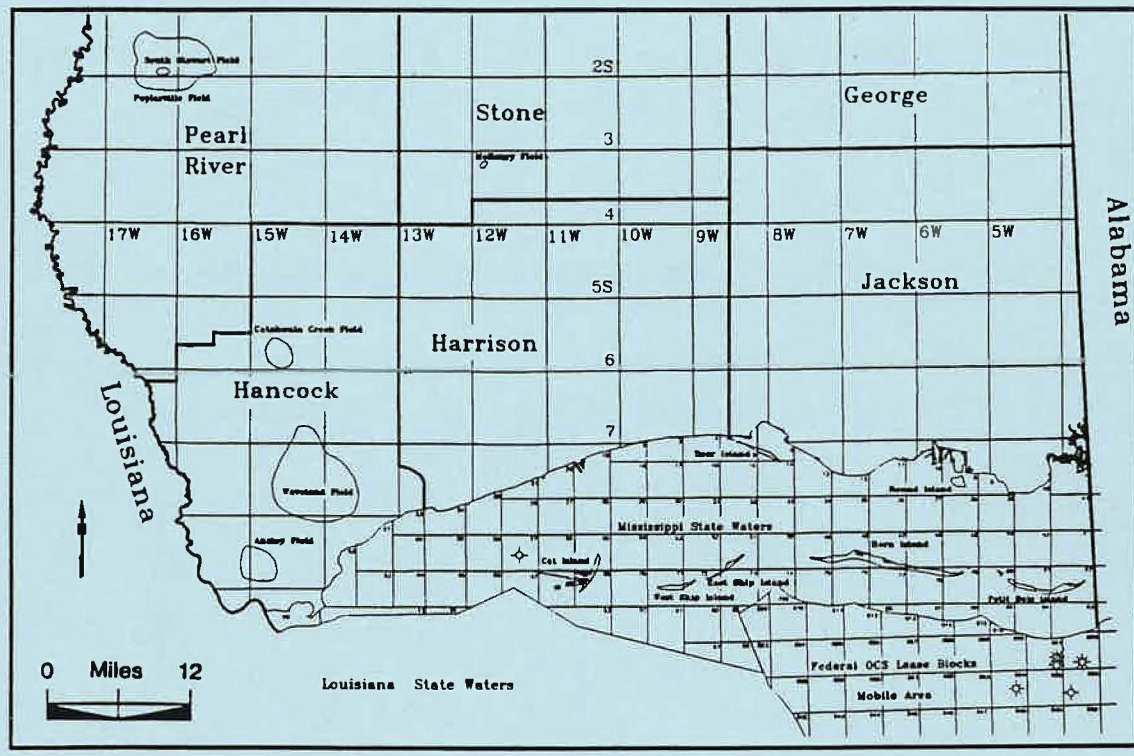
REGIONAL GEOLOGIC FRAMEWORK OF THE MIOCENE, COASTAL AND OFFSHORE MISSISSIPPI

Stephen D. Champlin, S. Cragin Knox, and T. Markham Puckett

OPEN-FILE REPORT 23



MISSISSIPPI OFFICE OF GEOLOGY

Department of Environmental Quality

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State Geologist

Energy and Coastal Division

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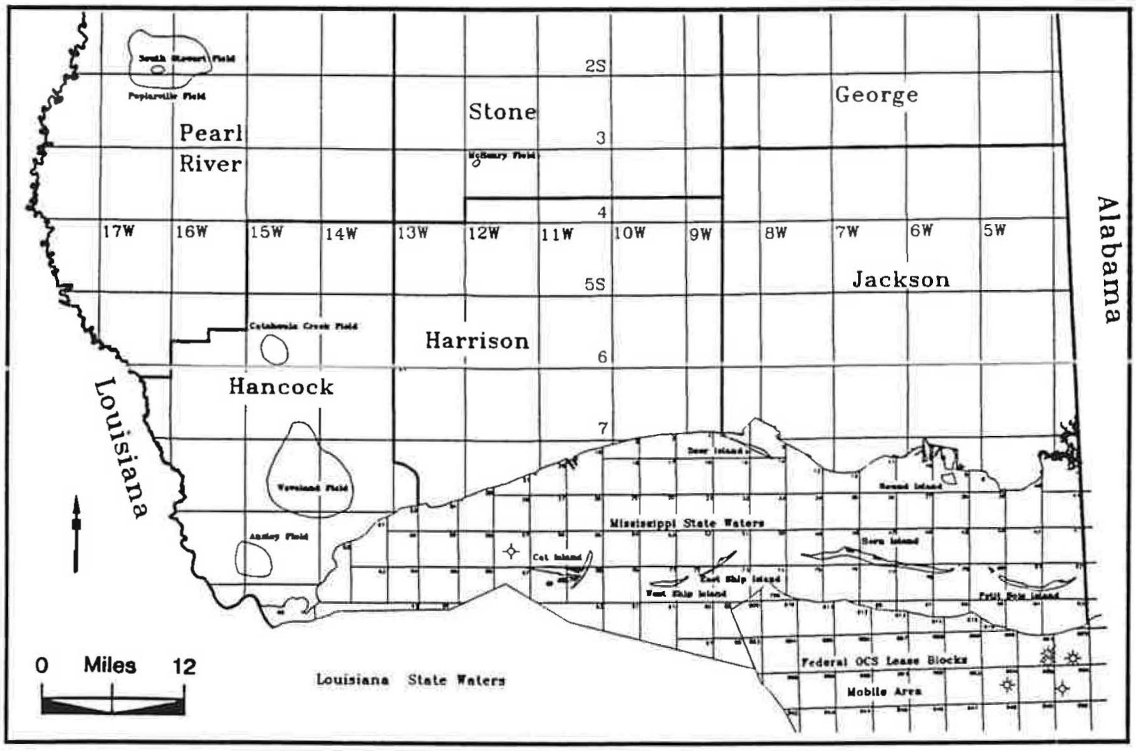

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ABSTRACT

Although oil and gas have both been produced in large quantities for many years in the Louisiana-Texas coastal area and offshore waters, and since 1979 in the Alabama coastal and offshore area, Mississippi lacks commercial Miocene oil or gas production.

The Miocene of the Mississippi/Alabama coastal and offshore areas is comprised primarily of a southwestward-thickening wedge of middle and upper Miocene clastic material deposited unconformably on a stable Miocene/Oligocene carbonate shelf. The stratigraphic units included in the Mississippi coastal Miocene section, from youngest to oldest, are the Pascagoula Formation, the Hattiesburg Formation and the upper portion of the Catahoula Formation above the *Heterostegina* zone limestones. Stratigraphically, the upper portion of the Catahoula Formation (informally called the Catahoula clay) extends across the Mississippi coastal area and is equivalent to the shallow gas productive Pensacola Clay of the southwestern Alabama Miocene. Paleontological information indicates the Miocene of coastal Mississippi to have been deposited initially in normal marine conditions. By middle Miocene times, marginal marine conditions were present and persisted through the rest of the Miocene.

With fields producing or having produced gas from Miocene sediments only a few miles from the Mississippi state borders in Louisiana, Alabama and the Federal OCS (Mobile Area), and because of stratigraphic, depositional environment and paleontologic similarities, particularly in the eastern portion of the study area, it is possible that Mississippi's coastal counties and adjacent state waters contain significant natural gas reserves in shallow Miocene-age sediments.

ACKNOWLEDGMENTS

The authors would like to extend their thanks to the following staff of the Mississippi Office of Geology for their work on a portion of or assistance in the completion of this report: Jack Moody, Bill Moore, Michael Bograd, Rick Ericksen, and Stan Thieling. We would also like to acknowledge the well sample cuttings provided by Chevron, U.S.A., Inc. and by the other companies, which were used in this study. The major portion of the paleontological work for this study was provided by Mark Puckett of the Geological Survey of Alabama.

The views and conclusions contained in this document are those of the authors and should not be interpreted as representing the official policies or recommendations of the U. S. Department of the Interior, Minerals Management Service, or the Bureau of Economic Geology, The University of Texas at Austin.

INTRODUCTION

Although strata of Miocene age have produced oil and gas in the Gulf of Mexico basin for many years, first in the Louisiana-Texas offshore and later in the Alabama coastal area and offshore, little attention has been focused on the Miocene of coastal and offshore Mississippi (Fig. 1). Rainwater (1964) mentioned Mississippi briefly and a few Masters theses have examined the Miocene, but this is rather sparse treatment.

Almost half the petroleum reserves in the Gulf of Mexico basin are in the Miocene (Murray et al., 1985). The regional Miocene trend extends from the southern Texas outer continental shelf, across southern Louisiana on and offshore, and then northeast through Federal OCS areas south and east of Mississippi state waters, to coastal Alabama (Fig. 2). The lower Miocene, middle Miocene and upper Miocene comprise three of the five major producing trends in the central Gulf of Mexico (Risotto and Collins, 1986).

Production has been associated with a variety of structural conditions including diapiric salt structures, faults, shale uplifts and combinations of the above. There is also production from stratigraphic traps associated with the above types of structures. Most of the production in the eastern part of the central Gulf of Mexico has been oil and in the western part natural gas (Pearcy and Ray, 1986). Cumulative production from the Miocene has been over 13 billion barrels of oil and over 60 trillion cubic feet of gas. Most of the Miocene production has been from the offshore Louisiana-Texas region, particularly from the area of the major Miocene depocenter in southern and offshore Louisiana.

In 1979, the first shallow Miocene gas production was established in southwestern Alabama. Since then a number of shallow gas fields have been found in the southwestern Alabama coastal area, onshore and offshore. This area continues to be reasonably active. Numerous shallow Miocene gas fields also have been discovered in the Federal OCS areas south and southwest of Alabama state waters and into southeastern Louisiana state waters.

To date, there has been no production from the Mississippi Miocene, nor have there been many documented shows. Few wells have been drilled in the study area and considerable work needs to be done. Certainly additional wells need to be drilled to gain a better understanding of the petroleum potential of this intriguing group of sediments.

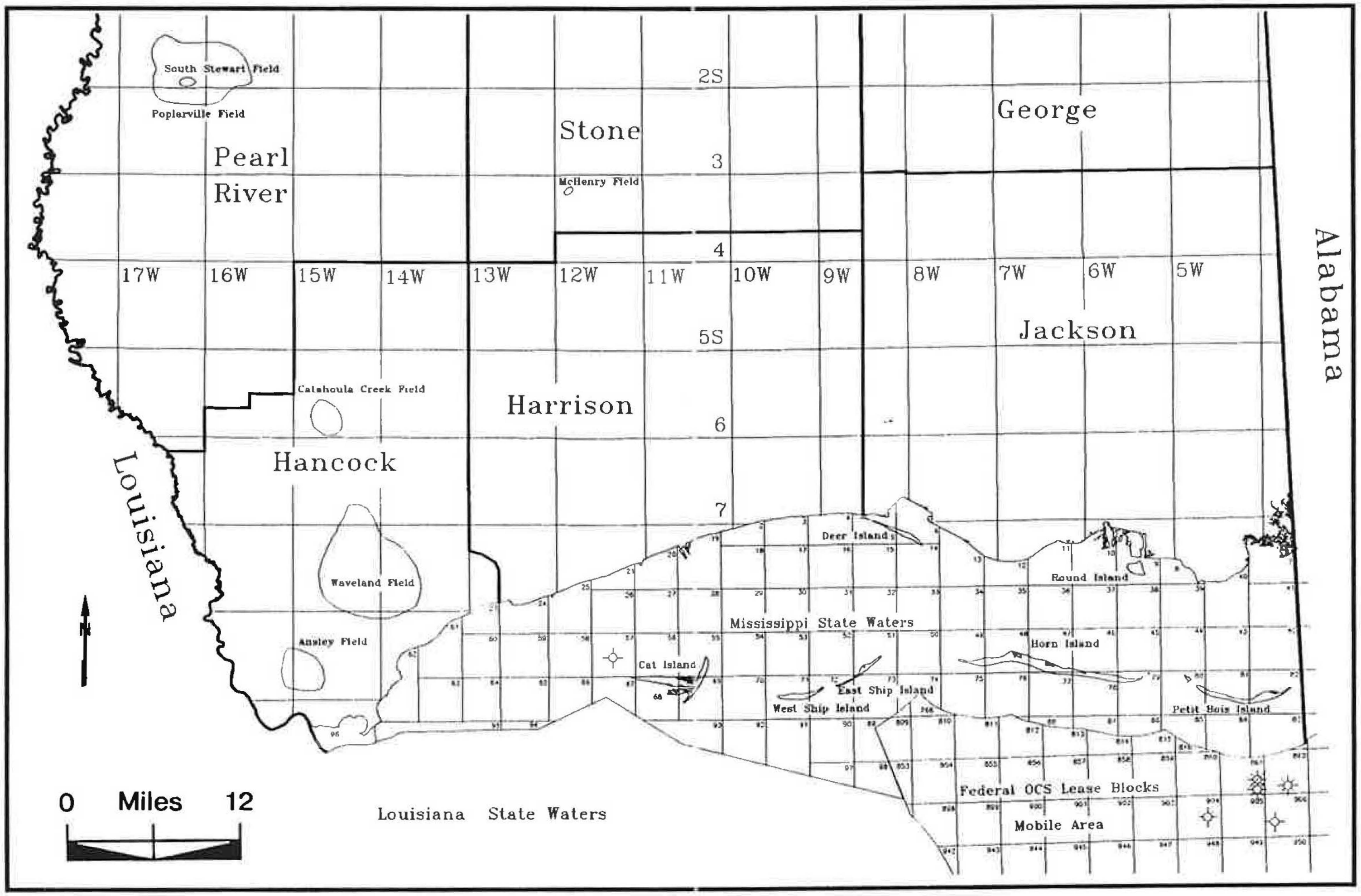

Figure 1. Mississippi coastal counties and offshore area.

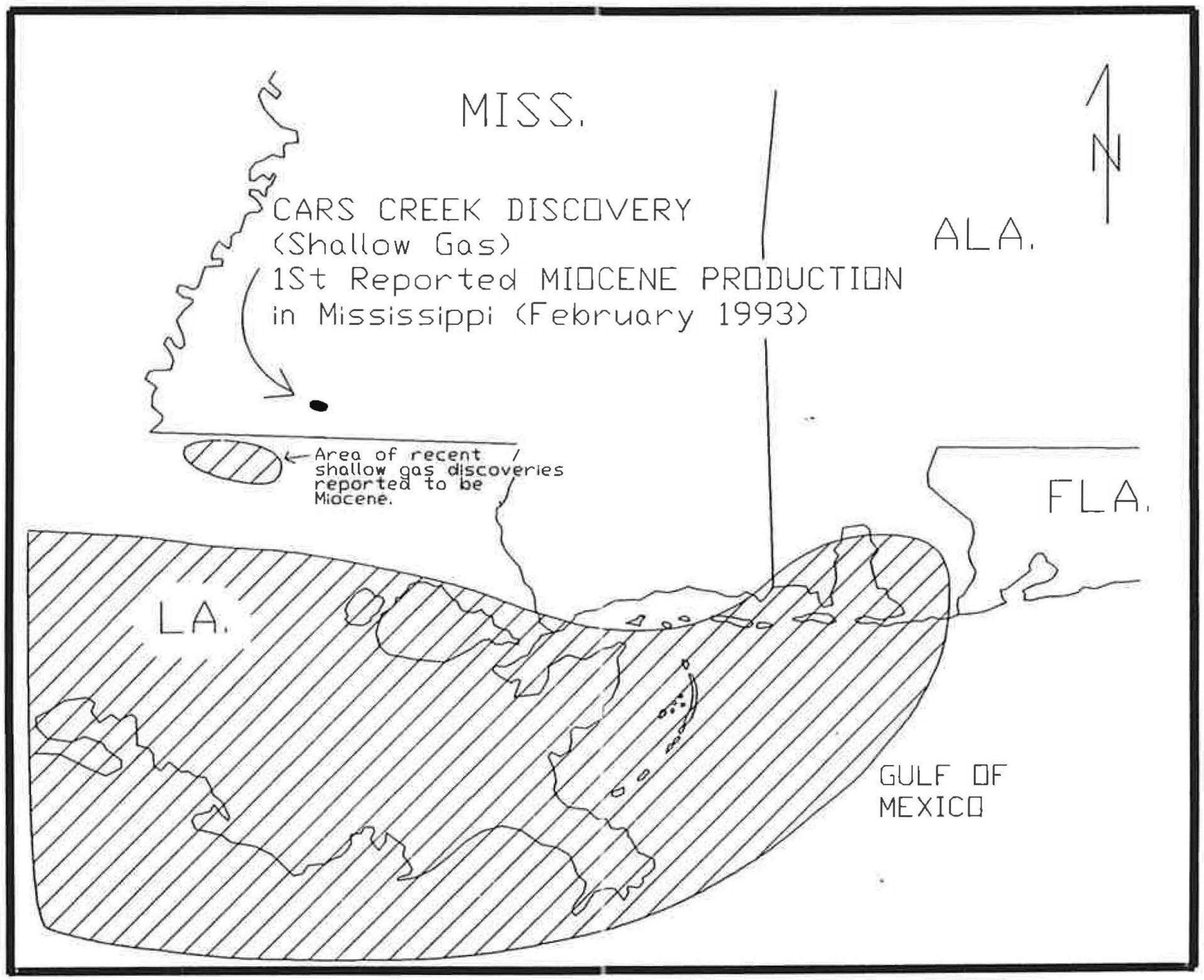

Figure 2. Miocene production trend of northern Gulf Coastal area.

PURPOSE AND SCOPE

The purpose of this study is to provide a regional geologic framework of the Miocene in an effort to better understand the potentially productive area of the Mississippi coastal onshore and offshore state waters, provide a tool for the exploration geologist, and encourage greater interest in Mississippi's nearshore oil and gas potential.

To accomplish the above objectives evaluation of considerable material has been made. Electrical logs of some 60 wells were examined along with geophysical data to aid in the construction of maps and cross sections demonstrating regional structure. Samples of the Miocene and the enclosing formations were examined from 10 wells to obtain stratigraphic information. Selected wells were analyzed for paleontological correlation within the study area and with neighboring states. The basic stratigraphy of the Mississippi Miocene derived from this study was compared to earlier work to determine if changes in terminology and formation boundaries were needed.

REGIONAL SETTING

Coastal and offshore Mississippi is usually thrown together with Louisiana and Alabama (Fig. 3) and said to be a part of the northern Gulf Coast margin. The stratigraphic column consists primarily of a wedge of Mesozoic and Cenozoic sediments that accumulated from Jurassic time to the present (Murray, 1961; Martin, 1978). The sediments were derived from continental interior drainage. Sediment supply in most of the area exceeded the subsidence rate; this resulted in the seaward progradation of the Gulf continental margin. In the Mississippi offshore this was not the case; there has been less sediment supply and less progradation. Still, the Miocene of coastal and offshore Mississippi attains considerable thickness.

The Miocene in the coastal counties of Mississippi is from 1400 to 2500 feet thick and thickens to over 5000 feet in the Mississippi offshore. Near the southwestern edge of coastal and offshore Mississippi, the Miocene becomes considerably thicker approaching the Louisiana depocenter. This depocenter is generally referred to as having derived much of its sedimentary fill, which exceeds 20,000 feet (Fig. 4), from major continental drainage following the Laramide orogeny and has undergone rapid subsidence and oceanward tilting through the Miocene. The Mississippi area may have received sediment from the Laramide orogeny, but less than areas farther west. Also, there was additional drainage from the Appalachian region, but the streams were not as large as those furnishing the Louisiana depocenter with sediment.

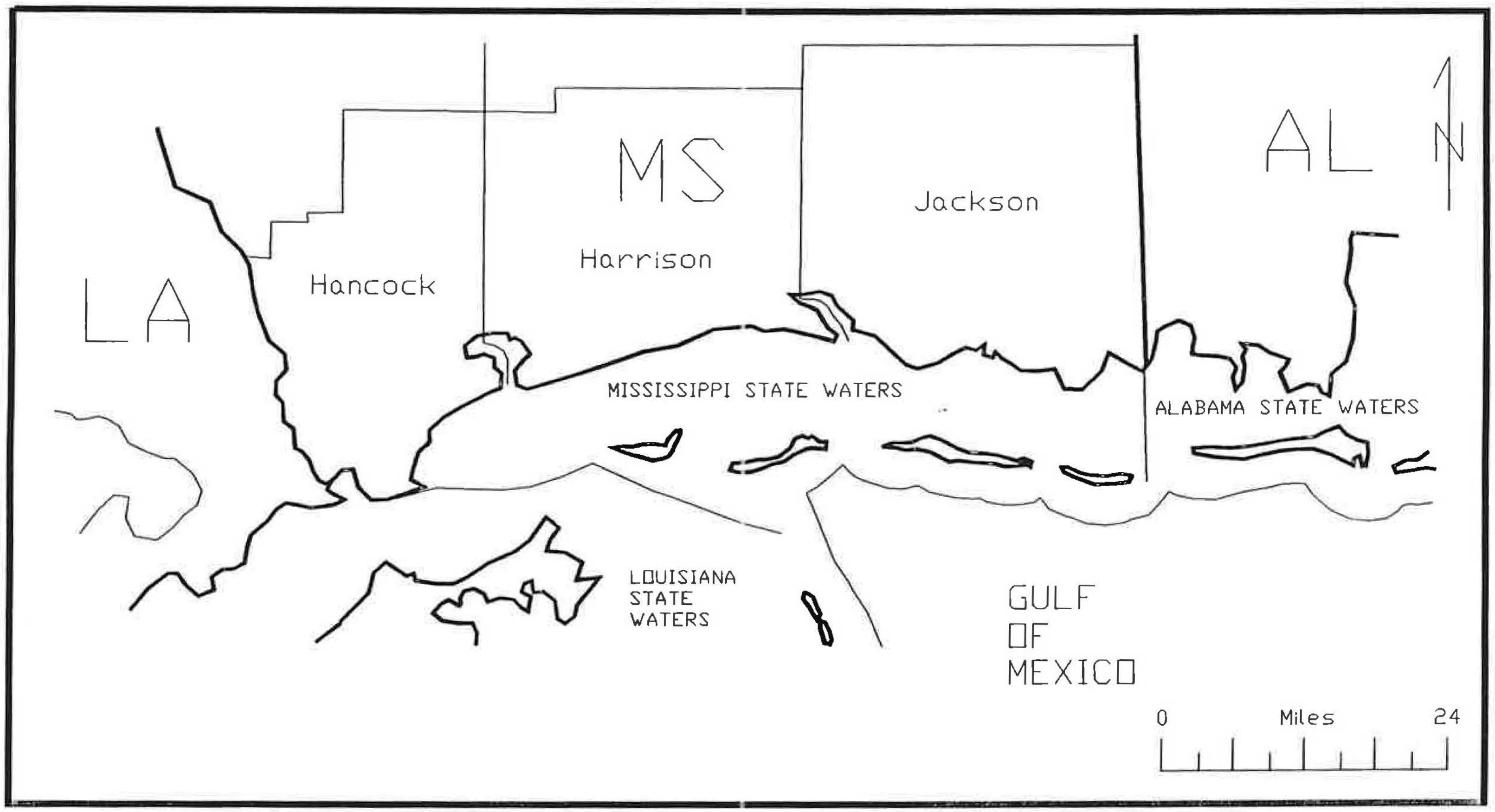

Figure 3. Study area of coastal and offshore Mississippi and pertinent areas of adjacent states.

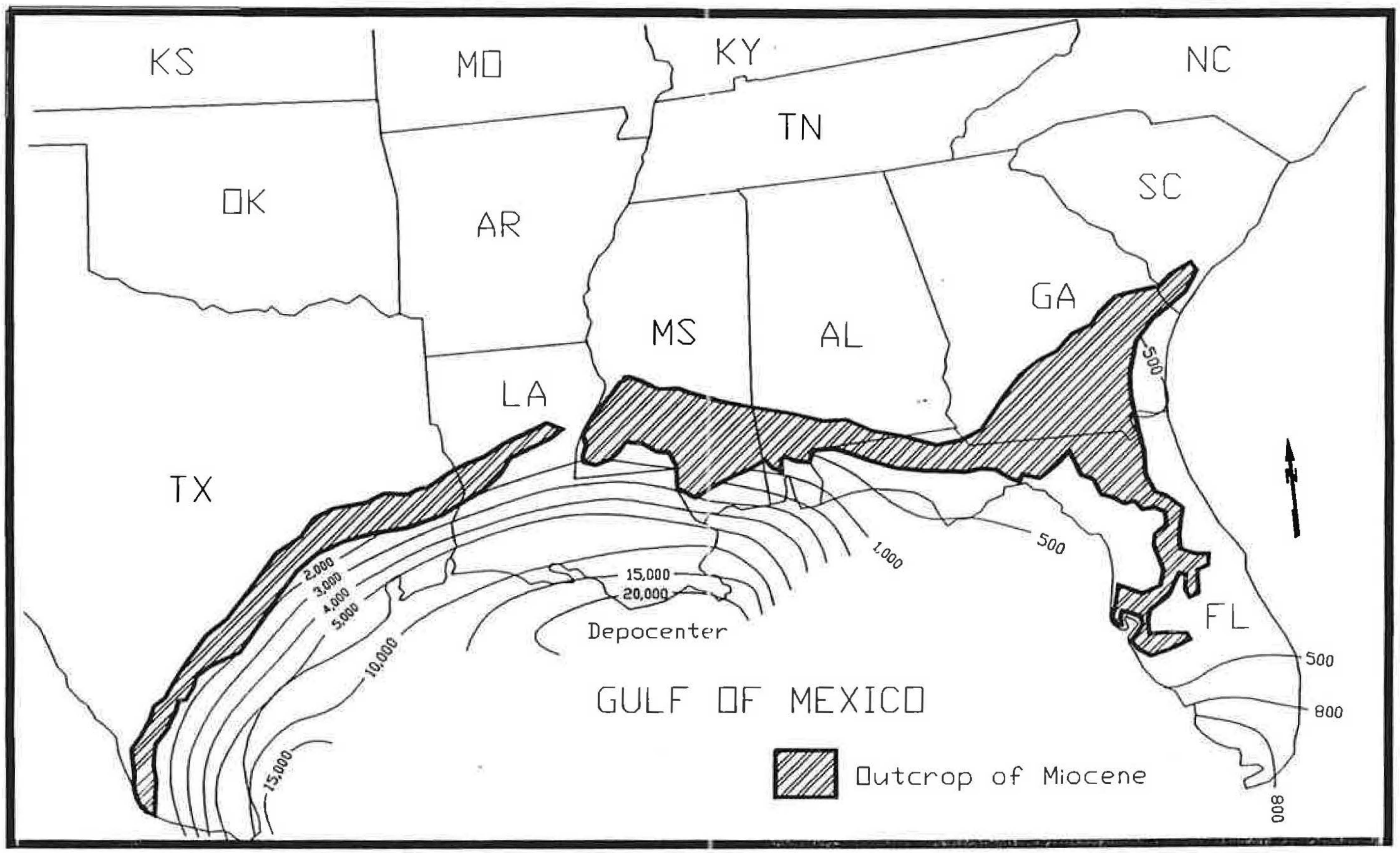

Figure 4. General Miocene outcrop and thickness map across southern United States (modified from Rainwater, 1964).

