle shelf	sandy clay	*Venericardia diversidentata* *Corbula densata* *Caestocorbula wailesiana*	2.4	38	-species diverse -infaunal -suspension
E	inner middle shelf	clay-rich, fine sand - sandy clay	*Alveinus minutus* *Kelliella boettgeri* *Turritella perdita* Bryozoans	2.4	37	-species diverse -infaunal/epifaunal -suspension
F	outer middle shelf	sandy clay	*Nucula spheniopsis* *Hipponix pygmaea* *Verticordia cossmanni* Solitary corals	2.8	23	-species diverse -infaunal/epifaunal -suspension/detritus

Table 1. Summary of fossil assemblages.

H' = average Shannon Weiner diversity index for each assemblage.

S = average number of species for each assemblage.

similar but the proportions of individuals are different. For the most part the assemblages coincide with distinct sedimentological changes, although these changes become more subtle higher in the section. Fossil assemblages A and B are found in the northern facies, and the environmental interpretation agrees with that of Dockery (1976, 1977). The identification of the inner and middle shelf environments does not refer to absolute depths but to position relative to the shoreline. A brief summary of the major characteristics of each fossil assemblage is given in Table 1.

The sediments of the OPEN BAY environment (A) are highly bioturbated and composed primarily of fine sand and sand-sized glauconite pellets. Lignite fragments and pyrite are also preserved. The fauna is dominated by *Spisula jacksonensis* which comprises about 30% of the population. Other consistently abundant fossils are *Yoldia mater* and *Venericardia*. Species nearly exclusive to this environment are *Periploma claibornense parvum*, *Calorhadia albirupina*, and two unidentified turrid species. Although suspension feeders are most abundant, deposit feeders and carnivores are also present in significant numbers. Common deposit feeders are *Yoldia mater*, *Nucula spheniopsis*, and *Calorhadia albirupina*. *Retusa jacksonensis*, *Pyramidella meyeri*, and *Acteon idoneus* are the most numerous carnivores.

Faunal density and number of species increase from the bottom to the top of the facies. The lowermost stations may be indicative of marginal bay environments and lower salinities while the uppermost stations may be bay center or inlet-influenced environments (Parker, 1960).

Sediments of the NEARSHORE, WAVE-INFLUENCED environment (B) are predominantly medium- to fine-grained, clean quartz sand with abundant *Ophiomorpha* burrows. *Spisula* again dominates the fauna by comprising 48% of the population. *Glycymeris idoneus* and *Diplodonta ungulina yazoocola* are the next most abundant species and both of these are nearly restricted to this environment. The large number of *Glycymeris* suggests this is an environment of high stress because through geologic history *Glycymeris* has been found in sandy, rigorous habitats (Thomas, 1975). The large *Glycymeris* valves form an imbricated shell bed which is evidence of sustained wave energy.

The trophic structure of the assemblage is dominated by shallow, infaunal suspension feeders which comprise 87% of the molluscan population. Other common suspension feeders are *Turritella alveata* and *Callista annexa*. Deposit feeders are scarce because fine particulate organic matter suitable for deposit feeding does not settle to the bottom in agitated water.

The *Ophiomorpha* complex is composed primarily of a network of horizontal burrows. *Ophiomorpha* burrows are found in numerous nearshore environments and their morphology can be useful as an environmental indicator (Frey et al., 1978). In general, horizontal complexes predominate in lower energy environments while vertical shafts are common in higher energy environments. It seems reasonable to suggest that these *Ophiomorpha* burrows were nearshore but slightly removed from the beach in the lower energy sublittoral shoreface.

Large numbers of the sand dollar, *Periarchus lyelli*, are found in a bed overlying the *Ophiomorpha* and *Glycymeris* beds. Living sand dollars inhabit shallow, offshore sand bars below the surf zone. The well-preserved specimens of *Periarchus* probably also inhabited offshore bars removed from the rigorous wave action of the *Glycymeris* shell bed.

