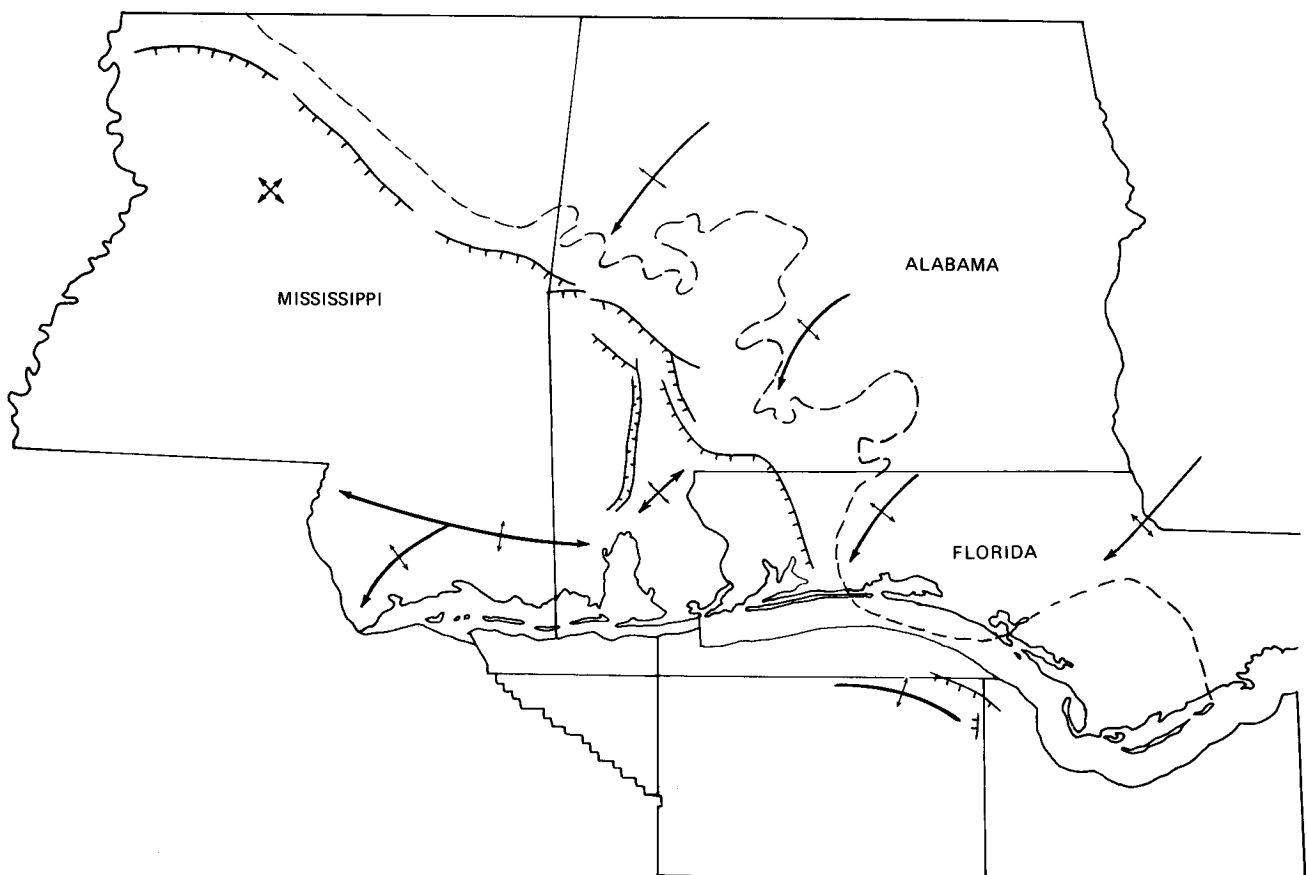


REGIONAL JURASSIC GEOLOGIC FRAMEWORK OF ALABAMA COASTAL WATERS AREA AND ADJACENT FEDERAL WATERS AREA



State Oil and Gas Board

Oil and Gas Report 12

The views and conclusions contained in this document are those of the authors and should not be interpreted as necessarily 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.

All reviewers of this report should satisfy themselves as to the accuracy of all data, maps, and interpretations presented.

**GEOLOGICAL SURVEY OF ALABAMA
AND
STATE OIL AND GAS BOARD**

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GEOPHYSICS AND OFFSHORE DIVISION

OIL AND GAS REPORT 12

**REGIONAL JURASSIC GEOLOGIC FRAMEWORK
OF ALABAMA COASTAL WATERS AREA AND
ADJACENT FEDERAL WATERS AREA**

By

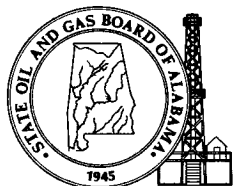
Robert M. Mink, Bennett L. Bearden,
and Ernest A. Mancini

Prepared by the Geological Survey/State Oil and Gas Board of Alabama in fulfillment of U.S. Department of the Interior, Minerals Management Service Cooperative Agreement No. 14-12-0001-30115 through the Bureau of Economic Geology, The University of Texas at Austin.

Tuscaloosa, Alabama
1985

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December 20, 1985

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Honorable George C. Wallace
Governor of Alabama
Montgomery, Alabama

Dear Governor Wallace:

I have the honor to transmit herewith a report entitled "Regional Jurassic Geologic Framework of Alabama Coastal Waters Area and Adjacent Federal Waters Area," by Robert M. Mink, Bennett L. Bearden, and Ernest A. Mancini, which has been printed as Oil and Gas Report 12.

The offshore Alabama region continues to be a very active area for hydrocarbon exploration in the state. This report was prepared to provide the public and the petroleum industry with geologic information on the oil and gas potential of the offshore Alabama region.

Respectfully,

Ernest A. Mancini
State Geologist and
Oil and Gas Supervisor

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By

Robert M. Mink, Bennett L. Bearden, and Ernest A. Mancini

ABSTRACT

To date, numerous Jurassic hydrocarbon fields and pools have been discovered in the Cotton Valley Group, Haynesville Formation, Smackover Formation, and Norphlet Formation in the tri-state area of Mississippi, Alabama, and Florida, and in Alabama state coastal waters and adjacent federal waters area. Petroleum traps are basement highs, salt anticlines, faulted salt anticlines and extensional faults associated with salt movement. Reservoirs include continental and marine sandstones, limestones and dolostones. Hydrocarbon types are oil, condensate and natural gas. The onshore stratigraphic and structural information can be used to establish a regional geologic framework for the Jurassic for the state coastal waters and adjacent federal waters areas. Evaluation of the geologic information along with the hydrocarbon data from the tri-state area indicates that at least three Jurassic hydrocarbon trends (oil, oil and gas-condensate, and deep natural gas) can be identified onshore. These onshore hydrocarbon trends can be projected into the Mobile Area in the Central Gulf of Mexico and into the Pensacola, Destin Dome and Apalachicola Areas in the Eastern Gulf of Mexico. Substantial reserves of natural gas are expected to be present in Alabama state waters and the northern portion of the Mobile Area. Significant accumulations of oil and gas-condensate may be encountered in the Pensacola, Destin Dome, and Apalachicola Areas.

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Thanks are extended to Steve Walkinshaw, President, Mississippi Geological Society, for permission to publish structure maps of Diamond, Bay Springs and Jay-Little Escambia Creek fields contained in this report.

INTRODUCTION

The Eastern and portions of the Central Gulf of Mexico regions (fig. 1) are frontier areas for petroleum exploration. In 1979, natural gas was discovered in Mobile Bay in the Jurassic Norphlet Formation. This discovery led to the establishment of the Lower Mobile Bay-Mary Ann field and to active leasing and drilling programs in the adjacent offshore areas. Additional offshore discoveries in the Jurassic have emphasized the importance of understanding the regional Jurassic geologic framework of the Alabama coastal waters area and adjacent federal waters area. Identification of the Jurassic hydrocarbon, structural and stratigraphic trends in the onshore tri-state area of Mississippi, Alabama, and Florida is critical to the projection of these Jurassic petroleum trends into the Eastern and parts of the Central Gulf of Mexico regions.

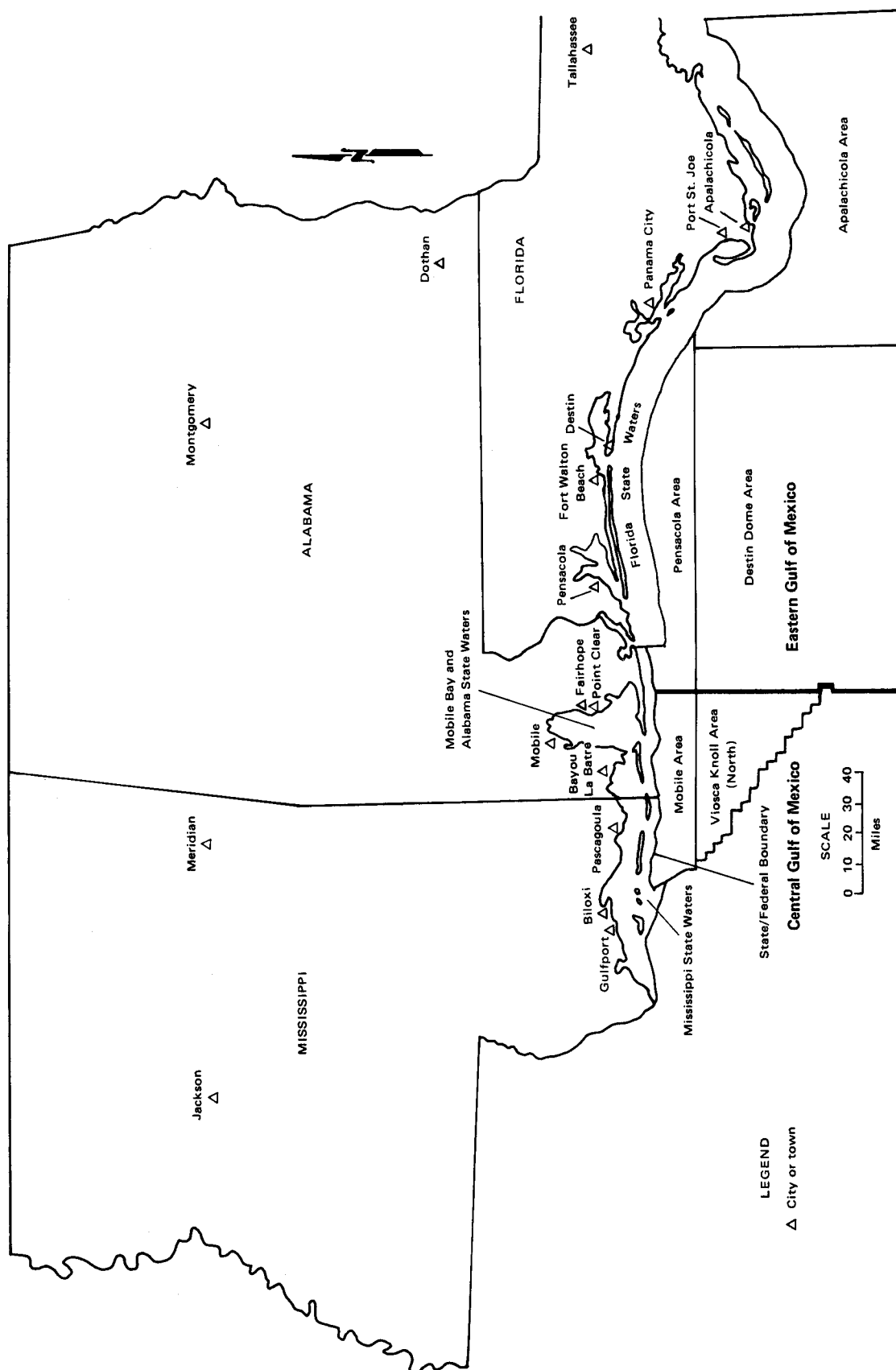


Figure 1.--Geographic index map.

Over 4,000 feet of Jurassic strata are present in the Mobile Bay area. These strata include the Cotton Valley Group, Haynesville Formation, Smackover Formation, Norphlet Formation, and the Louann Salt. The discovery of Jurassic hydrocarbons in southwestern Alabama occurred in 1967 when oil was found in the Smackover Formation at Toxey field in Choctaw County. To date, more than 200 Jurassic fields and pools have been discovered in the onshore tri-state area with production established from the Cotton Valley Group, Haynesville Formation, Smackover Formation, and Norphlet Formation.

Of the Jurassic units, to date, natural gas has been tested only in the Norphlet Formation in offshore Alabama and Mississippi. When the offshore area is considered in context with the established onshore production, it is clear that both the Smackover and Norphlet have excellent hydrocarbon potential in Alabama state waters and the adjacent federal waters off Alabama, Mississippi, and the Florida panhandle.

PURPOSE AND SCOPE

This report describes the regional petroleum potential of the Jurassic strata for onshore southwestern Alabama, Alabama state waters area, and adjacent federal waters area. Included within this report are maps, cross sections, diagrams, and tables that illustrate the regional Jurassic geologic framework of the study area (fig. 1).

The purpose of this study has been to establish a regional geologic framework for the Jurassic of onshore southwestern Alabama, Alabama state waters area, and adjacent federal waters area within 100 miles of Alabama's coast, which includes the Mobile, Viosca Knoll (north), Pensacola, Destin Dome, and Apalachicola Areas. Particular emphasis has been placed on the stratigraphic and structural relationships and petroleum geology of established onshore Jurassic fields in southwestern Alabama and panhandle Florida. In addition, data on the established onshore Jurassic fields of southern Mississippi have been incorporated in order to more thoroughly define the Jurassic trends. Available Jurassic data from wells in Alabama and Florida state waters and wells in the Mobile, Pensacola, and Destin Dome Areas have been utilized to formulate a geologic framework for the purpose of projecting regional stratigraphic, structural, and hydrocarbon trends into the adjacent federal waters area.

Information utilized for this study has included well logs, sample and core descriptions, seismic data and test and production data by formation from onshore and offshore Jurassic wells and fields. Onshore production data have been incorporated as have available lease and well data for the Alabama state waters and adjacent federal waters area.

STRUCTURE

The northern Gulf basin extends from DeSoto Canyon to northern Mexico and is composed of a broad wedge of Mesozoic and Cenozoic strata that accumulated almost continuously from Jurassic time to present (Martin, 1978). The northern Gulf basin is that part of the Gulf region that is roughly outlined by the updip limits of Jurassic sediments and ranges in extent from east Texas to northwest Florida (Murray, 1961; Beall, 1973; Murray and others, 1985). Along the inner regions of this basin from Alabama to southwestern Texas, updip members of Mesozoic and Cenozoic strata rest unconformably on complexly faulted and folded Paleozoic rocks of the Ouachita-Appalachian system. The most common structural styles in the northern Gulf region are normal faults, extensional faults associated with salt movement, salt diapirs and syndepositional growth faults. Normal faults in the region typically exhibit down-to-the-basin displacement and in the Jurassic strata may have angles of 45° to 70° (Beall, 1973).

The most pronounced structural system of the northern Gulf region is a group of related faults, typically referred to as the regional peripheral fault trend (Martin, 1978), which rims the Gulf basin and corresponds approximately to the updip limit of Louann Salt deposition in the region. In Mississippi, Alabama, and Florida the faults that comprise this trend include: (1) the Pickens-Gilbertown-West Bend systems of eastern Mississippi and southwestern Alabama, which roughly borders the edge of the Mississippi interior salt basin; (2) the Pollard-Foshee systems of southern

Alabama and panhandle Florida; and (3) related faults in the Pensacola, Destin Dome and Apalachicola Areas (fig. 2).

The present day Mississippi-Alabama Shelf lies in offshore Louisiana, Mississippi, Alabama and western Florida and, according to Martin (1978), is separated from the Texas-Louisiana Shelf by the Mississippi Delta and adjoins the West Florida Shelf along an arbitrary boundary that extends from the southeastward bend of the shelf break to the shoreline near Pensacola, Florida. The Mississippi-Alabama Shelf is characterized by pronounced relict topography and a gentle gradient (Martin, 1978).

Large paleohighs are found in the northern Gulf region of Mississippi, Alabama, and Florida, including the Wiggins arch and Conecuh ridge systems in southeastern Mississippi and southwestern Alabama, and the Pensacola ridge in northwestern Florida (fig. 2). In addition, the Appalachian structural trend had a significant influence on the distribution of Jurassic sediments and served as a major source area for Jurassic clastic sediments.

The widespread Louann Salt created a complex network of structures in the northern Gulf region. Various types of salt-related structures have been documented by Martin (1978). These salt-related structures include salt diapirs, salt massifs, growth faults, extensional fault systems related to salt flowage, and graben systems caused by salt movement adjacent to a stable basement. The updip regional peripheral fault trend that rims the northern Gulf basin is the result of salt flowage. Grabens similar to the Mobile graben of southwestern Alabama (fig. 2) are associated with this fault trend. Numerous anticlines and faulted anticlines related to the movement of thick salt are located downdip of these extensional fault systems. According to Martin (1978), the structural fabric of most of the northern Gulf margin is largely the result of salt flowage.

In the offshore panhandle Florida region, the most pronounced structural elements are the Destin anticline and the DeSoto Canyon salt basin (fig. 2). The Destin anticline is thought to be related to a deep-seated salt feature (Pontigo, 1982). The DeSoto Canyon salt basin lies on the western edge of the West Florida Slope. This salt basin is characterized by numerous salt piercements.

Based on analyses of selected seismic lines, the authors interpret a major fault system north and northeast of the Destin anticline in the Pensacola, Destin Dome, and Apalachicola Areas. This fault system is interpreted to be an extension of the regional peripheral fault trend that occurs along the approximate updip edge of deposition of Jurassic strata in the northern Gulf rim. This observation is believed to be consistent with that of Martin (1978).

STRATIGRAPHY

Jurassic strata of the northern Gulf rim were originally defined on the basis of subsurface sections in northern Louisiana and southern Arkansas (Weeks, 1938). The Jurassic units extend from northeastern Texas to Mississippi into southwestern Alabama and western Florida; however, formational boundaries are less distinct for the southwestern Alabama region than are the boundaries to the west.

The Jurassic stratigraphic section in the study area consists of over 4,000 feet of clastics, carbonates and evaporites. One group and five formations comprise the Jurassic section and are, in descending order, the Cotton Valley Group, Haynesville Formation, Smackover Formation, Norphlet Formation, Louann Salt and Werner Formation (fig. 3). Basal Jurassic sediments unconformably overlie either clastics of the Triassic Eagle Mills Formation or igneous/metamorphic Paleozoic basement rocks. Eagle Mills sediments fill Late Triassic grabens in the northern Gulf rim. These grabens are probably related to the continental rifting of the Gulf of Mexico (Pilger, 1981). Jurassic formations in the study area are known only from the subsurface. These formations range in age from Callovian (Middle Jurassic) to Tithonian (Late Jurassic) according to Imlay (1980). The Hosston Formation (Early Cretaceous) overlies the Jurassic strata in the study area with the Cretaceous-Jurassic boundary probably somewhere in the upper part of the Cotton Valley Group. A typical geophysical log of the Jurassic strata in the study area is illustrated on figure 4.