Deposition in the Mississippi study area is usually said to have been influenced by the Wiggins Arch to the north (Fig. 5). It is possible and even probable that the Wiggins Arch was never an area of uplift but rather a buried ridge, bounding the Mississippi interior salt basin to the north and the Gulf of Mexico to the south (Williams et al., 1967). As the Gulf of Mexico basin tilted south and west, the Wiggins Arch may have influenced the amount of sediment entering the Mississippi study area.

In coastal Texas and Louisiana, structural conditions are present that are not found in the Miocene of the Mississippi/Alabama shelf area. These structural features include diapiric salt and growth faults, particularly down-to-the-basin growth faults. There are often broad anticlinal structures and rollovers on the downthrown side of these faults (Martin et al., 1982). An example of structurally controlled Miocene production in Louisiana is the Unknown Pass-Lake Saint Catherine Fields area (Fig. 6) located in Orleans Parish, only 10 miles southwest of the western end of the study area.

These two fields are the closest fields to the study area in Louisiana which have been productive of gas from the Miocene. The fields are located just south of the *Heterostegina* Zone Hinge Line/Shelf Edge (Fig. 7) described by Krutak and Beron (1990, 1992) and Jackson (1991). This hinge line/shelf edge appears to be the boundary between the deeper structurally controlled Miocene oil and gas production of southeastern Louisiana and the shallow updip Miocene gas production of the Mississippi/Alabama Shelf area, which Mink et al. (1988) determined is primarily stratigraphically trapped.

In addition to apparently not being affected by the above mentioned structural conditions, faults such as those seen in the deep Mobile Bay fault trend (Bearden, 1987) seem to have little if any influence on the sediments deposited during or after the Oligocene *Heterostegina* Zone time period in the Mississippi/Alabama shelf area. A structure map contoured on a "Het Lime" marker near the base of the Miocene clastic section (Fig. 7) indicates the base of the Miocene dips gently to the south-southwest at 70 feet to the mile in most of the study area. Dip increases in the southwestern end of the Mississippi coastal area and the offshore waters, closer to the southern Louisiana Miocene depocenter.

It seems sufficient to say that Miocene sedimentation on the Mississippi/Alabama shelf is characterized by generally slow subsidence, a lower rate of sedimentation than seen to the southwest in the major Miocene depocenter and a gradual thickening of the overall Miocene section to the south and southwest. The Miocene of the Mississippi coastal area is made up of a clastic wedge comprised primarily of middle and upper Miocene sediments

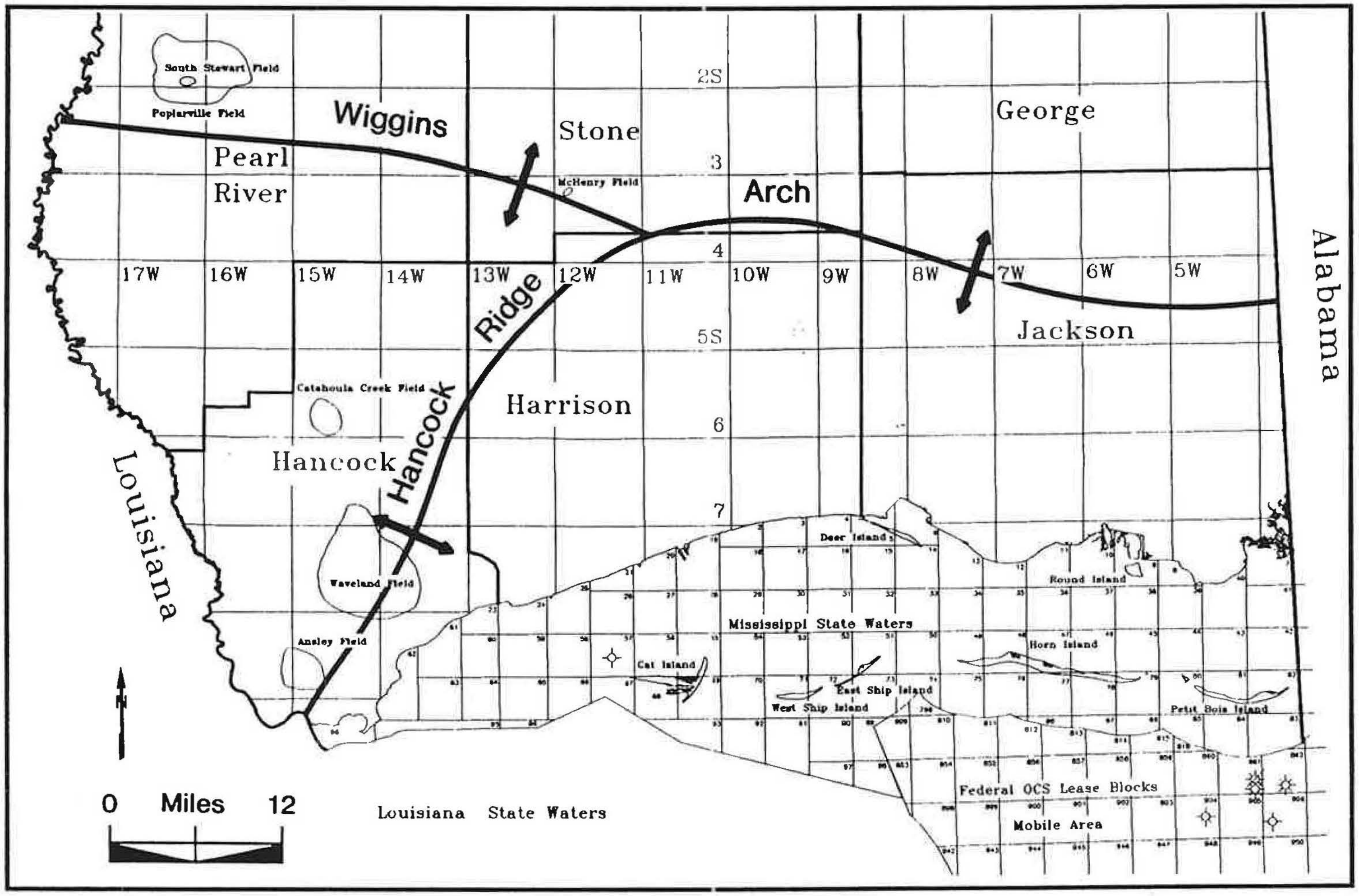

Figure 5. Structural features in Mississippi Gulf Coastal area (from Ericksen and Thieling, 1993).

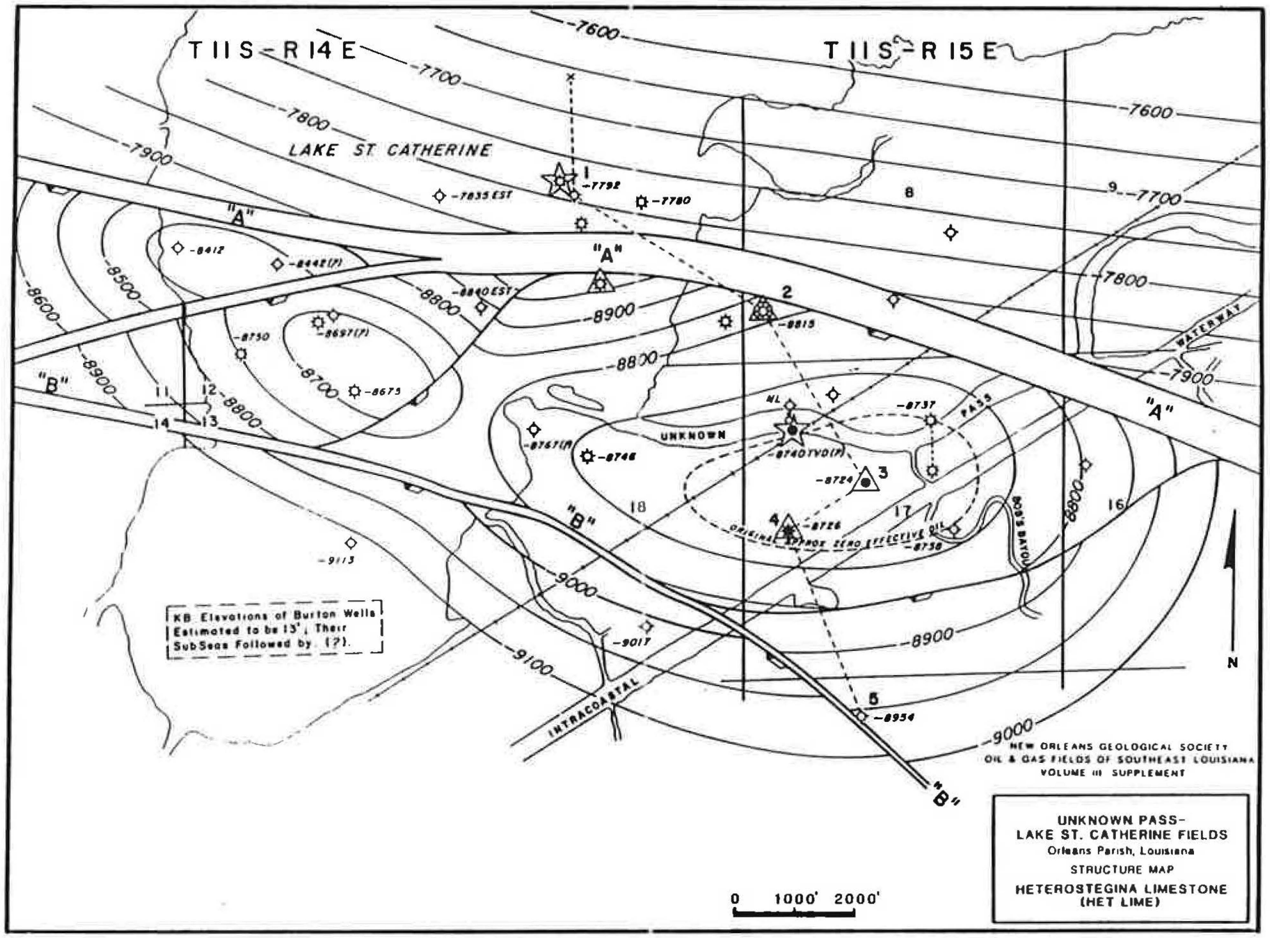

Figure 6. Structure map on "Het Lime", Unknown Pass-Lake St. Catherine Fields area, Orleans Parish, southeastern Louisiana (from Bowen, 1987).

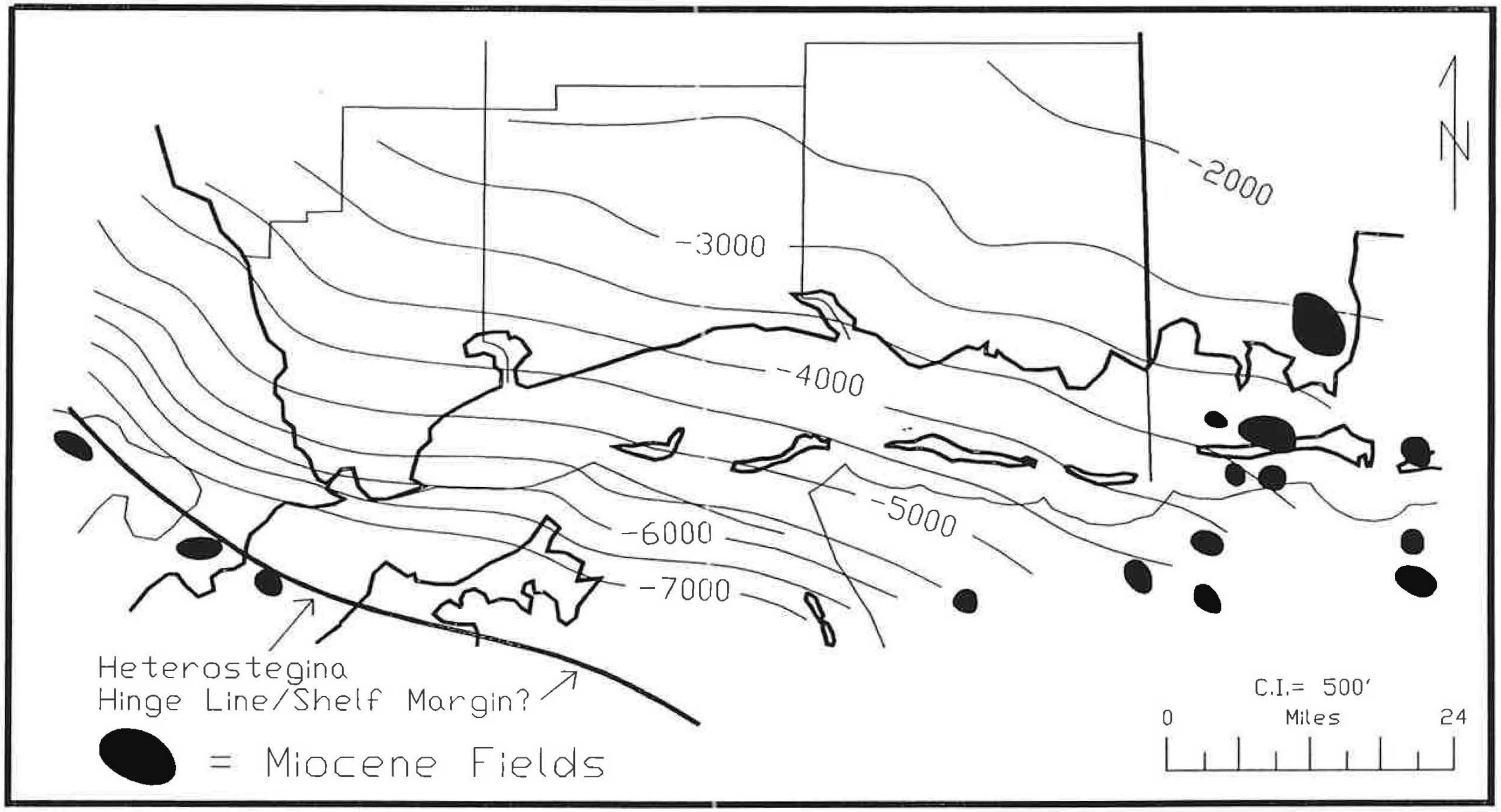

Figure 7. Structure map on a "Het Lime" marker near the base of the Miocene in the Mississippi coastal area.

deposited unconformably on a broad and gently dipping lower Miocene/Oligocene carbonate shelf.

STRATIGRAPHY

Based on previous paleontological zonation of the subsurface Miocene in Hancock County, Mississippi, by Havard (1978), and using well logs, an attempt was made to trace the stratigraphic units of the Mississippi Miocene across the Mississippi coastal area and compare them to the Miocene of southwestern Alabama, primarily to the gas-productive interval of the middle and early Miocene Pensacola Clay. Due to the small number of wells drilled, particularly in the offshore areas, the lack of recognizable and correlative stratigraphic log markers in the younger Miocene section, the few wells examined paleontologically, and the lack of more age-diagnostic fossils in the younger Miocene sediments, detailed stratigraphy of the younger Miocene sediments is not within the scope of this report.

Plates 1 and 2 comprise two structural cross sections (A-A' and B-B') through eight wells. The western end of Cross Section A-A' (Plate 1, Fig. 8, and Table 1) parallels structural strike (west-southwest to east-southeast) of the base of the Miocene, from Well #1 (located onshore in southern Hancock County, Mississippi) through well #2 (located in Mississippi State Waters Block 57) to well #3 (Block 90, Mississippi State Waters). The section is then oriented northeast, in an updip direction from well #3, to well #4 (located in Block 48, Mississippi State Waters), and then extended southeast, again roughly parallel to strike, to well #5, located in Federal OCS waters (Mobile Area, Block 861). Finally, the section is oriented northeast, updip, to well #6 (Block 72, Alabama State Waters just west of North Dauphin Island Field), for a line of section over 87 miles in length across the study area.

Cross Section B-B' (Plate 2, Fig. 9, and Table 2), is oriented in an updip direction from well #4 (Block 48, Mississippi State Waters), where Cross Section B-B' intersects Cross Section A-A', and runs north-northeast to well #7 (onshore, south-central Jackson County, Mississippi), then easterly, still moving generally updip, to well #8 in Alabama (onshore southern Mobile County, Alabama). Cross Section B-B' has a total length of 41 miles.

Generally, the Miocene thickens from the north and east to the west-southwest across the study area, as seen on both Cross Sections A-A' and B-B' (Plates 1 and 2). However, in the western end of the study area, in southern Hancock County, the area of the Hancock Ridge (Fig. 5) appears to have been a positive feature prior to and throughout the Oligocene and Miocene times. In southern Hancock County, the lower portion of the Miocene and the Oligocene

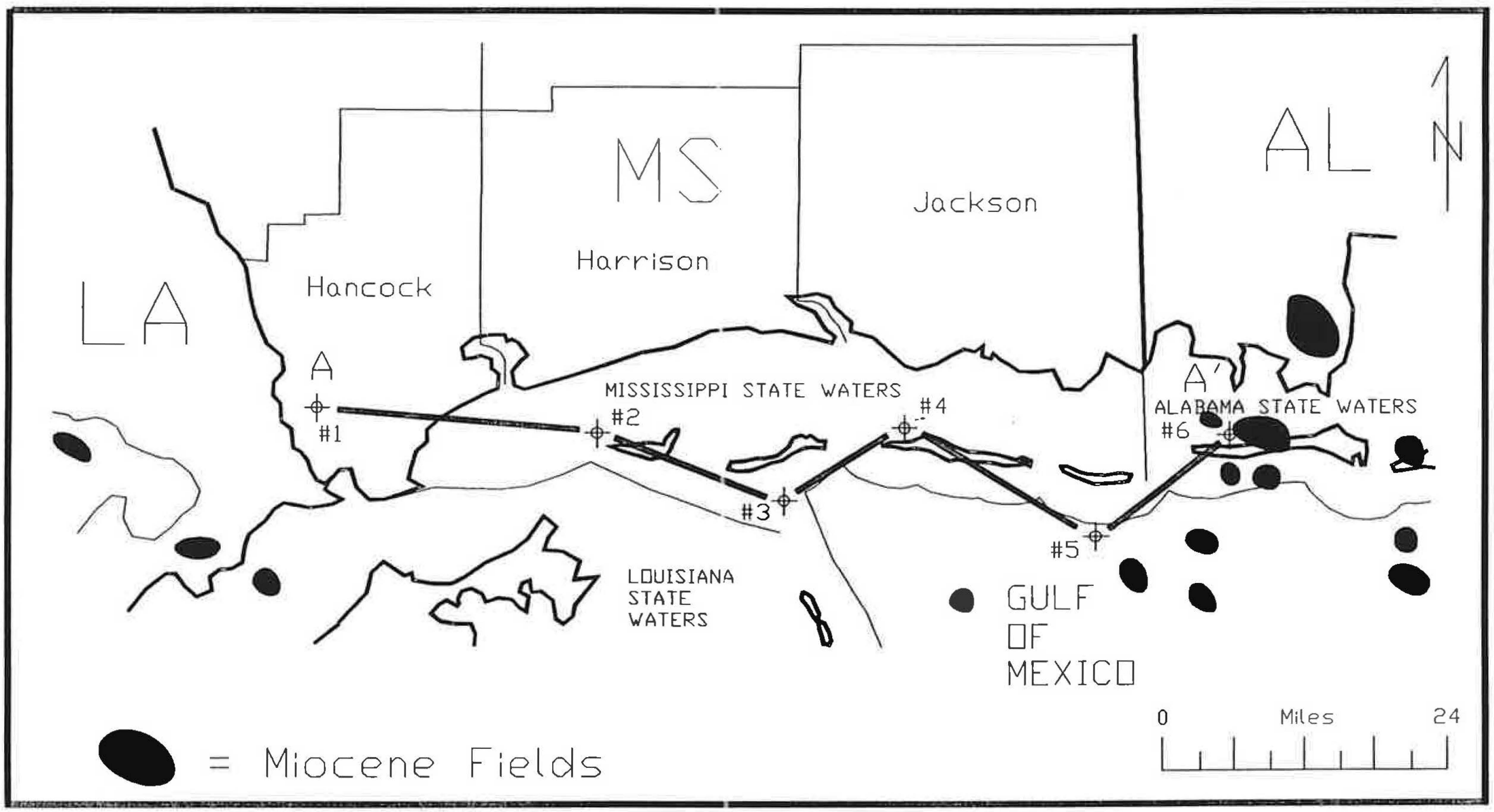

Figure 8. Index map showing location of wells used and orientation of cross section A-A'.

Well No.

#1 J. Willis Hughes
R. S. Russ et al. #1
Section 18, Township 9 South, Range 16 West
Wildcat
Hancock County, Mississippi

#2 Chevron USA Inc.
MS 87-01-OS #1
Mississippi Sound Block 57
Wildcat
Offshore, Mississippi

#3 Sapphire Exploration & Production Co.
SL-MS-85-4-OS No. 1
Mississippi Sound Block 90
Wildcat
Offshore, Mississippi

#4 C. A. Floto
State of Mississippi #1
Mississippi Sound Block 48
Wildcat
Offshore, Mississippi

#5 Chevron USA Inc.
OCS G 5062 Well #1
Mobile Area Block 861
Wildcat
Offshore, Mississippi

#6 Mobil
State Lease 528 No. 1
Mississippi Sound Block 72
Wildcat
Offshore, Alabama

Table 1. Name and location of wells used in constructing cross section A-A' (Plate 1 and Figure 8).

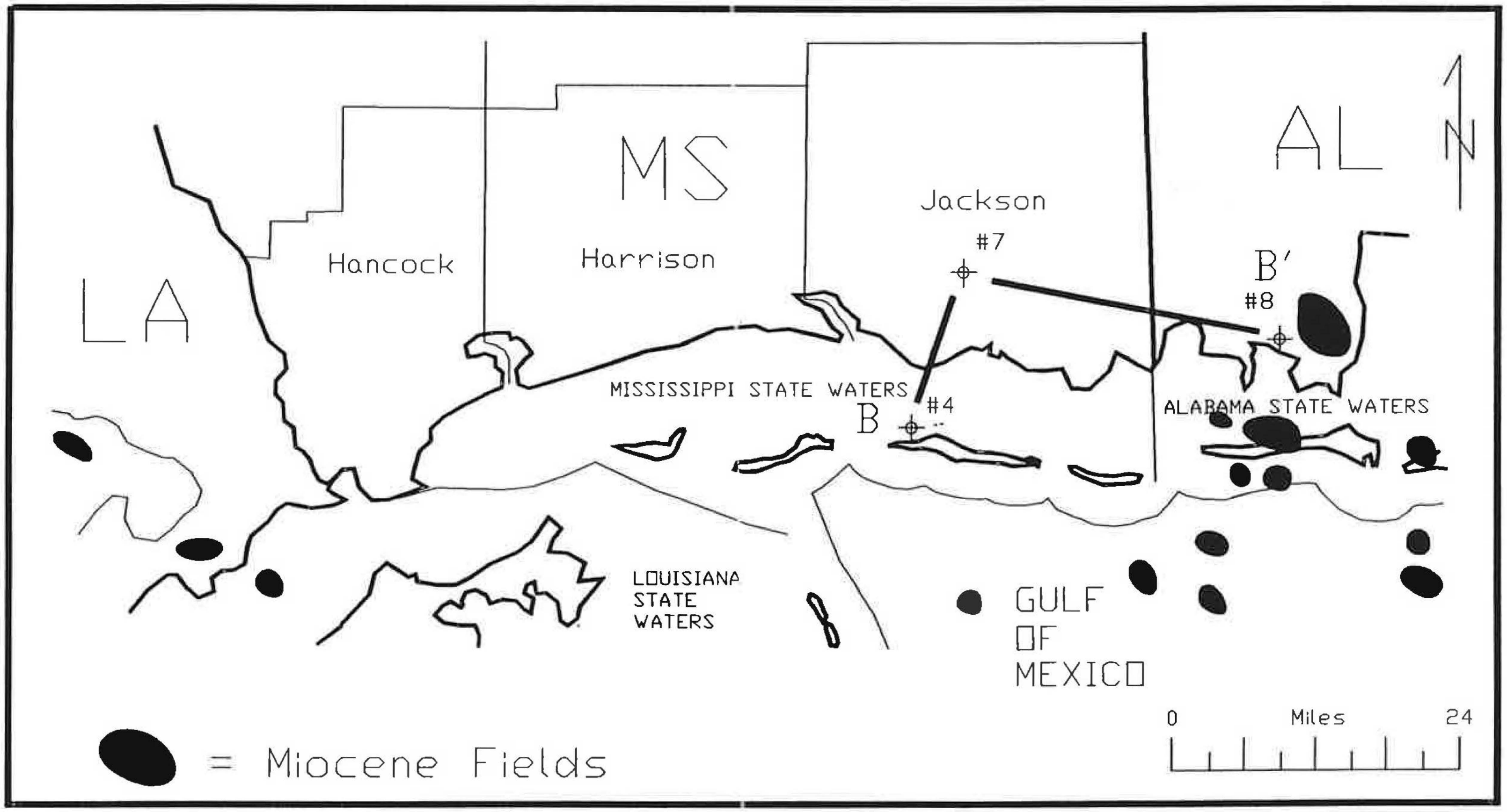

Figure 9. Index map showing location of wells used and orientation of cross section B-B'.

Well No.

#4	C. A. Floto State of Mississippi #1 Mississippi Sound Block 48 Wildcat Offshore, Mississippi
#7	Chesley Pruet Drilling Co. William C. Quinn #1 Section 15, Township 7 South, Range 7 West Wildcat Jackson County, Mississippi
#8	Petersen Drilling Co. S. A. Smith #1 Section 8, Township 8 South, Range 2 West Wildcat Mobile County, Alabama

Table 2. Name and location of wells used in constructing cross section B-B' (Plate 2 and Figure 9).

section (Catahoula Formation) thins significantly versus the section seen to the east in the south-central offshore area as shown on Cross Section A-A' (Plate 1).

Catahoula clay

The Catahoula Formation is referred to as the lowermost formation of the Miocene in Mississippi, with the *Heterostegina* zone (Oligocene) positioned somewhere near the middle of the Catahoula (Brown et al., 1944). The writers of this paper use the name Catahoula clay informally to mean the upper member of the Catahoula Formation lying below the overlying Hattiesburg Formation and above the *Heterostegina* zone limestone or Tatum/Chickasawhay undifferentiated limestones; the latter are accepted here as late Oligocene in age.

In the coastal and offshore areas of Mississippi the Catahoula clay consists primarily of gray to light gray shale, clay and silt, sandy shale, sand, and gravelly sands containing black chert. The upper contact of the Catahoula clay with the base of the Hattiesburg Formation consists of primarily continental sands and clays deposited over mainly transitional clays and shale (Havard, 1978). In the Sun #2 Weston Lumber well in Hancock County, the top of the Catahoula clay is a fairly distinctive lithologic marker that can be correlated in the subsurface across most of the Mississippi coastal area onshore to the southwestern Alabama onshore area.

The Catahoula clay varies in thickness across the study area. The Catahoula clay is 615 feet thick in south-central Hancock County, and thickens to over 1700 feet in the south-central offshore portion of the study area (Plate 1 and Fig. 8).

Stratigraphically, the Catahoula clay is equivalent to the Pensacola Clay of the Alabama onshore subsurface. In the subsurface of the eastern portion of the study area, well correlations show the sediments that comprise the Pensacola Clay extend into and across the study area. Correlations are good across the coastal onshore areas but become more difficult in the central offshore area of the Mississippi state waters, in the area of the Floto well (Figs. 8 and 9). This is because of more sand deposition in the upper portion of the Catahoula clay, a lack of well control in the central study area, and general thickening of the Miocene section.