The EASTERN INNER SHELF assemblage (C) is found in the basal part of the eastern-most localities where the sediments are clayey, fine sand. *Alveinus minutus*, a very small infaunal suspension feeder, dominates the fauna and makes up as much as 77% of the assemblage. *Lucina curta, Spisula jacksonensis,* and *Eburneopecten scintillatus* are the other consistently abundant species. Species restricted to this assemblage are the carnivorous gastropod *Bittium koeneni* and the pteropod *Clio simplex*.

The detritus feeders *Hilgardia multilineata, Yoldia mater, Nucula spheniopsis, Hipponix pygmaea,* and *Calytraphorus stamineus* comprise up to 15% of the population. Carnivores such as *Euspira jacksonensis, Retusa jacksonensis,* and *Tritonoatractus pearlensis* are diverse but not abundant.

Several trends are noted in the samples of this assemblage with increasing distance from shore: a decrease in the abundance of *Alveinus, Spisula,* and *Eburneopecten*, and an increase in *Venericardia diversidentata* and *Caestocorbula wailesiana.* The opportunists, *Spisula* and *Alveinus*, decrease in dominance as the environment becomes more equitable and suitable to other species such as venericards and corbulas. *Eburneopecten* decreases because pectens typically prefer sandy nearshore substrates to offshore clayey sediments.

Found in the basal portion of the western-most localities, the sediments of the WESTERN, INNER MIDDLE SHELF (D) are mostly a sandy clay, becoming more clayey in higher samples. *Alveinus minutus* again dominates the fauna but not nearly to the same degree as in the previous assemblage. It comprises an average of only 28% of the fauna. The shallow infaunal suspension feeders, *Caestocorbula, Venericardia diversidentata,* and *Corbula densata*, make up a major portion of the fauna; *Limopsis radiata* is also quite abundant in some samples. In addition to the suspension feeders, the population supports numerous detritus feeders and fewer carnivores. Solitary corals also are quite prolific.

The EASTERN, INNER MIDDLE SHELF assemblage (E) is found only at the Riverside locality in Jackson, Mississippi. The sediments are clayey, fine sand to sandy clay. The dominant species are *Alveinus* and *Kelliella boettgeri*, which is found very infrequently elsewhere. *Venericardia diversidentata, Lucina curta, Hilgardia multilineata,* and *Limopsis radiata* are also abundant. The gastropod *Turritella perdita* is a diagnostic species of this assemblage.

The bivalve fauna is very diverse but the gastropods are sparse. *Natica permunda* and *Euspira jacksonensis* are the only carnivorous gastropods, and they are rare. Deposit feeding bivalves and gastropods make up a small portion of the fauna, but the suspension feeders predominate.

Although bryozoans are found throughout the Moodys Branch there is a dramatic increase of them in this assemblage. In general, abundant bryozoans are found in normal marine, gently agitated water on an impure, calcareous clastic substrate at depths of 60 - 300 feet (Cheetham, 1963; Duncan, 1957). According to Cheetham bryozoans occupied the shallow terrigenous Eocene shelf but were locally distributed in the lower Jackson. The unusual bloom of bryozoans at these stations may be one of these local patches.

The OUTER MIDDLE SHELF assemblage (F) occurs at the top of the Moodys Branch where the sediment type is sandy clay. *Nucula spheniopsis* is most prominent and comprises about 10% of the population. *Hipponix pygmaea, Verticordia cossmanni, Flabellum cuneiforme,* and *Endopachys maclurii* are also characteristic of this fauna.

This fauna is sparse with only 22 preserved molluscan species, but they are fairly evenly distributed. Deposit feeders and suspension feeders dominate the trophic structure of the fossil assemblage, although an abundance of otoliths and crustacean remains suggests a much more diverse original community. The large number of suspension feeding corals indicates there was enough wave energy for the transport of nutrients but little turbidity; the large number of epifaunal species is indicative of a stable environment.