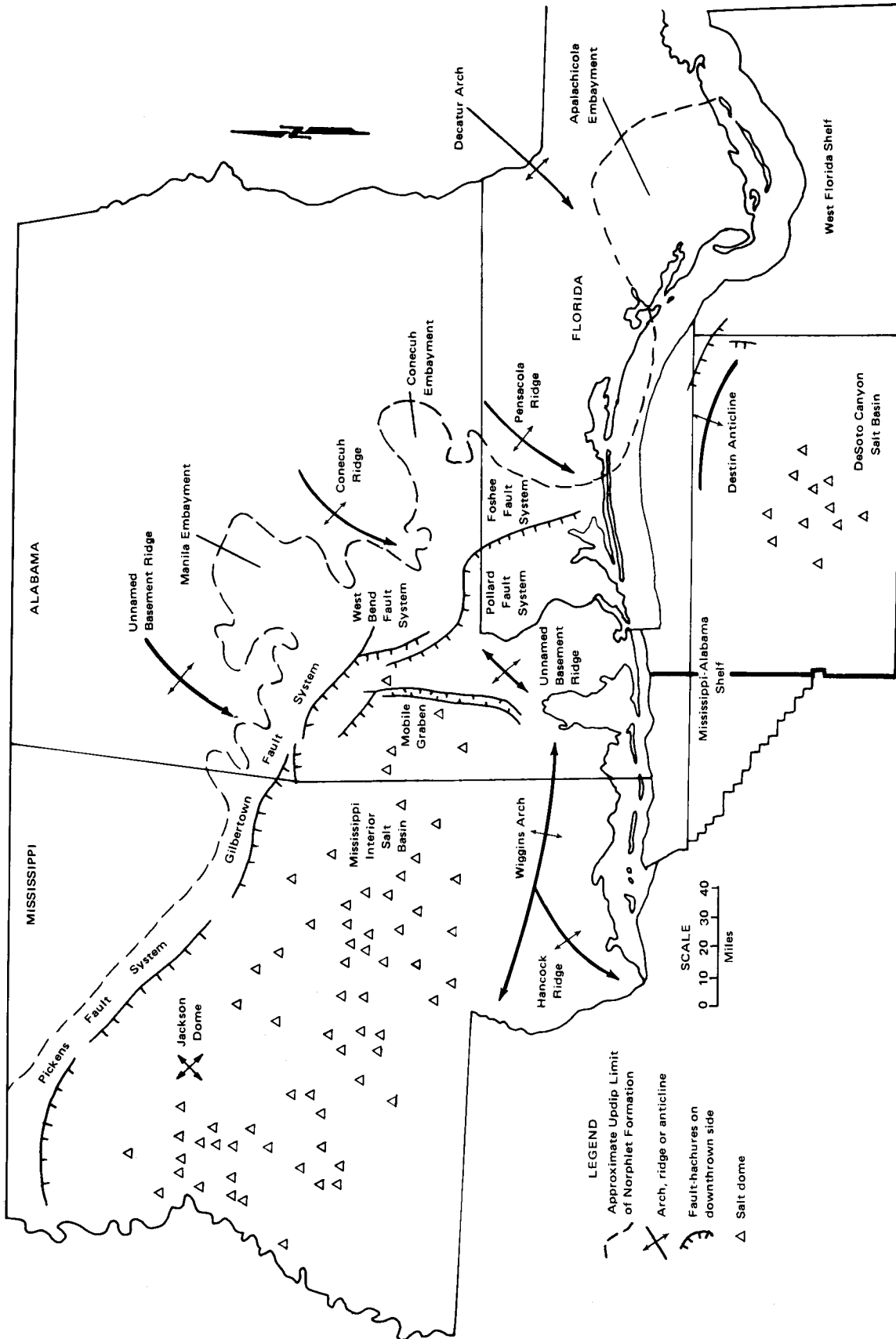


Figure 2.--Major structural features of the study area.

SERIES	ROCK UNIT
UPPER JURASSIC	Cotton Valley Group
	Haynesville Formation
	Buckner Anhydrite Member
	Smackover Formation
	Norphlet Formation
	Pine Hill Anhydrite Member
	Louann Salt
MIDDLE JURASSIC	Werner Formation
UNDER-LYING BEDS	Triassic Eagle Mills Formation
	Paleozoic Rocks

Figure 3.--Generalized Jurassic stratigraphy of the study area.

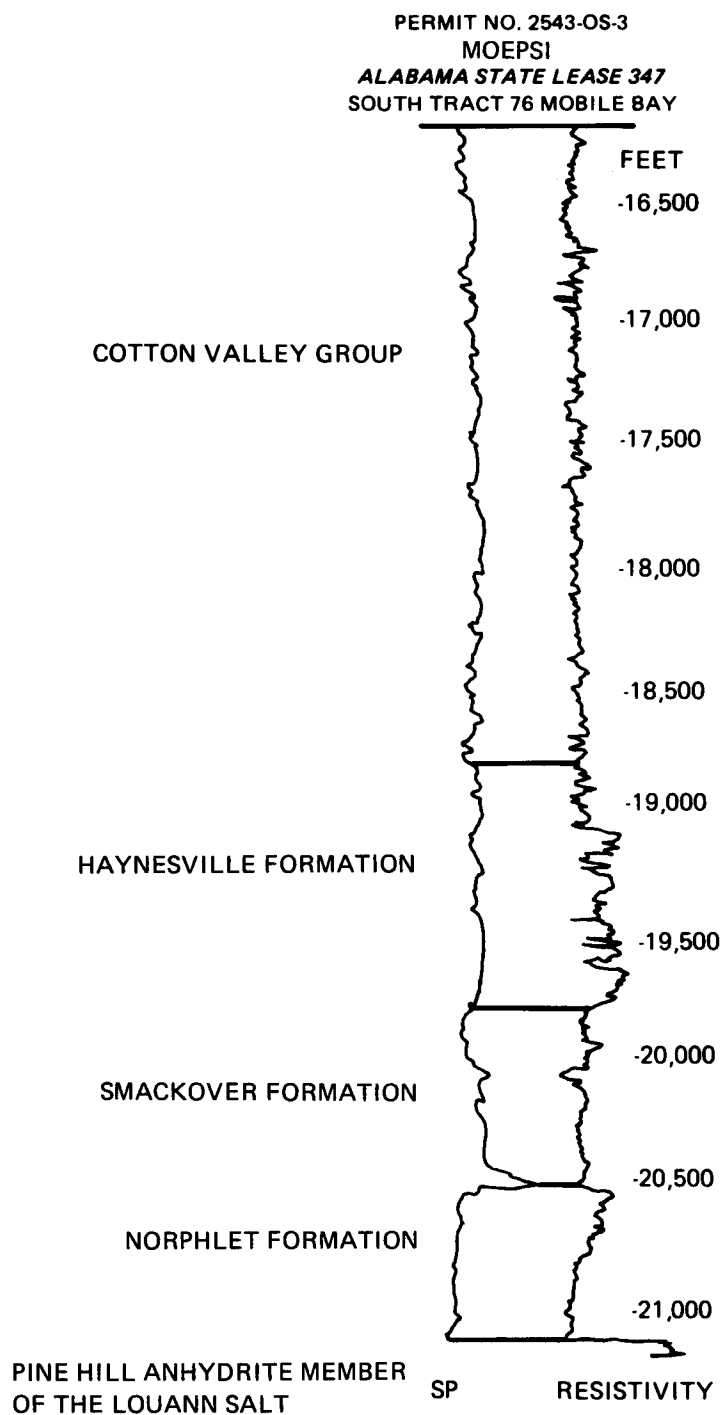


Figure 4.--Type log for the offshore Alabama area illustrating the characteristic log curves for the Jurassic strata.

COTTON VALLEY GROUP

In southwestern and offshore Alabama, panhandle Florida, and offshore northwestern Florida, the Cotton Valley Group (Kimmeridgian to Tithonian) consists of moderate- to pale-red, light-gray and white, fine- to very coarse-grained to conglomeratic, angular to subrounded, quartzose sandstone that locally contains chert and abundant metamorphic rock fragments (Tolson and others, 1983). Sandstones contain calcite and silica cements and may contain clay matrix. Muscovite and chlorite are the predominant micas. Sandstone units in the Cotton Valley are friable. Shale units in the Cotton Valley Group are typically dark to dusky red updip with gray shales occurring downdip. Coal and lignitized wood fragments are found in the upper part of the Cotton Valley Group (Tolson and others, 1983). The Cotton Valley Group overlies the Haynesville Formation in the study area (fig. 3). Cotton Valley sediments show an overall thickening trend downdip; however, some thickness variations may be the result of the difficulty of differentiating the Cotton Valley Group from the Haynesville Formation.

An index to the stratigraphic cross sections prepared to illustrate a Jurassic geologic framework of the study area is presented in figure 5. On cross section A-A' (fig. 6), the Cotton Valley Group thickens from well 1512 to well 1643 into the Mississippi interior salt basin, which was subsiding during Cotton Valley time. The Cotton Valley Group thins over the Wiggins arch as seen in well 2069 and thickens into the Mobile Bay area as observed in well 2543. On cross section B-B' (fig. 7), the Cotton Valley Group thickens in Escambia County, Alabama (well 2991), and thins in the Pensacola Bay area (well F 1097). The Cotton Valley Group increases in thickness in the offshore Florida area where it becomes more carbonaceous and marine (wells OCS-G-3886 and OCS-G-2468). Thickening of the Cotton Valley Group in offshore Florida is displayed on cross section C-C' (fig. 8, well OCS-G-3890). Cross section D-D' (fig. 9) shows a relatively consistent thickness for the Cotton Valley Group along strike from the Mobile Bay area into the Destin Dome Area. The Cotton Valley section also appears to be more carbonaceous and becomes more marine to the southeast.

Moore (1983) has subdivided the Cotton Valley in Mississippi into three units--the lower, middle, and upper. However, no attempt is made to subdivide the Cotton Valley in Alabama and Florida because the section consists primarily of clastic lithologies. Some thin limestone beds do occur locally in Alabama and Florida but correlation of these beds is difficult.

In general, in the study area the Cotton Valley Group is a southward thickening wedge of clastics that is conglomeratic updip and contains abundant rock fragments eroded from a Paleozoic basement complex (southern Appalachians), indicating an emergent land mass to the north and northeast of the Gulf of Mexico region during Late Jurassic time (Tolson and others, 1983). In the study area, the Cotton Valley is interpreted to represent terrestrial to marginal marine sediments that were deposited partly in oxidizing environments (updip red conglomerates). Deposition was dominated by a southward prograding clastic wedge as the seas retreated basinward (fig. 10-G). Thickening of the Cotton Valley Group was influenced by positive basement paleohighs and by basin subsidence (Tolson and others, 1983).

HAYNESVILLE FORMATION

In the study area, the Haynesville Formation conformably overlies the Smackover Formation (fig. 3). The Haynesville is a transitional unit between the underlying Smackover carbonates and the terrestrial deposits of the Cotton Valley Group. In Alabama the top of the Haynesville is generally picked above the uppermost anhydrite bed at the base of the clastics of the Cotton Valley (Tolson and others, 1983). Imlay (1980) has interpreted a Late Jurassic (Early Kimmeridgian) age for the Haynesville, which in the study area may be divided into two distinct units. The lower unit, the Buckner Anhydrite Member, consists of massive anhydrite containing dolomite, anhydritic shale, and anhydritic sandstone beds. Above the Buckner, the Haynesville Formation includes interbedded fine and coarse siliciclastics containing anhydrite either as distinct beds or as an accessory mineral in the clastics. In places where the massive anhydrite is absent, the lower part of the Haynesville consists of anhydritic shale and sandstone, thin anhydrite and salt stringers. In the Mississippi interior salt basin

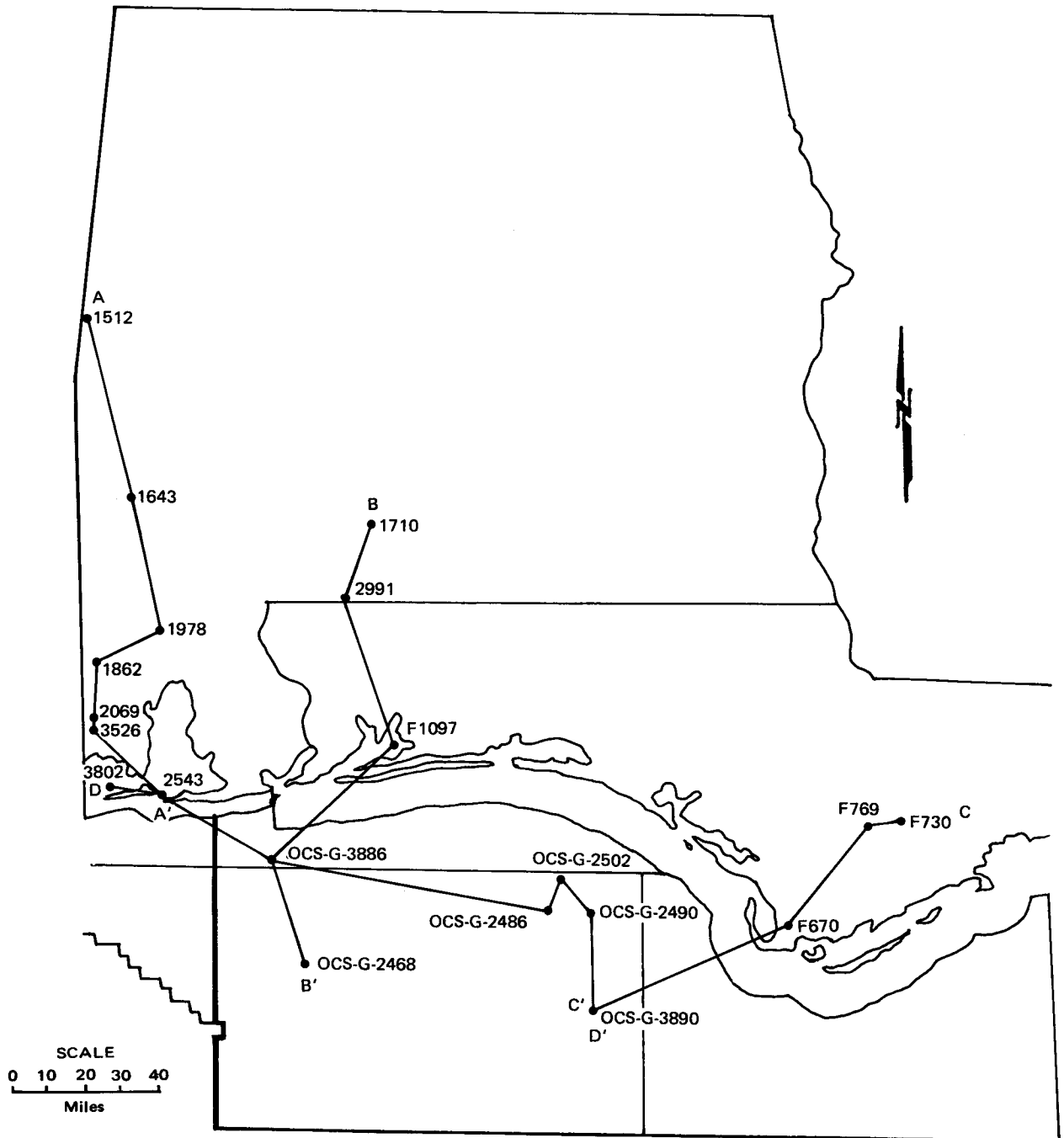
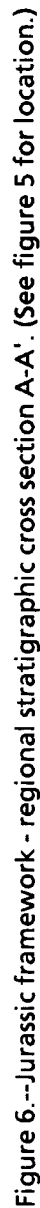
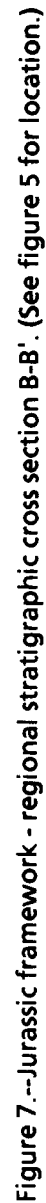


Figure 5.--Index map to cross sections.





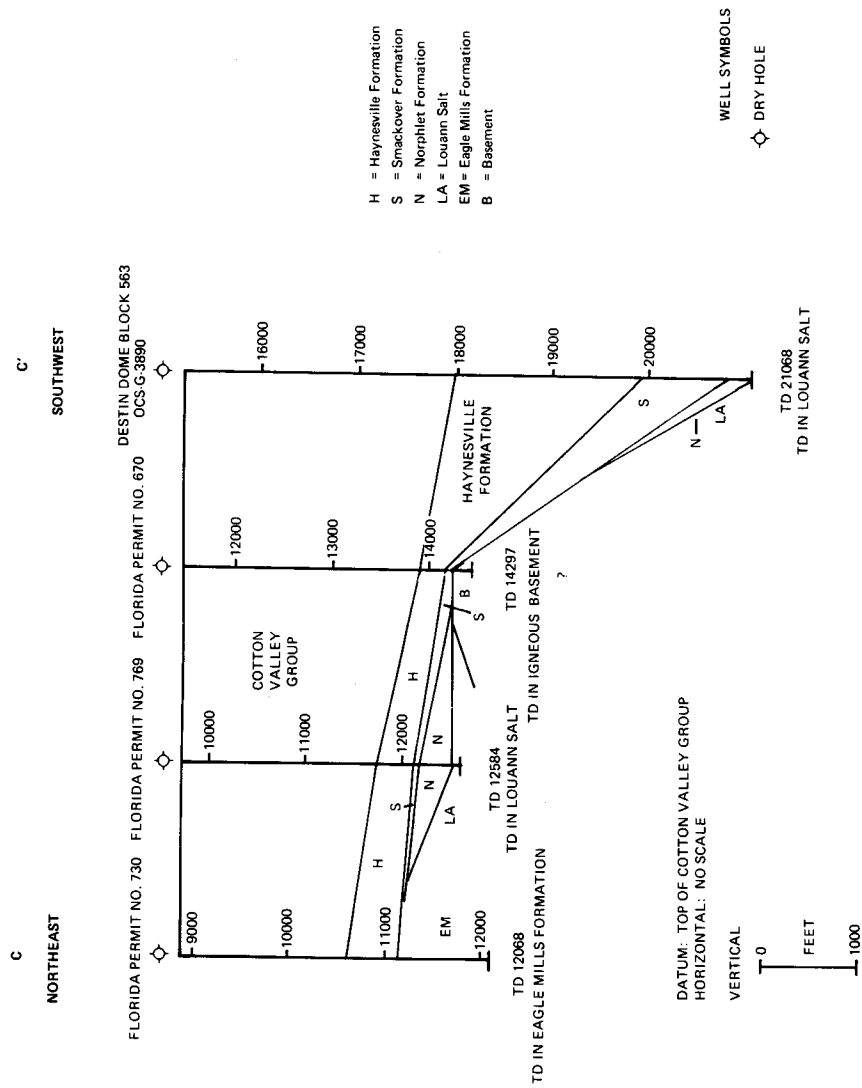


Figure 8.--Jurassic framework - regional stratigraphic cross section C-C'. (See figure 5 for location.)