The two easily recognized and traceable sand members of the Pensacola Clay, seen in the southwestern Alabama onshore area, are the Amos Sand and the Escambia Sand. These two sand units are also present in the Catahoula clay of Mississippi and are traceable over a large portion of the

Mississippi study area, particularly the eastern and central onshore portion (Plate 2 and Fig. 9).

As in Alabama where the basal Miocene clay was determined to lie unconformably above a Miocene-Oligocene aged lime section (Mink et al., 1988), evidence supporting this interpretation was also seen in samples from the wells described for this study. This will be discussed later. The Miocene-Oligocene boundary is defined in a number of ways, but for this paper the authors accept a definition similar to that of Havard (1978) and others of the Miocene-Oligocene contact being near and above the youngest occurrence of *Heterostegina* sp.

Hattiesburg Formation

Havard (1978) defined the Hattiesburg Formation of Hancock County as the non-marine clastic sediments below the beds abounding in *Rangia* sp., along with *Rotalia beccarii,* and lying above the Catahoula Sandstone. The Hattiesburg Formation is made up of gray-green and blue-green shale and clay, gray sand and silt, and is mostly carbonaceous and non-calcareous, being 605 feet thick in the above mentioned Sun Oil Company well. The contact between the Pascagoula and Hattiesburg formations has no distinct lithologic character in the subsurface which can be correlated over any large distances between wells. This is especially true in the offshore areas. Therefore, the differentiation of the units is primarily a paleontological pick in the subsurface.

Pascagoula Formation

The Pascagoula Formation is the youngest member of the Mississippi Miocene; it lies below the Pliocene-age Graham Ferry Formation and above the Miocene Hattiesburg Formation. Havard (1978) described the Pascagoula Formation as consisting of clay and shale, generally blue-green, silt, sandy shale, gray and green sand, gray silty clay and dark sandy gravel containing numerous grains and pebbles of polished black chert.

In the subsurface there is no distinct lithologic break between the overlying Graham Ferry Formation and the Pascagoula Formation. A determination of the top of the Miocene must be based on paleontological data from well samples having the first occurrence of the marker fossil *Rangia (Miorangia) microjohnsoni*. In the Sun Oil Company, #2 Weston Lumber Company well, located in Section 6, T8S-R15W, Hancock County, Mississippi, the Pascagoula Formation is 785 feet thick. It thickens to the southeast (offshore) and southward toward southeastern Louisiana. Havard (1978) stated the Pascagoula Formation is of estuarine or deltaic origin.

A stratigraphic correlation chart (Fig. 10) was prepared for this report and shows the proposed relationship of the Mississippi coastal Miocene and that of the southwestern Alabama onshore area.

BIOSTRATIGRAPHY

Samples from five wells located in the study area were selected to be analyzed paleontologically (Fig. 11 and Table 3). Three of the wells are located onshore and two are located offshore in Mississippi state waters. The sample descriptions and paleontological information on the above wells has been included as Appendix "A" of this report. Paleontological information and sample descriptions of two additional wells in the study area (Fig. 11 and Table 4) have been included where appropriate in the text and as Appendixes "B" and "C".

The stratigraphic thickness of the Miocene sections in the wells studied for the report ranged from over 2400 feet (DuPont well in Harrison County) to just under 1400 feet (Chesley Pruet-Quinn well in Jackson County), although the thickness may be somewhat greater than these figures due to the fragmentary condition of *Rangia* (*Miorangia*) *microjohnsoni* and significant reworking in the uppermost levels of the Miocene.

The stratigraphic interval containing age-diagnostic microfossils in the Miocene of the wells studied is relatively thin. For example, the Chesley Pruet-Quinn well in Jackson County included about 300 feet of datable strata, and the DuPont well in Harrison County contained only about 200 feet of datable strata. The overlying Miocene section in these wells was deposited under fluvial to marginal marine settings, conditions unfavorable for inhabitation by commonly used biostratigraphic markers (e.g., those of Skinner, 1972). For this report, the foraminiferal datum levels of Mink et al. (1988) will be followed (Fig. 12).

Oligocene Carbonate

The Oligocene carbonate rocks form a very distinctive lithologic marker on the well logs examined for this study. In general, this carbonate was a recrystallized sucrosic limestone, with abundant specimens of *Amphistegina* "B", *Amphistegina* sp., and *Nummulites* sp., with few occurrences of soritids, *Heterostegina* sp., *Lepidocyclina* and planktonic Foraminifera. In most wells, *Heterostegina* sp., a regional Oligocene marker, was found at or near the top of the carbonate; for example, in the Chesley Pruet-Quinn well in Jackson County, and in the Floto well offshore Jackson County, *Heterostegina* sp. was found in the uppermost limestone sample.

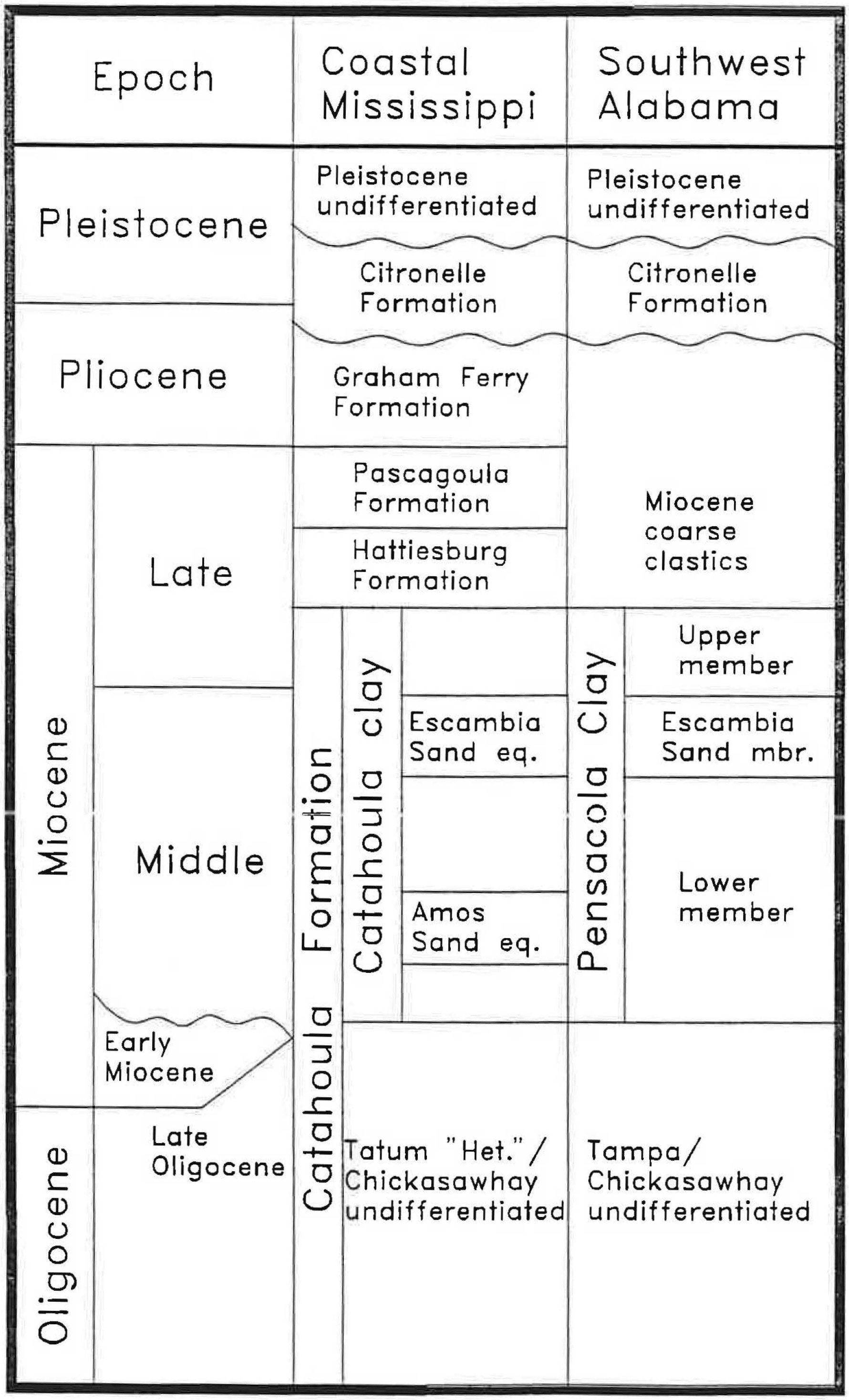

Figure 10. Generalized correlation chart for Miocene and younger units of coastal Mississippi and Alabama (modified from Raymond, 1985).

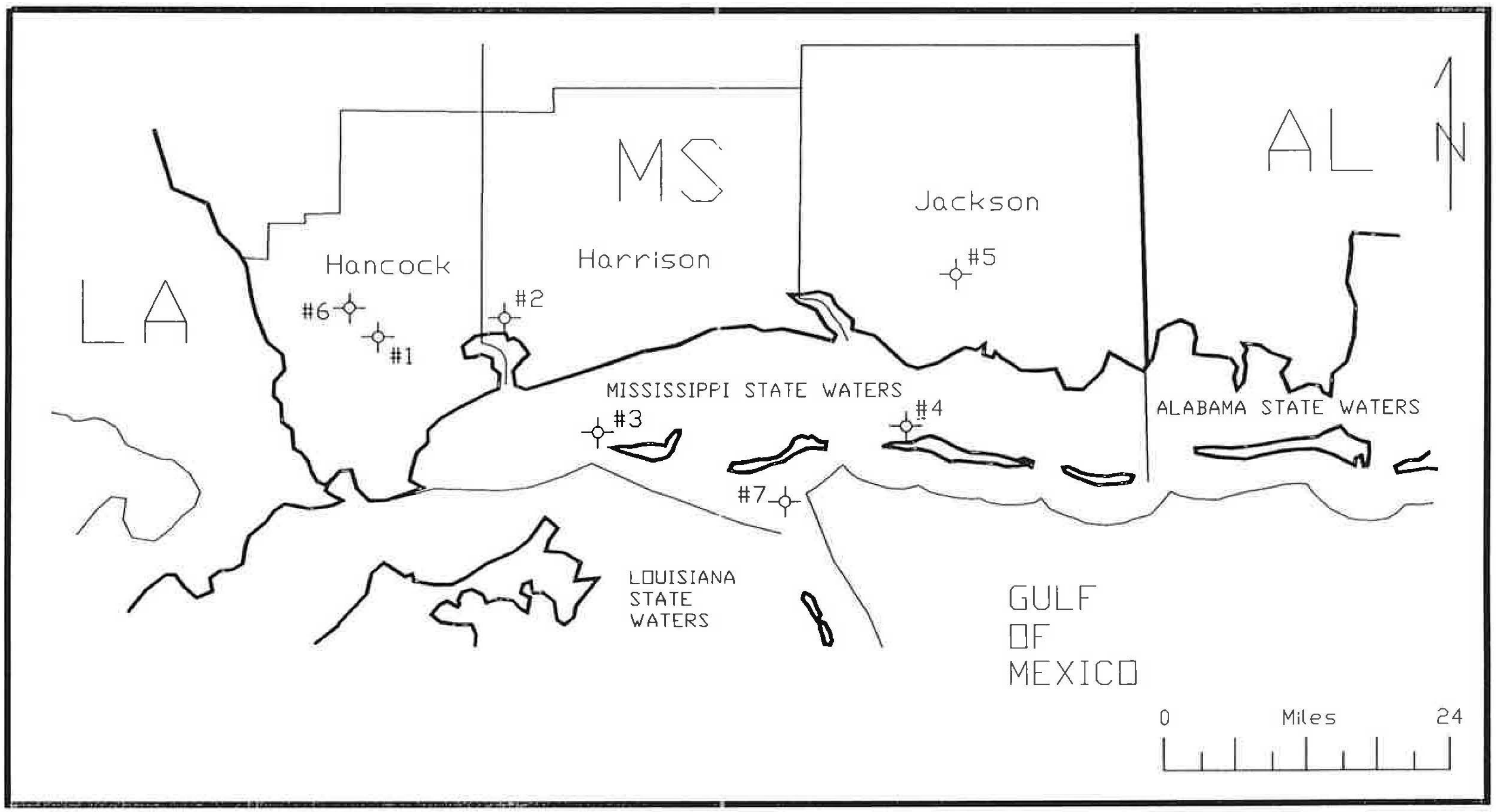

Figure 11. Index map showing location of wells with samples and paleontological information used in this study.

Well No.	
#1	Marshall Young Nellie Stem et al. #1 Section 22, Township 8 South, Range 15 West Wildcat Hancock County, Mississippi
#2	E. I. DuPont De Nemours & Co., Inc. Lester Earnest #1 Section 4, Township 8 South, Range 13 West Wildcat Harrison County, Mississippi
#3	Chevron USA, Inc. MS 87-01-OS #1 Mississippi Sound Block 57 Wildcat Offshore, Mississippi
#4	C. A. Floto State of Mississippi #1 Mississippi Sound Block 48 Wildcat Offshore Mississippi
#5	Chesley Pruet Drilling Co. William C. Quinn #1 Section 15, Township 7 South, Range 7 West Wildcat Jackson County, Mississippi

Table 3. Name and location of wells which had drilling samples studied for this paleontological report (Figure 11).

WELLS WITH PRE-EXISTING PALEONTOLOGICAL WORK ADDED TO THIS REPORT

Well No.

#6 Sun Oil Company
Weston Lumber Co. #2
Section 6, Township 8 South, Range 15 West
Wildcat
Hancock County, Mississippi

#7 Sapphire Exploration & Production Co.
SL-MS-85-4-OS No. 1
Mississippi Sound Block 90
Wildcat
Offshore, Mississippi

Table 4. Name and location of wells with paleontological work done prior to this report and included herein (Figure 11).

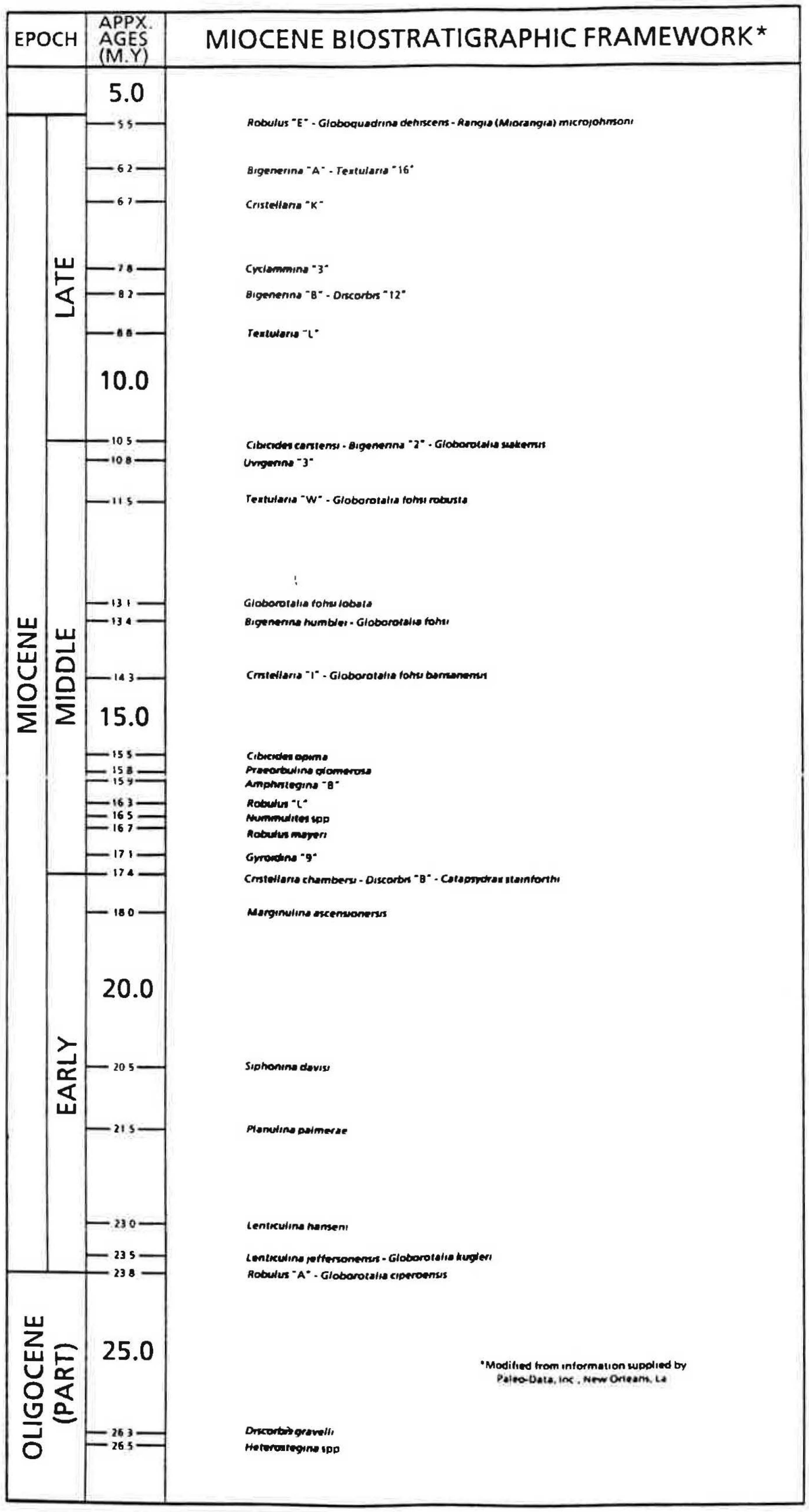

Figure 12. Miocene biostratigraphic framework of southwestern Alabama (from Mink et al., 1988).

In other wells, the uppermost occurrence of *Heterostegina* sp. was found significantly below the top of the carbonate; for example, in the DuPont Well in Harrison County, *Heterostegina* sp. was found approximately 100 feet below the top of the carbonate. In the Marshall Young well in Hancock County, the basal 100 feet of the Miocene section contained approximately equal proportions of limestone and clay, suggesting the possibility of significant reworking of the Oligocene carbonate during the Miocene.

Miocene-Oligocene Unconformity

In all wells examined during this study, the fine clastic sediments overlying the Oligocene carbonate contained specimens of *Nummulites* sp., but no lower Miocene age-diagnostic Foraminifera, indicating that the oldest Miocene strata overlying the Oligocene carbonate are of early middle Miocene age (see following section). This indicates the presence of a regional unconformity consisting of a large portion of the lower Miocene section, or a hiatus of about ten million years. Besides the apparent reworking of the Oligocene carbonate rocks into the Miocene clastic rocks stated above, one well (Floto) contained iron staining in the sample that included the unconformity.

As stated previously, pre-existing paleontological information on two additional wells (wells #6 and #7, Fig. 11 and Table 4) was included in this report and compared to the information obtained from the samples of the five wells studied for this report. Both of the reports on the Sun Oil Company, Weston Lumber Co., No. 2 well (located onshore Hancock County) (Havard, 1978) (well #6, Fig. 11) and the Sapphire Exploration & Production Co. SL-MS-85-4-OS No. 1 well (located offshore Mississippi state waters, Block 90) (well #7, Fig. 11) indicate the presence of lower Miocene age-diagnostic Foraminifera in the sediments lying above the first occurrence of *Heterostegina* (Dockery, 1986). This contradicts the information from the wells studied for this report which indicates a lack of lower Miocene sediments in the study area.

A possible explanation for the presence of lower Miocene age-diagnostic Foraminifera in the samples of the Sun well (located a few miles from the Marshall Young well) is the reworking of lower Miocene sediments during the early middle Miocene. On the other hand, the Sapphire well is located on the southern edge of the Mississippi study area further south than any of the five wells studied for this report. The presence of the *Camerina* 1 zone, *Discorbis bolivarensis* zone (*Discorbis* "B"), and *Cristellaria* "R" zone, which are lower Miocene foraminiferal age-diagnostic zones, over a 320-foot interval above the *Heterostegina* zone, indicates that lower Miocene-aged sediments are definitely present in the extreme south-central offshore portion of the study area (Fig. 13).

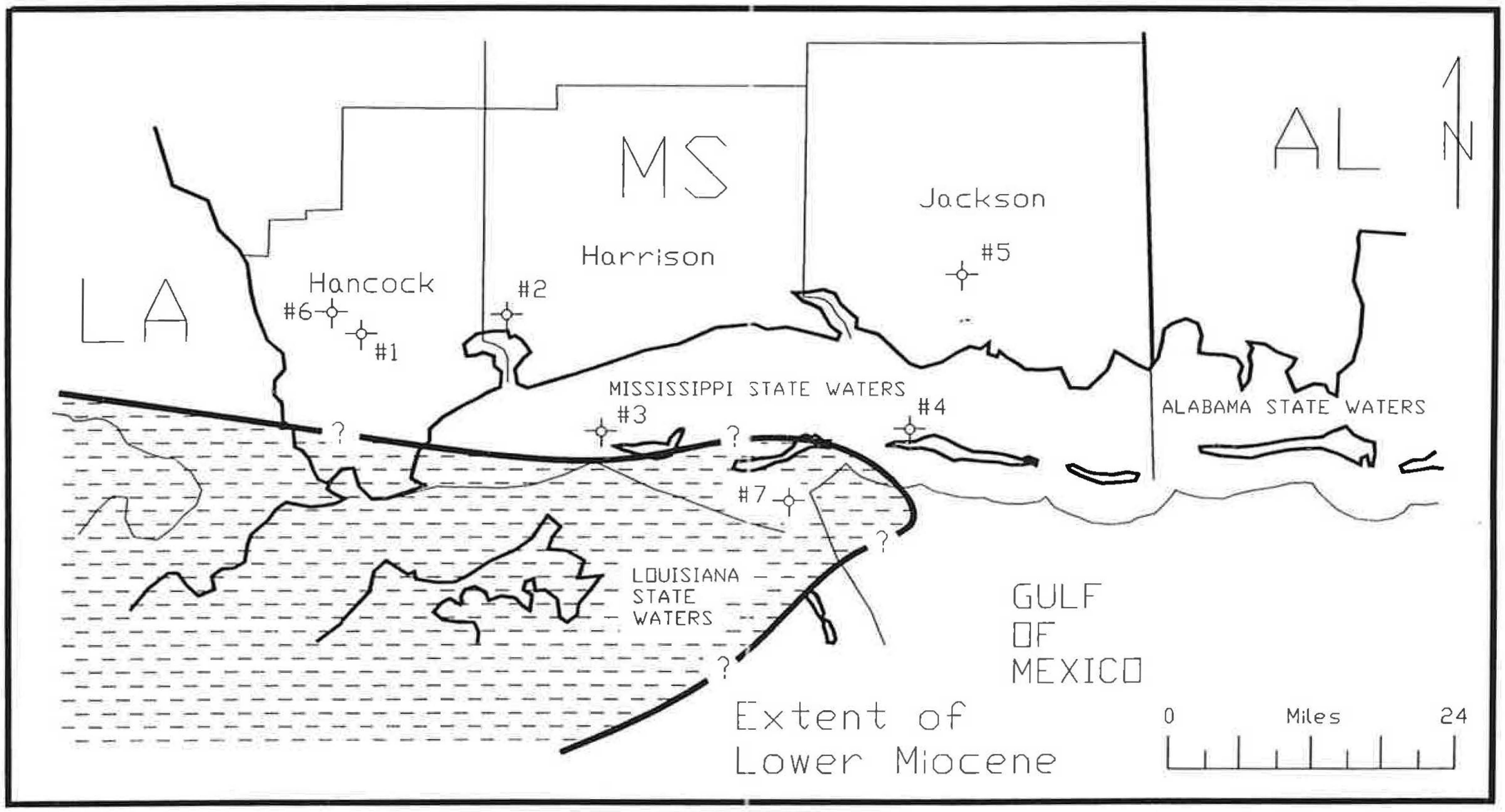

Figure 13. Index map showing possible areal extent of lower Miocene-age sediments in the Mississippi study area.

In any case, detailed paleontological study of as many additional wells as possible should be done, including several wells in Louisiana adjacent to the Mississippi study area, and perhaps a re-examination of the samples from the seven wells included in this report. This additional information should help in future attempts to better understand the areal extent and depositional history of lower Miocene sediments in the south-central and southwestern portions of the Mississippi study area.

Basal Miocene

The basal Miocene clay is the interval between the top of the Oligocene carbonate and the uppermost stratigraphic occurrence of the *Nummulites* sp. biohorizon. All or part of this interval was found in all wells examined for this report. The top of this interval was not observed on three out of the five wells (Chesley Pruet-Quinn, Floto and DuPont wells); in these cases, paleoenvironmental conditions precluded inclusion of age-diagnostic microfossils. For example, in the Chesley Pruet-Quinn well, *Nummulites* sp. and *Amphistegina* "B" were found together in the youngest interval datable by microfossils, but were overlain by sediments with only rare occurrences of microfossils.

Typically, the basal Miocene clay contains an abundant and diverse microfauna. Besides *Nummulites* sp. and *Amphistegina* "B", the basal clay often contained *Cristellaria* "I", *Cibicides carstensi, Uvigerina* spp., *Eponides* sp., *Siphonina* sp., *Nonionella* sp., *Bolivina* sp., *Bulimina* sp., and *Buliminella* sp. as well as a diverse and abundant planktonic foraminiferal fauna, including *Globigerina* spp. and *Globigerinoides* spp.

Amphistegina "B" Interval-zone

The *Amphistegina* "B" Interval-zone is defined as the stratigraphic interval between the *Nummulites* sp. Biohorizon and *Amphistegina* "B" Biohorizon. Chronostratigraphically, the interval is early, but not earliest, middle Miocene, and is of approximately 0.8 million years duration (Mink et al., 1988) (Figure 12). This interval zone was found in only two wells, the Chevron and Floto wells, both of which are the offshore wells. The top of the zone was found only in the Chevron well; in the Floto well, samples containing *Amphistegina* "B" were overlain by samples containing only rare occurrences of Foraminifera.

The *Amphistegina* "B" Interval-zone is about 150 feet thick in the Chevron well and about 100 feet thick in the Floto well. Associated fauna includes *Cristellaria* "I", *Cibicides* spp., *Lenticulina* spp. and *Liebusella* sp., in addition to a diverse planktonic foraminiferal fauna, including *Globigerina* cf. *praebulloides, Globigerina* spp., *Globigerinoides* spp., and *Globoquadrina* spp.

Cristellaria "I"-*Globorotalia fohsi barisanensis* Interval-zone

The *Globorotalia fohsi barisanensis* Interval-zone is defined as the stratigraphic interval between the *Amphistegina* "B" Biohorizon and the *Globorotalia fohsi barisanensis* Biohorizon. Part of this zone was found in only one well, the Chevron well. The top was not observed; samples containing *Cristellaria* "I" and *G. fohsi barisanensis* were overlain by samples with a microfossil assemblage indicative of marginal marine conditions. Since the top of this interval zone was not observed, the chronostratigraphic duration cannot be determined.

The stratigraphic thickness of samples within the *Cristellaria* "I"-*G. fohsi barisanensis* Interval-zone in the Chevron well was about 100 feet. Associated benthic foraminiferal fauna include *Amphistegina* spp., *Bolivina floridana, Buliminella* sp., *Cibicides carstensi*, *Eponides* sp., *Lenticulina* spp., *Siphonina* sp., *Uvigerina altacostata* ("3"), and *Uvigerina* spp. Planktonic Foraminifera were abundant and diverse, including *Globigerina* spp., *Globigerinoides* spp., and *Praeorbulina* spp.