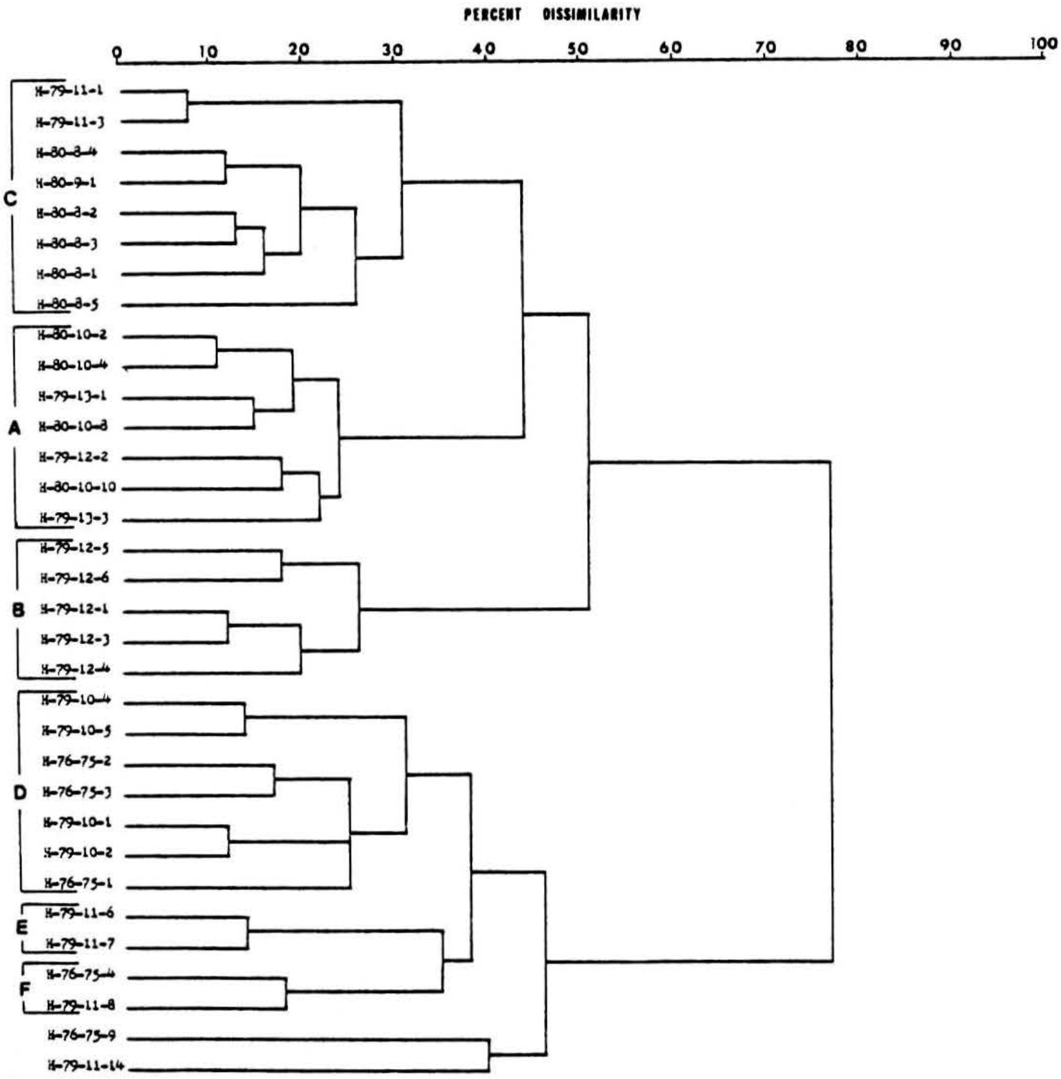

Figure 1. Cluster diagram for Q mode analysis of 33 samples. Six station groups are identified.

This widespread assemblage is furthest from the shoreline where ecological conditions are more stable and removed from nearshore influences. According to Parker (1960) nearshore environments vary in species composition from east to west, whereas on the continental slope there is no lateral difference in species. Although assemblage F is not the continental slope, it shows much less variability from east to west than the more shallow assemblages.

Discussion

Fossil assemblages C and D both occupy the basal portion of the southern facies, but C occurs at the eastern localities and D at the western localities. The sediment in the west is muddier than the east so substrate type may explain this difference. Some of the species reflect this substrate preference. Corbulas, which are more abundant in the western assemblage, most often inhabit low energy environments of fine sand and mud (Lewy and Samtleben, 1979). The greater abundance of *Eburneopecten* in the east reflects the preference of scallops for sandy substrates.