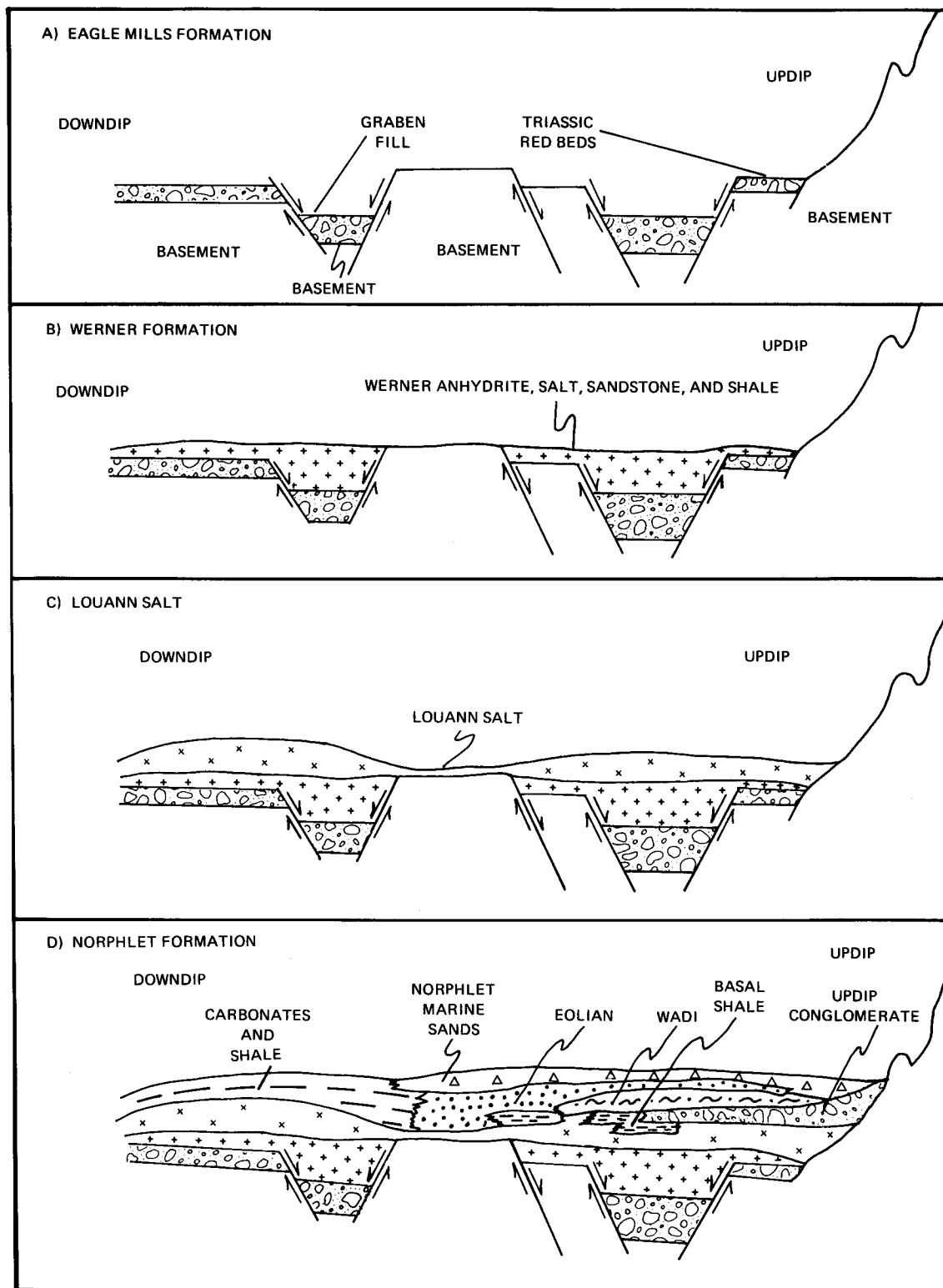


Figure 10.--Generalized sequence of deposition of Triassic and Jurassic lithofacies of the study area.

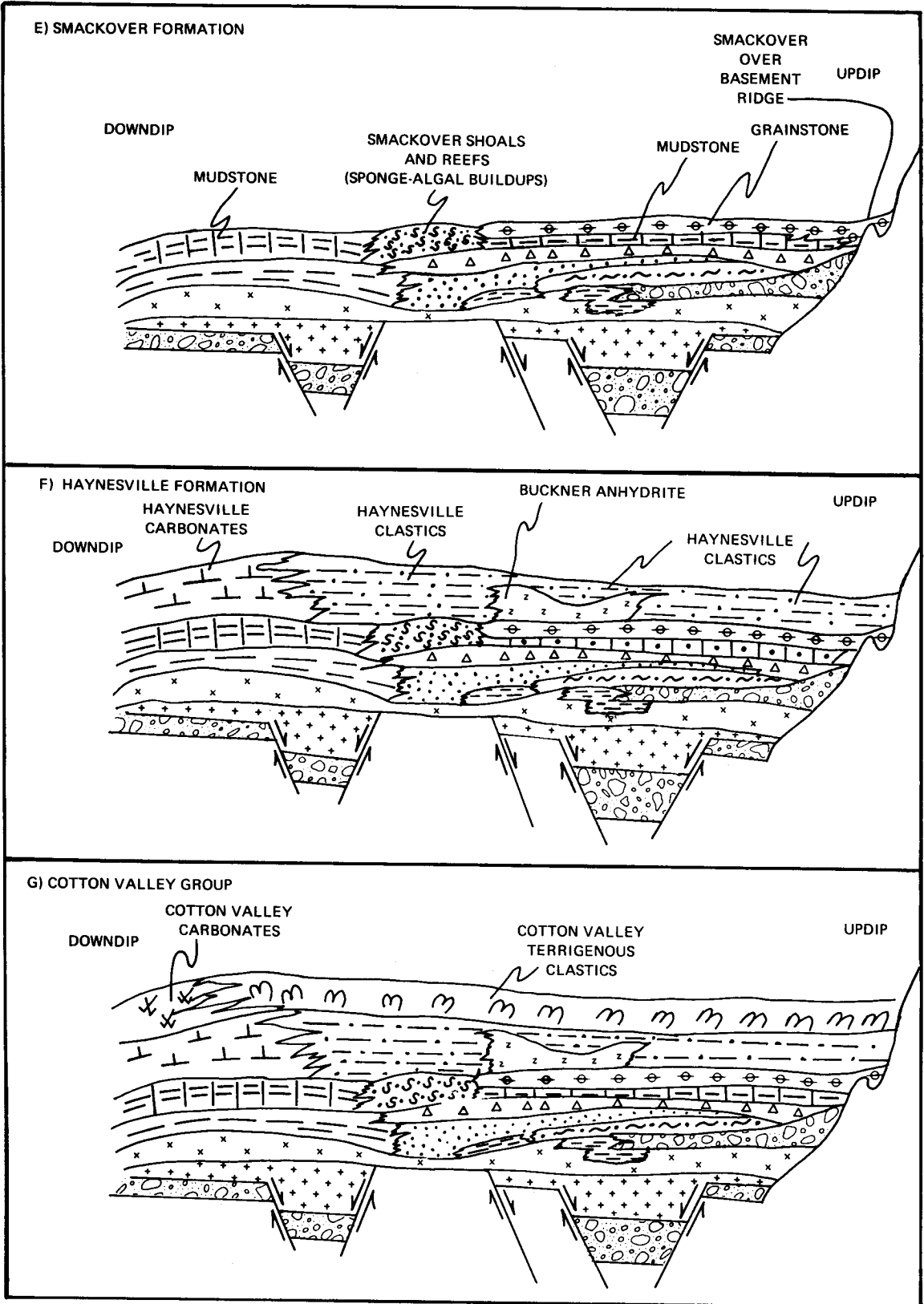


Figure 10.--Continued.

the Buckner reaches thicknesses of more than 600 feet, and the Haynesville, excluding the Buckner, reaches thicknesses of more than 2,500 feet (Tolson and others, 1983).

The Buckner Anhydrite Member at the base of the Haynesville Formation is easily delineated as a separate, distinct unit only where it is composed primarily of massive anhydrite with minor amounts of clastic and carbonate sediments. The Buckner in conventional cores is typically olive gray to light bluish-gray, dense, massive, and fibrous anhydrite. Irregular polygonal anhydrite crystals are bordered by thin films of organic mud that cause a fabric described as "chicken wire anhydrite" (Tolson and others, 1983). The Buckner is absent in updip areas in Choctaw, Clarke, and Wilcox Counties, Alabama, and is thickest in the Mississippi interior salt basin. Near the areas of the Wiggins arch and Conecuh ridge the Buckner is thin. The Buckner in the northeastern part of the Conecuh embayment is more than 400 feet thick and thins toward the south (Tolson and others, 1983). The Buckner is not recognized as a distinct stratigraphic unit in southern Mobile and Baldwin Counties and the Mobile Bay area where it is replaced by carbonate mudstone, oolitic grainstone and anhydrite in the lower Haynesville (Tolson and others, 1983). The Buckner is also recognizable in the Destin Dome Area in well OCS-G-2490.

Cross section A-A' (fig. 6) illustrates the increase in thickness of the Haynesville Formation to the south into the Mississippi interior salt basin and thinning over the Wiggins arch (well 2069). South of the Wiggins arch in the Mobile Bay area, the Haynesville Formation becomes very carbonaceous and increasingly marine. Regional thickening of the Haynesville Formation to the south is apparent on cross section B-B' (fig. 7) as is thickening to the southwest from the Apalachicola embayment to the Destin Dome Area on cross section C-C' (fig. 8). Apparent thinning of the Haynesville Formation in the area of well 2543 on cross section D-D' (fig. 9) in Mobile Bay is probably due to faulting. A noticeable increase in thickness of the Haynesville Formation to the east is shown on cross section D-D'.

According to Oxley and others (1967), the Haynesville lithologies represent deposition in environments ranging from restricted shelf to littoral and may include some terrestrial deposits (fig. 10-F). The Buckner represents deposition in a sabkha environment (Sigsby, 1976). The thickness and distribution of the Buckner indicate that, following Smackover deposition, a restricted evaporite basin remained in southwestern Alabama. Positive features such as the Wiggins arch and Conecuh and Pensacola ridges probably had a significant influence on Buckner deposition (Tolson and others, 1983).

SMACKOVER FORMATION

The Smackover Formation (Oxfordian) of the northern Gulf rim, according to Moore (1984), was controlled depositionally by basement paleohighs and Jurassic highs coupled with local and regional basin subsidence and sea level fluctuations. Extensional fault systems of southwestern Alabama, including the Pickens-Gilbertown-West Bend, Pollard-Foshee, and Mobile graben fault systems, as well as regional and local salt anticlinal trends, locally interrupted Smackover deposition. Salt movement and pre-Jurassic paleohighs (Wiggins arch, Conecuh ridge, and Pensacola ridge) modified sediment distribution throughout Jurassic time.

In the study area, the Smackover Formation is underlain by the Norphlet Formation having an abrupt or gradational formational contact. The Buckner Anhydrite Member of the Haynesville Formation overlies the Smackover throughout most of the area. The Smackover-Haynesville contact grades from dolomite through interbedded dolomite/anhydrite to anhydrite (Mancini and Benson, 1980). Cagle and Khan (1983) have suggested that the lower Haynesville was deposited contemporaneously with the Smackover in the area around the Wiggins arch. In the study area, the Smackover Formation (Oxfordian) generally consists of two distinct lithofacies. The regressive upper lithofacies is usually a grain-supported dolomitic limestone and/or dolostone, while the transgressive lower part of the formation frequently referred to as the "brown dense" is a lime mudstone, wackestone or dolostone. The thickness of the Smackover ranges from 0 feet along its updip limit of deposition to more than 1,000 feet in offshore Florida (well OCS-G-3886). Wakelyn (1977) reported an onshore thickness of 900 feet in southeastern Mississippi.

On cross section A-A' (fig. 6), the Smackover Formation increases in thickness to the south in the Mississippi interior salt basin in well 1643. Further to the south, the Smackover Formation pinches out on the north flank of the Wiggins arch as evidenced by its absence in well 2069. The Smackover Formation thickens rapidly to the southeast in the Mobile Bay area. On cross section B-B' (fig. 7), the Smackover Formation thickens to the south (well OCS-G-3886). The Smackover Formation increases in thickness to the southwest on cross section C-C' (fig. 8). A dramatic thickening of the Smackover Formation is illustrated on cross section D-D' (fig. 9) from the Mobile Bay area to the Pensacola Area (well OCS-G-3886). The Smackover Formation has a relatively constant thickness along strike from the Pensacola Area to the Destin Dome Area as seen on cross section D-D'.

Smackover carbonates in the northern Gulf rim have been interpreted as having been deposited in two depositional settings: on a carbonate shelf (Leiker, 1977) and/or on a carbonate ramp (Ahr, 1973; Mancini and Benson, 1980; Benson and Mancini, 1982; Cunningham, 1984). According to Moore (1984), the lower Smackover mudstones represent basin fill deposited in response to rapid transgression, whereas the upper Smackover represents regional shoaling upwards in response to a stillstand in sea level due to an equilibrium in sedimentation and subsidence rates. Smackover deposition in the northern Gulf has been interpreted by Mancini and Benson (1980) as closely approximating present-day ramp sedimentation in the Persian Gulf. Ramps associated with the Smackover Formation were probably formed by the Louann Salt. However, application of the ramp model as described by Ahr (1973) indicates that Smackover lithofacies should be distributed in bands that parallel the ancient Jurassic coastline, that the higher energy lithofacies should predominate in updip areas, and that grainstone should grade into mudstone downdip. This predicted sequence of lithofacies has been observed only in parts of southwestern Alabama, primarily in the Mississippi interior salt basin and possibly in the Apalachicola embayment area. The presence of grainstones in Mobile and Baldwin Counties and Mobile Bay in Alabama, which would have been offshore areas during Smackover deposition, is related to the Wiggins arch and Conecuh ridge which acted as basinward highs during Smackover time. Grainstones are found along the crest and flanks of these paleohighs, whereas lower energy lithofacies occur around the features. Grainstones are associated with paleotopographic highs, and mudstones were deposited between these highs (Mancini and Benson, 1980). In the study area, Smackover deposition took place in subtidal, intertidal, and supratidal environments that were influenced by the aforementioned paleotopographic highs (fig. 10-E).

In the Mississippi interior salt basin and the Conecuh and Manila embayments (fig. 2), distinctive Smackover lithofacies are present, suggesting variations in depositional conditions in these areas. Because of these distinct lithofacies in the aforementioned Smackover depocenters, Mancini and Benson (1980) have pointed out that ramp deposition does not completely explain Smackover deposition in southwestern Alabama and adjacent areas. In southwestern Alabama the lower Smackover lithofacies is principally a low-energy mudstone deposited during a marine transgression that was probably initiated during Late Norphlet time. The upper Smackover regressive lithofacies is predominantly a moderate- to high-energy subtidal and intertidal packstone to grainstone with secondary dolomite. Baria and others (1982) have reported the occurrence of "reefs" in the Smackover in southwestern Alabama. The reefs have been described as similar to those for sponge-algal buildups and patch "reefs" from the Upper Jurassic of Europe. Smackover "reefs" are commonly elongate, 10 to 130 feet thick and cover several square miles.

In southwestern Alabama, the Conecuh ridge separates the Conecuh and Manila embayments (fig. 2) and Smackover carbonates thin to less than 100 feet (fig. 11) over this structural trend (Mancini and Benson, 1980). Seismic and gravity data suggest that the Wiggins arch and Conecuh ridge acted as stable basement highs throughout Smackover deposition (Wilson, 1975).

The northwest-southeast trend of Smackover lithofacies in southwestern Alabama is generally similar to the current strike of the regional structural configuration. The continuation of this structural and stratigraphic trend should continue across Baldwin County, Alabama, and Escambia, Santa Rosa, and Okaloosa Counties, Florida. In the Gulf of Mexico, similar lithofacies trend easterly to the Apalachicola embayment and into the Destin Dome Area.

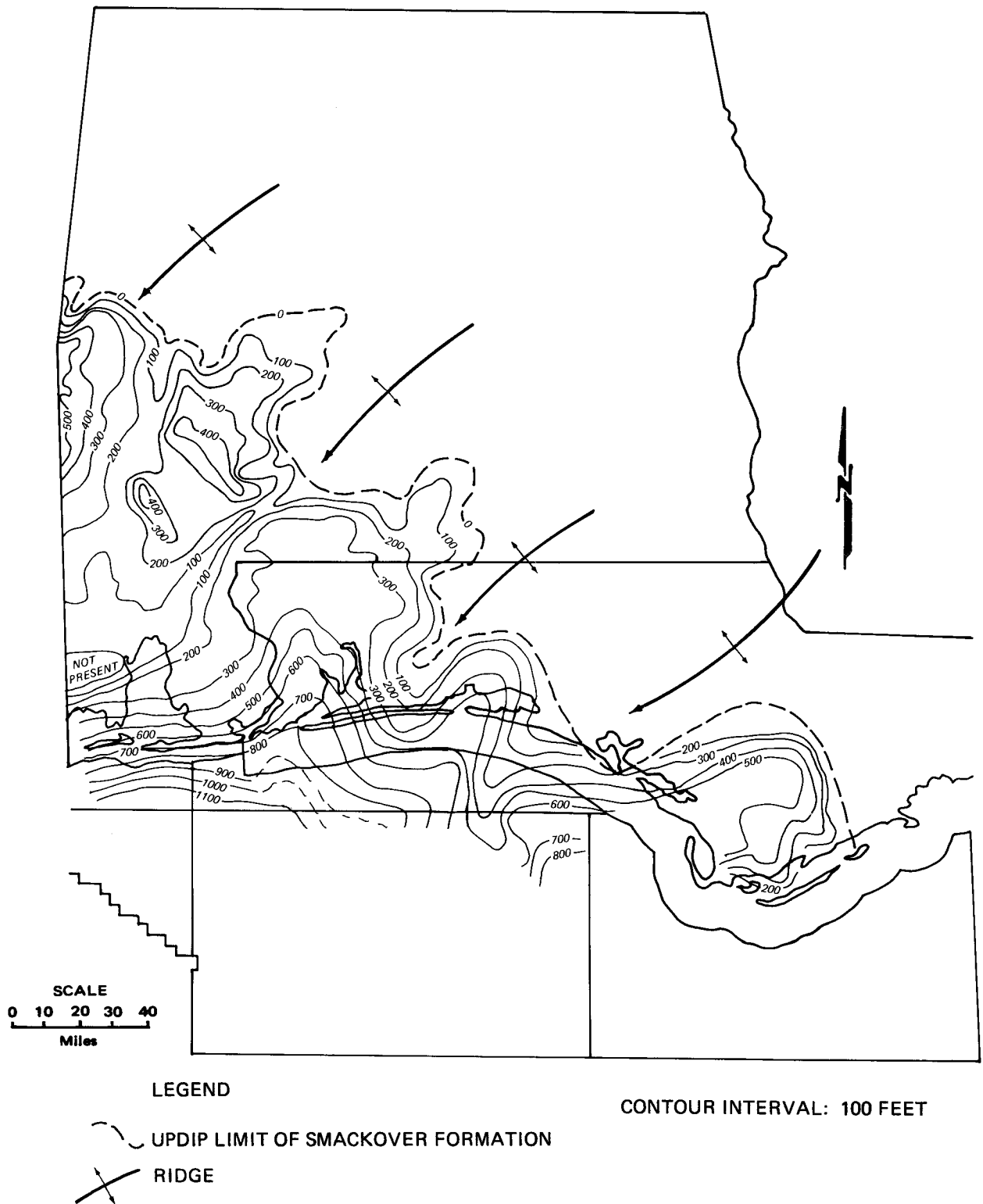


Figure 11.--Regional isopach map of Smackover Formation for the study area.

NORPHLET FORMATION

The Norphlet Formation of Late Jurassic (Oxfordian) age (Imlay, 1980) unconformably overlies the Louann Salt, the Werner Formation, Eagle Mills Formation (Triassic) or undifferentiated basement rocks of probable Paleozoic age. The formation is present in the subsurface throughout most of the study area, but the character and thickness are incompletely known because most of the Jurassic test wells are completed in the overlying Smackover Formation or are terminated within the Norphlet. The Norphlet in the study area ranges in thickness from 0 (updip limit) to possibly as much as 1,400 feet (Pepper, 1982) in the Mississippi interior salt basin (fig. 12). The Norphlet is overlain by the Smackover Formation.

Badon (1975), Wilkerson (1981), Pepper (1982), and Mancini and others (1985) recognize four lithofacies within the Norphlet Formation, and these are a discontinuous and localized basal shale, an updip conglomeratic sandstone, red beds, and an upper quartzose sandstone (Denkman Sandstone Member of Tyrrell, 1972). The basal shale has a discontinuous distribution in the study area. The conglomeratic sandstone occurs along the updip margins of the region. The red beds extend downdip into the inner margins of the salt basin and embayments of the region and the quartzose sandstone lithofacies occurs in the downdip and central parts of the salt basin and embayments in the study area (fig. 10-D).