Younger Miocene Strata

The stratigraphic distribution of samples bearing *Rangia (Miorangia) microjohnsoni* were also identified for this study in an attempt to identify sediments of Miocene age that were lacking age-diagnostic microfauna. The top occurrence of *R. (M.) microjohnsoni* could not be identified with confidence, owing to apparent reworking and the general fragmentary condition of the megafossils. All of the wells, however, contain significant stratigraphic thicknesses of the samples bearing *R. (M.) microjohnsoni*.

In the Chesley Pruet-Quinn well, *R. (M.) microjohnsoni* is found at 2060 feet, and possibly as shallow as 1760. In the Floto well, *R. (M.) microjohnsoni* is found at 2095 feet. In the Chevron well, the highest stratigraphic occurrence of *R. (M.) microjohnsoni* is found at 3700 feet, although the overlying 300 feet of stratigraphic thickness were not sampled. In the DuPont well, the highest stratigraphic occurrence of *R. (M.) microjohnsoni* was at 1750 feet. Finally, in the Young-Stem well, the highest occurrence of specimens positively identified as *R. (M.) microjohnsoni* was at 2575 feet, although this may range up to 2420 feet.

PALEOENVIRONMENTAL ANALYSIS

The majority of the Miocene sediments studied for this report were deposited under fluvial to marginal marine conditions. This included the intervals above samples containing age-diagnostic microfossils, typically well over half the Miocene section. Following the foraminiferal paleoecologic model of Culver (1988), sediments devoid of fossils are considered non-marine, sediments containing certain Foraminifera such as *Ammonia* ("*Rotalia*") *beccarii* and *Elphidium* spp. are considered marginal marine, and sediments containing a diverse and abundant microfossil content are considered normal marine.

In a broad sense, the Miocene samples graded, from bottom to top, from clay containing a diverse and abundant microfossil content, especially planktonic Foraminifera, through sand and clay containing a depauperate microfauna consisting of *Ammonia* ("*Rotalia*") *beccarii*, *Elphidium chipolensis* and *Lenticulina* spp., through sand and gravel containing whole or fragmented mollusk shells, to a fossiliferous sand. This stratigraphic occurrence suggests an initial transgression followed by a relatively slow regression for the Miocene interval.

The interval in the lower part of the Miocene section that contained age-diagnostic microfossils often contained a high percentage of planktonic Foraminifera, in addition to *Amphistegina*, *Nummulites*, *Cristellaria*, *Cibicides*, *Uvigerina*, *Nonion*, *Nonionella*, *Eponides*, and *Siphonina*, in addition to the ubiquitous occurrences of *Lenticulina*. Following the model of Culver (1988), this places the environment of deposition at middle to outer shelf conditions.

Since the two offshore wells, the Chevron and Floto wells, contained microfossils diagnostic of slightly younger time intervals than the onshore wells, normal marine conditions probably persisted longer in the offshore areas than in the onshore areas. By middle Miocene time, marginal marine conditions encroached on the area of the wells studied and persisted through the rest of the Miocene.

PETROLEUM EXPLORATION

Onshore History

Oil and gas exploration of Mississippi's three coastal counties, Jackson, Harrison, and Hancock (Fig. 1), began in 1911 with Pascagoula Development Company drilling the #1 Delamorton in southern Jackson County. The well was drilled to 3010 feet and tested the Upper Oligocene/Miocene *Heterostegina* Formation. The well tested salt water and was plugged and abandoned.

Through the first half of the 20th century, exploration of the coastal area of Mississippi was primarily confined to the relatively shallow Oligocene/Vicksburg Group and Catahoula Formation in Jackson County. There were 26 wells drilled during this period and all failed to establish any oil and/or gas production.

In the second half of the century, exploration interest moved to the west and centered on Hancock County. Wells were drilled down to the Washita-Fredericksburg (10,500 feet) and deeper. Production was first established in the area in December 1955. Marshall R. Young Company drilled the Cuevas Heirs No. 1, Sec. 30-T9S-R15W, in southern Hancock County. This is the discovery well for Ansley Field and it tested oil and gas from perforations between 10,841 and 10,852 feet in the Cuevas Sand of the basal Dantzler or the uppermost Washita-Fredericksburg formation (upper Lower Cretaceous). The development of the field resulted in production from pools in the Upper and Lower Tuscaloosa (Upper Cretaceous) and two separate Washita-Fredericksburg horizons (Lower Cretaceous).

A slow and rather erratic pace of exploration and development drilling over the years since the discovery of Ansley Field in 1955 has resulted in the discovery of three additional fields producing oil and gas from the Lower Cretaceous (Kiln Field, 1959, and Waveland Field, 1965) and/or deep Jurassic Cotton Valley (Catahoula Field, 1981, 19,700-20,200 feet) in Hancock County (Mississippi Geological Society) along the Hancock Ridge. The Hancock Ridge is a southward plunging spur of the Wiggins Arch (Fig. 5).

In the last few years, development of Waveland Field has continued and a renewed interest in shallower Miocene and Oligocene zones, productive in southwestern Alabama and southeastern Louisiana, has resulted in several wells drilled in Harrison and Jackson counties. Commercial quantities of oil or gas have yet to be found.

Offshore History

For many years there has been a viable offshore oil and gas industry in Louisiana and in more recent years in Alabama. Exploration in Mississippi's state waters has not been as robust as that of its neighbors. The first Mississippi offshore well was drilled in 1952. Gulf Refining Company spudded the #1 Gulf Melben northeast of Grand Island in Block 95 of the Mississippi Sound. The well was drilled to a depth of 10,571 feet (Lower Cretaceous) and was plugged and abandoned in September l952 as a dry hole.

In 1954, the C. A. Floto was drilled in Block 48 of the Mississippi Sound near Horn Island off the coast of Jackson County, Mississippi. The well was drilled to a depth of 13,041 feet (Paluxy) and was abandoned with no shows of oil or gas reported.

Two years later (1956) the J. Willis Hughes Company drilled the No. 3 State of Mississippi in the St. Louis Bay, Block 23, off the coast of Hancock County. The well was drilled to a depth of 9996 feet (Lower Tuscaloosa) and abandoned in November 1956. No shows were reported.

Mississippi's offshore waters were not tested again until 1986 when Sapphire Exploration and Production drilled the No. 1 State of Mississippi south of Ship Island in Block 90 of the Mississippi state waters. The well was drilled to a depth of 5927 feet in the *Heterostegina* "Reef" Formation of the Upper Oligocene/Miocene. In September 1986 the well was abandoned as a dry hole.

In December 1988, Chevron spudded the No. 1 Mississippi Sound, Block 57, near Cat Island off the coast of Long Beach, Mississippi. The well was drilled to 23,550 feet (Jurassic). In October 1989, the well was plugged and abandoned as a dry hole. No oil or gas shows were encountered in the Miocene. To date, there has been no production established under Mississippi state offshore waters.

PETROLEUM GEOLOGY

At the completion of this report, the authors believe that no commercial quantities of Miocene oil or gas have been discovered in the State of Mississippi and certainly not in the coastal counties or offshore state waters. In February of 1993, a Miocene shallow gas discovery was reported and a completion report filed with the Mississippi State Oil and Gas Board. The new field discovery, Cars Creek Field (Fig. 2), is located in Amite County, southwestern Mississippi. Because the logs for the reported discovery well were held confidential and not released, only the completion report information was available to be compared with the well logs from a well approximately 300 feet away. It is believed that because of the depth of the reported perforations for the producing zone in the new well, the discovery well is actually completed in a Frio gas sand and that the State of Mississippi is still lacking its first verified Miocene production.

Because of the proximity of the shallow Miocene gas production of offshore and onshore southwestern Alabama to the Mississippi study area, a review of southwestern Alabama's onshore and offshore Miocene gas trend and petroleum geology follows.

Shallow Miocene natural gas production was first discovered in southwestern Alabama in 1979 with the drilling of the Amoco Production Company-Amos 32-12 #1 well, in southern Baldwin County. This well, which encountered shallow gas in the Miocene "Amos" Sand, was designated the discovery well for Foley Field (Mink et al., 1988). Since then, some 32 fields productive from shallow Miocene gas sands have been discovered in the onshore area of Baldwin and Mobile counties and the adjacent Alabama state waters. Figure 14 shows the locations of Miocene fields adjacent to the study area of Mississippi.

Cumulative gas production from the Alabama Miocene as of 2/28/93 is 21,709,953 mcf of gas from the onshore area and 23,510,627 mcf of gas from the offshore Alabama state waters, for an overall total of 45,220,580 mcf of gas (State Oil and Gas Board of Alabama, Monthly Production Report, Feb. 1993).

Gas production has come from five different sand members of the Pensacola Clay. From oldest to youngest they are: the Amos Sand (*Cibicides carstensi* Interval-zone, middle Miocene) (Mink et al.,1988), the Luce Sand, the Escambia Sand, the Meyer Sand (*Discorbis* "12" Interval-zone, early late Miocene) (Mink et al., 1988) (Fig. 15), and the Dauphin Sand (offshore, 1990) (probably also *Discorbis* "12" Interval-zone or younger). Figures 16 and 17 are type logs for the southwestern Alabama onshore (Fig. 16) and offshore (Fig. 17) Miocene.

Producing depths for the Alabama Miocene gas reservoirs range between 1100 and 2400 feet. Porosities vary from sand to sand between 11 and 35 percent, but usually average from 27 to 30 percent. The Amos Sand reservoirs commonly exceed 30 percent porosity (Bolin et al., 1989). Measured permeabilities for Miocene reservoirs range from 8 to over 2000 millidarcies (Mink et al., 1988).

Depositional environments for the Miocene sands in southwestern Alabama have been interpreted to be either transitional-marine, inner neritic, or middle neritic (Mink et al., 1988). These marine bars are generally narrow, elongate, sand bodies oriented northwest-southeast and parallel to regional strike. The trapping mechanism for the shallow Alabama Miocene gas reservoirs is primarily stratigraphic with marine sand bars draped across subtle structural noses or parallel to strike. Generally, the updip and lateral loss of porosity and permeability at or near sand shale-outs form the hydrocarbon trap (Figures 18 and 19).

The source for the shallow Miocene gas reservoirs of southwestern Alabama is believed to be the middle and outer neritic clays interbedded with the reservoir sands (Mink et al., 1988). Depth of burial of the source clays is

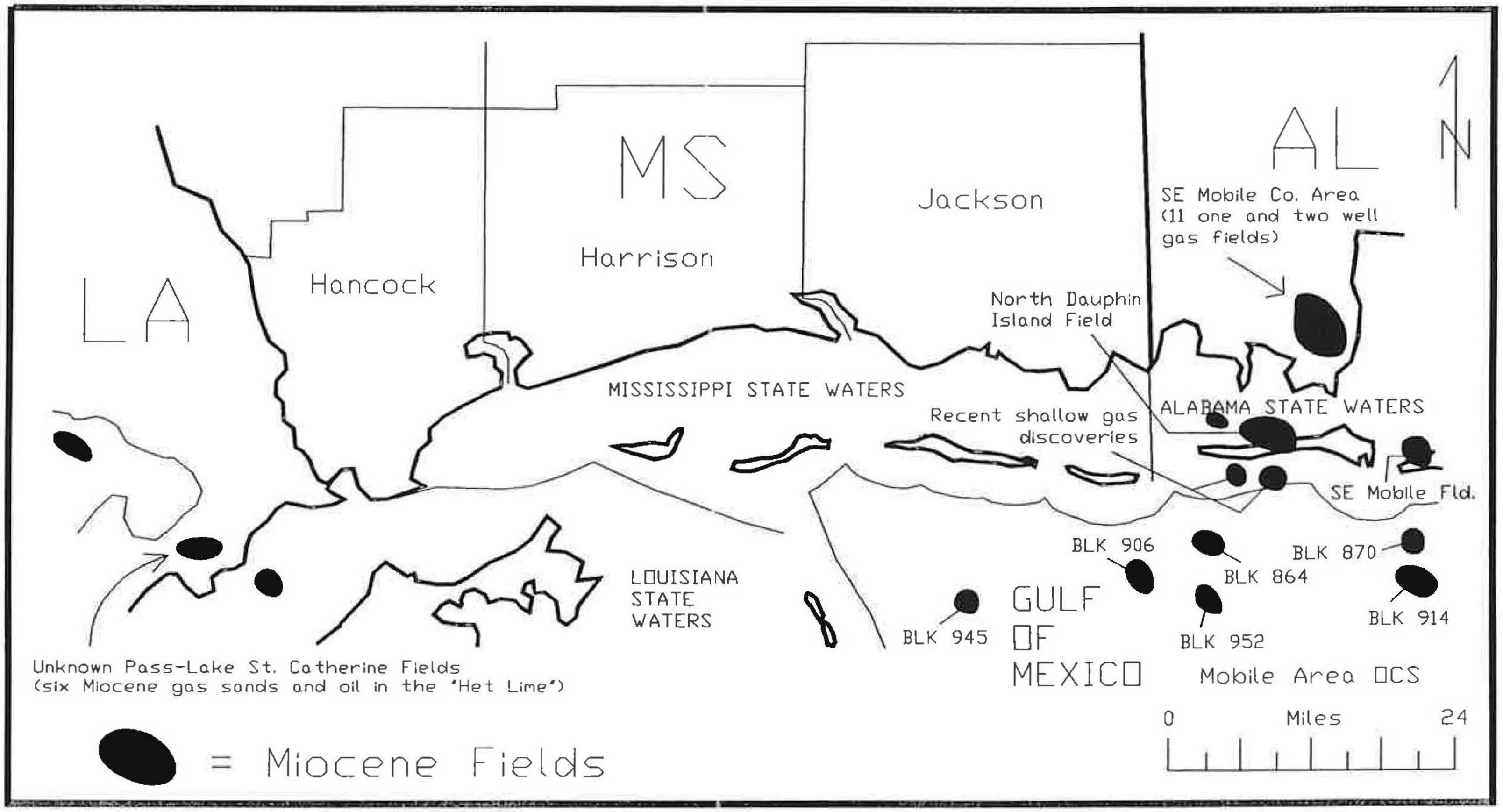

Figure 14. Index map showing Miocene field locations in areas adjacent to the Mississippi study area.

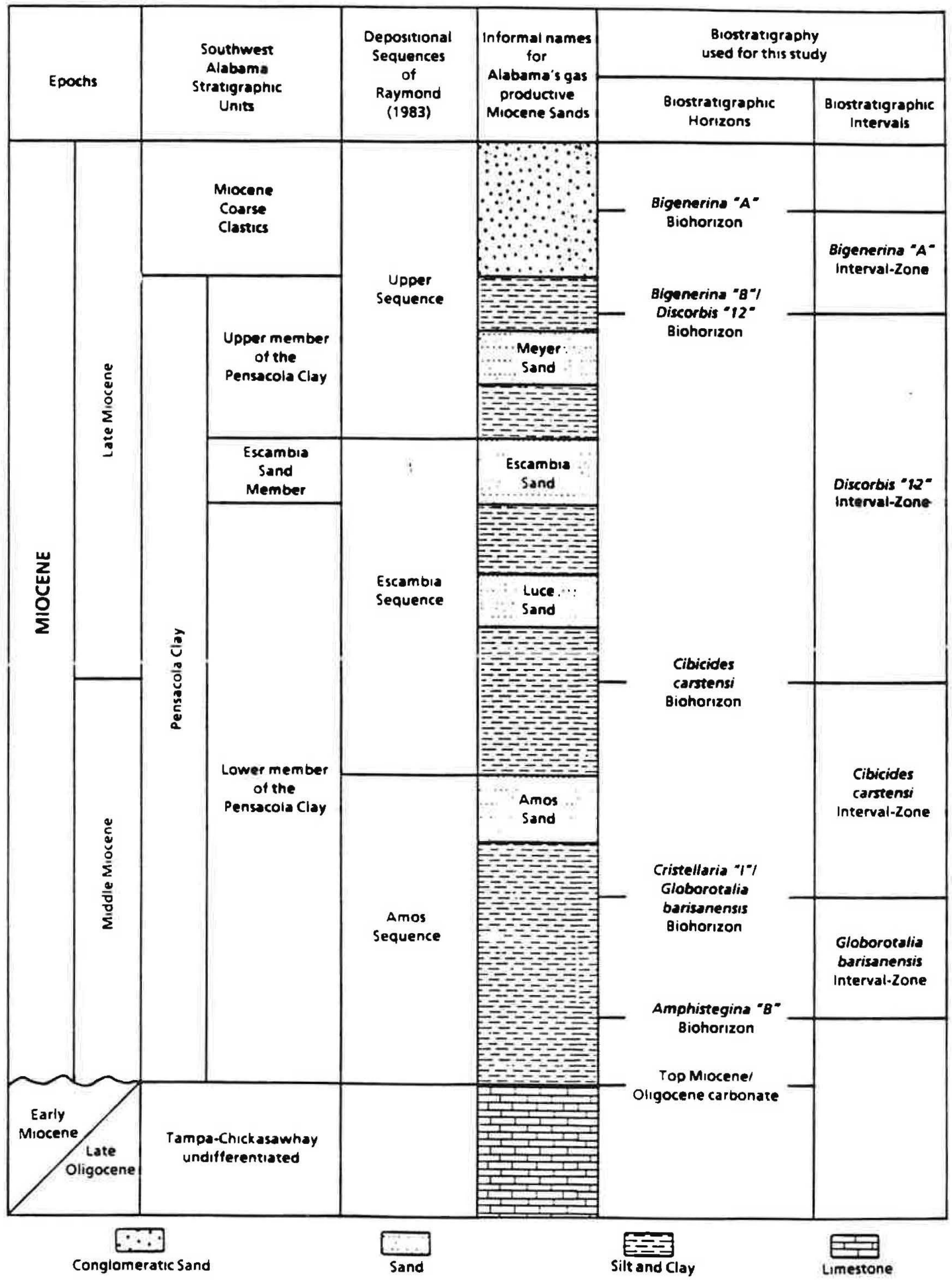

Figure 15. Miocene stratigraphy and biostratigraphy for southwestern Alabama (from Mink et al., 1988).

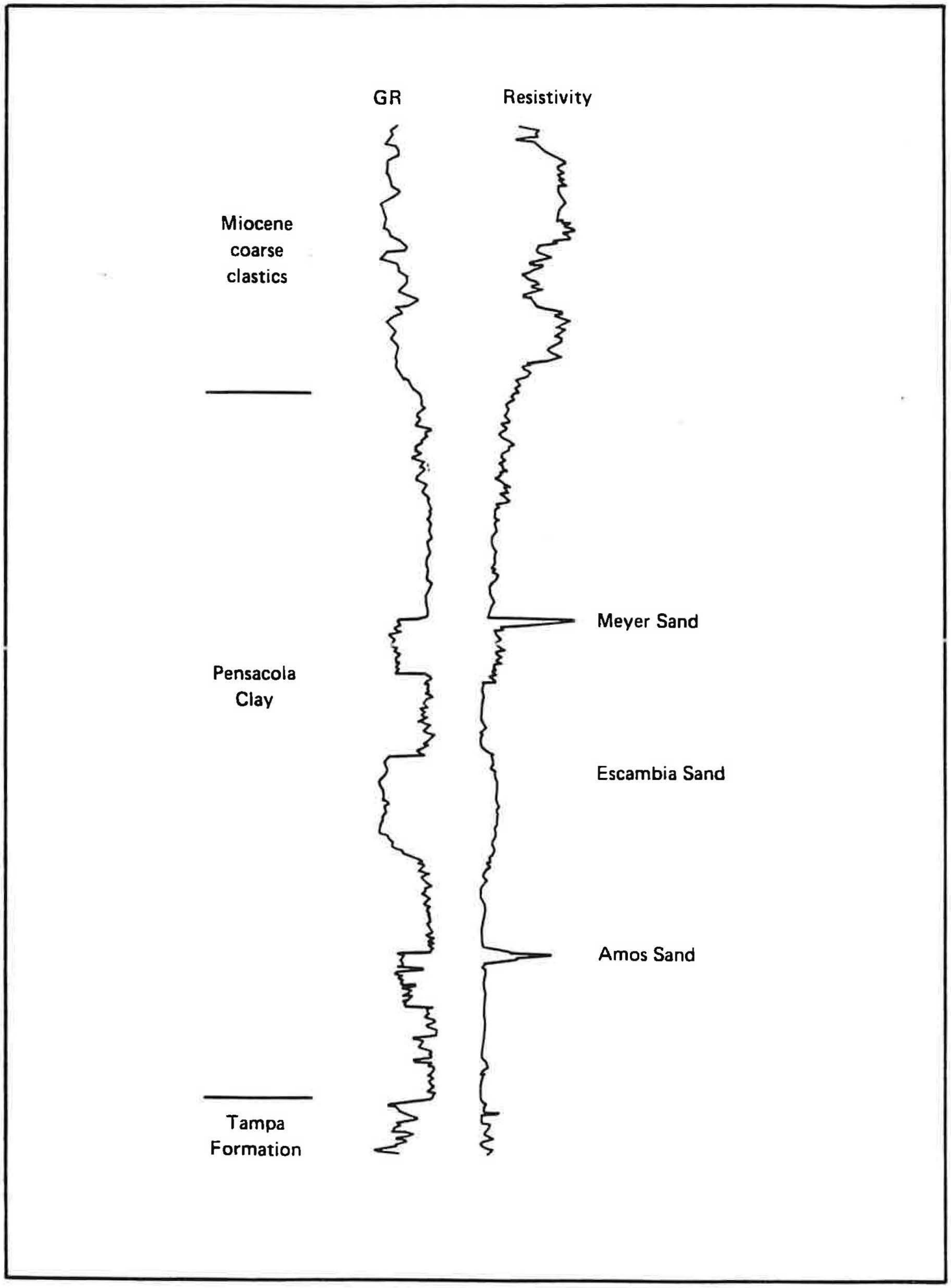

Figure 16. Onshore type log, southwestern Alabama Miocene (from Raymond, 1985).

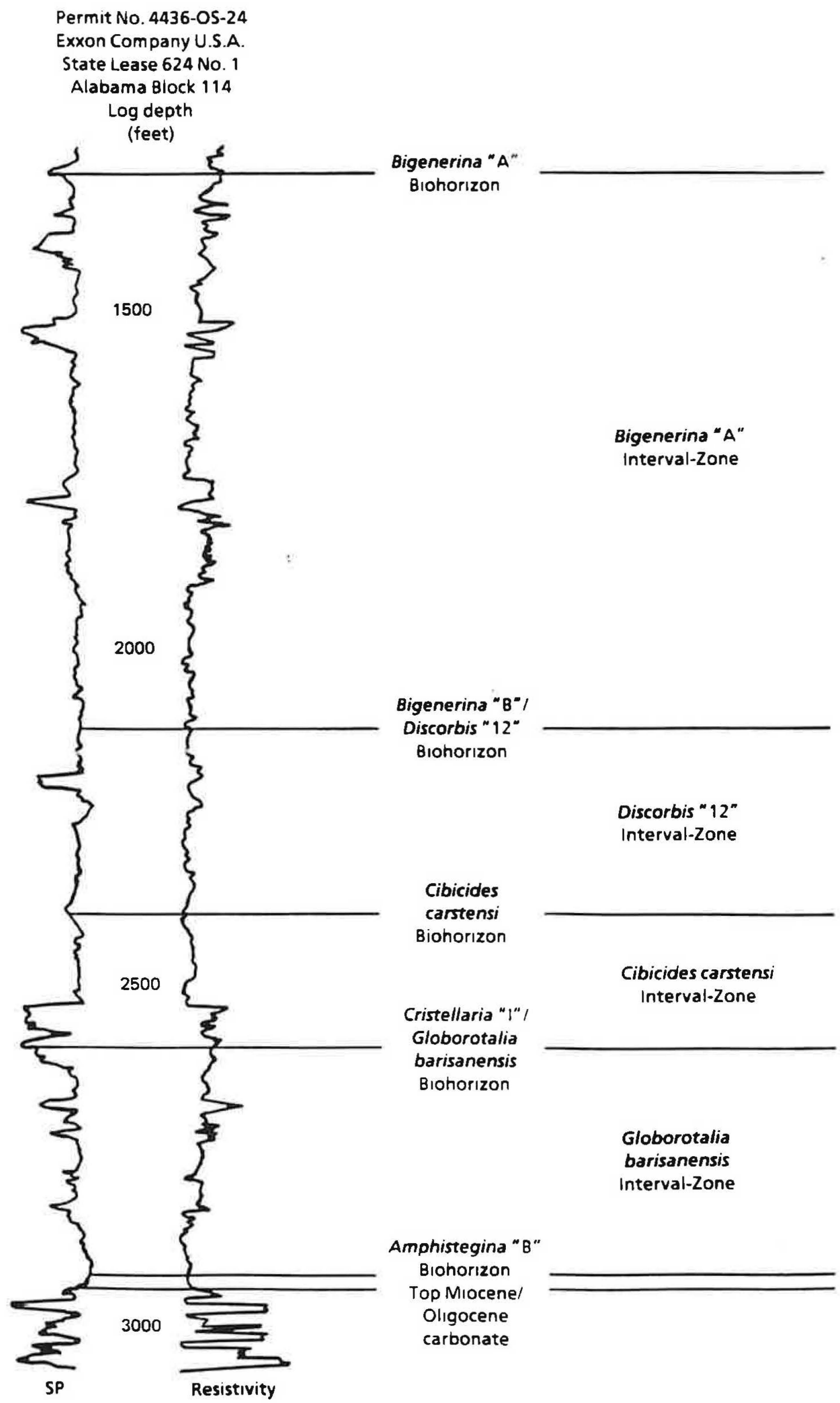

Figure 17. Offshore type log, offshore Alabama Miocene (from Mink et al., 1988).