Other criteria suggest that assemblage D was a more stable, perhaps slightly deeper, environment. *Alveinus minutus*, an opportunistic species, greatly dominates the eastern assemblage, and this abundance is suggestive of a shallow, physically controlled environment (Levinton, 1970). Diversity is higher in the west, which indicates a more stable environment there.

The bay assemblage also displays high diversity, but this is probably not due to stability but rather to a heterogeneous environment. The fauna is a time-averaged collection of several bay subenvironments, e.g. bay center, bay margin, marsh, channel. Also through time the bay may have undergone periods of extreme stress and successional stages of rebuilding. Each successional stage consisted of a slightly different population, and the accumulation of these yielded a diverse fauna.

The nearshore, wave-influenced environment has low diversity because of the unstable and homogeneous environment. The inner shelf is still a shallow, unstable environment, but diversity progressively increases in the offshore middle shelf environments. Although the number of species decreases offshore, equitability is higher as opportunists no longer dominate and new offshore species gain in abundance.

Conclusions

Six macrofossil assemblages can be recognized in the Moodys Branch Formation with the aid of cluster analysis. These assemblages can be useful in further refining the paleoenvironmental interpretation of the formation. Evidence from the fossil record suggests that heterogeneity, environmental stability, and substrate composition were responsible for the distribution of these assemblages. Eocene onshore to offshore trends of increasing diversity and equitability show the same pattern in Gulf Coast molluscan and total fauna communities today. This supports the premise that fossil assemblages are useful in interpreting environmental influences affecting benthic communities.