The Norphlet Formation is thickest in the Mississippi interior salt basin on cross section A-A' (fig. 6) in well 1643. The Norphlet pinches out on the north flank of the Wiggins arch on cross section A-A' as shown in well 2069. The Norphlet thickens into the Mobile Bay area (well 2543-OS-3B) on cross section A-A'. The Norphlet Formation apparently pinches out (fig. 7) in the Pensacola Bay area (East Bay area) on the Pensacola ridge (cross section B-B', well F 1097); however, facies relationships in this area are not completely understood. The Norphlet increases in thickness into the offshore Pensacola Area and exhibits a facies change (well OCS-G-3886, cross section B-B') wherein the Norphlet becomes an interbedded carbonate, sandstone and shale lithofacies. Norphlet sandstones pinch out along the updip edge of the Apalachicola embayment (fig. 8, cross section C-C') as illustrated in well 730. The Norphlet Formation is locally thick in the Apalachicola embayment (well 769) and pinches out onto basement rocks in a southwesterly direction (well 670) on cross section C-C'. In the Destin Dome Area, the Norphlet thickens (cross section C-C', well 563) and is of fairly constant thickness along strike except where it pinches out against the Louann Salt in well OCS-G-2490 on cross section D-D'. The approximate location of the facies change present in the Norphlet Formation in well OCS-G-3886 is shown on cross section D-D' (fig. 9).

The Norphlet was deposited in several distinct environments, which include alluvial fan and plain, wadi, eolian, intertidal, and beach to shoreface (Badon, 1975; Sigsby, 1976; Wilkerson, 1981; Pepper, 1982; Mancini and others, 1985). The conglomeratic and red bed lithofacies were deposited in alluvial fan and plain and wadi environments. The shale lithofacies is representative of lagoonal or mudflat deposition related to a retreating Louann sea. The quartzose sandstone has been interpreted as inland and/or coastal eolian dune deposits (Badon, 1975; Wilkerson, 1981; Pepper, 1982; Mancini and others, 1985). The uppermost sandstone beds represent marine beach-shoreface deposits (Sigsby, 1976).

The present regional structural trends of the Norphlet Formation (fig. 13) are very similar to those of the Smackover Formation. This same regional dip to the southwest was a controlling factor in the distribution of Norphlet lithofacies, which are generally aligned in bands trending northwest-southeast.

The accumulation of thick Jurassic salt deposits, anhydrites, and red beds in association with Norphlet sandstone suggests that arid climatic conditions were prevalent during Norphlet deposition. Usually an association of salt, anhydrite and red bed lithologies indicates arid climatic conditions, and eolian sands can be expected to accumulate under such depositional conditions (Walker, 1967).

The area in and around the study area contains southward projections of features of the Appalachian ridges. Features associated with Norphlet deposition include the Wiggins arch, the Conecuh ridge and the Pensacola ridge. These paleohighs were probably of importance during

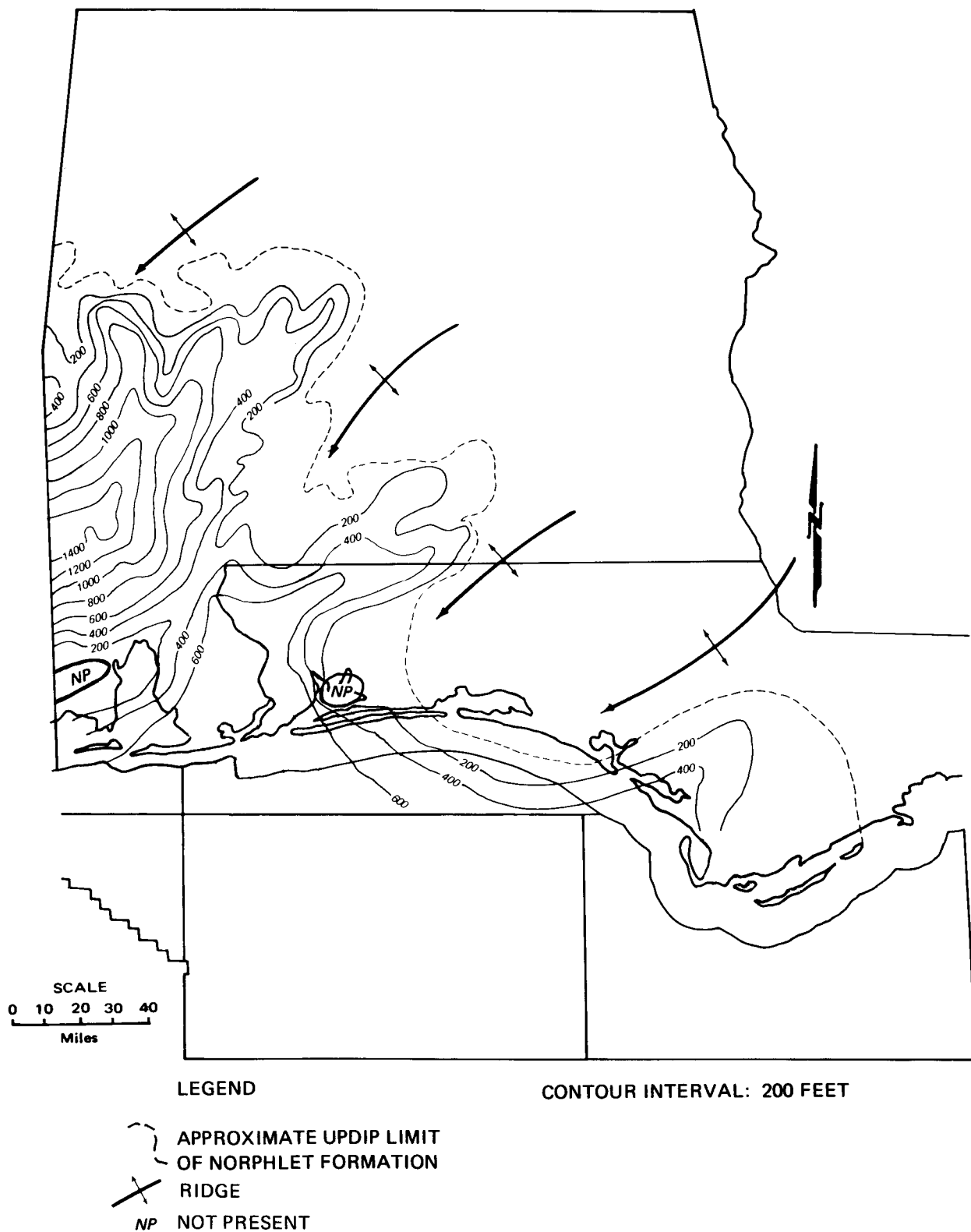


Figure 12.--Regional isopach map of Norphlet Formation for the study area (modified in part from Pepper, 1982, and Pontigo, 1982).

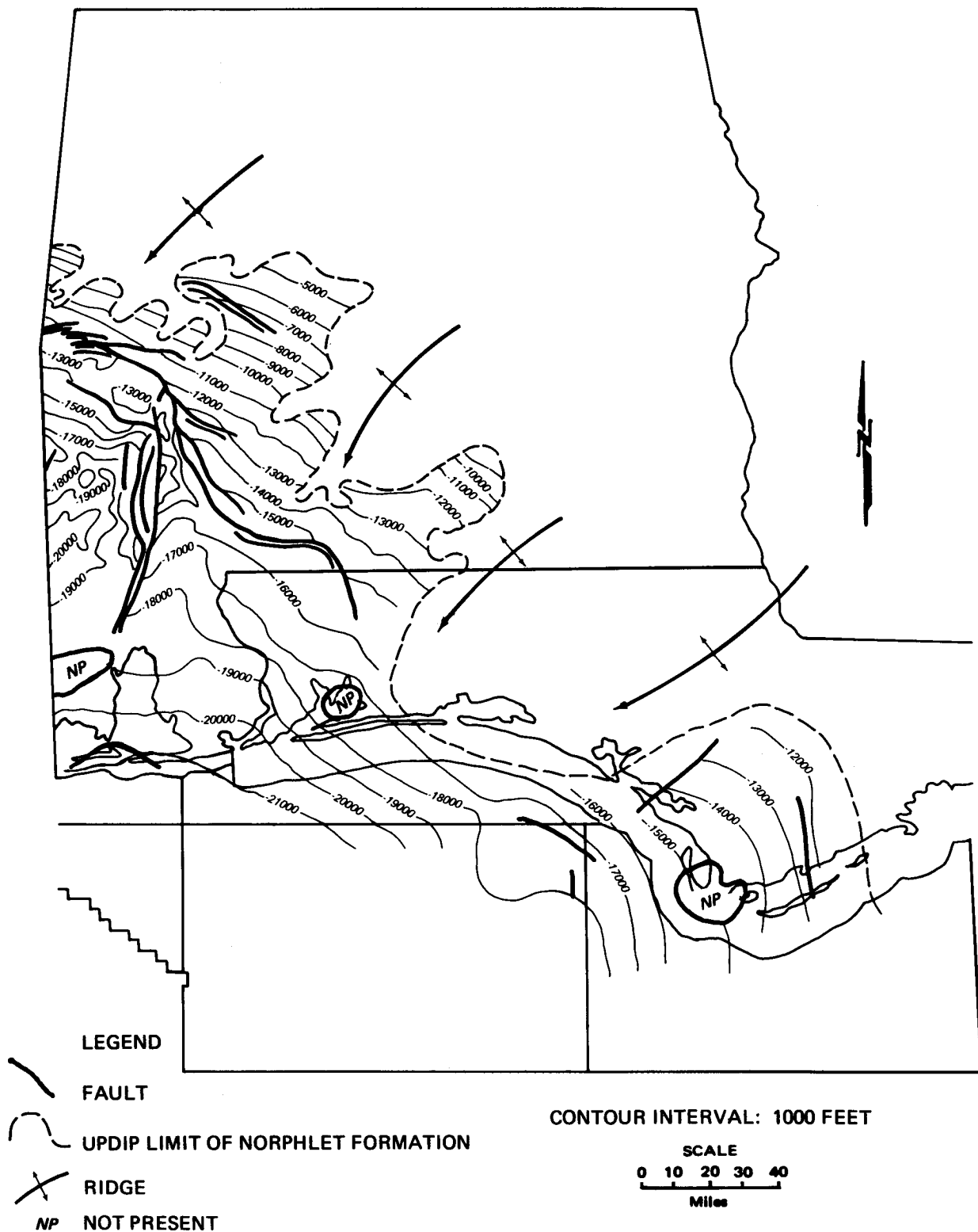


Figure 13.--Regional structure map of top of Norphlet Formation for the study area (modified in part from Pontigo, 1982, and Wilson and Tew, 1985).

Norphlet time in that they provided local sediment sources and influenced Norphlet deposition and sedimentation (Sigsby, 1976; Wilkerson, 1981).

The sequence of deposition of the Norphlet (fig. 10-D) and associated facies would include accumulation of intertidal shale in isolated lagoons or bays along an emerging shoreline, followed by Norphlet sandstone accumulation initiated with the uplift and erosion of the Appalachian system. Conglomeratic sandstones were deposited in alluvial fans while red beds accumulated in alluvial fan and plain and wadis. Sand from these environments was transported toward the coast across a desert plain. Subsequent reworking of this sand led to the Norphlet dune and interdune facies. A marine transgression initiated in Late Norphlet time resulted in the reworking of underlying sediments. The marine transgression continued into Smackover time.

Excellent ancient analogs for the mode of deposition of the Norphlet Formation are the Permian sandstones of the North Sea (Gage, 1980; Glennie and Buller, 1983) and of Scotland (Clemmensen and Abrahamsen, 1983).

LOUANN SALT

In the study area, the Louann Salt (Callovian and Oxfordian) consists of a silty, sandy, massive halite with interbedded anhydrite (Tolson and others, 1983). The upper part of the Louann is informally referred to as the Pine Hill Anhydrite Member (Oxley and Minihan, 1969) (fig. 3). The Louann is an extensive evaporite covering an estimated area of 180,000 square miles in the Gulf of Mexico region (Hazzard and others, 1947). The Louann is usually considered to be economic basement in oil and gas test wells drilled in the study area, and thus, the maximum thickness of the salt in the region is unknown (Tolson and others, 1983). The Louann is reported to reach thicknesses as great as 6,000 feet in the Mississippi interior salt basin (Wilson, 1975). The Louann salt sequence represents evaporitic deposition in a restricted shallow-water to deep-water basin most likely associated with the initial opening of the Gulf of Mexico (fig. 10-C). Salt tectonics associated with Louann flowage in the onshore tri-state area and adjacent offshore areas have resulted in the numerous petroleum traps (salt anticlines, faulted salt anticlines, and extensional fault systems) that are present in the region. The Louann overlies the Werner Formation in some areas and Paleozoic rocks in others (fig. 10-C). The Louann Salt was encountered in the Pensacola Area (well OCS-G-3886), the Apalachicola embayment (well F 769), and the Destin Dome Area (wells OCS-G-2486, OCS-G-2502, OCS-G-2490, and OCS-G-3890; figs. 6, 7, and 8); however, the thickness is unknown since these wells did not penetrate the full section of salt.

WERNER FORMATION

The Werner Formation (Callovian) is an evaporite sequence representing the initial transgression of marine waters into the Gulf of Mexico basin (Tolson and others, 1983). The Werner consists of red, gray, and black shale, gray and red sandstone, conglomerate, salt and anhydrite and overlies the Triassic Eagle Mills Formation (fig. 10-A) or Paleozoic basement rocks in the study area (fig. 3). Werner deposition in the region was controlled by basement structure or by deposition near its updip limit (fig. 10-B). Sediments comprising the Werner Formation may possibly represent deposition in a deep-water evaporitic basin as described by Schmalz (1969) or in a shallow-water newly forming restricted basin (Tolson and others, 1983). No wells penetrated the Werner Formation in the offshore Florida area; however, the Werner is present in well 1862 on the north flank of the Wiggins arch in Mobile County, Alabama, (fig. 6, cross section A-A') and further to the north in well 3589, Choctaw County, Alabama.

GEOLOGICAL CHARACTERIZATION OF JURASSIC HYDROCARBON TRENDS

COTTON VALLEY GROUP

The Cotton Valley Group of Kimmeridgian to Tithonian age has produced more than 77,600,000 barrels of oil and 54,400,000 thousand cubic feet of gas from 51 fields in Mississippi and 1 discovery

in southwestern Alabama (table 1). Sands of the Cotton Valley Group comprise the chief reservoir rocks, and although no recent discoveries have been made in southwestern Alabama, the Cotton Valley has been shown to be productive with the discovery of oil in the Phillips Petroleum Company No. 1 Harrel "C" well (Permit No. 1482) drilled in 1968 near Okatuppa Creek in Choctaw County. Before this well was plugged in 1971, it produced more than 53,000 barrels of oil from Cotton Valley strata from a depth of 8,794 to 8,798 feet. The well was never put into an established petroleum field. The Cotton Valley Group in Mississippi has produced from numerous fields, the majority of which are associated with structural traps, principally salt anticlines and faulted salt anticlines similar to the Diamond field in Wayne County (fig. 14). Through 1984, the Diamond field has produced in excess of 4,000,000 barrels of oil and 1,800,000 thousand cubic feet of gas from an elongate faulted anticlinal structure associated with salt. Productive Cotton Valley sands in the Diamond field range from approximately 12,000 to 12,500 feet in depth.

The main productive hydrocarbon trends of the Cotton Valley Group in the study area (fig. 15) occur downdip from the Pickens-Gilbertown fault systems in the central Mississippi interior salt basin and along the Hancock County ridge in southern Mississippi. To date, no productive Cotton Valley strata have been encountered in offshore Alabama, the Florida panhandle, or offshore Florida. However, this trend may be potentially productive in the offshore where geologic conditions may have been favorable for Cotton Valley hydrocarbon preservation. Cotton Valley sands have been proven productive of natural gas at depths as deep as 19,816 to 20,038 feet in southern Mississippi (Sannes and Hancock, 1982). Potential petroleum traps in the Cotton Valley Group in the study area are likely to be similar to the Cotton Valley traps in Mississippi--that is, structural traps associated with salt movement downdip from the regional peripheral fault trend. The key to discovering new Cotton Valley fields in the area is the delineation of salt-induced structures in the Jurassic strata that directly affect Cotton Valley sands. The Mobile, Pensacola and Destin Dome Areas possibly have potential for Cotton Valley production.

HAYNESVILLE FORMATION

To date, no petroleum discoveries have been made in the Haynesville Formation in Alabama or Florida; however, conditions (Louann Salt flowage) have been favorable for hydrocarbon production in Mississippi. Haynesville/Buckner production has occurred in Mississippi since 1969. Eleven Haynesville/Buckner fields have produced over 2,800,000 barrels of oil and 4,600,000 thousand cubic feet of gas (table 2). The productive trend in Mississippi (fig. 16) is principally the result of hydrocarbon accumulations associated with fault traps and/or salt anticlines downdip to the Pickens-Gilbertown fault systems. An example of one of the fields is the Bay Springs field (fig. 17), which has produced more than 150,000 barrels of oil and 192,030 thousand cubic feet of gas since its discovery in 1978. The structure in the Bay Springs field is a salt anticline.

The hydrocarbon trend of the Haynesville/Buckner strata in Mississippi (fig. 16) is principally along the regional peripheral fault trend. This trend may extend across southwestern Alabama and panhandle Florida into the offshore area. It is postulated that Haynesville/Buckner hydrocarbon traps in the offshore area would be similar to the Haynesville/Buckner traps in Mississippi and, similarly, would be related to salt anticlines and/or fault traps downdip to the regional peripheral fault trend. The Pensacola and Destin Dome Areas possibly have potential for Haynesville/Buckner production.

SMACKOVER FORMATION

The Smackover Formation is the most prolific hydrocarbon reservoir in southwestern Alabama (table 3). In Mississippi, Alabama, and Florida, the Smackover productive trends occur along the edge of Jurassic deposition updip to the regional peripheral fault trend, in the Mississippi interior salt basin, and along the Mobile graben (fig. 18). Through December 1984, 121 Smackover fields and pools have been discovered in the tri-state area and have resulted in the production of more than 569,800,000 barrels of oil, 63,700,000 barrels of condensate, and 1,500,000,000 thousand cubic feet of gas. The largest field in the area is the Jay field (fig. 19) in Santa Rosa County, Florida (table 3 and

Table 1.--Cotton Valley fields of Mississippi¹ and Alabama^{2, 3}

Field number	Field	Discovery date	County	Cumulative production through 1984	
1	Bay Springs	1965	Jasper	31,765,259	BO ⁴
				17,588,484	MCFG ⁵
2	Bay Springs (13,300' sand)	1966	Jasper	460,675	BO
				339,452	MCFG
3	Bovina	1982	Warren	2,737	BO
				1,756,769	MCFG
4	Bryan	1969	Jones	4,017,486	BO
				533,926	MCFG
5	Calhoun	1975	Jones	378,495	BO
				1,749,456	MCFG
6	Catahoula Creek	1981	Hancock	3,739,777	MCFG
7	Chaparral	1968	Wayne	18,139	BO
				495	MCFG
8	Collins (gas pool)	1984	Covington	25,699	BO
				48,383	MCFG
	(oil pool)	1983	Covington	118,294	BO
				62,146	MCFG
9	Diamond (12,000')	1968	Wayne	2,877,100	BO
				1,099,397	MCFG
10	Diamond (12,350')	1969	Wayne	286,874	BO
				260,424	MCFG
11	Diamond (12,250')	1969	Wayne	568,327	BO
				246,583	MCFG
12	Diamond (12,100')	1970	Wayne	209,513	BO
				205,667	MCFG
13	Diamond (12,500')	1974	Wayne	223,638	BO
				57,954	MCFG
14	East Tallahala Creek	1968	Smith	1,025,925	BO
				1,259,021	MCFG
15	Glancy	1972	Copiah	870	BO
				94,172	MCFG
16	Lorena	1965	Smith	31,690	BO
				3,587	MCFG
17	Martinville	1977	Simpson	236,746	BO
				95,843	MCFG
18	McNeal	1973	Jasper	3,091,612	BO
				4,918,882	MCFG

¹Data derived from the Mississippi State Oil and Gas Board.²Data derived from the State Oil and Gas Board of Alabama.³Only one oil discovery--Okatuppa Creek--is in Alabama.⁴BO = barrels of oil.⁵MCFG = thousand cubic feet of gas.⁶Okatuppa Creek was never given an official field status and is considered an informal field.