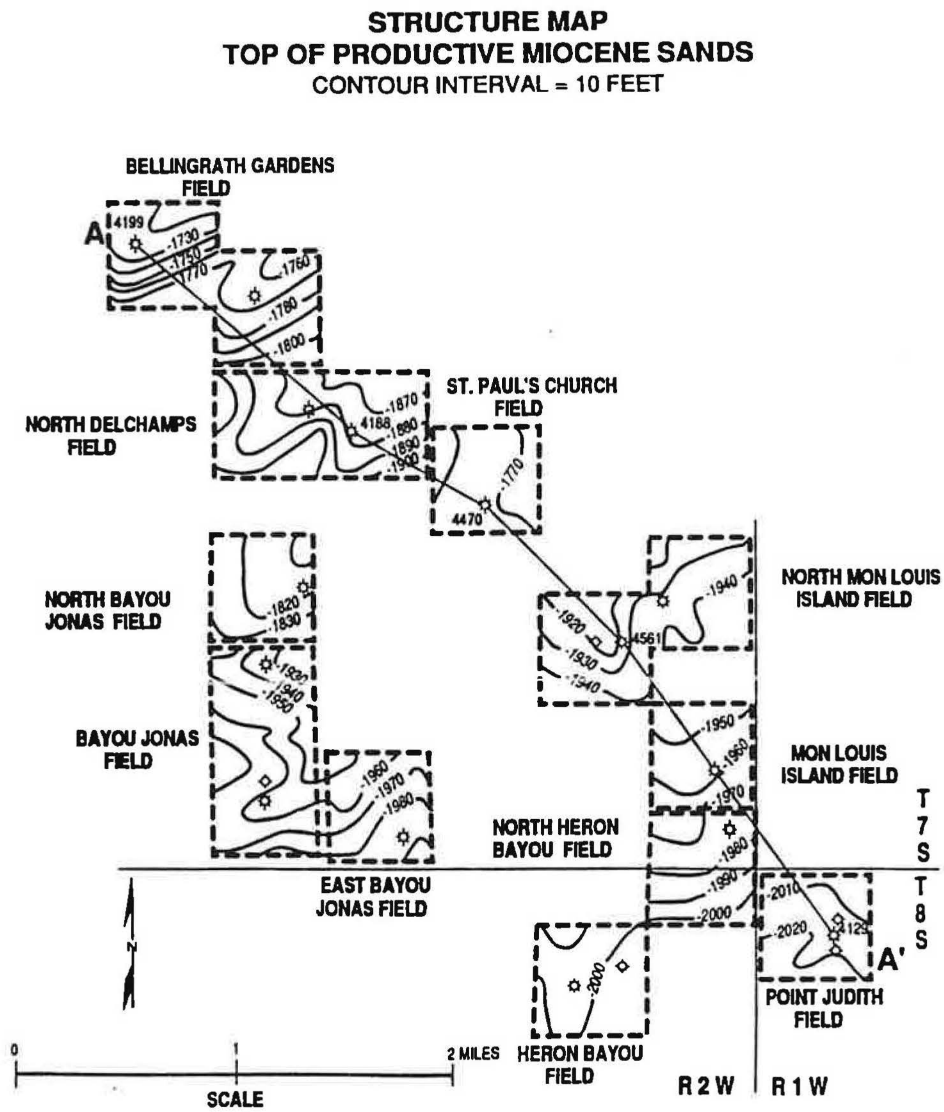

Figure 18. Structure map of Miocene fields in southeastern Mobile County, Alabama (from Bolin et al., 1989). See Fig. 19 for cross section A-A'.

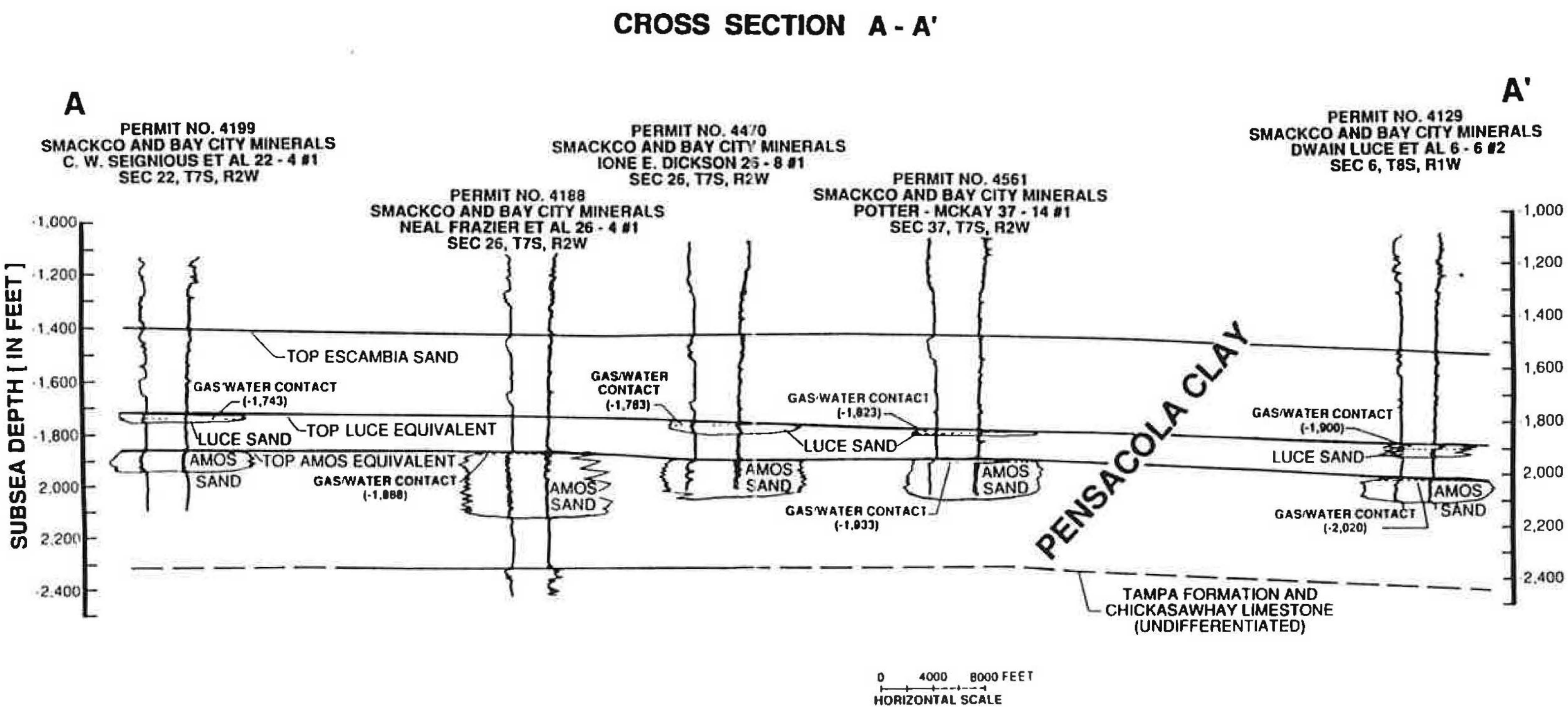

Figure 19. Cross section through Miocene fields in southeastern Mobile County, Alabama (from Bolin et al., 1989). The line of section is shown on Fig. 18.

an important factor influencing the quantity and immaturity of hydrocarbons in the Miocene reservoirs. Analysis of gas from the Amos Sand at Foley Field indicates that the gas in that reservoir is 99.9 percent methane and is of biogenic origin (Jenden, 1985). Most of the gas in the shallow Miocene of southwestern Alabama is probably biogenic.

The primary producing sand onshore Alabama has been the Amos Sand with 87% of the onshore Miocene gas production. The Amos Sand at Foley Field has produced 6,314,127 mcf of gas and 6,029,292 mcf of gas at West Foley Field (State Oil and Gas Board of Alabama, Monthly Production Report, Feb. 1993). West Foley Field is actually a western extension of Foley Field. The Amos Sand reservoir is a marine bar oriented northwest to southeast parallel to regional strike. The primary trap is an updip shale-out to the northeast of the Amos Sand, although some structural closure is present in the Foley Field area (Fig. 20). The two fields are located onshore Alabama, in Baldwin County.

Offshore in the Alabama state waters, the Dauphin Sand at North Dauphin Island Field is the primary producing zone, having a cumulative production of 22,333,981 mcf of gas from the field, or 95% of the total offshore Miocene gas. The field was discovered by Arco Oil & Gas Co. in 1990 at their No. 1 State Lease 686, Tract 73 well. The vertically drilled well was perforated from 1870' to 1929' (59 feet) (Fig. 21) and tested flowing 4115 mcf of gas per day through a 29/64-inch choke with flowing tubing pressure of 745 pounds (Southeastern Oil Review, 1991). In February 1993, the five then-producing wells produced 1,304,609 mcf of gas for the month (State Oil and Gas Board of Alabama, Monthly Production Report, Feb. 1993) or an average daily rate of 9318 mcfpd of gas per well. Three of these wells are horizontally-drilled development wells.

The Dauphin Sand gas reservoir at North Dauphin Island Field is believed to be a marine bar and is oriented northwest to southeast parallel to regional strike. As at Foley and West Foley fields, the trapping mechanism for the gas is apparently an updip shale-out to the northeast of the Dauphin Sand (Figures 22 and 23). North Dauphin Island Field lies approximately eight miles east of Mississippi state waters offshore, encompassing blocks 72, 73 and parts of blocks 90 and 91 of the Alabama state waters (Arco, 1991).

The primary factors controlling cumulative gas production in the shallow Alabama Miocene are the normally pressured initial reservoir pressures, reservoir areal extent, and water production. Because of the shallow depth, initial reservoir pressures of 478 psi (Meyer Sand, 1214 feet at Skunk Bayou Field, onshore Baldwin County) to 1073 psi (Amos Sand, 2300 feet at Southeast Mobile Bay Field, offshore Alabama state waters) (Bolin et al., 1989),

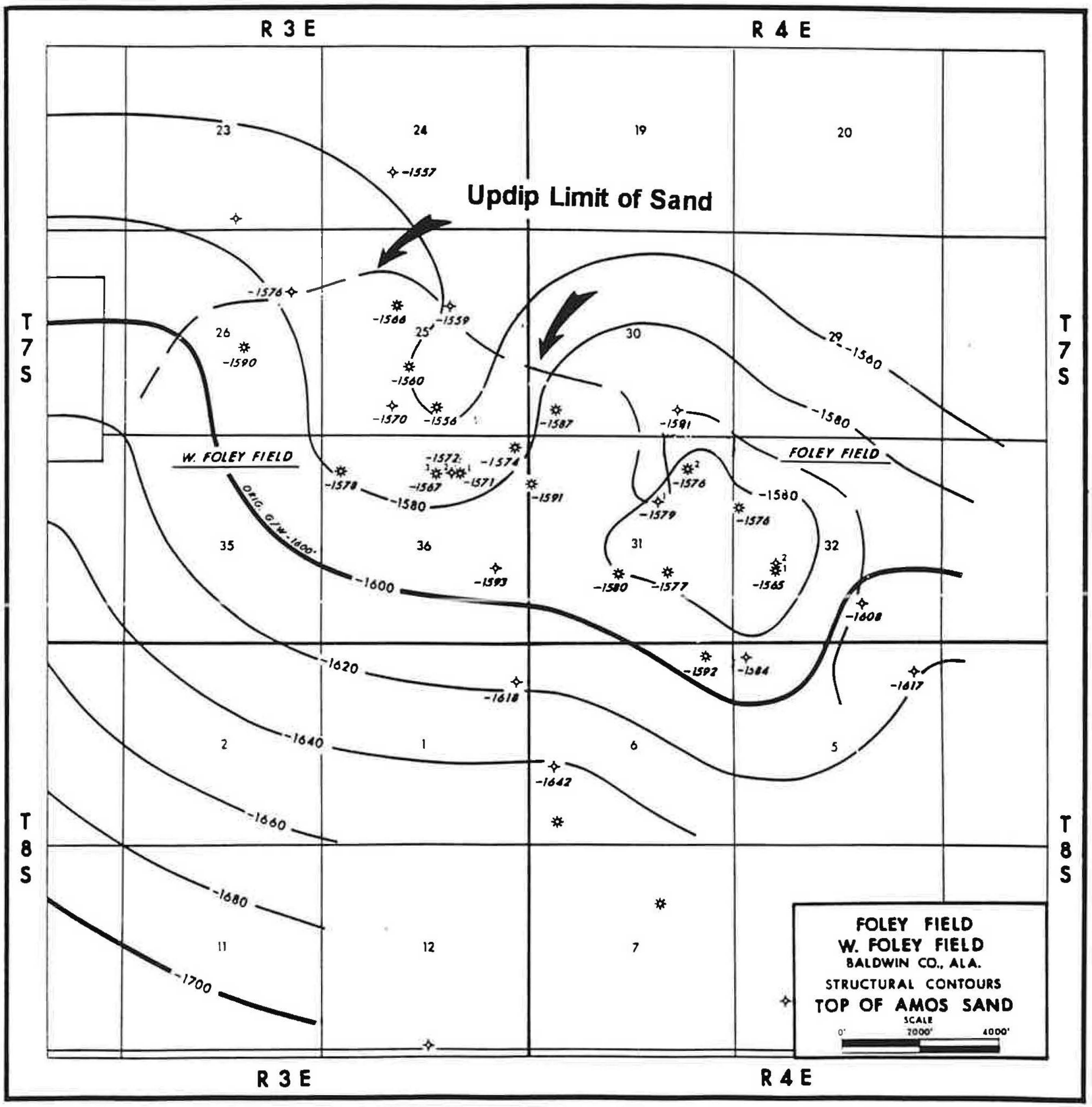

Figure 20. Structure map, Amos Sand, Foley and West Foley Fields, onshore Baldwin County, Alabama (modified from Mississippi Geological Society, 1986).

ARCO Oil and Gas Company
S.L. 686 No. 1
T73 MOBILE COUNTY, ALABAMA
NORTH DAUPHIN ISLAND FIELD
Permit # 7236-OS-37

EXHIBIT No. 3
DOCKET No. 9 26 91 2
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PREPARED BY J.A. WORTHEN

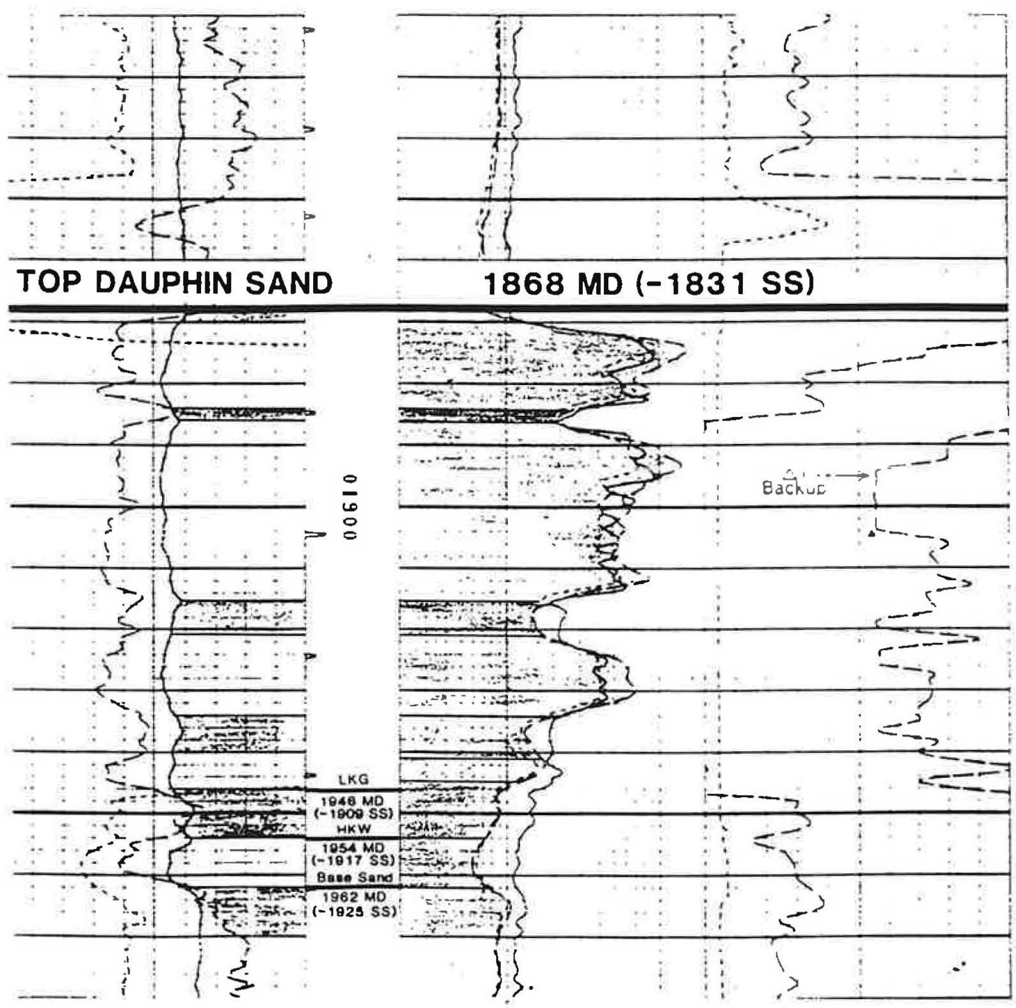

Figure 21. Log section through "Dauphin Sand" in the discovery well for North Dauphin Island Field, offshore Alabama state waters (from Arco, 1991).

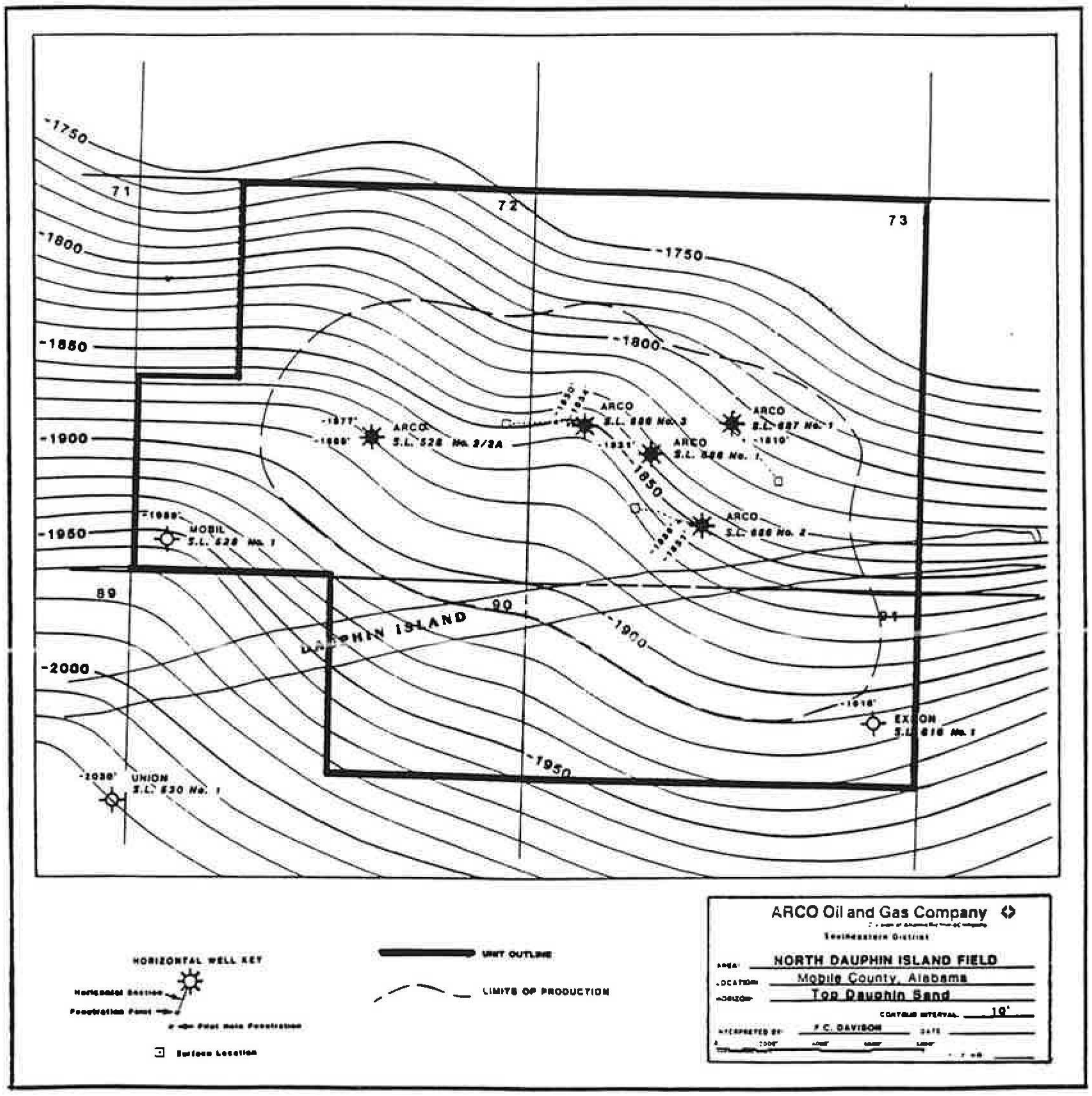

Figure 22. Structure map, North Dauphin Island Field, offshore Alabama state waters (from Arco, 1991).

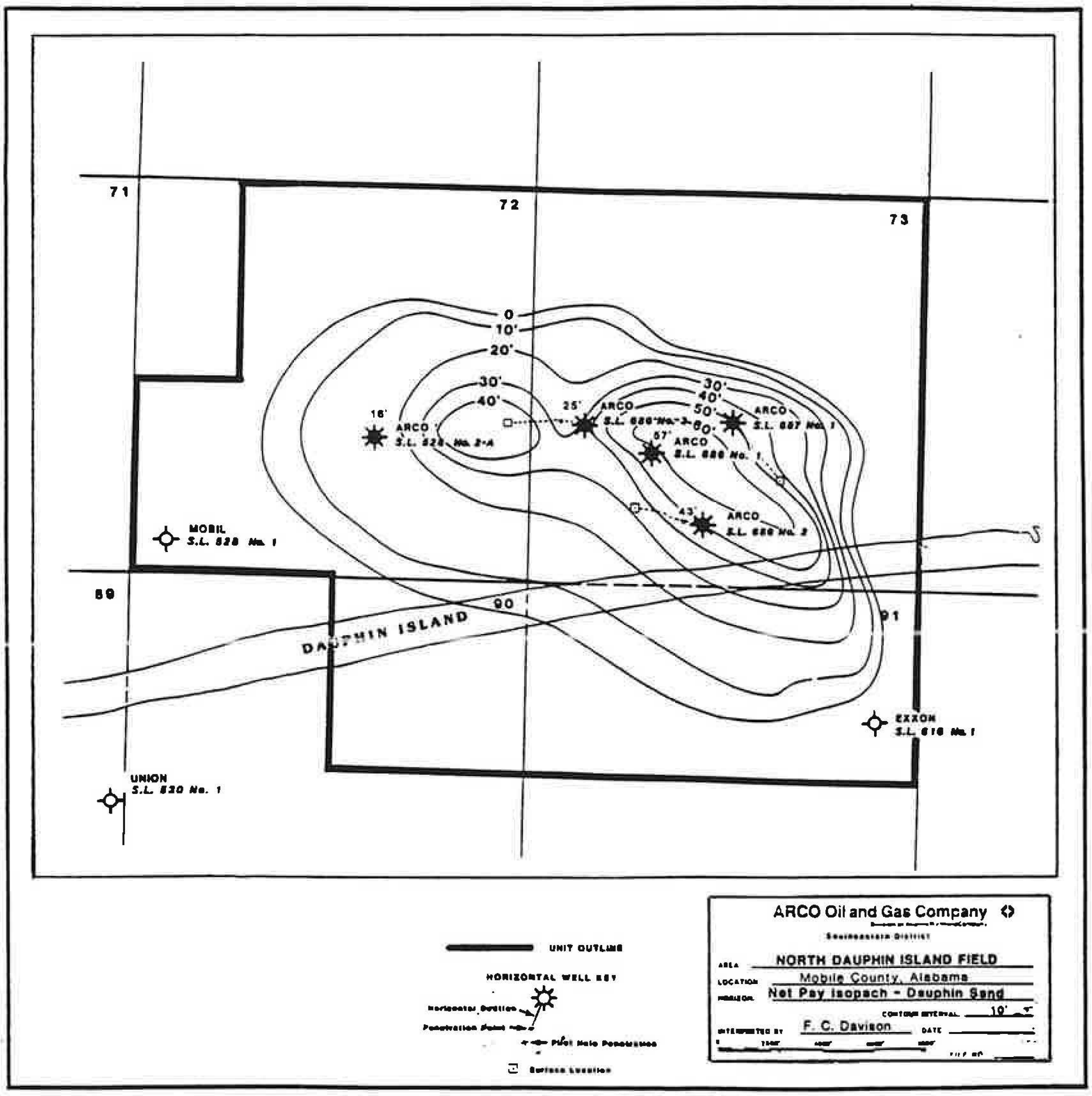

Figure 23. Net pay isopach, North Dauphin Island Field, offshore Alabama state waters (from Arco, 1991).

less gas will be compressed into the available pore space of the reservoir. This means less gas is in place initially and ultimate gas recovery will be lower than from gas reservoirs found at greater depths with similar porosity and permeability.

Many of the southwestern Alabama onshore fields are small one and two well fields (Luce Sand, one well, 19 acres reported, St. Paul's Church Field, onshore Mobile County) (Bolin et al., 1989). It is also common for wells to encounter relatively thin net gas pay (5 to 15 feet) above thick water-productive sand in the Miocene reservoirs of southwestern Alabama, especially in Amos Sand reservoirs (Fig. 19). Because of the high porosities and permeabilities seen in Miocene sands, vertical permeability is also probably high. A combination of the presence of thick water sand and high vertical permeability will often result in early water production by the coning of the water up into the production perforations and thus "water out" the production zone.

Combinations of the above factors have resulted in many of the shallow Miocene gas fields of southwestern Alabama having low ultimate gas recovery and probably poor economic results. Special consideration should be given to the probable areal extent of the reservoir, thickness of the net pay, and presence of water sand, before completing a potential Miocene shallow gas well.

The primary exploration tool used in the Miocene trend of southwestern Alabama and the offshore of the Mississippi/Alabama shelf area is the detection of seismic amplitude anomalies or bright spots (Mink et al., 1988). As seen on a seismic section or profile, a bright spot is a reflection that is much stronger than usual for a limited distance. Its importance is that it may indicate hydrocarbons directly, particularly gas (Coffeen, 1978). Figure 24 is a portion of a seismic profile showing an amplitude anomaly associated with Foley and West Foley fields, onshore Mobile County, Alabama. The anomaly is about 2.5 miles in length along the strike of the two fields. Figure 25 is a typical Miocene amplitude anomaly in offshore Alabama. This bright spot occurs in the *Discorbis* "12" Interval-zone. Structure does not appear to be significant in this trap (Mink et al., 1988).