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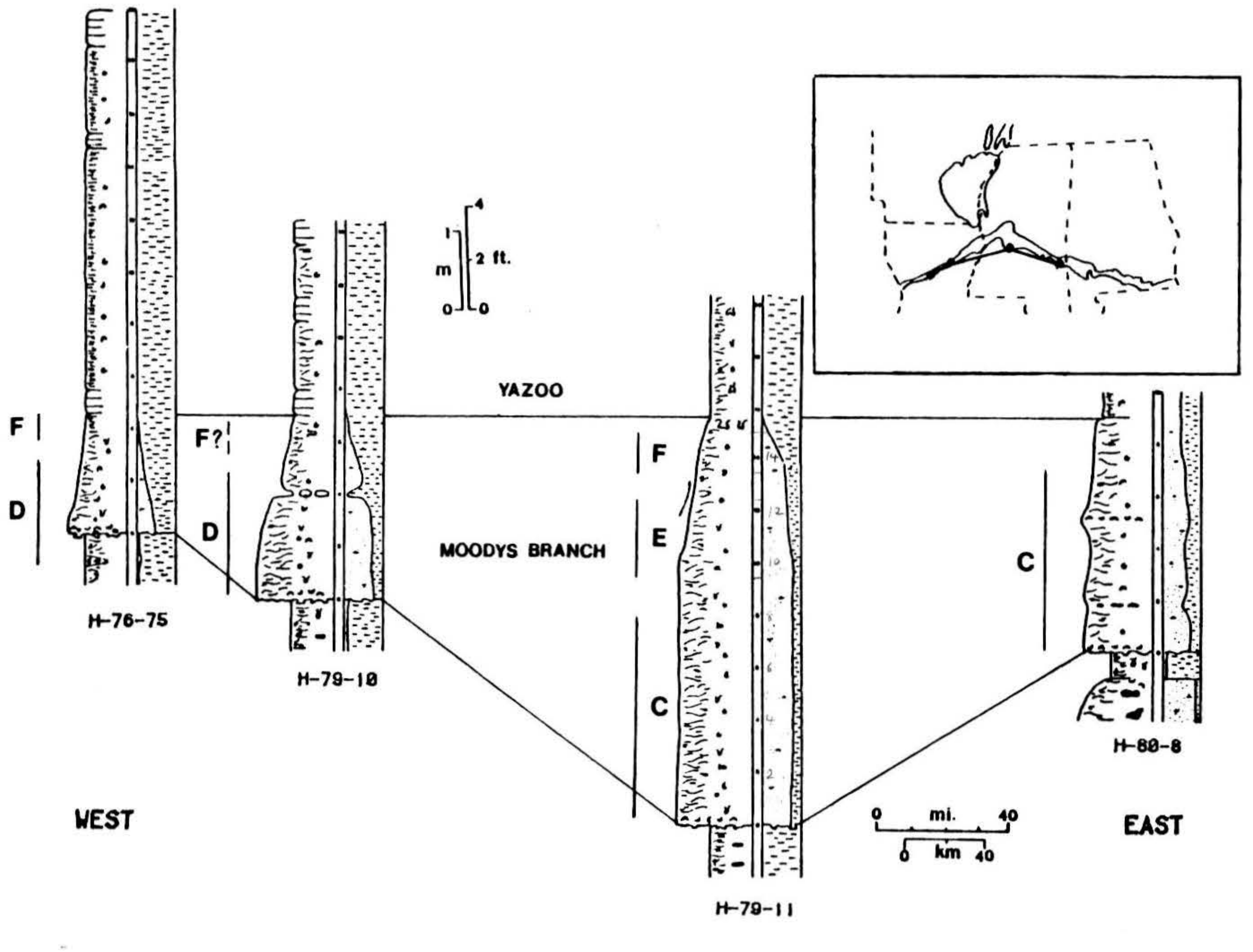
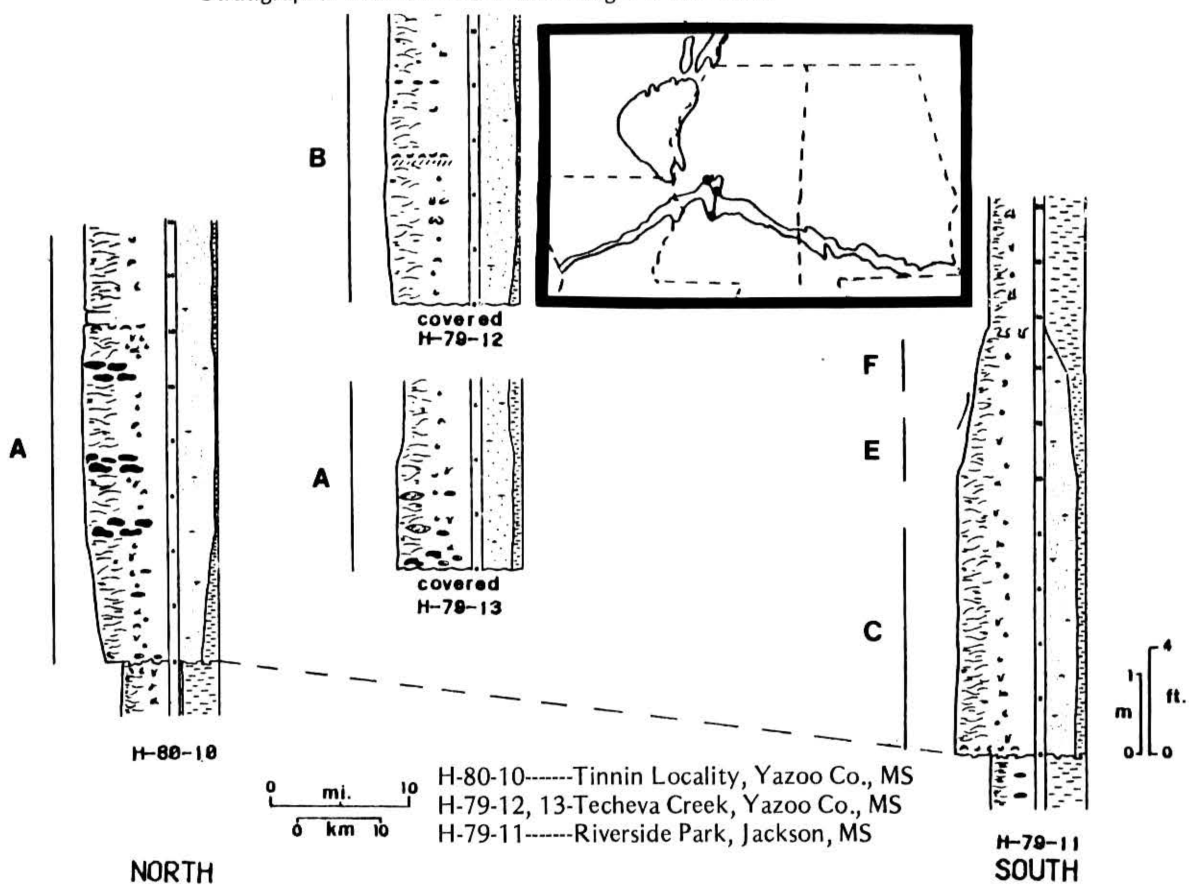