Table 1.--Cotton Valley fields of Mississippi¹ and Alabama^{2,3} - Continued

Field number	Field	Discovery date	County	Cumulative production through 1984	
19	Mechanicsburg (Ferguson oil pool)	1980	Yazoo	23,624 BO 7,958 MCFG	
20	Mechanicsburg (gas pool)	1980	Yazoo	55,948 BO 530,976 MCFG	
21	Mill Creek	1979	Wayne	2,366 BO	
22	Missionary	1971	Jasper	795,770 BO 4,248 MCFG	
23	Mossville	1977	Jasper	1,447 BO	
24	Newman	1984	Hinds	288,710 MCFG	
25	Okatuppa Creek ⁶	1968	Choctaw	53,087 BO	
26	Orange	1980	Jasper	96,125 BO	
27	Pool Creek	1964	Jones	1,251,015 BO 326,467 MCFG	
28	Quitman (11,150')	1966	Clarke	7,697,182 BO 2,271,075 MCFG	
29	Quitman (11,000')	1966	Clarke	2,513,075 BO 652,378 MCFG	
30	Quitman (9,700')	1967	Clarke	433,982 BO 116,389 MCFG	
31	Quitman (10,150')	1967	Clarke	1,125,699 BO 307,461 MCFG	
32	Quitman (11,175)	1969	Clarke	2,175,018 BO 477,531 MCFG	
33	Quitman (10,500)	1969	Clarke	90,776 BO 21,111 MCFG	
34	Reedy Creek	1977	Jones	1,254,316 BO 1,899,484 MCFG	
35	Satartia	1970	Yazoo	12,377 BO 82,124 MCFG	
36	Sharon	1981	Jasper	10,382 BO 9,450 MCFG	
37	Shelton Creek	1976	Jones	22,050 BO 12,992 MCFG	
38	Shongelo Creek	1966	Smith	874,240 BO 1,220,010 MCFG	
39	Soso	1958	Jasper	1,537,020 BO 586,695 MCFG	

¹Data derived from the Mississippi State Oil and Gas Board.²Data derived from the State Oil and Gas Board of Alabama.³Only one oil discovery--Okatuppa Creek--is in Alabama.⁴BO = barrels of oil.⁵MCFG = thousand cubic feet of gas.⁶Okatuppa Creek was never given an official field status and is considered an informal field.

Table 1.--Cotton Valley fields of Mississippi¹ and Alabama^{2, 3} - Continued

Field number	Field	Discovery date	County	Cumulative production through 1984	
40	South Summerland	1974	Jones	482,770 BO	169,582 MCFG
41	Stringer (Middle Cotton Valley)	1969	Jasper	1,002,110 BO	1,038,501 MCFG
42	Stringer (Upper Cotton Valley)	1970	Jasper	12,192 BO	168,443 MCFG
43	Stringer (14,800')	1970	Jasper	166,291 BO	52,056 MCFG
44	Tallahala Creek	1966	Smith	3,101,880 BO	9,293,781 MCFG
45	Waldrup	1973	Jasper	594,238 BO	8,409 MCFG
46	West Clara	1970	Wayne	32,846 BO	17,430 MCFG
47	West Eucutta	1984	Wayne	25,635 BO	
48	West Heidelberg	1959	Jasper	5,265,641 BO	358,371 MCFG
49	West Yellow Creek (Upper Cotton Valley)	1962	Wayne	1,010,531 BO	244,096 MCFG
50	West Yellow Creek (Lower Cotton Valley)	1962	Wayne	431,781 BO	194,364 MCFG
51	Winchester (12,611')	1969	Wayne	163,737 BO	52,342 MCFG
52	Winchester (12,918')	1969	Wayne	26,912 BO	8,304 MCFG

¹Data derived from the Mississippi State Oil and Gas Board.

²Data derived from the State Oil and Gas Board of Alabama.

³Only one oil discovery--Okatuppa Creek--is in Alabama.

⁴BO = barrels of oil.

⁵MCFG = thousand cubic feet of gas.

⁶Okatuppa Creek was never given an official field status and is considered an informal field.

fig. 18), which was discovered in 1970 and since that time has produced over 339,300,000 barrels of oil and 426,300,000 thousand cubic feet of gas.

Smackover petroleum traps in the onshore tri-state area are principally structural involving basement paleohighs, salt anticlines, faulted salt anticlines, and extensional fault systems and combination structural-stratigraphic traps involving porosity pinch-outs and reefs associated with paleotopography. According to Moore (1984), five major trap types are common in the Smackover in the northern Gulf rim, and these are mechanical (faulting and folding) traps, salt anticlines, basement structures (no salt or thin salt), complex graben systems and stratigraphic traps. Subtle salt-cored anticlines are perhaps the most common and most important trap type in the Smackover. These anticlinal features are generally elongate faulted structures, which began to form in response to loading from overlying sediments.

Petroleum traps in the Smackover Formation in southwestern Alabama, according to Mancini and Benson (1980), are principally combination traps involving favorable stratigraphy and salt

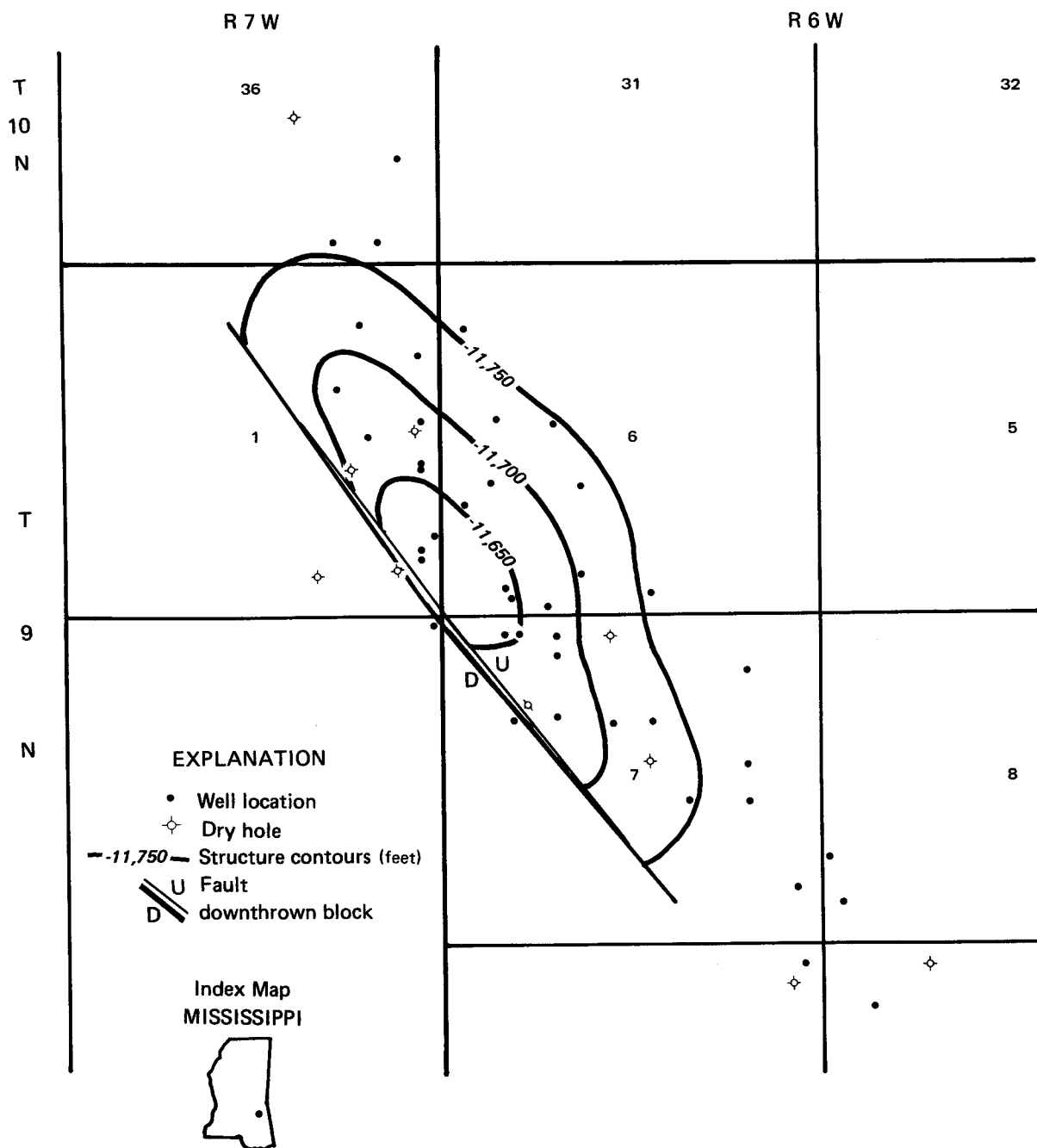


Figure 14.--Structure map of the Cotton Valley Group in Diamond field, Wayne County, Mississippi (modified from Davis and Lambert, 1963).

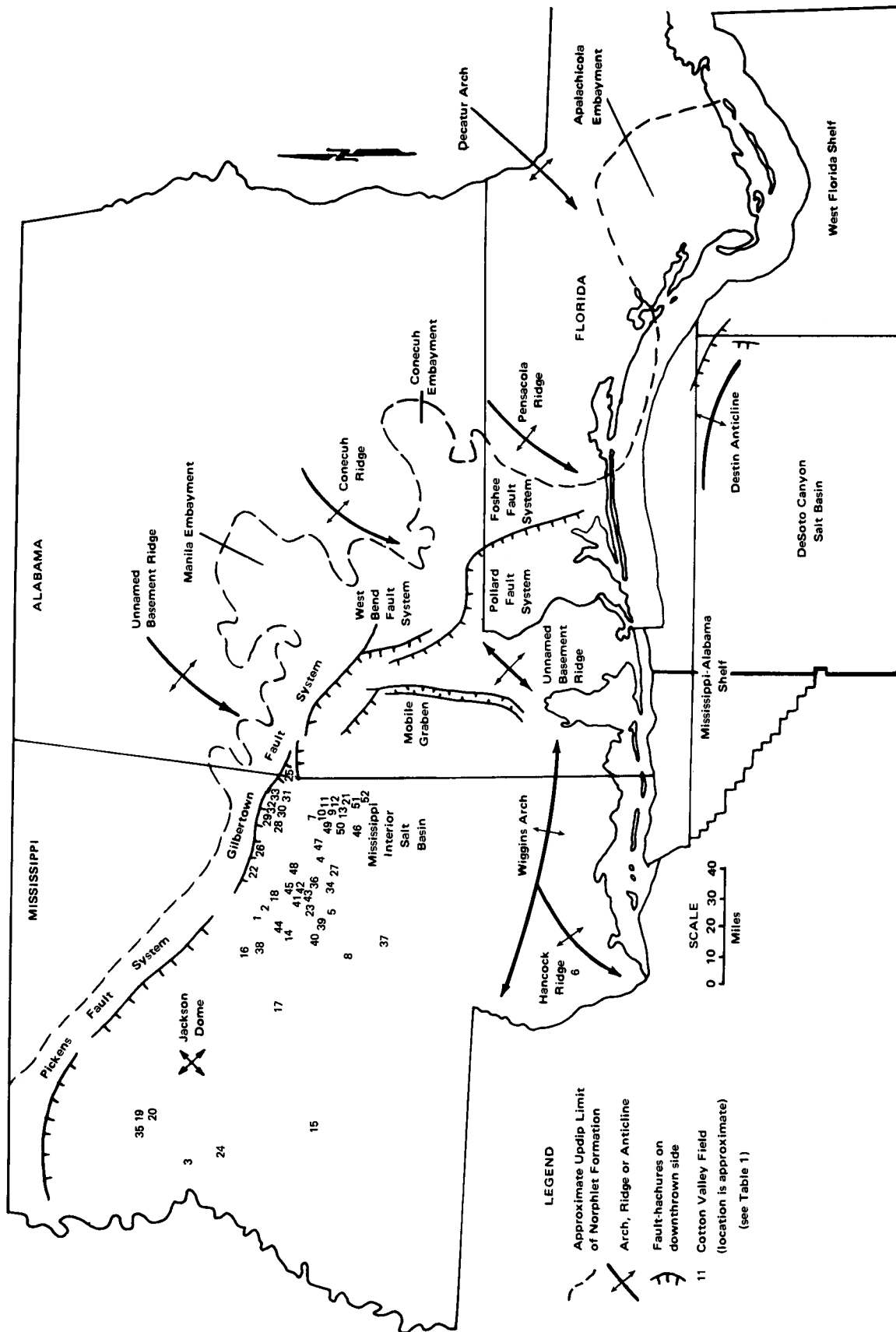


Figure 15.--Regional trend map of Cotton Valley producing fields in the study area.

Table 2.--Haynesville/Buckner fields of Mississippi¹

Field number	Field	Discovery date	County	Cumulative production through 1984	
1	Barnett	1975	Clarke	5,491	BO ²
2	Bay Springs	1978	Jasper	150,266	BO
				192,830	MCFG ³
3	Boykin Church	1971	Smith	3,737	BO
				810	MCFG
4	Morton	1976	Scott	77,308	BO
				9,206	MCFG
5	North Nancy	1974	Clarke	28,865	BO
				1,427	MCFG
6	South Summerland	1974	Jones	1,669,825	BO
				1,681,590	MCFG
7	Stafford Springs	1970	Jasper	28,524	BO
				122,825	MCFG
8	Stringer	1970	Jasper	489	BO
				147	MCFG
9	West Barnett	1975	Jasper	201,049	BO
				75,748	MCFG
10	West Nancy	1970	Clarke	331,456	BO
				1,265,537	MCFG
11	West Paulding	1969	Jasper	336,347	BO
				1,295,031	MCFG

¹Data derived from the Mississippi State Oil and Gas Board.

²BO = barrels of oil.

³MCFG = thousand cubic feet of gas.

movement. In the Conecuh embayment, faulted salt anticlines, and salt anticlines associated with the Pollard-Foshee fault systems such as the Jay-Little Escambia Creek fields (fig. 19) are the principal petroleum traps. In the Mississippi interior salt basin, petroleum traps are principally salt anticlines, such as Chatom and Chunchula (fig. 20), or faulted salt anticlines, such as the Hatter's Pond field. In the Manila embayment, basement paleohighs similar to that at Vocation field (fig. 21) are the principal petroleum traps.

Smackover reservoir rocks in the tri-state area include grainstones, leached and dolomitized wackestones, packstones and grainstones, and dolostones (Ottmann and others, 1973; Sigsby, 1976; Mancini and Benson, 1980; Baria and others, 1982; Jackson and Harris, 1982; Bradford, 1984; Vinet, 1984). In addition, Smackover sandstones can be productive in Mississippi as reported by Olsen (1982). Porosity is both primary (interparticulate) and secondary resulting from the dolomitization and leaching of grainstones. Smackover reservoirs in the Mississippi interior salt basin are typically leached and dolomitized grainstones with intercrystalline dolomite and grain moldic porosity. In the Manila embayment, reservoir rocks are primarily dolostones with intercrystalline dolomite and minor fracture porosity (Mancini and Benson, 1980; Cunningham, 1984). Reservoir rocks in the Conecuh embayment are dolomitized peloidal packstones and wackestones that have intercrystalline dolomite and grain moldic porosity (Oxley and others, 1967; Sigsby, 1976; Mancini and Benson, 1980; Bradford, 1984; Vinet, 1984). Smackover reservoir rocks also include reefal boundstones, which are similar to the sponge-algal buildups of the Jurassic in Europe (Baria and others, 1982).

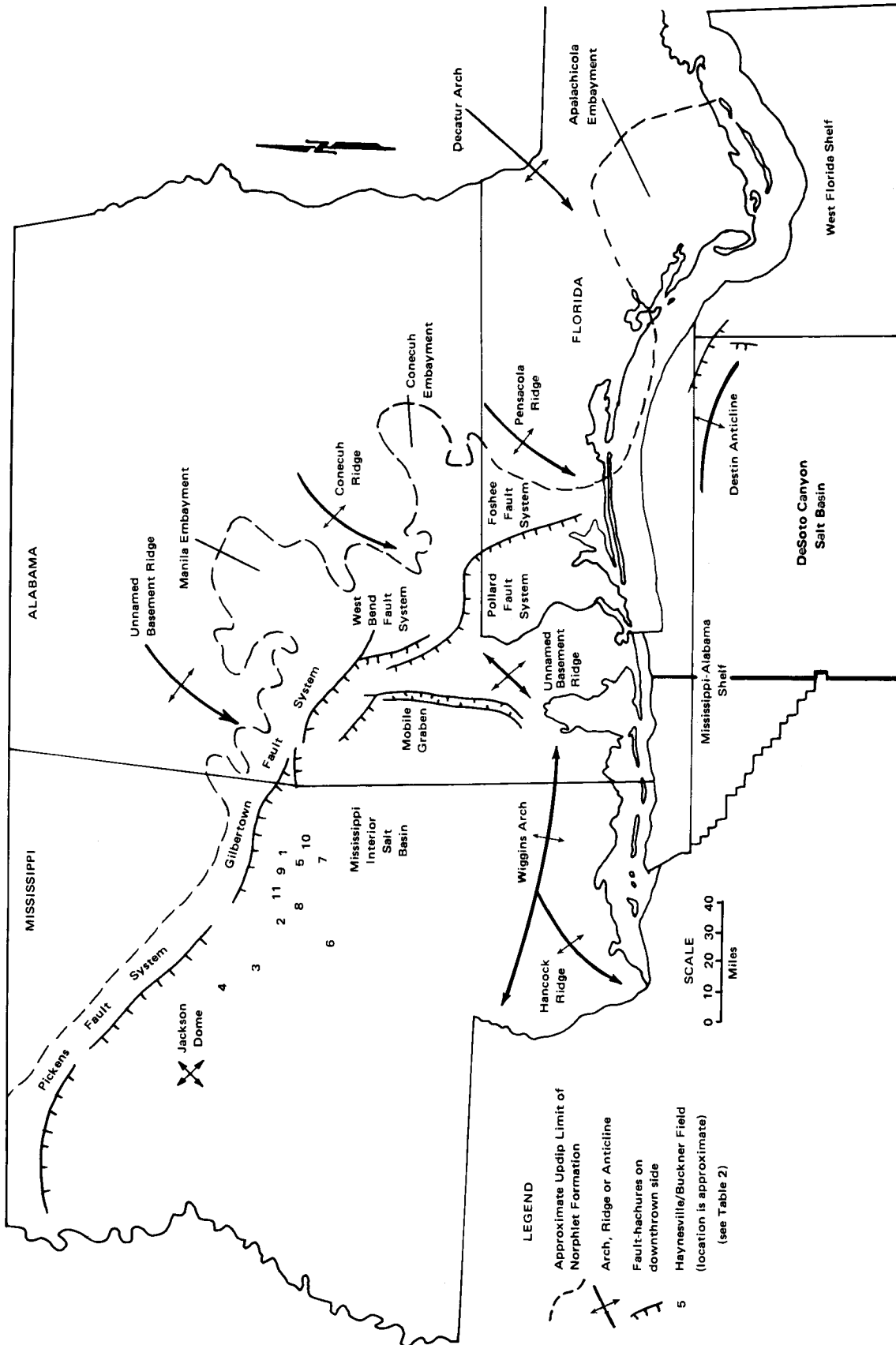


Figure 16.--Regional trend map of Haynesville/Buckner producing fields in the study area.