Several important similarities are apparent between the geology of the Mississippi study area and southwestern Alabama. The same basic stratigraphic units extend from Alabama into much of the study area. The environments of deposition seen in southwestern Alabama extend into the Mississippi study area (at least the eastern coastal and offshore portion). Structural conditions in both areas appear to be the same. Because of these similarities the same basic stratigraphic trapping of hydrocarbons (gas) and reservoir characteristics seen in the Alabama Miocene should be present in the

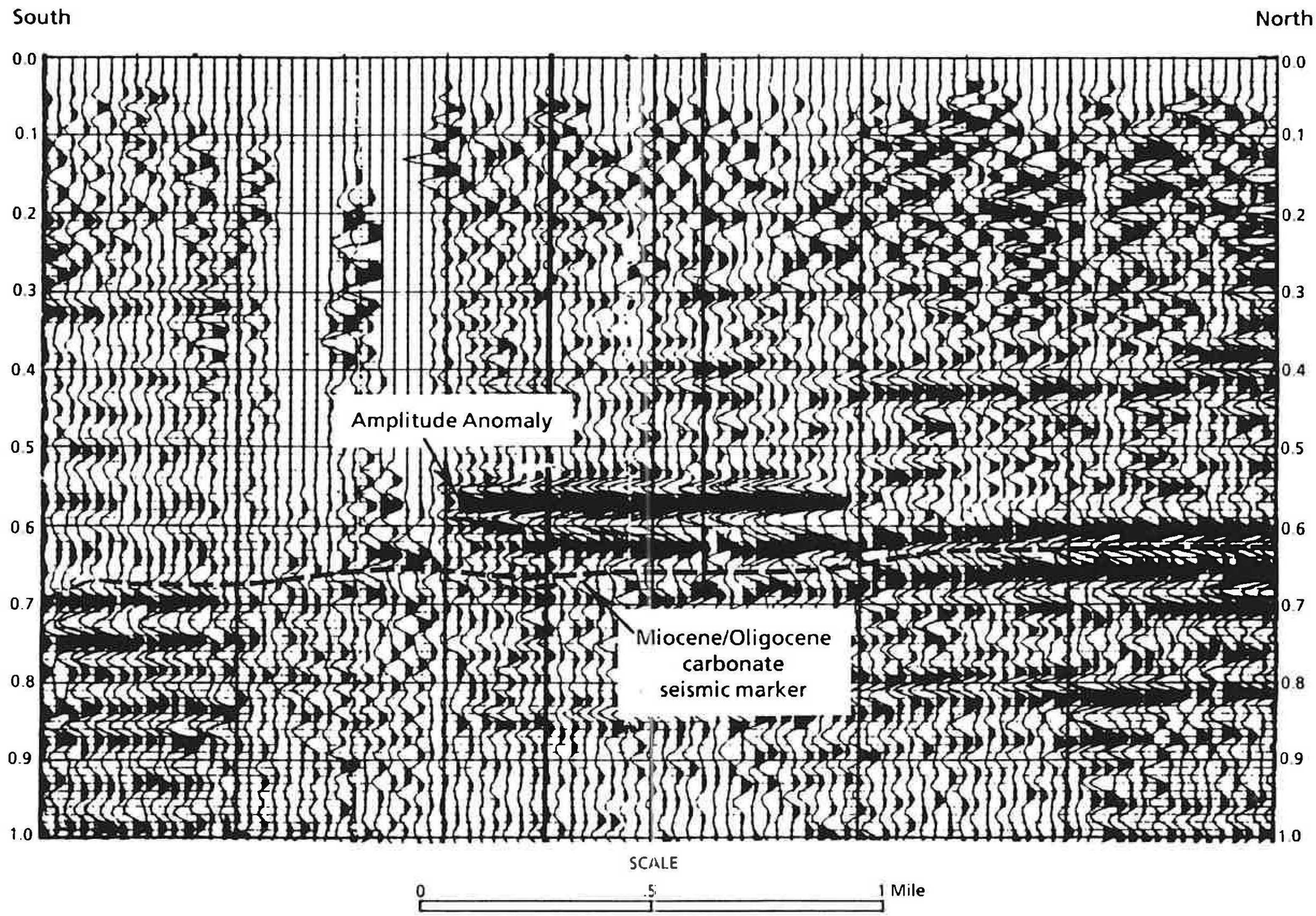

Figure 24. Amplitude anomaly associated with Amos Sand reservoir, Foley Field, Baldwin County, onshore southwestern Alabama (from Mink et al., 1988).

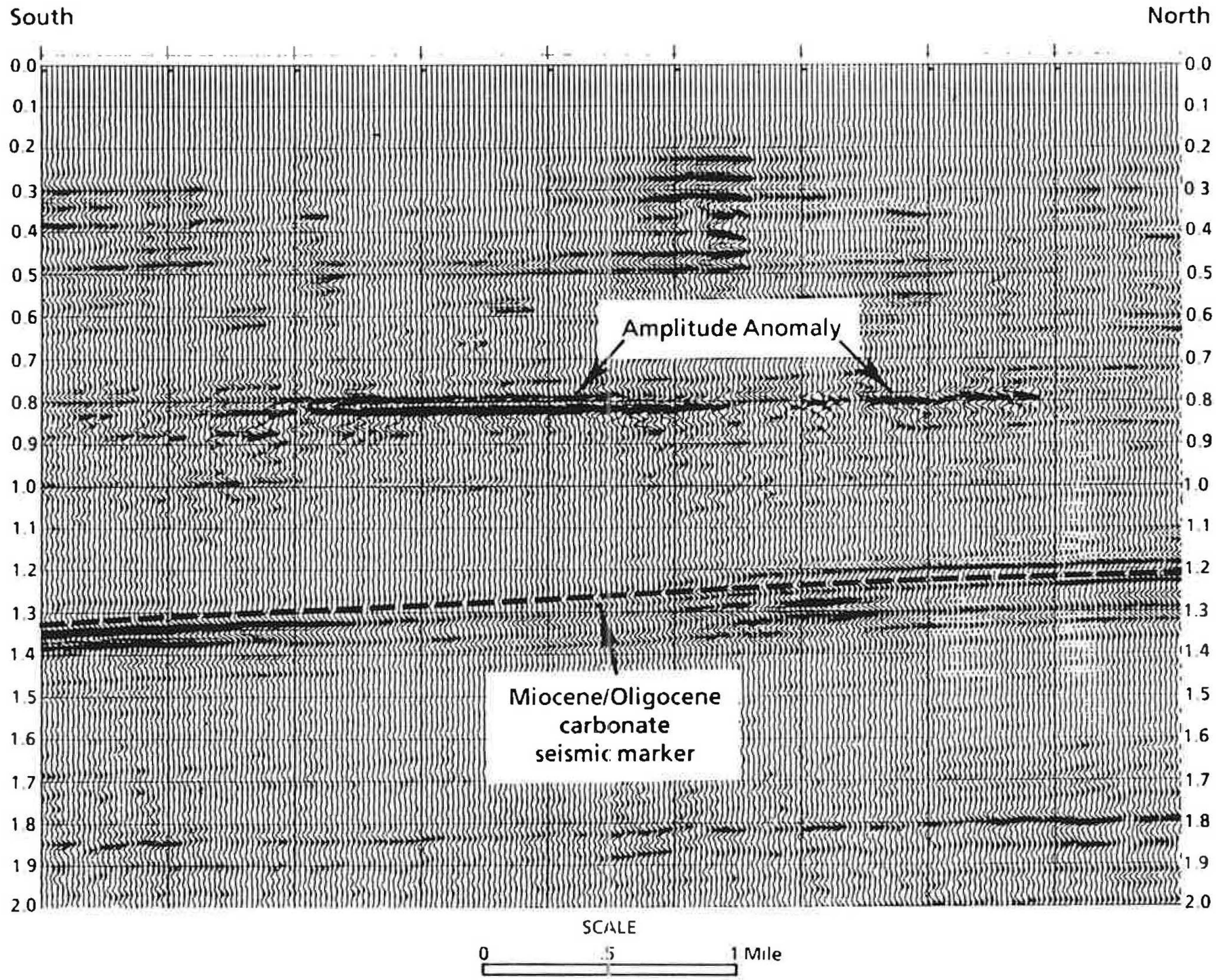

Figure 25. Typical amplitude anomaly in offshore Alabama (from Mink et al., 1988).

Mississippi Miocene underlying the central and eastern coastal and offshore portions of the study area.

Use of multiple seismic lines to delineate the areal extent of Miocene gas sand reservoirs is of great importance, not only for indicating the presence of these gas reservoirs, but in helping to insure that the reservoirs are economically developable accumulations of gas.

CURRENT STATUS OF OFFSHORE LEASES

As of the end of November 1993, no oil and gas leases were in effect covering Mississippi state offshore waters. This could change because of higher interest in the area as additional exploration and development successes continue in the North Dauphin Island Field area in Alabama state waters only a few miles east of Mississippi state waters.

In the Mobile Area of the Federal OCS waters south of Mississippi state waters, several operators have blocks under lease. Only one shallow gas Miocene field (one well) is on production (Mobile Area Block 945, nine miles south of Mississippi state waters) (Petty, 1993). A second field which has not yet been developed (Mobile Area Block 906, five miles south of Mississippi state waters) (Mink et al., 1988) (Fig. 14) is located in the Mobile Area of the Federal OCS waters. Several additional shallow Miocene gas fields are located farther east in the Mobile Area, south of Alabama state waters.

Deep Jurassic Norphlet gas sands of the Alabama and Federal offshore waters have been the primary targets for the deep wells drilled to date. Three deep Norphlet gas discoveries south of Mississippi state waters (Mobile Area Block 861, Block 862 and Block 904) have resulted and will help to keep operators interested in the area.

SUMMARY AND CONCLUSIONS

After evaluation of the available geological and paleontological information in the coastal and offshore areas of Mississippi, and review of data and work previously done covering the gas productive Miocene sediments of states adjacent to the study area, the following conclusions can be made concerning the Miocene of coastal and offshore Mississippi:

1. The Miocene sediments in the Mississippi coastal and offshore study area form a southwestward thickening clastic wedge of primarily middle and upper Miocene-age sediments, deposited unconformably on a stable

and gently dipping Miocene/Oligocene carbonate shelf. Lower Miocene-aged sediments appear to be present in the extreme southern offshore portion of the study area.

2. Thinning in the extreme western onshore portion of the study area (southern Hancock County) indicates the Hancock Ridge was a positive feature affecting deposition prior to and during the Miocene.

3. The shallow gas producing sediments of the middle and early upper Miocene Pensacola Clay in southwestern onshore and the offshore waters of Alabama extend into and across the Mississippi coastal and offshore area as the upper member of the Catahoula Formation, referred to informally here as the Catahoula clay. Equivalent sands to the Amos and Escambia Sand members of the Pensacola Clay in southwestern Alabama are traceable over a large portion of the Mississippi study area.

4. Normal marine conditions persisted longer in the Mississippi offshore than in the onshore areas. By middle Miocene time marginal marine conditions were present over most of the study area and persisted through the rest of the Miocene.

5. Mississippi has no verified Miocene oil or gas production and certainly none in the Mississippi coastal or offshore area. However, because of the common Miocene stratigraphy and depositional environments in the eastern portion of the study area adjacent to the gas producing Miocene of southwestern Alabama (onshore and offshore), the stratigraphic trapping of gas in sand reservoirs and the same basic reservoir characteristics should be present, particularly in southeastern Harrison County, southern Jackson County, and the eastern half of the offshore Mississippi state waters.

6. Much stratigraphic and paleontological work still needs to be done and certainly more wells need to be drilled in the study area, but with the close proximity of shallow Miocene gas production in southwestern onshore Alabama, offshore state waters of Alabama and the Federal OCS Mobile Area, and the successful use of seismic amplitude anomalies to locate and delineate shallow gas accumulations, the authors believe that it will not be long before Mississippi has Miocene gas production in its onshore coastal counties and offshore waters.

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Appendix A

Well sample descriptions and paleontological record prepared for this report by Dr. Mark Puckett of the Geological Survey of Alabama, Tuscaloosa, Alabama, 1990.

Sample Descriptions

Chesley Pruet - #1 William C. Quinn, Jackson County, Mississippi

470-920	Sand, glauconite, few accessary minerals; afossiliferous.
920-950	Same, but with lignite.
950-1760	Same, but without lignite.
1790-1880	Same, but with bivalve fragments [*Rangia* (*Miorangia*) *microjohnsoni* ?].
1880-1970	Same, but with other bivalve and gastropod fragments.
1970-2060	Same, but with feldspar fragments.
2060-2210	Same, but with good *R.* (*M.*) *microjohnsoni*.
2210-2630	Same, but with clay and rock fragments.
2630-2660	Same lithology. ?*Globigerina* *praebulloides* (rare)
2660-2690	Same. *Lenticulina* sp. (rare)
2690-2720	Same. *Globigerina* sp. ostracode (rare)
2720-2750	Same. *Lenticulina* sp. (1)
2750-2780	Same lithology; no foraminifera.
2780-2810	Same. *Lenticulina* sp. ostracode (rare)
2810-2870	Same lithology; no foraminifera.
2870-2930	Same. *Lenticulina* sp. (rare)
2930-2960	Same lithology.

	No foraminifera.
2960-2990	Same lithology. ? _Nodosaria affinis_ ostracode (rare)
2990-3050	Same. _Lenticulina_ sp. ostracode (rare)
3050-3070	Same. _Lenticulina_ sp. (rare)
3070-3130	Same. _Amphistegina_ "B" _Nummulites_ sp.
3130-3160	Same. _Amphistegina_ "B" _Nummulites_ sp. ostracode
3160-3330	Same. _Amphistegina_ "B" _Nummulites_ sp.
3330-3390	Same. _Amphistegina_ "B" _Cibicides_ sp. _Globigerina_ cf. _praebulloides_ _Globorotalia_ sp. _Nummulites_ sp.
3390-3420	Same. _Amphistegina_ "B" _Cibicides_ sp. _Globigerina_ cf. _praebulloides_ _Globorotalia_ sp. _Nummulites_ sp. _Quinqueloculina_ sp.
3420-3450	Recrystallized, sucrosic limestone _Amphistegina_ "B" _Globigerina_ cf. _praebulloides_ _Heterostegina_ sp. _Nummulites_ sp. _Lenticulina_ spp. ostracode

C. A. Floto, #1 State of Mississippi-Mississippi Sound, Jackson, Mississippi

2025-2065	Quartz sand, well rounded, subspherical; few rock fragments, some lignite; abundantly megafossiliferous, mostly bivalves [Rangia (Miorangia) microjohnsoni ?].
2065-2095	Quartz sand and clay, in approximately equal proportions; quartz sand well rounded, subspherical; some sulfurous material (sulfur salts ?); afossiliferous.
2095-2155	Same, but with common megafossil fragments, including R. (M.) microjohnsoni.
2155-2185	Same, but with one worn Cristellaria.
2185-2215	Same, but with no microfossils.
2215-3320	Gap.
3320-3350	Quartz sand, well sorted, well rounded, spherical; few rock fragments; rare oyster shells.
3350-3410	Same, but afossiliferous.
3410-3440	Clay and quartz sand; rare mollusc fragments; Lenticulina sp. (1)
3440-3560	Same, but amicrofossiliferous.
3560-3650	Same, but with rare Amphistegina sp.
3650-3680	Mostly quartz sand, little clay; sand moderately sorted, well rounded, subspherical; common mollusc fragments; amicrofossiliferous.
3680-3710	Quartz sand and shell debris, mostly bivalves. ?Cibicides carstensi (1) Amphistegina sp. (1 worn specimen)
3710-3740	Gap.
3740-3800	Quartz sand and shell debris, mostly bivalves. Amphistegina sp. (1 worn specimen in each)
3800-3860	Same lithology; microfossils rare. Amphistegina sp. Lenticulina sp. Broken chambers of planktonic foraminifera

3860-3880	Same lithology; microfossils rare. _Discorbis_ cf. "12" _Lenticulina_ sp.
3880-3890	Same lithology; microfossils rare, _Amphistegina_ sp. _Lenticulina_ sp.
3890-3920	Less shale debris, more rock fragments; very rare microfossils. _Amphistegina_ sp. _Lenticulina_ sp.
3920-3950	Same lithology; microfossils rare. _Amphistegina_ sp. _Cibicides_ sp. _Lenticulina_ sp. Broken chambers of planktonic foraminifera
3950-3980	Same lithology; microfossils very rare. _Globigerinoides_ sp. _Lenticulina_ sp.
3980-4010	Same lithology; microfossils more common. _Amphistegina_ "B" _Cibicides_ cf. _carstensi_ _Cristellaria_ "I" _Globigerina_ sp. _Globigerinoides_ sp. _Hanzawaia_ sp. _Lenticulina_ spp. _Liebusella_ sp.
4010-4020	Same. _Amphistegina_ "B" _Cristellaria_ sp. (broken) _Globigerina_ sp. _Globigerinoides_ sp. _Lenticulina_ spp. _Liebusella_ sp.
4020-4035	Same. _Amphistegina_ "B" _Cristellaria_ "I" _Eponides_ sp. _Globigerina_ sp. _Globigerinoides_ sp. _Globoquadrina_ cf. _baroemoenensis_ _Lenticulina_ spp. _Liebusella_
4035-4050	Same.

	Amphistegina "B" Cibicides cf. carstensi Discorbis sp. Globigerina spp. Globigerinoides cf. sicanus Globigerinoides cf. conglobatus Globoquadrina cf. baroemoenensis Lenticulina spp. Liebusella sp. Uvigerina sp.
4050-4080	More calcium carbonate; microfossils much less common. Amphistegina "B" Cibicides sp. Cristellaria "I" Globigerina spp. Globigerinoides spp. Lenticulina spp.
4080-4110	Same lithology. Amphistegina sp. Cibicides sp. Cristellaria "I" Discorbis sp. Epistomina sp. Globigerina spp. Globigerinoides spp. Lenticulina sp. Nummulites sp.
4110-4140	Same. Amphistegina cf. "B" Cristellaria "I" Globigerina sp. Globigerinoides sp. Lenticulina spp. Nummulites sp. ?Praeorbulina transitoria ?Praeorbulina glomerosa
4140-4170	Same. Amphistegina "B" Cristellaria "I" Discorbis cf. "12" Globigerina sp. Globigerinoides spp. Lenticulina spp. Nummulites sp. ?Praeorbulina transitoria
4170-4200	Same.

	Amphistegina sp. Buliminella sp. Cristellaria "I" Epistomina sp. Globigerina sp. Globigerinoides sp. Lenticulina sp. Nummulites sp. Bairdia sp. (ostracode)
4200-4230	Same. Amphistegina "B" Amphistegina sp. Cristellaria "I" Globigerinoides spp. Lenticulina sp. Liebusella sp. Nummulites sp.
4230-4260	Same. Amphistegina "B": Cristellaria "I" Globigerinoides spp. Lenticulina sp. Liebusella sp. Nummulites sp. Bairdia sp. (ostracode)
4260-4290	Very little sample. Amphistegina "B" Amphistegina sp. Globigerinoides sp. Lenticulina sp. Lenticulina sp. (beaded) Liebusella sp.
4290-4320	Limestone. Amphistegina "B" Amphistegina sp. Globigerinoides sp. Heterostegina sp.

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1090-1540	Quartz sand, well rounded, few rock fragments; afossiliferous.
1540-1630	Same lithology, but with bivalve fragments. [Rangia (Miorangia) microjohnsoni ?].
1630-1720	Gap.
1720-1750	Same as 1540'-1630' interval.
1750-1780	Same, but with 1 fish vertebra.
1780-1870	Same, but no fish vertebrae.
1870-1900	Same, but more abundant shell debris.
1900-1930	Same, but with less shell debris.
1930-2080	Same, but with more shell debris.
2080-2110	Same, but with rare chambers of planktonic foraminifera.
2110-2140	Same, but with one foraminiferan (?) and one ostracode.
2140-2170	Same lithology, amicrofossiliferous.
2170-2200	Same lithology, rare Ammonia sp.
2200-2320	Same lithology. Ammonia beccarii Elphidium chipolensis
2320-2410	Mostly shell debris and sand. Ammonia beccarii
2410-2440	Same, but with Elphidium chipolensis.
2440-2470	Quartz sand, coarse-grained, less shell debris. Ammonia beccarii (1)
2470-2500	Slightly finer-grained. Ammonia beccarii (common) ostracode
2500-2530	Same, but slightly coarser-grained; same fauna.

2530-2590	Same, but with rare Ammonia beccarii.
2590-2620	Same lithology, but amicrofossiliferous.
2620-2680	Same lithology, but rare Ammonia beccarii.
2680-2710	Same lithology, but amicrofossiliferous.
2710-2800	Same lithology, rare Ammonia beccarii.
2800-2830	Same lithology, but amicrofossiliferous.
2830-2860	Slightly finer-grained quartz sand, no fossils.
2860-2950	Quartz sand, fine-grained; few rock fragments; common shell fragments; no microfossils.
2950-2980	Same lithology, found one Ammonia beccarii.
2980-3010	Same lithology, but amicrofossiliferous.
3040-3100	Same lithology, rare Ammonia beccarii.
3100-3130	Same lithology, but afossiliferous.
3130-3400	Slightly coarser grained; afossiliferous.
3400-3700	Gap.
3700-3970	Quartz sand, glauconitic, slightly pyritic, with rock fragments and shell debris; R. (M.) microjohnsoni; no foraminifera.
3970-4000	Same lithology, with rare Ammonia beccarii.
4000-4030	Same lithology, microfossils very rare. Cibicides sp. Globigerina sp.
4030-4060	Same lithology; microfossils very rare. Bigenerina cf. humbeli ?Cibicides sp.
4060-4090	Same lithology; microfossils still rare. Ammonia beccarii Cibicides sp. Globigerina sp.
4090-4120	Same. Ammonia beccarii

4120-4150	Same, but finer-grained; amicrofossiliferous.
4150-4180	Same lithology; microfossils rare Globorotalia fohsi barisanensis
4180-4210	Same lithology; microfossils more common. ?Cristellaria "I" (broken) Nonion sp. Uvigerina cf. altacostata ("3")
4210-4230	Same lithology. Cibicides sp. Globigerina sp. Lenticulina sp. Uvigerina altacostata ("3")
4240-4270	Same lithology. Ammonia beccarii Globigerina sp. Lenticulina sp. Uvigerina altacostata ("3")
4270-4300	Same lithology. Globigerina sp. Lenticulina sp. Spiroloculina sp. Textularia sp.
4300-4330	Same lithology. Cibicides sp. Globigerina sp. Textularia sp. Uvigerina sp.
4330-4360	Same lithology. Bolivina sp. Globigerina sp. (crushed) Uvigerina sp.
4360-4390	Same lithology; fewer microfossils. Ammonia beccarii Bolivina sp. Bulimina sp. Cibicides sp. Eponides sp. Textularia sp.
4390-4420	Gap.
4420-4480	Same as 4360-4390 Ammonia beccarii Bulimina sp.

	Cibicides sp. Eponides sp. Textularia sp.
4480-4510	Gap
4510-4540	Same as 4360-4390 Ammonia beccarii Bolivina cf. subaeriensis Cibicides sp.
4540-4570	Same. Ammonia beccarii Cibicides sp.
4570-4600	Same. Ammonia beccarii
4600-4630	Same. Ammonia beccarii Bolivina sp. Buliminella sp.
4630-4660	Same. Ammonia beccarii
4660-4690	Same. Ammonia beccarii Bolivina floridana Lenticulina sp. Nonionella sp.
4690-4720	Same. Ammonia beccarii Lenticulina sp. Textularia sp.
4720-4750	Same, but microfossils more diverse. Amphistegina sp. Bolivina floridana Buliminella sp. Cibicides sp. Globigerina sp. Globigerinoides sp. Uvigerina altacostata ("3")
4750-4780	Same lithology. Bolivina floridana Bulimina sp. Buliminella sp. Globigerina sp. Globigerinoides sp.

	Lenticulina spp. Nonionella sp. Uvigerina altacostata ("3")
4780-4810	Same lithology; microfossils rare. Ammonia beccarii Bolivina sp. ?Cibicides sp. ?Cyclogyra sp. Globigerina sp. ?Nonionella sp.
4840-4870	Very rich in microfossils. Amphistegina sp. Bolivina floridana Cibicides carstensi Cristellaria "I" Eponides sp. Globigerina sp. Globigerinoides sp. Lenticulina spp. Nummulites sp. Praeorbulina sp. Siphonina sp. Uvigerina altacostata ("3") Uvigerina lirettensis
4870-4900	Limestone. Bolivina floridana Buliminella sp. Cibicides sp. Cristellaria "I" Elphidium chipolensis Globorotalia fohsi barisanensis Glomospira sp. Lenticulina spp. Robulus "54B" Uvigerina altacostata ("3")
4900-4930	Limestone. Amphistegina "B" Bolivina floridana Buliminella sp. Cibicides carstensi Cristellaria "I" Elphidium chipolensis Eponides sp. Globigerina sp. Globigerinoides sp. Globoquadrina sp. Glomospira sp. Guttulina, other polymorphinids

	Nonionoides sp. Siphonina sp. Uvigerina altacostata ("3")
4930-4960	Foraminifera not quite as abundant. Amphistegina "B" Bolivina floridana Cibicides cf. carstensi Cristellaria "I" Elphidium chipolensis Eponides sp. Globigerina cf. sellii Globigerinoides sp. Lenticulina spp. Siphonina sp. Uvigerina altacostata ("3")
4960-4990	Same lithology. Amphistegina "B" Bolivina floridana Bulimina sp. Buliminella sp. Cibicides carstensi Cibicides sp. Cristellaria "I" Elphidium chipolensis Globigerina cf. praebulloides Globigerinoides sp. Lenticulina spp. Nonion sp. polymorphinids ?Praeorbulina sp. Uvigerina altacostata ("3") Uvigerina sp.
4990-5020	Same lithology. Amphistegina "B" Cibicides carstensi Cristellaria "I" Eponides sp. Globigerina cf. praebulloides Globigerinoides sp. Lenticulina spp. Quinqueloculina sp. Siphonina sp. Uvigerina alatacostata ("3")
5020-5050	Same lithology. Amphistegina sp. Cibicides carstensi ?Cristellaria "I" Eponides sp.

	Globigerina cf. *praebulloides* *Globigerinoides* cf. *sicanus* *Globoquadrina venezuelana* *Lenticulina* spp. polymorphinids. *Quinqueloculina* sp. *Uvigerina altacostata* ("3")
5050-5080	Same lithology. *Amphistegina* sp. *Cibicides* sp. *Cristellaria* "I" *Globigerina* cf. *praebulloides* *Globigerinoides* cf. *primordius* *Globigerinoides* cf. *bulloides* *Globoquadrina venezuelana* *Globoquadrina* sp. *Globorotalia fohsi barisanensis* *Globorotalia* cf. *siakensis* *Lenticulina* spp. *Nummulites* sp. ?*Textularia* sp. *Uvigerina altacostata* ("3") *Uvigerina* sp.
5080-5140	Same lithology. *Amphistegina* "B" *Cibicides carstensi* *Cibicides* sp. *Cristellaria* "I" *Dentalina* sp. *Discorbis* "12" *Elphidium* sp. *Epistomina* sp. *Globoquadrina venezuelana* *Globoquadrina baroemoenensis* *Globorotalia fohsi barisanensis* *Guttulina* sp. *Lenticulina* sp. (beaded) *Lenticulina* spp. *Nonionella* sp. *Nummulites* sp. (rare) *Quinqueloculina* sp. *Siphonina* sp. *Uvigerina* spp. *Valvulinaria* sp.
5140-5170	Same microfauna, except no *Dentalina* sp., *Siphonina* sp., and *Valvulinaria* sp.; with *Nonion* "21" and *Lepidocyclina* sp.
5170-5380	Mostly shale; microfossils relatively rare.

Amphistegina "B"
Eponides sp.
Globigerina cf. praebulloides
Globorotalia fohsi barisanensis
Lenticulina sp. (beaded)
Lenticulina spp.
Nonion "21"
Uvigerina sp.