Figure 2. Strike section of stations from the southern facies of the Moodys Branch. Fossil assemblages are indicated at their respective stratigraphic horizons. The left side of each column is proportional to grain size and the right side is a sand/clay histogram.
H-76-75----Montgomery Landing, Winn Parish, LA
H-79-10----Bunker Hill, Caldwell Parish, LA
H-79-11----Riverside Park, Jackson, MS
H-80- 8----Chickasawhay River, Clarke Co., MS

Figure 3. Approximate dip section from the northern nearshore facies to the southern offshore facies. Stratigraphic extent of fossil assemblages is indicated.



References

Anderson, D. R., 1971, Moodys Branch Formation (Eocene) in Gulf Coastal Plain: A model for transgressive marine sedimentation: Unpublished Ph.D. dissertation, Texas A & M Univ., 161 p.

Cheetham, A. H., 1963, Late Eocene zoogeography of the eastern Gulf Coast region: GSA Memoir 91.

Dockery, D. T., 1976, Depositional systems in the Upper Claiborne and Lower Jackson groups (Eocene) of Mississippi: Unpublished M.S. thesis, Univ. of Miss., 109 p.

Dockery, D. T., 1977, Mollusca of the Moodys Branch Formation, Mississippi: Mississippi Geol. Surv. Bull. 120, 212 p.

Dockery, D. T., 1980, The invertebrate macropaleontology of the Clarke County, Mississippi, Area: Mississippi Geol. Surv. Bull. 122, 387 p.

Duncan, H., 1957, Bryozoans, *in* Ladd, H. S., ed., Treatise on Marine Ecology and Paleoecology, vol. 2: GSA Memoir 67, p. 783-800.

Frey, R. W., J. D. Howard, and W. A. Pryor, 1978, *Ophiomorpha*: Its morphologic, taxonomic, and environmental significance: Palaeogeography, Palaeoclimatology, Palaeoecology, v. 23, p. 199-229.

Lewy, L., and G. Samtleben, 1979, Functional morphology and paleontological significance of the conchiolin layers in Corbulid pelecypods: Lethaia, v. 12, p. 341-351.

Levinton, J. S., 1970, The paleoecological significance of opportunistic species: Lethaia, v. 3, p. 69-78.

Parker, R. H., 1960, Ecology and distributional patterns of marine macroinvertebrates, northern Gulf of Mexico, *in* Shepard, F. P., F. B. Phleger, and Tj. H. Van Andel, eds., Recent sediments, northwest Gulf of Mexico: Tulsa, Okla., AAPG, p. 302-337.

Thomas, R. D. K., 1975, Functional morphology, ecology, and evolutionary conservatism in the Glycymerididae (Bivalvia): Palaeontology, v. 18, part 2, p. 217-254.

Tschudy, R. H., 1973, Stratigraphic distribution of significant Eocene palynomorphs of the Mississippi embayment: USGS Prof. Paper 743-B.

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MISSISSIPPI OIL AND GAS STATISTICS FIRST QUARTER 1981

Oil

	Bbls. Produced	Severance Tax	Average Price Per Bbl.
January	2,021,923	$ 3,386,784.16	$ 27.92
February	3,714,461	7,184,761.17	32.24
March	2,569,299	5,611,366.88	36.40
Totals	8,305,683	$ 16,182,912.21	$ 32.18

Gas

	MCF Produced	Severance Tax	Average Price Per MCF
January	8,427,664	$ 1,250,099.26	$ 2.47
February	25,418,009	3,846,089.21	2.52
March	13,847,846	2,499,944.97	3.22
Totals	47,693,519	$ 7,596,133.44	$ 2.73