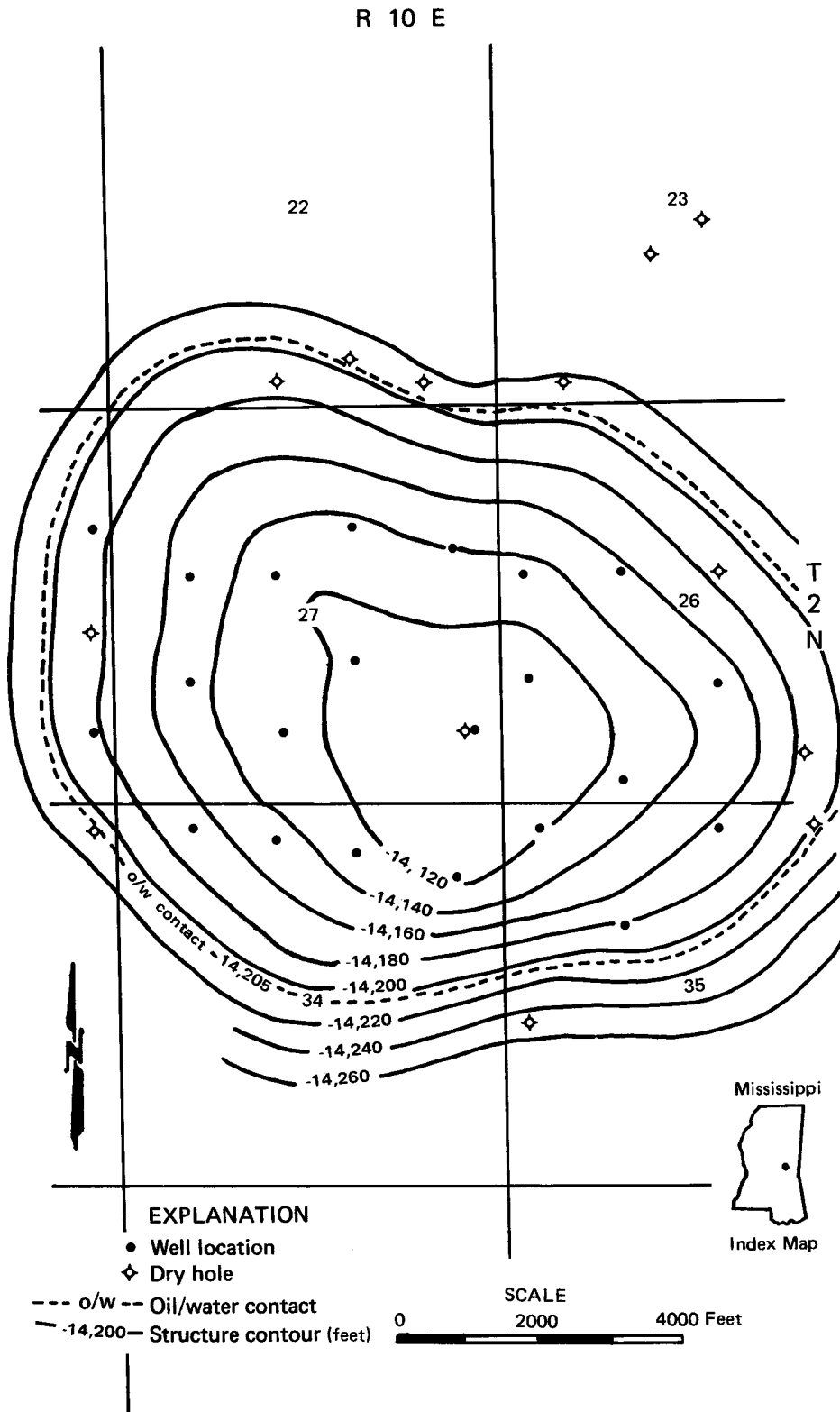


Figure 17.--Structure map of the Haynesville "14,500' Pay Sand" in Bay Springs field, Jasper County, Mississippi (modified from Davis and Lambert, 1963).

Table 3.--Smackover fields of Mississippi,¹ Alabama,² and Florida³

Field number	Field	Discovery date	County and state	Cumulative production through 1984	
1	Barber Creek	1964	Scott, Miss.	538,883	BO ⁴
				90,302	MCFG ⁵
2	Barnett	1974	Clarke, Miss.	889,514	BO
				271,833	MCFG
3	Barnett	1975	Conecuh and Escambia, Ala.	274,801	BO
				328,695	MCFG
4	Barrytown	1972	Choctaw, Ala.	2,687,181	BO
				1,103,101	MCFG
5	Belzoni	1971	Humphreys, Miss.	42,944	BO
				3,887	MCFG
6	Benton	1977	Yazoo, Miss.	13,278	BO
				122,014	MCFG
7	Bienville Forrest	1963	Smith, Miss.	380,118	BO
				179,251	MCFG
8	Big Escambia Creek	1972	Escambia, Ala.	25,613,952	BC ⁶
				349,327,823	MCFG
9	Black Creek	1965	Perry, Miss.	6,900	MCFG
10	Blackjack Creek	1972	Santa Rosa, Fla.	50,463,000	BO
				46,057,000	MCFG
11	Blacksher	1980	Baldwin, Ala.	712,702	BO
				730,334	MCFG
12	Boyce	1973	Wayne, Miss.	189,732	BO
				300,597	MCFG
13	Bucatumna Creek	1977	Clarke, Miss.	427,766	BO
				76	MCFG
14	Bucatumna Creek	1978	Choctaw, Ala.	731,558	BO
				268,654	MCFG
15	Chappell Hill	1977	Choctaw, Ala.	1,129,874	BO
				553,797	MCFG
16	Chatom	1970	Washington, Ala.	9,924,018	BC
				53,333,738	MCFG
17	Choctaw Ridge	1967	Choctaw, Ala.	3,180,020	BO
				1,831,730	MCFG
18	Chunchula	1974	Mobile, Ala.	27,586,257	BC
				70,343,224	MCFG

¹Data derived from the Mississippi State Oil and Gas Board.²Data derived from the State Oil and Gas Board of Alabama.³Data derived from the Florida Department of Natural Resources.⁴BO = barrels of oil⁵MCFG = thousand cubic feet of gas.⁶BC = barrels of condensate.⁷No production.

Table 3.--Smackover fields of Mississippi,¹ Alabama,² and Florida³ - Continued

Field number	Field	Discovery date	County and state	Cumulative production through 1984	
19	Cold Creek	1978	Mobile, Ala.	495,413 BO 494,871 MCFG	
20	Copeland	1972	Washington, Ala.	654,248 BC 10,547,236 MCFG	
21	Cypress Creek	1968	Wayne, Miss.	2,601,197 BO 700,573 MCFG	
22	Davis	1969	Clarke, Miss.	(7)	
23	DeSoto	1978	Clarke, Miss.	42,096 BO	
24	Double Creek	1968	Clarke, Miss.	97,642 BO	
25	East Barber Creek	1970	Scott, Miss.	417,539 BO 318,274 MCFG	
26	East Nancy	1968	Clarke, Miss.	5,654,054 BO 2,915,786 MCFG	
27	East Paulding	1966	Jasper, Miss.	29,762 BO 4,882 MCFG	
28	East Quitman	1981	Clarke, Miss.	22,481 BO	
29	East Tallahala Creek (Smackover B pool)	1967	Smith, Miss.	1,694,289 BO 1,399,625 MCFG	
30	East Tallahala Creek (Smackover A pool)	1967	Smith, Miss.	2,449,510 BO 2,141,919 MCFG	
31	East Tallahala Creek (A & B commingled pool)	1971	Smith, Miss.	2,030 BO 1,219 MCFG	
32	East Tallahala Creek (Smackover C pool)	1971	Smith, Miss.	574,640 BO 346,786 MCFG	
33	East Yellow Creek	1980	Wayne, Miss.	11,307 BO	
34	Fanny Church	1973	Escambia, Ala.	3,480,469 BO 5,168,138 MCFG	
35	Fluffer Creek	1983	Clarke, Miss.	444 BO	
36	Fomosla	1971	Humphreys, Miss.	126,114 BO 1,364,725 MCFG	
37	Garland Creek	1971	Clarke, Miss.	74,220 BO	
38	Goodwater	1969	Clarke, Miss.	4,465,872 BO 7,703,994 MCFG	
39	Hale	1973	Clarke, Miss.	909,486 BO 257,113 MCFG	

¹Data derived from the Mississippi State Oil and Gas Board.²Data derived from the State Oil and Gas Board of Alabama.³Data derived from the Florida Department of Natural Resources.⁴BO = barrels of oil⁵MCFG = thousand cubic feet of gas.⁶BC = barrels of condensate.⁷No production.

Table 3.--Smackover fields of Mississippi,¹ Alabama,² and Florida³ - Continued

Field number	Field	Discovery date	County and state	Cumulative production through 1984	
40	Harmony	1968	Clarke, Miss.	1,779,514	BO
				639,827	MCFG
41	Healing Springs	1978	Washington, Ala.	(7)	
42	Horseshoe Lake	1976	Holmes, Miss.	775,286	BO
				6,961,558	MCFG
43	Huxford	1982	Escambia, Ala.	103,447	BO
				188,448	MCFG
44	Jay	1970	Escambia and Santa Rosa, Fla.	339,382,000	BO
				426,336,000	MCFG
45	Johns	1980	Rankin, Miss.	9,808,096	MCFG
46	Jonathan	1961	Greene, Miss.	(7)	
47	Lake Como (Smackover A pool)	1971	Jasper, Miss.	512,920	BO
				790,436	MCFG
48	Lake Como (Smackover B pool)	1971	Jasper, Miss.	352,046	BO
				481,117	MCFG
49	Lake Utopia (Upper Smackover)	1971	Jasper, Miss.	1,322,633	BO
				1,248,118	MCFG
50	Lake Utopia (Lower Smackover)	1971	Jasper, Miss.	1,564,710	BO
				826,334	MCFG
51	Little Escambia Creek	1970	Escambia, Ala.	27,597,667	BO
				35,373,977	MCFG
52	Little Mill Creek	1978	Choctaw, Ala.	359,207	BO
				380,050	MCFG
53	Little River	1981	Baldwin, Ala.	110,113	BO
				129,565	MCFG
54	Loring	1954	Madison, Miss.	1,134,273	BO
				63,320,228	MCFG
55	Lovetts Creek	1982	Monroe, Ala.	96,394	BO
				86,392	MCFG
56	Melvin	1977	Choctaw, Ala.	42,109	BO
57	Mill Creek	1975	Choctaw, Ala.	770,966	BO
				564,676	MCFG
58	Movico	1982	Mobile, Ala.	649,911	BO
				521,682	MCFG
59	Nancy	1967	Clarke, Miss.	4,584,409	BO
				2,576,923	MCFG

¹Data derived from the Mississippi State Oil and Gas Board.²Data derived from the State Oil and Gas Board of Alabama.³Data derived from the Florida Department of Natural Resources.⁴BO = barrels of oil⁵MCFG = thousand cubic feet of gas.⁶BC = barrels of condensate.⁷No production.

Table 3.--Smackover fields of Mississippi,¹ Alabama,² and Florida³ - Continued

Field number	Field	Discovery date	County and state	Cumulative production through 1984	
60	North Choctaw Ridge	1972	Choctaw, Ala.	4,725,704	BO
				2,634,779	MCFG
61	North Shubuta	1970	Clarke, Miss.	610,932	BO
				1,370,369	MCFG
62	Northwest Quitman	1981	Clarke, Miss.	25,484	BO
63	Otho	1982	Smith, Miss.	245,944	BO
				179,067	MCFG
64	Pachuta Creek (Smackover Pool)	1968	Clarke, Miss.	8,782,432	BO
				4,011,663	MCFG
64A	Pachuta Creek (Lower West Smackover)	1972	Clarke, Miss.	10,189,033	BO
				5,202,448	MCFG
65	Pachuta Creek (Smackover A pool)	1968	Clarke, Miss.	2,579,297	BO
				1,170,593	MCFG
66	Pachuta Creek (Smackover B pool)	1968	Clarke, Miss.	1,857,237	BO
				891,571	MCFG
67	Paulding	1969	Jasper, Miss.	85,389	BO
				41,910	MCFG
68	Perdido	1983	Escambia, Ala.	25,940	BO
				70,411	MCFG
69	Pineville	1980	Smith, Miss.	19,034	BO
				602	MCFG
70	Piney Woods	1971	Rankin, Miss.	42,014,706	MCFG
71	Pleasant Ridge	1984	Clarke, Miss.	67,890	BO
				14,033	MCFG
72	Pool Creek	1965	Jones, Miss.	1,750,678	BO
				648,351	MCFG
73	Prairie Branch	1970	Clarke, Miss.	3,411,829	BO
				2,324,296	MCFG
74	Puss Cuss Creek	1978	Choctaw, Ala.	64,388	BO
				54,626	MCFG
75	Quitman	1966	Clarke, Miss.	4,299,899	BO
				537,665	MCFG
76	Red Creek	1979	Washington, Ala.	(7)	
77	Reedy Creek	1977	Jones, Miss.	69,484	BO
				135,618	MCFG

¹Data derived from the Mississippi State Oil and Gas Board.²Data derived from the State Oil and Gas Board of Alabama.³Data derived from the Florida Department of Natural Resources.⁴BO = barrels of oil⁵MCFG = thousand cubic feet of gas.⁶BC = barrels of condensate.⁷No production.

Table 3.--Smackover fields of Mississippi,¹ Alabama,² and Florida³ - Continued

Field number	Field	Discovery date	County and state	Cumulative production through 1984	
78	Shongelo Creek	1967	Smith, Miss.	83,900 BO 63,031 MCFG	
79	Shubuta	1969	Clarke, Miss.	545,202 BO 539,224 MCFG	
80	Silas	1975	Choctaw, Ala.	1,100,399 BO 1,321,788 MCFG	
81	South Cold Creek	1975	Mobile, Ala.	31,687 BO 38,679 MCFG	
82	South Cypress Creek (Smackover A pool)	1968	Wayne, Miss.	9,644,629 BO 2,654,881 MCFG	
83	South Cypress Creek (Smackover B pool)	1968	Wayne, Miss.	351,952 BO 103,896 MCFG	
84	South Harmony	1976	Clarke, Miss.	89,354 BO 624 MCFG	
85	South Paulding	1975	Jasper, Miss.	192,701 BO 123,677 MCFG	
86	South Pisgah	1978	Rankin, Miss.	547,000 MCFG	
87	South State Line	1971	Greene, Miss.	235,479 BO 10,819,213 MCFG	
88	Southwest Piney Woods	1974	Rankin, Miss.	61,748,237 MCFG	
89	Souwilpa Creek	1979	Choctaw, Ala.	165 BC 953 MCFG	
90	Stafford Springs	1970	Jasper, Miss.	740,135 BO 2,097,993 MCFG	
91	Stagecoach Road	1976	Clarke, Miss.	2,536 BO 7,325 MCFG	
92	Stave Creek	1979	Clarke, Ala.	1,211,557 BO 296,368 MCFG	
93	Stringer	1970	Jasper, Miss.	1,534 BO	
94	Sugar Ridge	1973	Choctaw, Ala.	2,830,604 BO 1,421,136 MCFG	
95	Sumrall	1982	Clarke, Miss.	68,097 BO	
96	Sylvarena	1965	Smith, Miss.	55,982 BO 52,542 MCFG	
97	Tallahala Creek	1967	Smith, Miss.	2,395,879 BO 4,300,571 MCFG	

¹Data derived from the Mississippi State Oil and Gas Board.²Data derived from the State Oil and Gas Board of Alabama.³Data derived from the Florida Department of Natural Resources.⁴BO = barrels of oil⁵MCFG = thousand cubic feet of gas.⁶BC = barrels of condensate.⁷No production.

Table 3.--Smackover fields of Mississippi,¹ Alabama,² and Florida³ - Continued

Field number	Field	Discovery date	County and state	Cumulative production through 1984	
98	Tchula Lake	1969	Holmes, Miss.	319,715 BO 3,103,010 MCFG	
99	Thomasville (oil)	1969	Rankin, Miss.	4,230 BO	
100	Thomasville (gas)	1971	Rankin, Miss.	238,837,158 MCFG	
101	Thornton	1973	Holmes, Miss.	(7)	
102	Tinsley	1951	Yazoo, Miss.	(7)	
103	Tinsley (gas)	1966	Yazoo, Miss.	(7)	
104	Toxey	1967	Choctaw, Ala.	1,583,714 BO 82,194 MCFG	
105	Turkey Creek	1969	Choctaw, Ala.	2,483,932 BO 124,198 MCFG	
106	Uriah	1970	Monroe, Ala.	117,594 BO 63,394 MCFG	
107	Vocation	1971	Monroe, Ala.	1,401,132 BO 3,196,096 MCFG	
108	Vossburg (Smackover A pool)	1972	Jasper, Miss.	45,088 BO 16,293 MCFG	
109	Vossburg (Smackover B pool)	1972	Jasper, Miss.	5,556 BO 1,618 MCFG	
110	Watts Creek	1969	Clarke, Miss.	849,462 BO 190,787 MCFG	
111	West Barnett	1976	Jasper, Miss.	6,511 BO 1,621 MCFG	
112	West Barrytown	1976	Choctaw, Ala.	504,177 BO 188,187 MCFG	
113	West Bend	1979	Clarke and Choctaw, Ala.	140,937 BO 32,636 MCFG	
114	West Clara	1966	Wayne, Miss.	563,119 BO 288,795 MCFG	
115	West Nancy	1970	Clarke, Miss.	14,178,650 BO 9,461,272 MCFG	
116	West Paulding	1969	Jasper, Miss.	1,096,798 BO 182,483 MCFG	
117	Wimberly	1976	Choctaw, Ala.	1,057,175 BO 456,418 MCFG	
118	Winchester	1969	Wayne, Miss.	(7)	

¹Data derived from the Mississippi State Oil and Gas Board.²Data derived from the State Oil and Gas Board of Alabama.³Data derived from the Florida Department of Natural Resources.⁴BO = barrels of oil⁵MCFG = thousand cubic feet of gas.⁶BC = barrels of condensate.⁷No production.

Table 3.--Smackover fields of Mississippi,¹ Alabama,² and Florida³ - Continued

Field number	Field	Discovery date	County and state	Cumulative production through 1984	
119	Wolf Creek	1969	Wayne, Miss.	1,347,514	BO
				1,426,446	MCFG
120	Womack Hill	1970	Choctaw and Clarke, Ala.	19,434,640	BO
				9,406,017	MCFG
121	Zion Chapel	1976	Choctaw, Ala.	359,716	BO
				711,235	MCFG

¹Data derived from the Mississippi State Oil and Gas Board.

²Data derived from the State Oil and Gas Board of Alabama.

³Data derived from the Florida Department of Natural Resources.

⁴BO = barrels of oil.

⁵MCFG = thousand cubic feet of gas.

⁶BC = barrels of condensate.

⁷No production.

Smackover algal carbonate mudstones are the main source for both Smackover and Norphlet hydrocarbons (Benson and Mancini, 1980; Oehler, 1984; Mancini and others, 1985). These mudstones are locally rich in algal and amorphous kerogen. The thermal alteration indices for these rocks indicate that the thermal history for much of southwestern and offshore Alabama was highly favorable for the generation and preservation of hydrocarbons.

No Smackover discoveries have been made in offshore areas. However, since 1974, four Smackover fields--Hatter's Pond, Churchula, Cold Creek, and South Cold Creek (fig. 20)--have been found within 20 miles of Mobile Bay. Of the more recent Smackover discoveries, Movico field (1982) lies 25 miles north of Mobile Bay, and Perdido field (1984) is 30 miles northeast of Mobile Bay (Mink, 1985).

The relatively close proximity of several producing fields and the prolific nature of the Smackover Formation in the onshore tri-state area suggest that the Smackover is a prospective Jurassic hydrocarbon trend in the offshore region. Wells drilled in the central and northern parts of the Mobile Bay area possibly could encounter Jurassic condensate or oil in addition to natural gas.