5380 Limestone.
Amphistegina sp.
Heterostegina sp.
Nummulites sp.

DuPont, Lester Earnest #1, Harrison County, Mississippi

70-250	Clay, light to medium brown and gray; little quartz sand; no fossils.
250-280	Same, but clay is about 50% gray and about 50% light brown.
280-310	Same, but mostly gray.
310-340	Same, but mostly buff.
340-430	Same, but little more sandy.
430-460	Same, but with a little pyrite.
460-490	Same, but little less sandy.
490-550	Same, but more sand and rock fragments.
550-580	Same lithology, but with one tooth.
580-640	Same, but without tooth.
640-670	Quartz sand, medium- to coarse-grained, well rounded, subspherical, moderately well sorted; with sand-sized rock fragments, some clay and lignite; no fossils.
700-790	Quartz sand, well rounded, subspherical, well sorted; rock fragments angular, poorly sorted; no fossils.
790-910	Gravel, same mineralogy; no fossils.
910-940	Gravel and sand.
940-1000	Mostly gravel.
1000-1060	Same, but more sand.
1060-1210	Mostly coarse sand, with a little clay.
1210-1300	Same lithology, with mollusc fragments.
1300-1330	Almost entirely lignite, with few mollusc fragments.
1330-1360	Mostly fine gravel, with some clay, lignite; rarer mollusc fragments.
1360-1420	Coarse gravel, less clay, lignite; very rare

	fossil fragments.
1450-1480	Same, but with more clay.
1480-1570	Mostly clay, with pebbles, fossil fragments still rare.
1570-1600	Quartz sand, well rounded, subspherical, well sorted; few rock fragments; no fossils.
1600-1630	Clay, medium gray; few fossil fragments.
1630-1660	Quartz sand, well rounded, subspherical, well sorted; few rock fragments; no fossils.
1660-1690	Coarse quartz sand/fine gravel, with abundnat lignite; quartz sand mostly well rounded, subspherical to oblong; rarer rock fragments, mostly angular; no fossil fragments.
1690-1720	Same lithology, but with rare fossil fragments.
1720-1750	Same, but with one good Rangia (Miorangia) microjohnsoni.
1750-1780	Quartz sand, fine-grained, moderately rounded, subspherical, moderately sorted; few rock fragments; no fossils.
1780-1810	Clay/fine gravel, approximately equal proportions; no fossils.
1810-1840	Mostly gravel, very poorly sorted; no fossils.
1840-1900	Quartz sand, medium-grained, with some pebbles, muscovite; no fossils.
1900-1930	Quartz sand, subrounded, subspherical, well sorted, some muscovite and rock fragments; no fossils.
1930-1990	Same, but with biotite.
1990-2020	Quartz sand, fine-grained, well sorted; no fossils.
2020-2110	Quartz sand/gravel, muscovitic; no fossils.
2110-2140	Fine gravel/clay, with lignite, mica; no fossils.

2140-2170	Mostly gray clay, with some sand and gravel, few bivalve fragments.
2170-2200	Gray clay/gravel; muscovitic, lignitic; no fossils.
2200-2230	Same, but with few _R_. (_M_.) _microjohnsoni_.
2230-2320	Gray clay, with sand and gravel, abundant muscovite; little plant debris; very rare fossil fragments.
2320-2380	Same lithology, but with _R_. (_M_.) _microjohnsoni_.
2380-2410	Quartz sand, medium- to coarse-grained, some gray clay, plant debris, mica; no fossils.
2410-2440	Same, but with little gravel.
2440-2500	Same, but with _R_. (_M_.) _microjohnsoni_.
2500-2560	Quartz sand/gravel, some plant debris; rare _R_. (_M_.) _microjohnsoni_.
2560-2590	Same lithology, but no fossils.
2590-2620	Same lithology, with lignite.
2620-2650	Same, but with rare _R_. (_M_.) _microjohnsoni_ fragments.
2650-2680	Same, but with one fish vertebra, one gastropod fragment.
2680-2710	Same lithology; no fossils.
2710-2740	Same, but slightly less gravel.
2740-2770	Same, but slightly more gravel.
2770-2800	Same, but more muscovite.
2800-2830	Mostly coarse quartz sand, less gravel.
2830-2920	Quartz sand, muscovitic, some gravel.
2920-2950	Same, but slightly less muscovite; few mollusc fragments.
2950-2980	Same, but with more fossil debris, including _R_. (_M_.) _microjohnsoni_.

2980-3040	Same, but fewer fossil fragments, less mica.
3040-3190	Same, but with _R_. (_M_.) _microjohnsoni_.
3190-3340	Quartz sand, highly muscovitic, with very little gravel, lignite and shell debris.
3340-3370	Gap.
3370-3550	Same as 3190'-3340'.
3550-3610	Quartz sand, fine-grained, few rock fragments; no fossils.
3610-3640	Same, but with little pyrite.
3640-3700	Coarse sand, composed mostly of rock fragments; very angular; _R_. (_M_.) _microjohnsoni_ fragments.
3700-3730	Lost circulation material.
3730-3760	Gap
3760-3790	Lost circulation material.
3790-3990	Gap
3990-4020	Quartz sand and limestone, some straw, pyrite; few mollusc fragments; foraminifera relatively rare. _Amphistegina_ cf. "B" _Eponides_ sp. _Globigerina_ sp. _Globigerinoides_ spp. _Lenticulina_ spp. _Nummulites_ sp. _Spiroloculina_ sp. _Uvigerina_ spp.
4020-4050	Same lithology. _Amphistegina_ sp. _Cibicides_ sp. _Discorbis_ cf. "12" _Discorbis_ sp. _Elphidium_ _chipolensis_ _Globigerina_ spp. _Lenticulina_ sp. _Nummulites_ sp. _Spiroloculina_ sp.
4050-4080	Same lithology; one pulmonate gastropod.

	Amphistegina sp. Elphidium chipolensis Eponides sp. Globigerina sp. Globigerinoides sp. Lenticulina spp. Nummulites sp. Spiroloculina sp.
4080-4110	Much more calcium carbonate. Amphistegina sp. Discorbis sp. Globigerina cf. bulloides Globigerinoides sp. Nummulites sp. Robulus cf. "3" Pontocypris sp. (ostracode) Cytherella sp. (ostracode)
4110-4140	Straw and mud (lost circulation material ?), some quartz sand, rock fragments, rare mollusc fragments; high percent planktonic foraminifera. Amphistegina cf. "B" Cibicides carstensi Eponides sp. Globigerina cf. praebulloides Globigerinoides sp. Globoquadrina cf. baroemoenensis Globorotalia cf. barisanensis Lenticulina spp. Nonionella sp. Nummulites sp. Quinqueloculina sp. Siphonina sp.
4140-4170	Still some straw, but mostly limestone. Amphistegina "B" Amphistegina sp. Cibicides sp. Cristellaria sp. Eponides sp. Globigerina sp. Globigerinoides sp. Lenticulina spp. Liebusella sp. Nonionella sp. Planulina sp. Robulus sp. (beaded) Brachycythere sp. (ostracode)
4170-4200	Limestone.

Amphistegina "B"
Amphistegina sp.
Cibicides sp.
Globigerina cf. _praebulloides_
Globigerina spp.
Globigerinoides sp.
Globoquadrina cf. _venezuelana_
Heterostegina sp.
Lenticulina spp.
Nonionella sp.
Nummulites sp.

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2200-2237	Quartz sand and gravel; sand coarse-grained, rounded, well sorted; pebbles composed mostly of rock fragments, very angular; very rare fossil fragments.
2237-2267	Same, but with lignite.
2267-2298	Same, but less lignite and more clay and shell debris.
2298-2331	Same, but with less clay, lignite and shell debris.
2331-2391	Clay and sand; clay light brown; sand subspherical, subrounded; some shell debris.
2391-2422	Same, but more clay.
2422-2451	Same, but with _Rangia_ (_Miorangia_) _microjohnsoni_ (?).
2451-2480	Same, but without _R_. (_M_.) _microjohnsoni_.
2480-2850	Same, but with _R_. (_M_.) _microjohnsoni_.
2850-2968	Much more sandy; quartz sand, medium- to coarse-grained, subrounded to subangular, moderately sorted; very little clay; few rock fragments; _R_. (_M_.) _microjohnsoni_, other bivalves and gastropods.
2968-3030	Same, but slightly finer grained.
3030-3094	Quartz sand, coarse-grained, subrounded to rounded, well sorted; some rock fragments; very little shell debris.
3094-3125	Less sand, more fine gravel, very angular; fossil debris rare.
3125-3157	Same, but with more shell debris.
3157-3190	Gap
3190-3221	Quartz sand, fine- to medium-grained, subangular to well rounded; some clay; abundant shell debris and rock fragments; _R_. (_M_.) _microjohsoni_.
3221-3252	Much more sandy, fewer rock fragments.

3252-3340	Quartz sand, coarse- to fine-grained, mostly subangular; some rock fragment; little pyrite and clay; few bivalve fragments.
3340-3368	Approximately 50%-50% quartz sand and clay, same megafossils; very rare *Ammonia beccarii*.
3368-3458	Quartz sand and clay; megafossil debris common; no microfossils.
3458-3487	Mostly quartz sand, some clay; quartz sand medium- to coarse-grained, mostly well rounded, subspherical; some megafossil fragments, including *R.* (*M.*) *microjohnsoni*.
3487-3518	Mostly coarse quartz sand, well rounded, subspherical; little pyrite; few mollusc fragments.
3518-3549	Gap.
3549-3702	Same as 3487'-3518'.
3702-3733	Same, but poorly sorted.
3733-3764	Mostly quartz sand; few fossil fragments.
3764-3858	Same, but with little more clay and rock fragments.
3858-3880	Gap.
3880-3951	Same as 3764'-3858'.
3951-3982	Mostly medium gray clay, little sand; few microfossils. *Buliminella* sp. *Cibicides* sp. *Globigerina* cf. *bulloides* *Globigerinoides* cf. *quadrilabatus* *Lenticulina* sp. *Nonionella* sp.
3982-4012	Same lithology *Amphistegina* sp. *Bulimina floridana* *Bulimina* sp. *Buliminella* sp. *Cibicides carstensi* *Cibicides* sp. *Globigerina* cf. *praebulloides* *Globigerinoides* sp.

	Lenticulina spp. *Nonion* cf. "21" *Planulina* sp. *Uvigerina* spp.
4012-4042	More calcium carbonate. *Amphistegina* "B" *Amphistegina* sp. *Bulimina* sp. *Cibicides carstensi* *Glogiberina* cf. *praebulloides* *Lenticulina* sp. *Nummulites* sp. soritid *Uvigerina* spp.
4042-4072	Same lithology; fewer foraminifera. *Amphistegina* "B" *Amphistegina* sp. *Eponides* sp. *Globigerinoides* sp. ?*Liebusella* sp. *Nummulites* sp. ?soritid
4072-4102	Mostly sand and clay, less $CaCO_3$; fewer foraminifera. *Amphistegina* spp. *Bolivina floridana* *Bulimina* sp. *Globigerina* cf. *praebulloides* *Globoquadrina* cf. *venezuelana* *Globorotalia* cf. *barisanensis* *Lenticulina* spp.
4102-4135	Same lithology. *Amphistegina* "B" *Amphistegina* sp. *Bulimina* sp. *Eponides* sp. *Globigerina* cf. *praebulloides* *Globoquadrina* cf. *dehiscens* *Lenticulina* spp. *Nodosaria* cf. *affinis* *Nonion* sp. *Nummulities* sp. ?*Siphonina* sp.
4135-4167	Same lithology. *Amphistegina* "B" *Amphistegina* sp. *Cristellaria* "I"

	Eponides sp.
	Globigerina spp.
	Globigerinoides spp.
	Lenticulina spp.
	Nummulites sp.
4167-4195	Same lithology.
	Amphistegina "B"
	Amphistegina sp.
	?_Cristellaria_ sp. (broken)
	Eponides sp.
	Globigerina bulloides
	Globigerina praebulloides
	Guttulina sp.
	Lenticulina spp.
	?_Nonion_ sp.
	Nummulites sp.
	Uvigerina sp.
4195-4226	Shale, medium grayish brown; foraminifera relatively rare.
	Amphistegina cf. "B"
	Amphistegina sp.
	Eponides sp.
	Globigerina cf. _praebulloides_
	Globoquadrina cf. _venezuelana_
	Lenticulina spp.
	Uvigerina spp.
4226-4253	Same lithology and foraminiferal abundance.
	Amphistegina cf. "B"
	?_Cristellaria_ sp. (broken)
	Globigerina cf. _praebulloides_
	?_Globigerinella_ cf. _obesa_
	Globoquadrina cf. _venezuelana_
	Lenticulina spp.
	Nonion sp.
4253-4284	Little more $CaCO_3$.
	Amphistegina "B"
	Cibicides cf. _opima_
	Cristellaria cf. "I"
	Discorbis cf. "12"
	Eponides sp.
	Globigerina cf. _praebulloides_
	Globigerinoides cf. _obliquus_
	Lenticulina spp.
	Nonion sp.
	Nummulites sp.
	Quinqueloculina sp.
4284-4315	Same lithology.
	Amphistegina "B"

	?_Cristellaria_ sp. (broken) _Discorbis_ sp. _Eponides_ sp. _Globigerina_ cf. _praebulloides_ _Globoquadrina_ cf. _baroemoenensis_ _Globoquadrina_ cf. _venezuelana_ _Guttulina_ sp. _Lenticulina_ spp. _Nummulites_ sp. _Quinqueloculina_ sp.
4315-4345	Little more $CaCO_3$. _Amphistegina_ "B" _Cibicides_ cf. _opima_ _Eponides_ sp. _Globigerina_ cf. _obliquus_ _Globigerina_ cf. _praebulloides_ _Globigerinoides_ cf. _sicanus_ _Guttulina_ sp. _Lenticulina_ spp. _Nummulites_ sp. _Quinqueloculina_ sp.
4345-4376	More $CaCO_3$. _Amphistegina_ "B" _Amphistegina_ sp. _Cibicides_ cf. _opima_ _Discorbis_ sp. _Globigerina_ cf. _praebulloides_ _Globigerinoides_ cf. _primordius_ _Guttulina_ sp. _Lenticulina_ spp. ?_Lepidocyclina_ sp. _Nummulites_ sp.
4376-4407	Limestone/shale. _Amphistegina_ "B" _Amphistegina_ sp. _Globigerina_ cf. _praebulloides_ _Globigerinella_ cf. _praesiphonifera_ _Globigerinoides_ cf. _sicanus_ _Guttulina_ sp. _Lenticulina_ spp. (including beaded form) _Nummulites_ sp.
4407-4440	Same lithology. _Amphistegina_ "B" _Amphistegina_ sp. _Cibicides_ sp. _Discorbis_ sp. _Globigerina_ cf. _praebulloides_ _Globigerinoides_ spp.

	<u>Lenticulina</u> sp. <u>Nummulites</u> sp. <u>Quinqueloculina</u> sp. polymorphinid
4440-4501	Same lithology. <u>Amphistegina</u> "B" <u>Amphistegina</u> sp. <u>Cibicides</u> sp. <u>Discorbis</u> sp. <u>Globigerina</u> cf. <u>praebulloides</u> <u>Globigerinoides</u> spp. <u>Lenticulina</u> sp. <u>Nonionella</u> sp. <u>Nummulites</u> sp. <u>Quinqueloculina</u> sp. polymorphinid
4501-4532	Limestone. <u>Amphistegina</u> "B" <u>Archaias</u> sp. <u>Heterostegina</u> sp. <u>Lenticulina</u> <u>Nummulites</u> sp.

Appendix B

Well Samples Description And Paleontological Record

Sun Oil Company, #2 Weston Lumber Company, Hancock County, Mississippi

by Deborah Ann Havard

1978, University of Southern Mississippi

PALEONTOLOGICAL RECORD

Sun Oil Company, #2 Weston Lumber Company
Hancock County, Mississippi

2180-2210 feet.

Gastropoda
Littoridina (*Texadina*) *sphinctostoma* ? Abbott and Ladd

Pelecypoda
Rangia sp.

2210-2240 feet.

Gastropoda
Littoridina (*Texadina*) *sphinctostoma* ? Abbott and Ladd

Pelecypoda
Rangia sp.

2240-2270 feet.

Gastropoda
Littoridina (*Texadina*) *sphinctostoma* ? Abbott and Ladd

Pelecypoda
Rangia sp.

2270-2300 feet.

Foraminifera
Cibicides floridanus (Cushman)
Rotalia beccarii (Linné)

Pelecypoda
Rangia sp.

2300-2330 feet.

Gastropoda
Littoridina (*Texadina*) *sphinctostoma* ? Abbott and Ladd

2330-2360 feet.

Foraminifera
Rotalia beccarii (Linné)

Gastropoda
Littoridina (Texadina) sphinctostoma ? Abbott and Ladd

Pelecypoda
Rangia sp.

2360-2390 feet.

Gastropoda
Littoridina (Texadina) sphinctostoma ? Abbott and Ladd

Pelecypoda
Rangia sp.

2390-2420 feet.

Foraminifera
Rotalia beccarii (Linné)

Gastropoda
Littoridina (Texadina) sphinctostoma ? Abbott and Ladd

Pelecypoda
Rangia sp.

2420-2450 feet.

Foraminifera
Rotalia beccarii (Linné)

Gastropoda
Littoridina (Texadina) sphinctostoma ? Abbott and Ladd

Pelecypoda
Rangia sp.

2450-2480 feet.

Gastropoda
Littoridina (Texadina) sphinctostoma ? Abbott and Ladd

2480-2510 feet.

Gastropoda
Littoridina (Texadina) sphinctostoma ? Abbott and Ladd

2510-2540 feet.

Foraminifera
Rotalia beccarii (Linné)

Gastropoda
Littoridina (*Texadina*) *sphinctostoma* ? Abbott and Ladd

Pelecypoda
Rangia sp.

2540-2570 feet.

Foraminifera
Rotalia beccarii (Linné)

Pelecypoda
Rangia sp.

2570-2600 feet.

Gastropoda
Littoridina (*Texadina*) *sphinctostoma* ? Abbott and Ladd

Pelecypoda
Rangia sp.

2600-2630 feet.

Foraminifera
Rotalia beccarii (Linné)

Pelecypoda
Rangia sp.

2630-2660 feet.

Foraminifera
Cibicides cf. *floridanus* (Cushman)
Elphidium sagrum (d'Orbigny)
Globigerina sp.
Nonion sp.
Rotalia beccarii (Linné)

Gastropoda
Littoridina (*Texadina*) *sphinctostoma* ? Abbott and Ladd

Pelecypoda
Rangia sp.

Scaphopoda
Dentalium sp.

2660-2690 feet.

Pelecypoda
Rangia sp.

2690-2720 feet.

Pelecypoda
Rangia sp. ?

2720-2750 feet.

Pelecypoda
Rangia sp. ?

2750-2780 feet.

Gastropoda

Pelecypoda
Rangia sp. ?

2780-2810 feet.

Gastropoda

Pelecypoda
Rangia sp.

2810-2840 feet.

Pelecypoda

2840-2870 feet.

Pelecypoda

2870-2900 feet.

Gastropoda

Pelecypoda

2900-2930 feet.

Pelecypoda

2930-2960 feet.

Pelecypoda

2960-2990 feet.

<u>Pelecypoda</u>

2990-3020 feet.

<u>Pelecypoda</u>

3020-3050 feet.

<u>Pelecypoda</u>

3050-3080 feet.

<u>Pelecypoda</u>

3080-3110 feet.

<u>Pelecypoda</u>

3110-3140 feet.

<u>Pelecypoda</u>

3140-3250 feet.

Unidentifiable shell fragments

3250-3280 feet.

<u>Pelecypoda</u>

3280-3310 feet.

<u>Pelecypoda</u>

3310-3340 feet.

<u>Pelecypoda</u>

3340-3370 feet.

<u>Pelecypoda</u>

3370-3400 feet.

<u>Pelecypoda</u>

3400-3430 feet.

<u>Pelecypoda</u>

3430-3460 feet.

Pelecypoda

3460-3490 feet.

Pelecypoda

3490-3520 feet.

Pelecypoda

3520-3550 feet.

Pelecypoda

3550-3580 feet.

Pelecypoda

3580-3610 feet.

Gastropoda

Pelecypoda

Scaphopoda
Dentalium sp.

3610-3640 feet.

Pelecypoda

Scaphopoda
Dentalium sp.

3640-3670 feet.

Pelecypoda

Scaphopoda
Dentalium sp.

3670-3700 feet.

Foraminifera
Rotalia beccarii (Linné)

Pelecypoda

3700-3730 feet.

Foraminifera
Robulus americanus (Cushman)

Pelecypoda

3730-3760 feet.

Foraminifera
Bolivina variant of floridana Cushman
Buliminella sp. cf. curta Cushman
Globigerina sp.
Nonion sp.
Nonionella auris (d'Orbigny)
Rotalia beccarii (Linné)

3760-3790 feet.

Foraminifera
Bolivina floridana Cushman
Bulimina sp.
Cibicides sp.
Robulus americanus (Cushman)

3790-3820 feet.

Foraminifera
Amphistegina sp.
Bolivina floridana variety
Cassidulina sp.
Cibicides floridanus (Cushman)
Cibicides sp.
Elphidium sp.
Eponides sp.
Globorotalia fohsi barisanensis (LeRoy)
Miliolina
Quinqueloculina sp.
Robulus vaughani (Cushman)
Uvigerina peregrina Cushman

Plant fragment

3820-3850 feet.

Foraminifera
Amphistegina sp.
Globigerina sp.
Robulus americanus (Cushman)

3850-3880 feet.

Foraminifera
- *Amphistegina* sp.
- *Cibicides* aff. *carstensi* Cushman and Ellisor
- *C. floridanus* (Cushman)
- *C.* sp.
- *Elphidium* sp.
- *Globigerina bulloides* (d'Orbigny)
- *Nonion pizarrensis* Berry
- *Robulus* sp.
- *Uvigerina peregrina* Cushman

3880-3910 feet.

Foraminifera
- *Amphistegina* sp.
- *Bolivina floridana* Cushman
- *Buliminella* sp.
- *Cibicides americanus* (Cushman)
- *C. carstensi* Cushman and Ellisor
- *C. floridanus* (Cushman)
- *C. floridanus* variety
- *C.* sp.
- *Elphidium* sp.
- *Eponides ellisorae* Garrett
- *Globigerina* sp.
- *Miliolina*
- *Nonion pizarrensis* Berry
- *Robulus* sp.

3910-3940 feet.

Foraminifera
- *Amphistegina* sp.
- *Cibicides carstensi* Cushman and Ellisor
- *C. concentricus* (Cushman)
- *C. floridanus* (Cushman)
- *Dyocibicides biserialis* Cushman and Ellisor
- *Globigerina* sp.
- *Nonion pizarrensis* Berry
- *Nonionella auris* (d'Orbigny)
- *Quinqueloculina* sp.
- *Robulus americanus* (Cushman)

Scaphopoda
- *Dentalium* sp.

3940-3970 feet.

Foraminifera
- *Amphistegina* sp.

Cassidulina sp.
Cibicides carstensi Cushman and Ellisor
C. sp.
Elphidium sp.
Eponides ellisorae Garrett
Globigerina sp.
Nonion pizarrensis Berry
Planularia cf. *vaughani* (Cushman)
Robulus sp.
Uvigerina sp.

Scaphopoda
Dentalium sp.

3970-4000 feet.

Foraminifera
Amphistegina sp.
Bulimina sp.
Cibicides carstensi Cushman and Ellisor
C. concentricus (Cushman)
C. floridanus (Cushman)
C. sp.
Eponides ellisorae
Globigerina bulloides (d'Orbigny)
Planularia cf. *vaughani* (Cushman)
Robulus americanus (Cushman)
Uvigerina altacosta Cushman and Ellisor

4000-4030 feet.

Foraminifera
Amphistegina sp.
Cibicides carstensi Cushman and Ellisor
C. floridanus (Cushman)
C. sp.
Elphidium sagrum (d'Orbigny)
Eponides sp.
Globigerina bulloides d'Orbigny
Nonion pizarrensis Berry
Oolina sp.
Operculinoides sp.
Quinqueloculina sp.
Robulus americanus (Cushman)
Siphonina davisi Cushman and Ellisor
Textularia stapperi ? Davis
Uvigerina altacosta Cushman and Ellisor

4030-4060 feet.

Foraminifera
Amphistegina sp.

Cibicides carstensi Cushman and Ellisor
C. floridanus (Cushman)
C. sp.
Elphidium sagrum (d'Orbigny)
Globigerina bulloides d'Orbigny
Guttulina sp.
Robulus americanus (Cushman)

4060-4090 feet.

Foraminifera

Amphistegina sp.
Cibicides carstensi Cushman and Ellisor
C. concentricus (Cushman)
Globigerina bulloides d'Orbigny
Globulina inaequalis Reuss
Nonion pizarrensis Berry
Robulus americanus (Cushman)

4090-4120 feet.

Foraminifera

Amphistegina sp.
Cibicides carstensi Cushman and Ellisor
C. floridanus (Cushman)
Discorbis subauracana Cushman
Elphidium sagrum (d'Orbigny)
Eponides repandus (Fitchel and Moll)
Globigerina bulloides d'Orbigny
Globorotalia fohsi barisanensis (LeRoy)
Nodosaria sp.
Nonion medio-costatum (Cushman)
Robulus americanus (Cushman)
Sorites sp.
Uvigerina altacosta Cushman and Ellisor

4120-4150 feet.

Foraminifera

Amphistegina sp.
Cibicides floridanus (Cushman)
Discorbis subauracana Cushman
Elphidium sagrum (d'Orbigny)
Eponides antillarum (d'Orbigny)
Globigerina bulloides d'Orbigny
Nonion pizarrensis Berry
Nonion sp.
Operculinoides sp.
Polymorphina
Quinqueloculina seminula (Linné)
Robulus mayeri Cushman and Ellisor
Sorites sp.

Triloculina aff. *trigonula* (Lamarck)
Uvigerina altacosta Cushman and Ellisor

4150-4180 feet.

Foraminifera

Amphistegina sp.
Cibicides carstensi Cushman and Ellisor
C. sp.
Discorbis subauracana Cushman
Elphidium sp.
Eponides antillarum (d'Orbigny)
Globigerina bulloides d'Orbigny
Nonion grateloupi (d'Orbigny)
Nonion pizarrensis Berry
Quinqueloculina sp.
Robulus aff. *mayeri* Cushman and Ellisor
Robulus americanus (Cushman)

Scaphopoda

Dentalium sp.

4180-4210 feet.

Foraminifera

Amphistegina sp.
Cassidulina laevigata var. *carinata* Cushman
Cibicides carstensi Cushman and Ellisor
Discorbis aff. *bolivarensis* Garrett
Discorbis bolivarensis Garrett
Discorbis sp.
Discorbis subauracana Cushman
Elphidium chipolensis (Cushman)
Elphidium poeyanum (d'Orbigny)
Eponides sp.
Globigerina bulloides d'Orbigny
Globorotalia quadraria Cushman and Ellisor
Guttulina sp.
Gyroidina aff. *vicksburgensis* (Cushman) Howe
Nodosaria vertebralis Batsch
Nonion pizarrensis Berry
Nonion sp.
Robulus aff. *mayeri* Cushman and Ellisor
Robulus americanus (Cushman)
Robulus mayeri Cushman and Ellisor

4210-4240 feet.

Foraminifera

Amphistegina sp.
Bolivina floridana Cushman
Cibicides floridanus (Cushman)

Discorbis *subauracana* Cushman
Miliolina
Nodosaria *vertebralis* (Batsch)
Operculinoides sp.
Robulus *americanus* (Cushman)
Robulus *mayeri* Cushman and Ellisor

Scaphopoda
Dentalium sp.

4240-4270 feet.

Foraminifera
Amphistegina sp.
Cibicides *floridanus* (Cushman)
Discorbis *subauracana* Cushman
Globigerina sp.
Miliolina
Nodosaria *vertebralis* (Batsch)
Operculinoides sp.
Robulus *americanus* (Cushman)
Robulus *mayeri* Cushman and Ellisor

Scaphopoda
Dentalium sp.

4270-4271 feet.

Foraminifera
Discorbis *subauracana* Cushman
Elphidium *chipolensis* (Cushman)
Nonion sp.
Quinqueloculina sp.

4270-4300 feet.

Foraminifera
Amphistegina sp.
Bulimina sp.
Cibicides *carstensi* Cushman and Ellisor
C. floridanus (Cushman)
Eponides sp.
Globigerina sp.
Nodosaria sp.
Nonion sp.
Operculinoides sp.
Quinqueloculina sp.
Robulus *americanus* (Cushman)
Robulus *mayeri* Cushman and Ellisor

Scaphopoda
Dentalium sp.