Projection of the onshore Smackover producing trends into the federal waters area suggests that several Smackover trends may be present in the Florida state waters and the Apalachicola, Pensacola and Destin Dome Areas. Reefal buildups formed on basement highs may be present near the Smackover updip limit in offshore areas. More importantly, downdip from the regional peripheral fault trend salt anticlines and extensional fault traps should have excellent potential as Smackover petroleum traps in offshore Florida. The density of known onshore Smackover fields in the tri-state area suggests that in offshore Florida the Smackover is the Jurassic formation most likely to be productive of hydrocarbons.

NORPHLET FORMATION

Norphlet petroleum traps in the onshore tri-state area of Mississippi, Alabama, and Florida are principally structural traps involving salt anticlines, faulted salt anticlines, basement paleo-topography and extensional fault traps associated with salt movement along the regional peripheral fault trend. Stratigraphy plays an integral part in the formation of Norphlet petroleum traps, as can be evidenced by the existing fields and recent Norphlet discoveries.

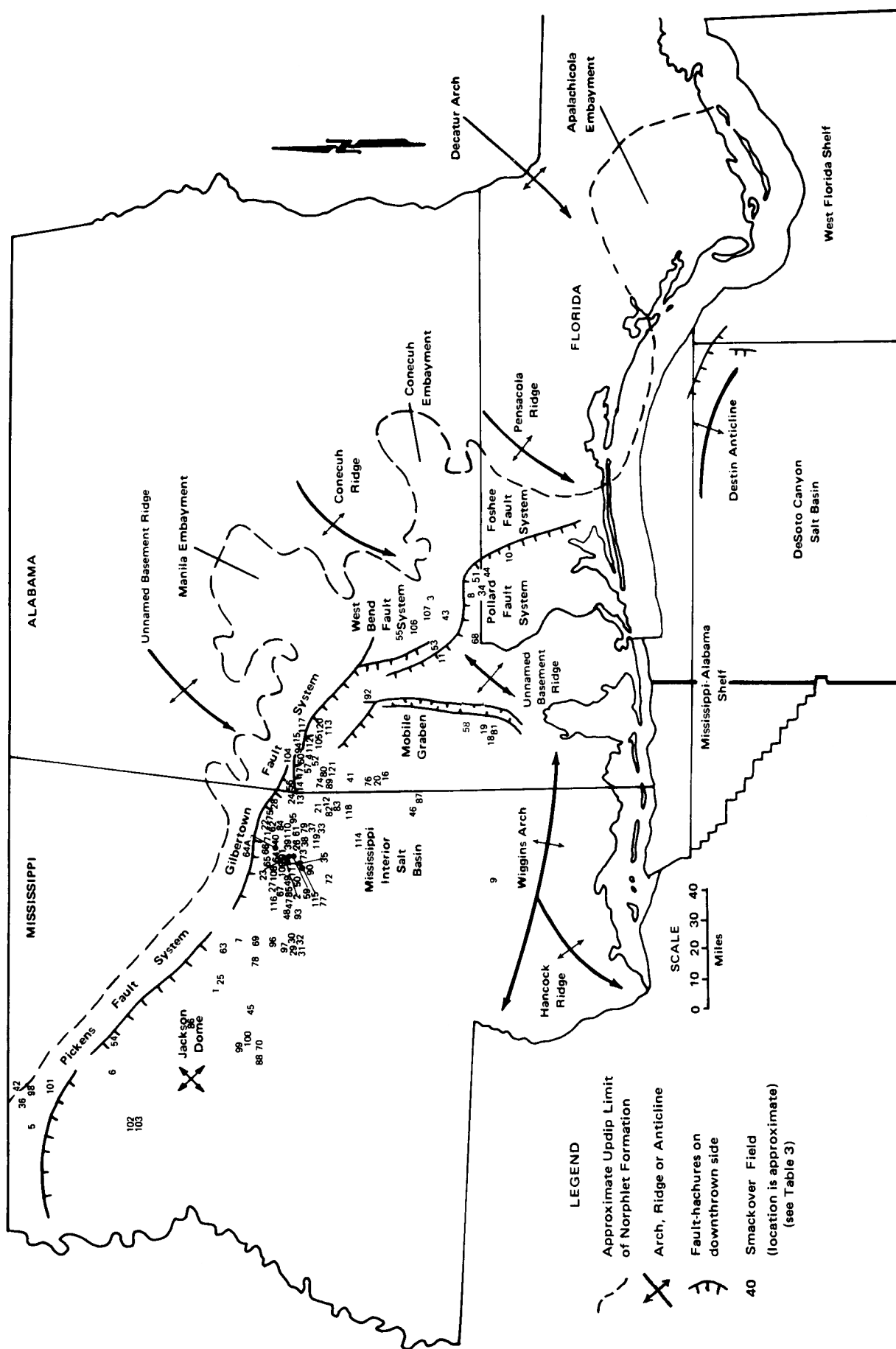


Figure 18.--Regional trend map of Smackover producing fields in the study area.

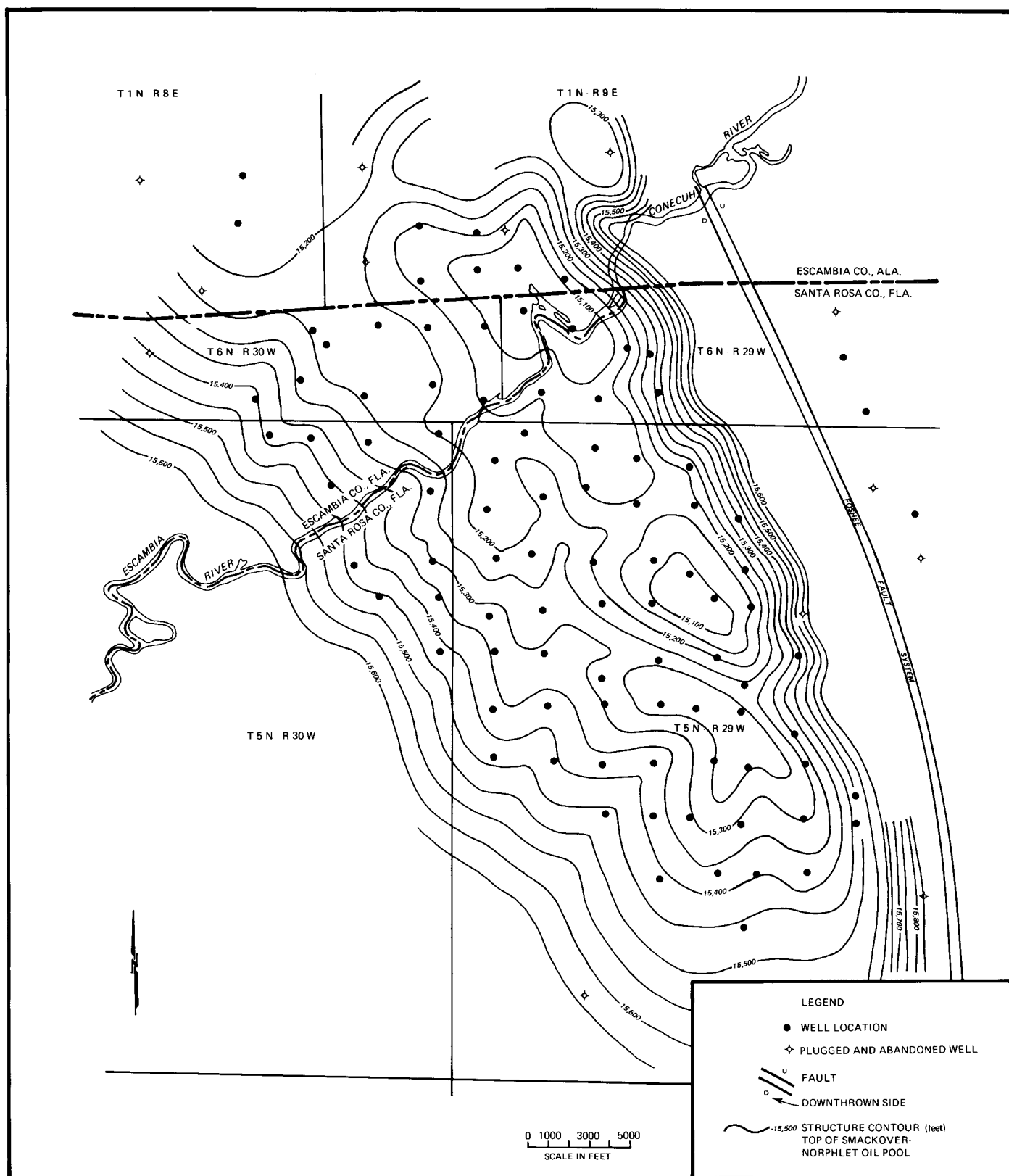


Figure 19.--Structure map of top of Smackover Formation in Jay-Little Escambia Creek fields, Santa Rosa and Escambia Counties, Florida, and Escambia County, Alabama (modified from Davis and Lambert, 1963).

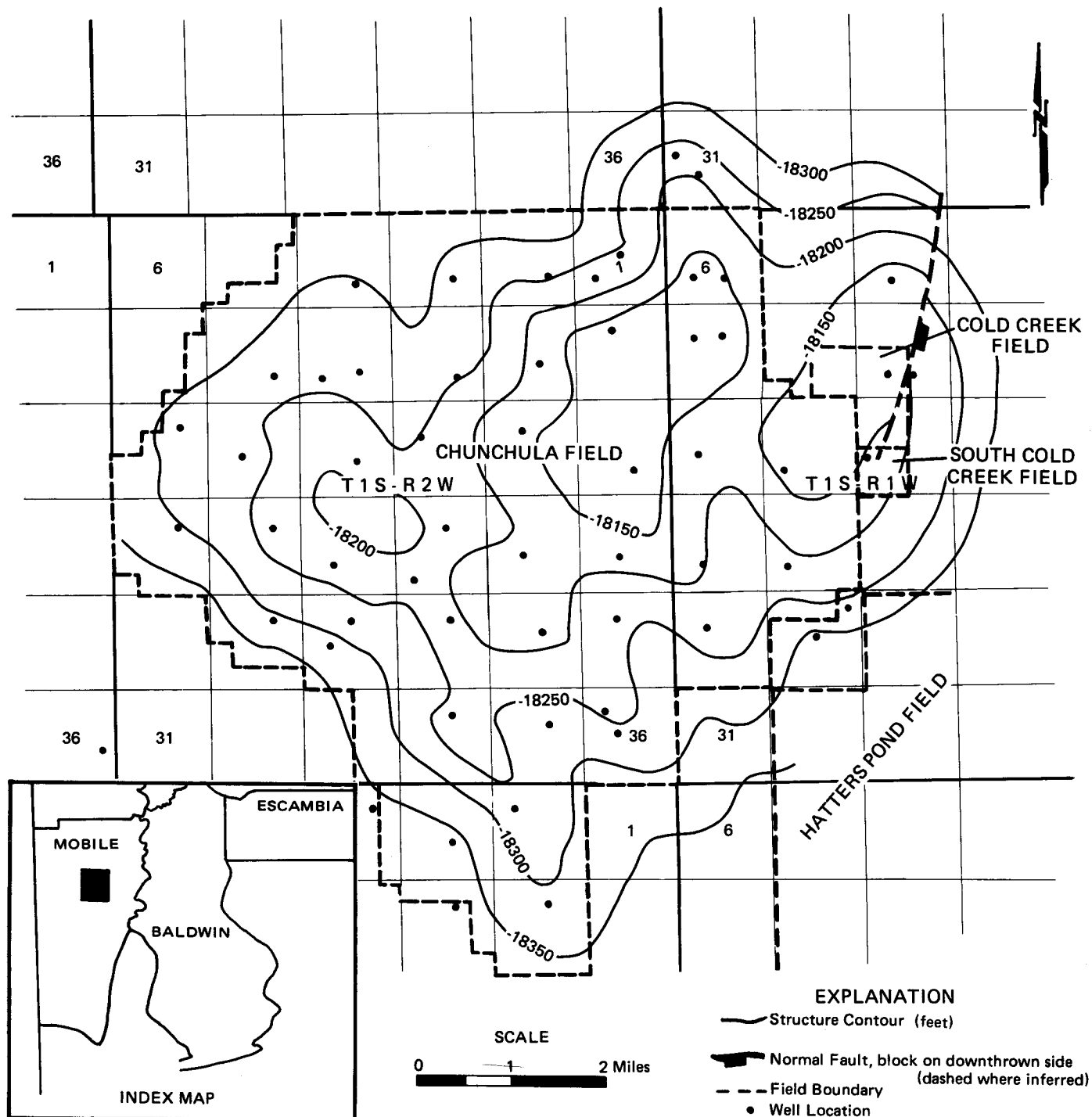


Figure 20.--Structure map of top of Smackover Formation in Chunchula field, Mobile County, Alabama (modified from Mink, 1985, figure 7).

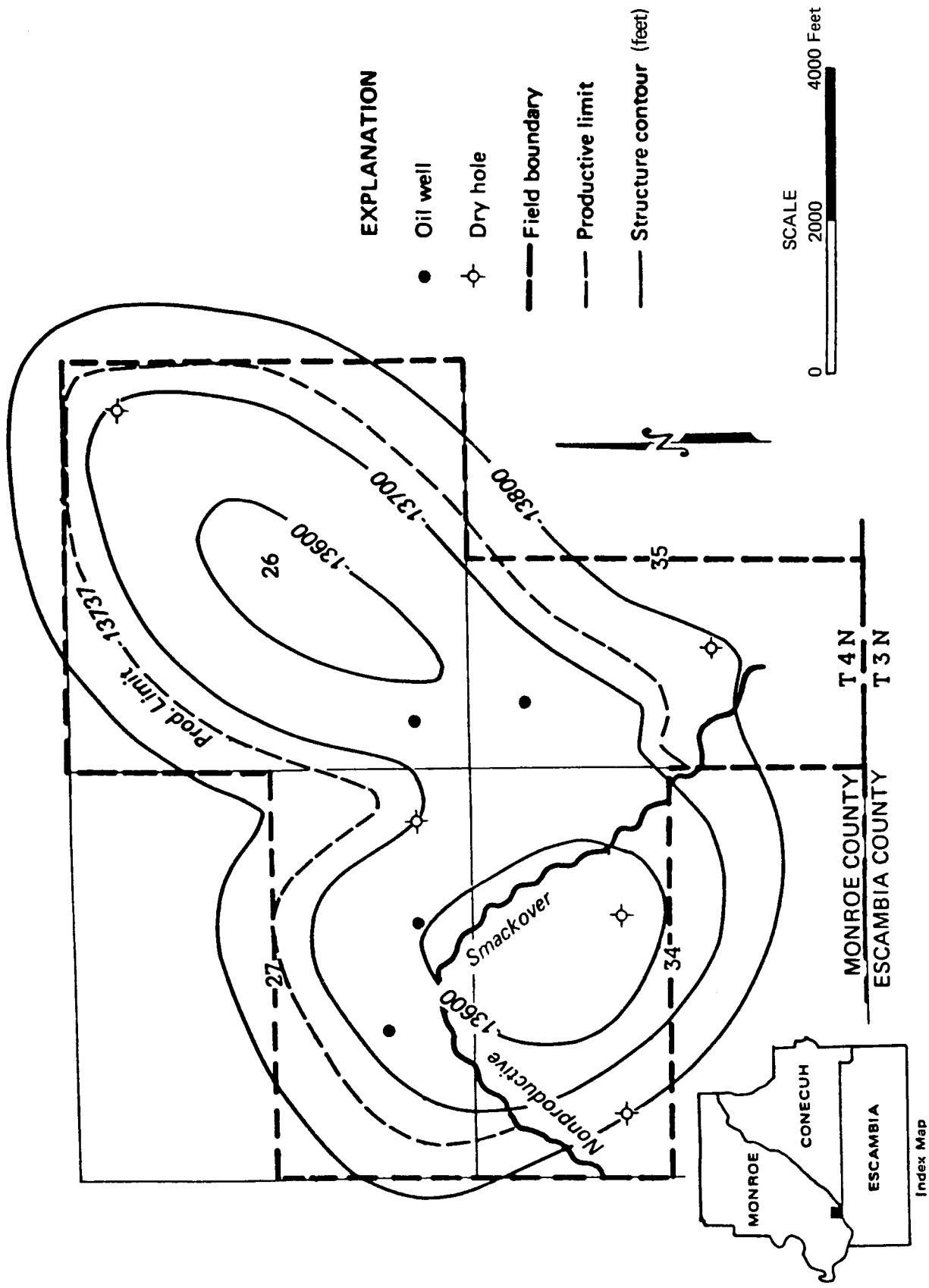


Figure 21.--Structure map of the top of Smackover Formation in the Vocation field, Monroe County, Alabama (modified from Exhibit No. G-2 as presented by Texaco, U.S.A., at the October 1980 meeting of the State Oil and Gas Board of Alabama, Docket No. 10-3-804).

In Mississippi, Alabama, and Florida, 20 Norphlet fields have been discovered and since 1967 (table 4) have produced more than 34,800,000 barrels of oil, 9,300,000 barrels of condensate and 248,900,000 thousand cubic feet of gas. The Norphlet productive trends (fig. 22) occur along the rim of the regional peripheral fault trend in the central Mississippi interior salt basin, along the Mobile graben and in the offshore Alabama area. The most important petroleum exploration play in the Norphlet is the prolific deep gas trend of Alabama state waters and adjacent federal waters. In 1979, Mobil discovered the Lower Mobile Bay-Mary Ann field with the drilling of the Block 76 No. 1 well (fig. 23), which tested 12.2 million cubic feet of gas per day from the Norphlet. The petroleum trap in the Lower Mobile Bay-Mary Ann field is a broad, low relief, faulted, salt anticline. Reserves for this field are estimated to be as much as 600 billion cubic feet of gas (Sumpter, 1981). Since the discovery of this field, several new discoveries have been made including those in Blocks 62, 63, 72, 112, and 115 in Alabama state waters and in Blocks 823, 861, and 867 in adjacent federal waters. The Norphlet in offshore Alabama state waters and adjacent federal waters has recently been cited as one of the top petroleum exploration plays in the entire United States and may contain gas reserves of several trillion cubic feet (Petrie and Wright, 1984). The large natural gas fields in the offshore Alabama region are similar to the Viking gas field in the United Kingdom portion of the North Sea, as described by Gage (1980).

Along the regional peripheral fault trend several fields have been established including the Flomaton, Sizemore Creek, and Chavers Creek fields (fig. 24). The petroleum trapping mechanism at Chavers Creek field is an elongate, faulted salt anticline associated with the Pollard-Foshee fault system. The Flomaton field consists of a low-relief, faulted salt anticline downthrown to the same extensional fault system.

In the Mississippi interior salt basin, the Copeland field is an excellent example of a salt anticline in the Norphlet Formation. Along the Mobile graben, the Hatter's Pond field in Mobile County is representative of prospective traps involving salt movement along the west side of the graben system.

The primary Norphlet reservoir in the study area is the Denkman Sandstone Member, with principally eolian, marine and wadi lithofacies being productive. Porosity in the wadi and dune sandstones is primarily secondary dissolution with some intergranular porosity. Porosity in the Norphlet averages approximately 10 percent, while permeability ranges from 0.5 to over 100 millidarcies. The Norphlet marine sandstones typically have lower porosity preserved because of the presence of high percentages of calcite and silica cements.

Projection of the onshore Norphlet producing trends into the federal waters area suggests that several Norphlet trends may be present in the Florida state waters and the Mobile, Apalachicola, Pensacola and Destin Dome Areas. Norphlet oil fields may be present updip to the offshore extension of the regional peripheral fault trend in the Florida state waters and the Apalachicola, Pensacola and Destin Dome Areas. These traps, similar to the Chavers Creek field, would be salt anticlines and faulted salt anticlines. Fields similar to Flomaton may be developed also along the offshore extension of the regional peripheral fault system, principally in the Florida state waters and the Apalachicola, Pensacola and Destin Dome Areas. The largest offshore Norphlet fields will continue to be discovered and established in the Alabama state waters and in the northern part of the Mobile Area. This trend may continue to develop to the south in the southern part of the Mobile Area and in the Viosca Knoll (north) Area. However, considering the facies change present in the Pensacola Block 973 No. 1 well, the downdip limit of Norphlet production in the western part of the study area is probably in the central part of the Mobile Area.