4307-4308 feet.

Foraminifera
Elphidium chipolensis (Cushman)
Quinqueloculina sp.

4309-4310 feet.

Foraminifera
Cassidulina sp.
Cibicides sp.
Discorbis sp.
Discorbis subauracana Cushman
Elphidium chipolensis (Cushman)
Elphidium poeyanum (d'Orbigny)
Elphidium sp.
Eponides sp.
Globigerina bulloides d'Orbigny
Globulina sp.
Nonion grateloupi (d'Orbigny)

Scaphopoda
Dentalium sp.

4340-4370 feet.

Foraminifera
Amphistegina sp.
Elphidium sp.
Globigerina sp.
Globulina inaequalis Reuss
Robulus americanus (Cushman)
Triloculina sp.

4370-4400 feet.

Foraminifera
Amphistegina sp.
Cibicides carstensi Cushman and Ellisor
C. sp.
Discorbis subauracana Cushman and Ellisor
Elphidium sagrum (d'Orbigny)
Elphidium sp.
Eponides sp.
Heterostegina sp.
Nonion grateloupi (d'Orbigny)
Polymorphina
Rotalia mexicana Nuttall

4402-4404 feet.

Foraminifera
Amphistegina sp.

Cibicides floridanus (Cushman)
C. sp.
Discorbis sp.
Globigerina sp.

Scaphopoda
Dentalium sp.

4420-4450 feet.

Foraminifera
Amphistegina sp.
Cibicides sp.
Elphidium sp.
Globigerina sp.
Globulina inaequalis Reuss
Nonion sp.
Quinqueloculina sp.
Triloculina sp.
Uvigerina aff. altacosta Cushman and Ellisor

4450-4480 feet.

Foraminifera
Cibicides carstensi Cushman and Ellisor
Discorbis subauracana (Cushman)
Eponides repandus (Richtel and Moll)
Globigerina sp.
Lepidocyclina sp.
Myogypsina sp. ?
Nonion pizarrensis Berry
Operculinoides sp.
Quinqueloculina sp.
Robulus mayeri ? Cushman and Ellisor
Robulus sp.
Rotalia mexicana Nuttall
Triloculina sp.

Otolith

4480-4510 feet.

Foraminifera
Lepidocyclina sp.
Operculinoides sp.
Quinqueloculina sp.

4510-4540 feet.

Foraminifera
Amphistegina sp.
Eponides sp.

Globigerina sp.
Lepidocyclina sp.

Gastropoda

4540-4570 feet.

Foraminifera
Cibicides sp.
Globigerina bulloides d'Orbigny
Lepidocyclina sp.
Nonion sp.
Quinqueloculina sp.
Robulus americanus Cushman
R. chambersi Garrett
R. sp.
Siphonina aff. davisi Cushman and Ellisor

Gastropoda

Scaphopoda
Dentalium sp.

4570-4600 feet.

Foraminifera
Lepidocyclina sp.
Myogypsina sp. ?

Gastropoda

4600-4630 feet.

Foraminifera
Camerina sp. ?
Elphidium sp.
Eponides sp.
Lepodocyclina sp.
Robulus americanus (Cushman)

Scaphopoda
Dentalium sp.

4630-4660 feet.

Foraminifera
Cibicides floridanus (Cushman)
C. sp.
Discorbis subauracana Cushman
Globigerina bulloides d'Orbigny
Lepidocyclina sp.
Nonion sp.

Operculinoides sp.
Quinqueloculina sp.
Robulus americanus (Cushman)

Gastropoda

Scaphopoda
Dentalium sp.

4660-4690 feet.

Foraminifera
Cibicides sp.
Globigerina bulloides d'Orbigny
Lepodocyclina sp.
Nodosaria vertebralis (Batsch)
Nonion sp.
Robulus sp.

4690-4720 feet.

Foraminifera
Cibicides sp.
Globigerina bulloides d'Orbigny
Lepidocyclina sp.
Nonion sp.
Robulus sp.

4720-4750 feet.

Foraminifera
Cibicides aff. *carstensi* Cushman and Ellisor
Eponides sp.
Globigerina sp.
Haplophragmoides sp.
Operculinoides sp.

4750-4780 feet.

Foraminifera
Cibicides aff. *carstensi* Cushman and Ellisor
Discorbis subauracana Cushman
Elphidium sp.
Haplophragmoides sp.
Globigerina bulloides d'Orbigny
Nonion sp.
Robulus americanus Cushman

4780-4810 feet.

Foraminifera
Amphistegina sp.
Bolivina sp.

Cibicides carstensi Cushman and Ellisor
Elphidium sp.
Globoquadrina sp.
Lepidocyclina sp.
Nonion sp.
Operculinoides sp.
Quinqueloculina sp.
Robulus americanus Cushman

4810-4840 feet.

Foraminifera
Cibicides floridanus (Cushman)
C. sp.
Discorbis subauracana Cushman
Elphidium sagrum (d'Orbigny)
Eponides sp.

4990-5020 feet.

Foraminifera
Elphidium sagrum (d'Orbigny)
Globigerina sp.
Nodosaria vertebralis (Batsch)
Nonion sp.

Appendix C

On Site Sample Descriptions And Paleontological Record

Sapphire Exploration and Production, Inc.
#1 State of Mississippi
Offshore Mississippi

by David T. Dockery III

1986

SAPPHIRE EXPLORATION AND PRODUCTION, INC.
#1 STATE OF MISSISSIPPI

ON SITE SAMPLE DESCRIPTIONS

3900-30	Shale, greenish-gray, glauconitic; some quartz sand. Fossils: Oyster shell fragments, barnacle valve, no forams.
3930-60	Shale, greenish-gray. Fossils: Small mollusks including the gastropods Architectonica, Natica, and Bittium. Abundant Amphistegina. Shells in larger fraction (i.e. Lucina) show abrasion.
3960-90	Shale, greenish-gray, and quartz sand. Fossils: Oyster shell fragments, aragonitic marine bivalve fragments, Rangia microjohnsoni, no forams.
3990-4020	Shale, greenish-gray; very little quartz sand. Fossils: Oyster shell fragments, Rangia microjohnsoni, Odostomia sp. ?, no forams.
4020-50	Shale, greenish-gray; very little quartz sand. Fossils: Shell fragments, Rangia microjohnsoni, Odostomia sp. ?, no forams.
4050-80	Shale, greenish-gray; very little quartz sand. Fossils: Rangia microjohnsoni, one foram.
4080-4110	Sand, quartz and some chert, coarse-grained, many spherical and frosted grains; some pyrite. Fossils: Rangia microjohnsoni, Discorbis sp.
4110-40	Sand, quartz, coarse-grained, numerous spherical and frosted grains. Fossils: Rangia microjohnsoni.
4140-70	Sand, quartz, several spherical grains; greenish-gray shale. Fossils: Rangia microjohnsoni.
4170-4200	Shale, greenish-gray; quartz sand. Fossils: Some dark gray shells, Rangia microjohnsoni, no forams.
4200-30	Shale, greenish-gray; some quartz sand. Fossils: Rangia microjohnsoni, no forams.
4230-60	Shale, greenish-gray; some quartz sand. Fossils: Rangia microjohnsoni, no forams.
4260-90	Shale, greenish-gray, silty; some quartz sand. Fossils: Rangia microjohnsoni, no forams.
4290-4320	Shale, greenish-gray, very little quartz sand or shell material.

4320-50	Shale, greenish-gray; some quartz sand. Fossils: Shell fragments, Bolivina sp.
4350-80	Shale, greenish-gray; very little quartz sand. Fossils: Shell fragments, Rangia. Forams in fine fraction including Cibicides concentricus, Uvigerina peregrina, Robulus americanus, Globigernoides extremis.
4380-4410	Shale, greenish-gray; some quartz sand. Fossils: Bolivina sp. L (fine costae continue onto final chamber). The Bolivina sp. L fauna is the down dip equivalent of the Textularia sp. L fauna.
4410-40	Shale, greenish-gray; very little quartz sand. Fossils: A few shell fragments, Uvigerina peregrina.
4440-70	Shale, greenish-gray. Fossils: A few shell fragments, Uvigerina peregrina (well preserved), Elphidium sp.
4470-4500	Shale, greenish-gray. Fossils: Elphidium sp.
4500-30	Shale, greenish-gray. Fossils: Cyclammina cancellata.
4530-60	Shale, greenish-gray.
4560-90	Shale, greenish-gray.
4590-4620	Shale, greenish-gray. Fossils: Globigerinoides, Cibicides carstensi, Buliminella curta, Bolivina floridanus.
4620-50	Shale, greenish-gray. Fossils: Uvigerina (smooth), Globigerinoides, Lenticulina, Bolivina, Cibicides carstensi, Globorotalia fohsi fohsi, Buliminella curta.
4650-80	Shale, greenish-gray. Fossils: Lenticulina, Cyclammina cancellata, Cibicides floridanus, (minus Globorotalia fohsi fohsi).
4680-4710	Shale, greenish-gray. Fossils: Lenticulina, Ammonia beccarii, Globigernoides, Planulina cf. P. harsigens, Robulus denericanes, Amphistegina sp., Cristellaria cf. C. I, Globorutalia fohsi fohsi (angular keel), Rotalia lucarn.
4710-40	Shale, greenish-gray. Fossils: Ammonia beccarii, Uvigerina (costate), Globorotalia fohsi barisanensis.
4740-70	Shale, greenish-gray. Fossils: Ammonia beccarii, Bolivina, Globigerinoides, Globorotalia foshi barisanensis (Same fauna as above).
4770-4800	Shale, greenish-gray. Fossils: Rotalia, Lenticulina.
4800-30	Shale, greenish-gray. Fossils: Very few forams.
4830-60	Shale, greenish-gray. Fossils: Bolivina, Gyroidina, not many forams.

4860-90	Shale, greenish-gray. Fossils: Bolivina sp.
4890-4920	Shale, greenish-gray. Fossils: Ammonia beccarii, Uvigerina sp., Eggerella (agglutinated), Globigerinoides, Globigerina, Bolivina floridana (appears to be triserial due to ornamentation).
4920-50	Shale, greenish-gray. Fossils: Gyroidina scalata (dorsal side flat, ventral side with umbilical plug), Ammonia beccarii, Bolivina sp., Globigerina sp.
4950-4980	Shale, greenish gray; some buff brown micritic limestone. Fossils: Ammonia beccarii, Globigerinoides, Lenticulina.
4980-5010	Shale, greenish-gray; some buff brown micritic limestone. Fossils: Minor increase in planktics, Globigerina, Uvigerina peregrina, Lenticulina vaughani (= Robulus E), Cibicides carstensi.
5010-40	Shale, greenish-gray, glauconitic. Fossils: Globigerinoides, Uvigerina, Rotalia, Bulimina.
5040-70	Shale, greenish-gray; some fine-grain calcarenite and fine-grain quartz sandstone. Fossils: Increase in planktics, Uvigerina, Cibicides carstensi.
5070-85	Shale, greenish-gray; some fine-grain calcarenite with forams comprising the sand-size grains. Fossils: Planktics common, Operculinoides.
5085-5100	Shale, greenish-gray. Fossils: Planktics common, Uvigerina, Anomalina, Lenticulina, Bulimina, Bolivina.
5100-30	Shale, greenish-gray. Fossils: Bulimina, Bolivina, Amphistegina; this is the next occurrence of Amphistegina after a long interval of absence. This genus may be a useful indicator for a zone just above the Het. limestone.
5130-60	Shale, greenish-gray; some glauconitic calcarenite. Fossils: Sorites, Operculinoides (this genus was just above the Het. lime in the adjacent Chevron well), Amphistegina, planktics, Uvigerina.
5160-90	Shale, greenish-gray; some calcarenite; hard rock at 5160 - drilling rate at 22 to 18 feet/hour. Fossils: Operculinoides, Amphistegina, Elphidium, planktics, Lenticulina, Bulimina sp., Bulimina floridanus.
5190-5205	Shale, greenish-gray; decrease in calcarenite. Fossils: Lenticulina jeffersoni (L. Miocene), Discorbis bolwarensis (L. Miocene).
5205-20	Shale, greenish-gray; increase in calcarenite. Fossils: Increase in planktics and in the overal fauna, high faunal diversity; Lenticulina jeffersoni, Discorbis bolwarensis, Discorbis E.

5220-35	Shale, greenish-gray; no limestone. Fossils: Same fauna.
5235-50	Shale, greenish-gray. Fossils: Same fauna.
5250-75	Shale, greenish-gray; a trace of limestone. Fossils: Same fauna.
5275-80	Shale, greenish-gray; 10% limestone, limestone is more consolidated and crystalized than that from uphole. Fossils: Same fauna, diverse, abundant *Operculinoides*.
5280-85	Shale, greenish-gray; trace of limestone. Fossils: Same fauna.
5285-90	Shale, greenish-gray; trace of limestone. Fossils: Same fauna.
5290-95	Shale, greenish-gray; 10% limestone. Fossils: Same fauna.
5295-5310	Shale, greenish-gray; 8 to 9% limestone. Fossils: Same fauna.
5280-5310	Shale, greenish-gray - 98%, 1% limestone, 1% quartz sand, glauconite. Fossils: *Camerina* 1, *Globigerina*, *Globigerinoides*, *Robulus americanus*, *Amphistegina*, *Siphonina advena*, *Eponides antillarum*, *Robulus* cf. *R.* L, *Discorbis* E, *Discorbis bolivarensis* *Globoquadrina* sp., *Globoquadrina altispira*, *Uvigerina peregrina*.
5310-36	Shale, greenish-gray, 20% limestone. Fossils: Same fauna, *Elphidium*, *Discorbis bolivarensis* nice specimens of *Lenticulina jeffersoni*.
5336	At this depth they replaced the bit and resumed drilling at 1:10 p.m. on Sunday, August 31st.
5336-40	Shale, greenish-gray; some limestone. Fossils: Same fauna.
5340-55	Shale, greenish-gray; 15% limestone. Fossils: Same fauna.
5355-70	Shale, greenish-gray; 25% glauconitic calcarenite. Fossils: Bivalvia - *Chione*; forams. - *Robulus chambersi* (sutures raised and tangential to umbilical plug - lower lower Miocene). *Robulus chambersi* occurs in the *Chris*. R zone (a noded or strongly beaded *Robulus*).
5370-80	Shale, greenish-gray, 30% limestone. Fossils: *Lepidocyclina* fragments in limestone.
5380-90	Limestone 50%; shale 50%. Fossils: *Lepidocyclina*.
5390-5400	Limestone 80%; 20% shale. Fossils: First occurrence of *Heterostegina* (Oligocene).
5400-06	Limestone 90%; 10% shale. Fossils: Nice specimens of *Heterostegina*.
5400-20	Limestone (calcarenite). Fossils: *Heterostegina*.

5440-48	Calcarenite, buff brown, Lepidocyclina and Heterostegina form large clasts within the carbonate sand matrix, sparry calcite cement is present.
5448-5460	Calcarenite, buff brown, with sparry calcite cement. Fossils: Miliolids - Quinqueloculina, Archaias, Sorites, Triloculina; Heterostegina, Lepidocyclina, Elphidium.
5460-70	Calcarenite, buff brwon, some gray calcarenite with sparry calcite. Fossils: Forams are difficult to see in the limestone.
5470-80	Calcarenite, gray, fine-grained, well sorted (hard - drilling rate 6-9 feet/hour); some buff brown calcarenite. Fossils: Ostracods are common in the gray limestone. Few forams. are visible; Elphidium sagrum? in gray limestone.
5480-90	Calcarenite, gray and grayish-white, well sorted, some gray shale. Fossils: Lepidocyclina, bryozoa, increase in ostracods.
5490-5520	Same as above.
5520-5557	Calcarenite (finely ground by the bit and with metal shavings).
5557-5570	Calcarenite (finely ground) with foram clast surrounded by sparry calcite. Fossils: Lepidocyclina, Heterostegina.
5570-80	Calcarenite (finely ground), some quartz sand.
5580-88	Calcarenite (finely ground), and large cuttings of dark gray shale and calcarenite. Fossils: Same fauna, Amphistegina.
5588-5600	Calcarenite (finely ground); some quartz sand. Fossils: Amphistegina, Heterostegina.
5600-5610	Calcarenite (finely ground); some quartz sand. Fossils: Some nice specimens of Peneroplis.
5610-20	Calcarenite (finely ground), buff brown, with 10% blue-gray "carbonate siltstone" with disseminated tiny biotite flakes. Fossils: Amphistegina, first occurrence of Miogypsinoides and Hanzawaia hazzardi (Frio - Oligocene). The Hanzawaia hazzardi probably came from the blue-gray carbonate siltstone.
5620-50	Calcarenite, buff brown, 40% blue-gray carbonate siltstone. Fossils: Abundant coral fragments, abundant Operculinoides and Amphistegina, Miogypsinoides. The Miogypsinoides are gray and probably came from the carbonate siltstone.
5650-60	Shale, blue-gray (70 to 80%); buff brown calcarenite. Fossils: Miogypsinoides common.
5660-77½	Core: Calcarenite, off white to light gray, with large clasts of algae and forams. (i.e. Lepidocyclina).

5677-5700	Limestone, tan, fine-grained matrix around fossil fragments. Fossils: Abundant Lepidocyclina, Nummulites, coral fragments.
5700-5715	Limestone, tan, foraminiferal with fine-grained matrix. Fossils: Fewer Lepidocyclina.
5715-30	Calcarenite, tan, with sparry calcite cement. Fossils: Coral fragments.
5730-40	Same as above but with 10% quartz sand in coarse fraction and 25% quartz sand in fine fraction (increase in drilling rate from 40 to 80 feet/hour). Fossils: Increase in coral fragments, Miogypsinoides and Camerina. According to Francis Plaisance, a coarse sand occurred above the Vicksburg Group in another well (possibly the Chevron, Viosca Block 30).
5740-50	Calcarenite, tan, with 20% quartz sand. Fossils: Lepidocyclina.
5750-60	Calcarenite, tan; 40% gray shale. Fossils: Lepidocyclina, Amphistegina, Miogypsinoides, Nummulites, corals, Haplophragmoides, Textularia cf. T. mississippiensis (Vicksburg Group).
5760-75	Shale (60-70%), dark gray with splintery fracture (different from the shale sequence above the limestone); calcarenite. Fossils: Textularia mississippiensis, Globigerina ciperoensis.
5775-90	Shale as above (90%); 10% calcarenite. Fossils: Textularia mississippiensis, Textularia warreni, Cibicides mississippiensis. Robulus vicksburgensis.
5790-5820	Shale as above, trace of limestone. Fossils: Cibicides mississippiensis, Anomalina bilateralis, Uvigerina vicksburgensis.
5820-50	Shale and fauna same as above.
5850-80	Shale, glauconite, trace of glauconitic limestone. Fossils: Globorotalia cocoaensis; Anomalina cocoaensis, Uvigerina cocoaensis (Jackson Group).
5880-5910	Shale. Fossils: Robulus gutticostata (Jackson).
5910-5921	Shale. Fossils: Globorotalia lehneri (Claiborne-Wilcox), planktics are common in the small fraction (plantics are common in the Claiborne Group).

ZONES

3840	First Sample Examined - In Ecologic Zone Z - Miocene
4380	_Textularia_ L Fauna
4500	Ecologic Zone 3
4560	Ecologic Zone 4
4590	_Cibicides carstensi_
4620	_Bigenerina humblei_ Fauna (_Globorotalia fohsi fohsi_)
4710	_Cristellaria_ 1 Fauna (_Globorotalia fohsi barisanensis_)
5070	_Camerina_ 1 Ecologic Zone 2
5170	_Discorbis bolivarensis_(Lower Miocene)
5355	_Cristellaria_ R (Lower Lower Miocene)
5390	_Heterostegina_ sp. (Top of Oligocene)
	missing zones
5610	_Hanzawaia hazzardi_ (Frio)
5750	_Textularia mississippiensis_ (Vicksburg Group)
5850	_Globorotalia cocoaensis_ (Jackson Group)
5910	_Globorotalia lehneri_ (Claiborne Group)

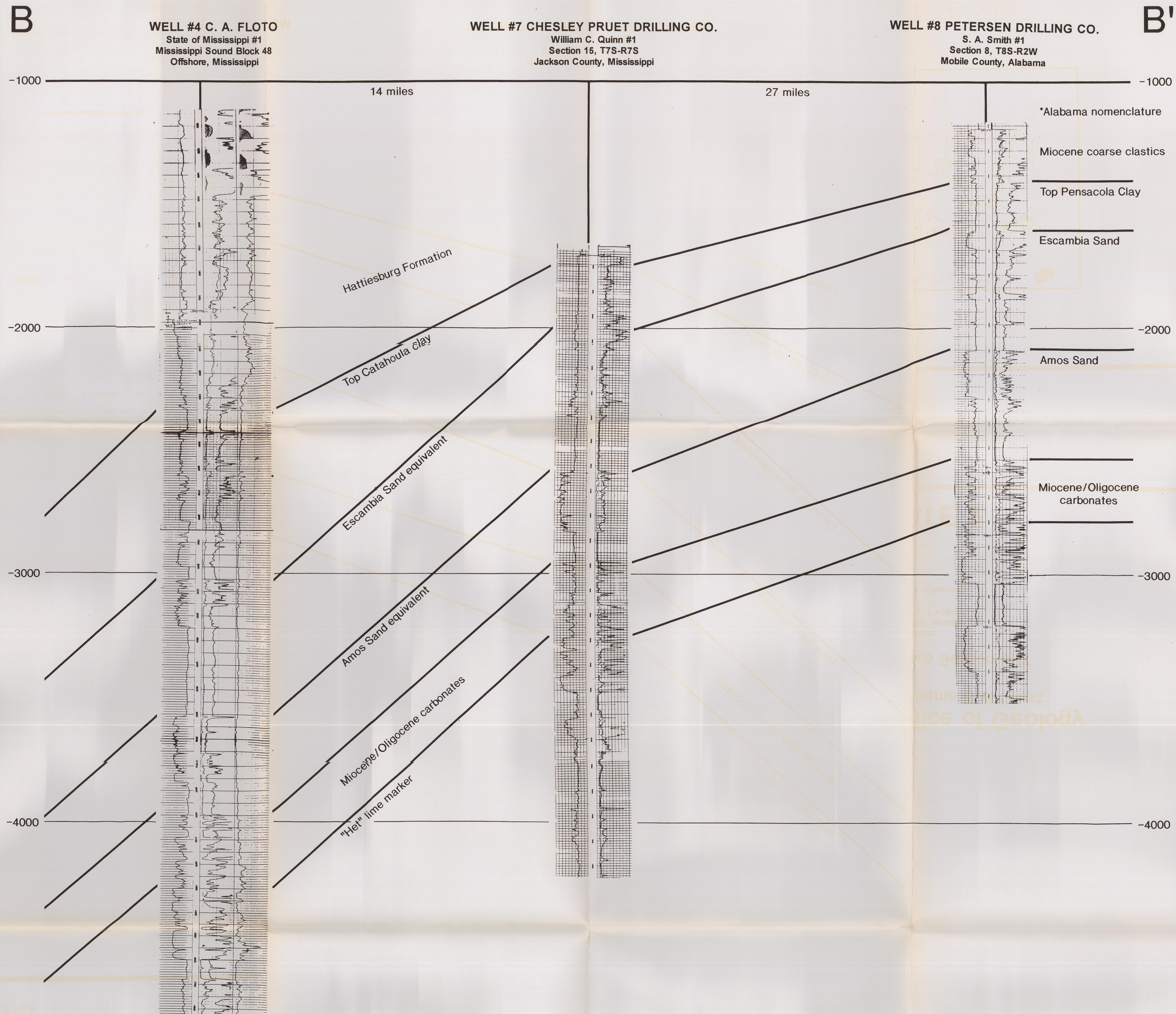
Mississippi Office of Geology
Mississippi/Alabama Gulf Coast

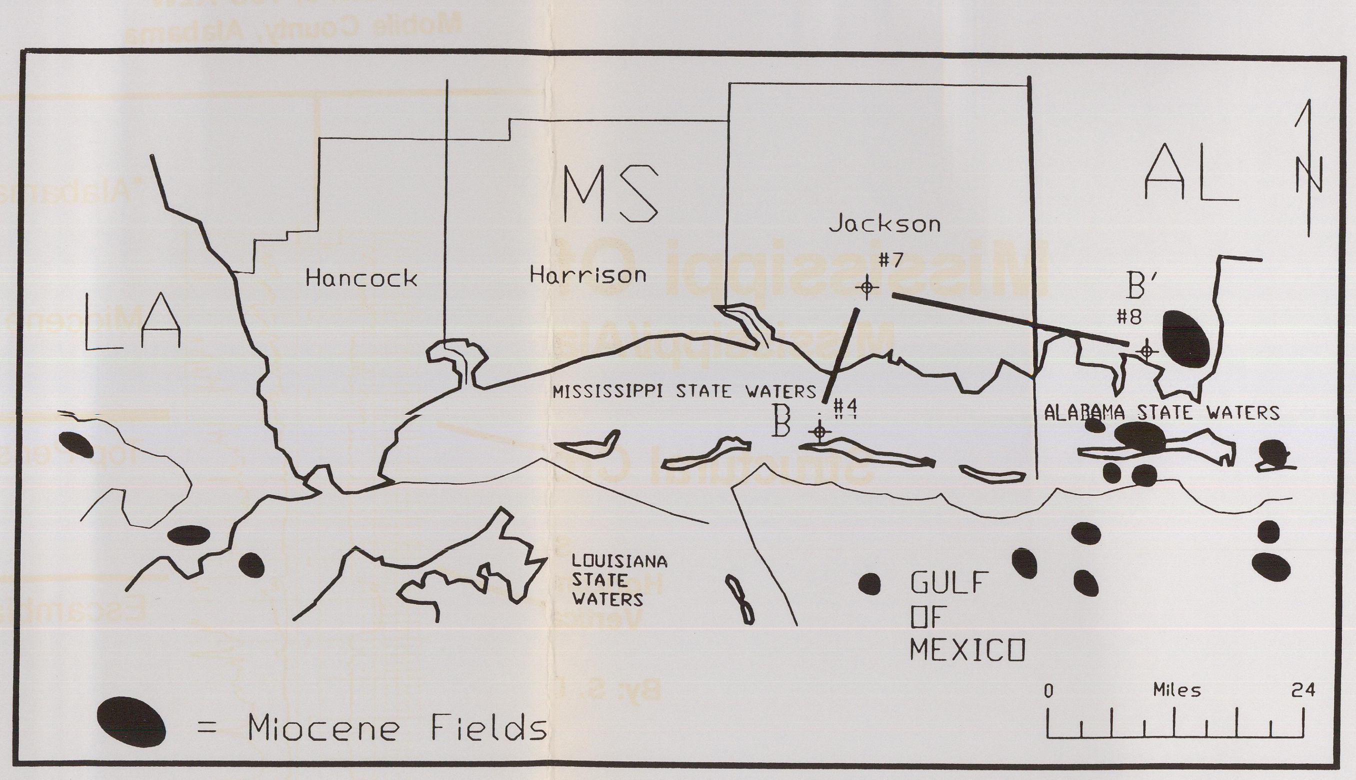
Structural Cross Section A-A'

Scale:
Horizontal variable
Vertical 1"=200'

By: S. D. Champlin

PLATE 1





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Structural Cross Section B-B'

Scale:
Horizontal variable
Vertical 1"=200'

By: S. D. Champlin

PLATE 2