SUMMARY OF JURASSIC HYDROCARBON TRENDS

Three Jurassic hydrocarbon trends can be identified in the study area. An oil trend and oil and gas-condensate trend are defined by existing onshore Jurassic fields in the tri-state area. A deep natural gas trend is defined by the Catahoula Creek field, the Lower Mobile Bay-Mary Ann field and numerous wildcat discovery wells in Alabama state waters and the adjacent federal waters area. The oil and gas-condensate trend and the deep natural gas trend would appear to be prospective for Jurassic hydrocarbons in the federal waters area evaluated for this study.

Table 4.--Norphlet fields of Mississippi¹, Alabama², and Florida³

Field number	Field	Discovery date	County and state	Cumulative production through 1984	
1	Archusa Springs	1971	Clarke, Miss.	15,126 BO ⁴ 5,704 MCFG ⁵	
2	Chavers Creek	1984	Escambia, Ala.	287,549 BO 319,057 MCFG	
3	Copeland	1974	Washington, Ala.	95,171 BO 58,995 MCFG	
4	East Nancy	1969	Clarke, Miss.	4,282,547 BO 1,000,050 MCFG	
5	Flomaton	1968	Escambia, Ala.	9,357,587 BC ⁶ 135,041,968 MCFG	
6	Fluffer Creek	1976	Clarke, Miss.	207,460 BO 556,544 MCFG	
7	Gluckstadt	1977	Madison, Miss.	13,904,482 MCFG	
8	Goshen Springs	1980	Rankin, Miss.	11,454,725 MCFG	
9	Hatter's Pond ⁷	1974	Mobile, Ala.	20,213,326 BO 78,676,028 MCFG	
10	Hollybush Creek	1979	Rankin, Miss.	0 (8)	
11	Lower Mobile Bay-Mary Ann	1979	Mobile and Baldwin, Ala.	0 (8)	
12	Mt. Carmel ⁷	1972	Santa Rosa, Fla.	4,445,000 BO 4,625,000 MCFG	
13	North Hiwannee	1979	Wayne, Miss.	157,468 BO 375,232 MCFG	
14	Pelahatchie	1967	Rankin, Miss.	668,908 BO 676,879 MCFG	
15	Piney Woods	1976	Rankin, Miss.	66,791 MCFG	
16	Prairie Branch	1970	Clarke, Miss.	4,213,828 BO 1,480,370 MCFG	
17	Sizemore Creek	1984	Escambia, Ala.	50,819 BO 59,273 MCFG	
18	South Pisgah	1978	Rankin, Miss.	630,000 MCFG	
19	South State Line	1970	Greene, Miss.	167,552 BO 2,449 MCFG	
20	Watts Creek	1976	Clarke, Miss.	3,144 BO	

¹Data derived from the Mississippi State Oil and Gas Board.²Data derived from the State Oil and Gas Board of Alabama.³Data derived from the Florida Department of Natural Resources.⁴BO = barrels of oil.⁵MCFG = thousand cubic feet of gas.⁶BC = barrels of condensate.⁷Includes Smackover and Norphlet production.⁸No production.

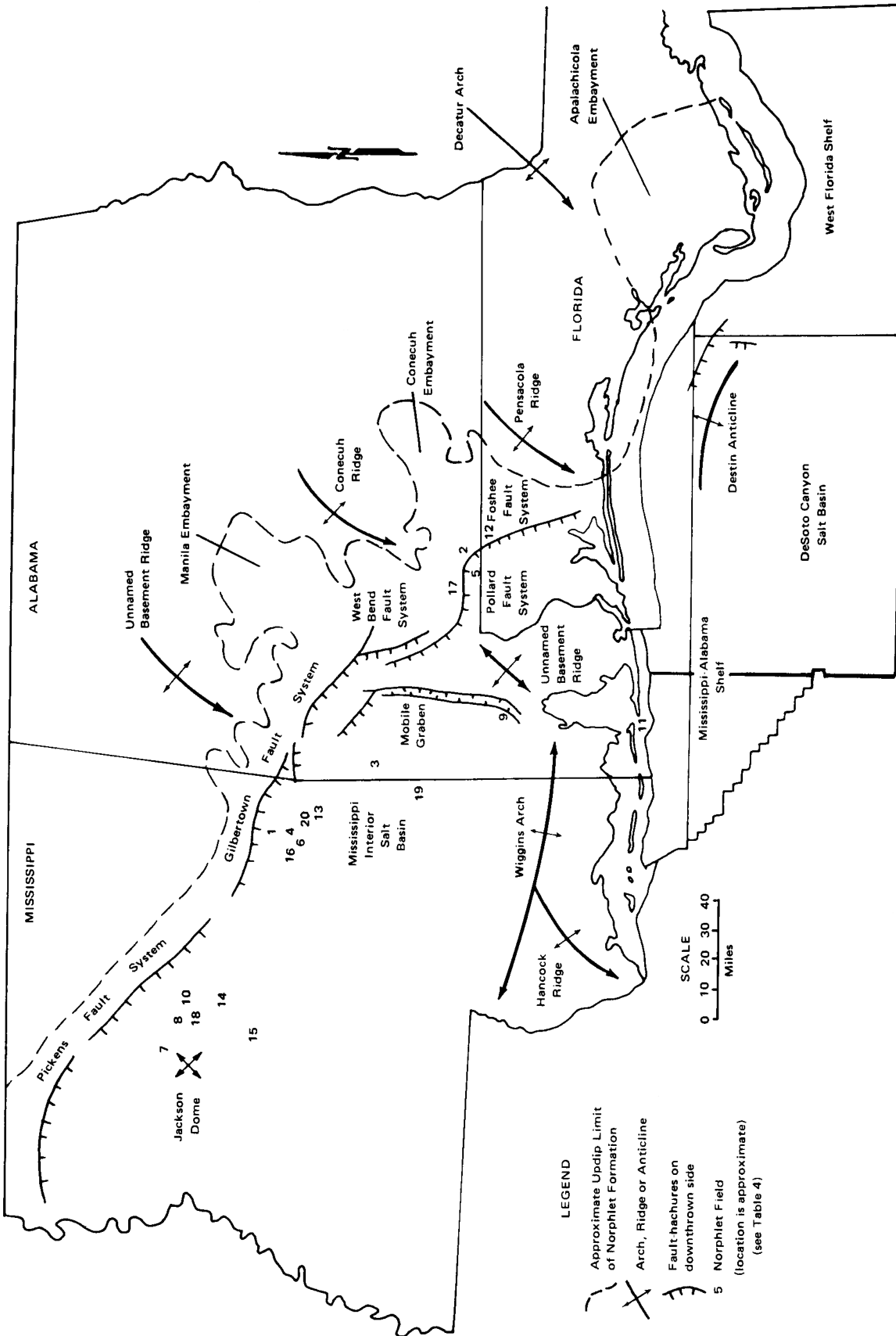


Figure 22.--Regional trend map of Norphlet producing fields in the study area.

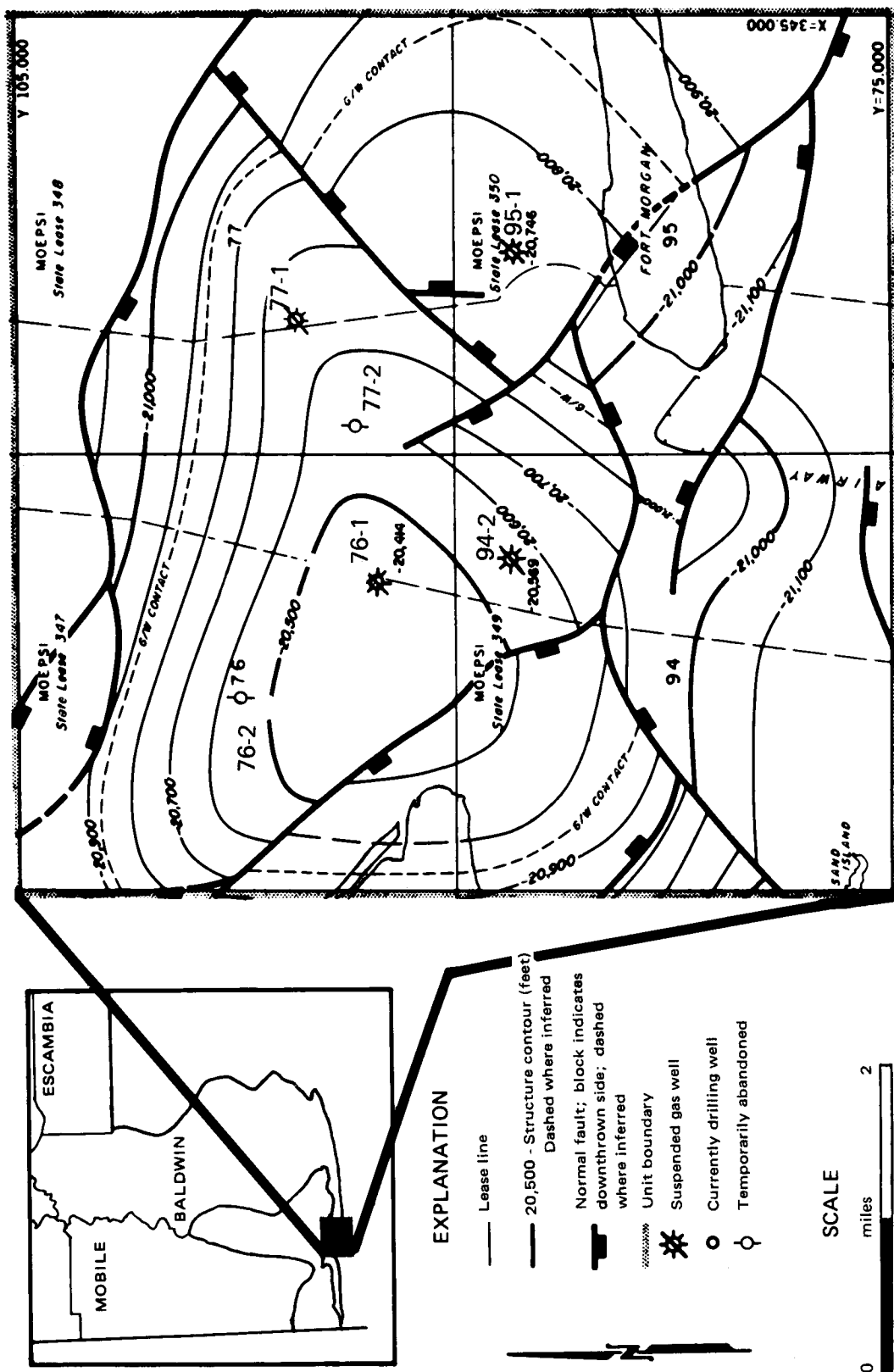
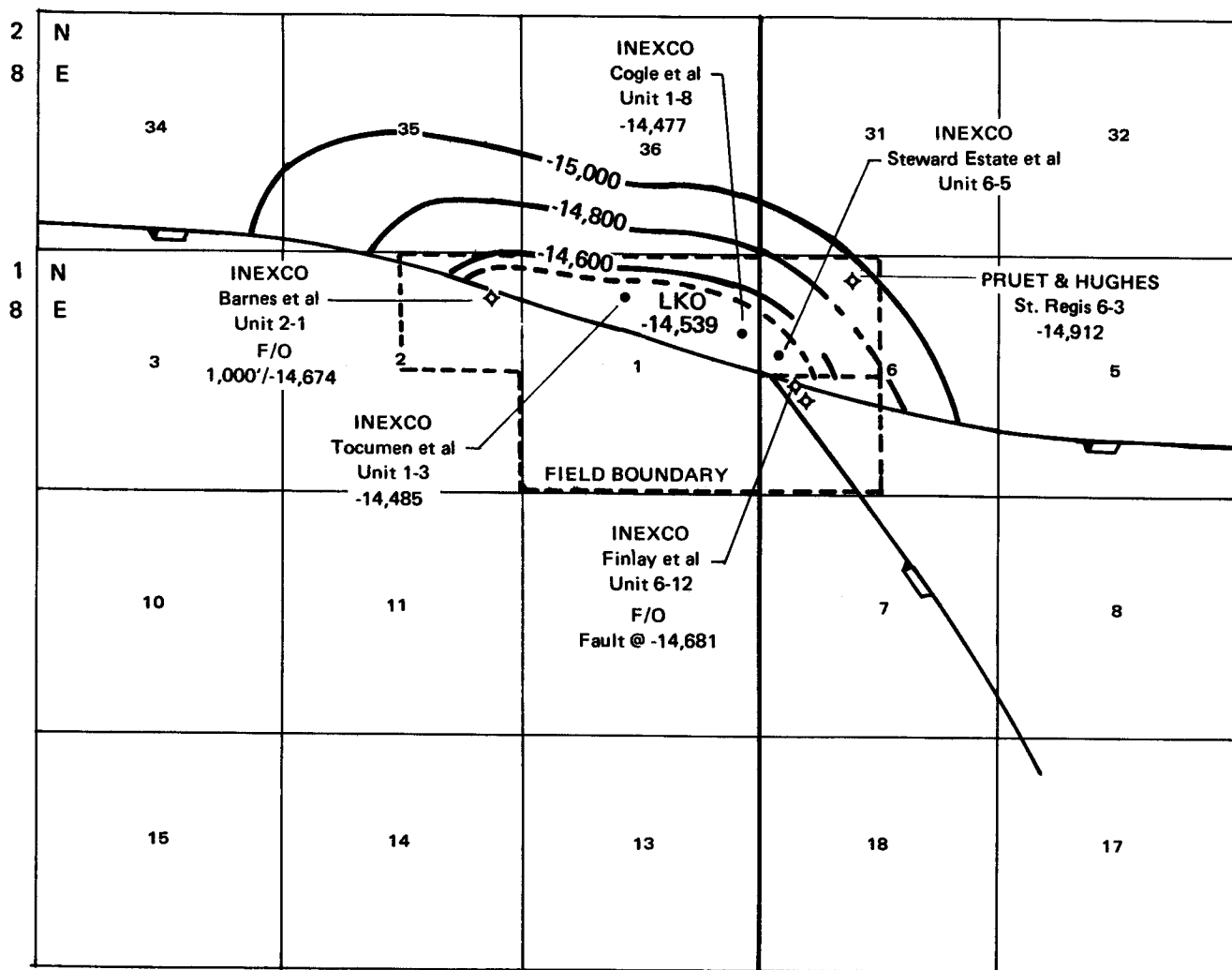


Figure 23.--Structure map of top of Norphlet gas pool in the Lower Mobile Bay-Mary Ann field (modified from Exhibit No. 4 as presented by Mobil Oil Exploration and Producing Southeast, Inc., at the December 1982 meeting of the State Oil and Gas Board of Alabama, Docket No. 10-26-822).



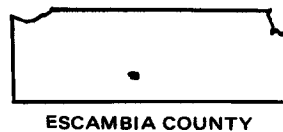
EXPLANATION

- OIL WELL
- ◊ DRY HOLE
- LKO LOWEST KNOWN OIL
- FAULT
- DOWNTHROWN SIDE
- 14,800 STRUCTURE CONTOUR (feet)

SCALE

0 3000 Feet

INDEX MAP



ESCAMBIA COUNTY

Figure 24.--Structure map of top of Norphlet Formation in the Chavers Creek field, Escambia County, Alabama (modified from Exhibit No. G-1-AS presented by Inexco Oil Company at the November 1984 meeting of the State Oil and Gas Board of Alabama, Docket No. 11-1-841).

The oil trend is located updip from the regional peripheral fault trend. Both basement and salt-related structures are found in this trend. Smackover and Norphlet fields have been established in the trend with oil being the principal hydrocarbon produced. The projection of this trend into federal waters (fig. 25) would be into the eastern portion of the Pensacola Area, the extreme northeastern corner of the Destin Dome Area, and the northwestern corner of the Apalachicola Area. Although the potential for Jurassic hydrocarbon accumulations in the federal waters portion of the oil trend would appear to be relatively high, onshore data evaluated for this study suggest that the amount of reserves are probably insufficient to justify offshore development.

Most of the onshore Jurassic fields in the tri-state area are located in the oil and gas-condensate trend. Essentially all of the Cotton Valley and Haynesville/Buckner fields are in this trend as are most of the Smackover fields. Substantial Norphlet production also has been from fields in this trend. The oil and gas-condensate trend is located downdip of the regional peripheral fault trend and most, if not all, of the productive structures are related to salt movement. Oil, condensate, and natural gas are all produced from Jurassic fields in this trend and, in some cases, production can be in substantial quantities. The projection of this trend into federal waters (fig. 25) would be into the central part of the Pensacola Area and the northwest quarter of the Destin Dome Area. The potential would appear to be high for significant Jurassic hydrocarbon accumulations in the federal waters area included in the oil and gas-condensate trend.

The deep natural gas trend includes Norphlet and Cotton Valley hydrocarbon potential and appears to be concentrated in the Alabama state waters area and the northeast and north-central portions of the Mobile Area. The Lower Mobile Bay-Mary Ann and the Catahoula Creek fields are the only established fields in this trend although numerous Norphlet wildcat discoveries have been made in both Alabama state waters and the adjacent federal waters area. The Cotton Valley has possible deep gas potential in the Mobile Area. The deep natural gas trend appears to have the highest potential in the Norphlet Formation in Alabama state waters and the northern portion of the Mobile Area.

CURRENT STATUS OF LEASING, DRILLING AND PRODUCTION

STATE WATERS AREA

The discovery of hydrocarbons in Alabama's coastal waters was made by MOEPSI with the completion of Alabama Block 76 well no. 1 (fig. 26 - map no. 5, table 5 - map no. 5) drilled to a total depth of 21,113 feet. During an initial 11-hour test on November 27-28, 1979, the well flowed at a rate of 12.2 million cubic feet of dry gas per day through a 28/64-inch choke with a tubing pressure of 2,996 psig. The perforated interval tested is at a depth of 20,634 to 20,883 feet in sandstones of the Jurassic Norphlet Formation. The Lower Mobile Bay-Mary Ann field (fig. 27) was established in November 1980 encompassing Tracts 76, 77, 94, and 95.

The discovery of the Lower Mobile Bay-Mary Ann field in 1979 focused attention on the hydrocarbon potential of Alabama's coastal waters and adjacent federal waters. The discovery was important for at least three reasons. First, the Lower Mobile Bay-Mary Ann field is a relatively large natural gas field with reserves estimated to be as high as 600 billion cubic feet of gas (Sumpter, 1981). Second, the location of the field has extended the area of known Jurassic production. The nearest Jurassic production (Smackover/Norphlet) prior to this discovery was the Hatter's Pond field located onshore and 50 miles to the north in Mobile County. Third, the Lower Mobile Bay-Mary Ann field is the first offshore Jurassic discovery in the northern Gulf of Mexico. Discovery of the Lower Mobile Bay-Mary Ann field might be compared to the 1968 discovery of the Flomaton field in Escambia County, Alabama, which extended Jurassic production 75 miles southeast of established fields in Choctaw County, Alabama (Bolin and Masingill, 1983). The discovery of the Flomaton field was followed by intense leasing and drilling, which led to the discovery of numerous Jurassic fields, including the prolific hydrocarbon producing Big Escambia Creek and Jay fields.

At present, 37 state blocks are under lease in Alabama state waters (fig. 27). These leases were awarded in October 1969, March 1981, September 1982, and August 1984. The total bonuses received for these 37 state blocks were \$799,856,881.35. All of the leased state blocks have primary

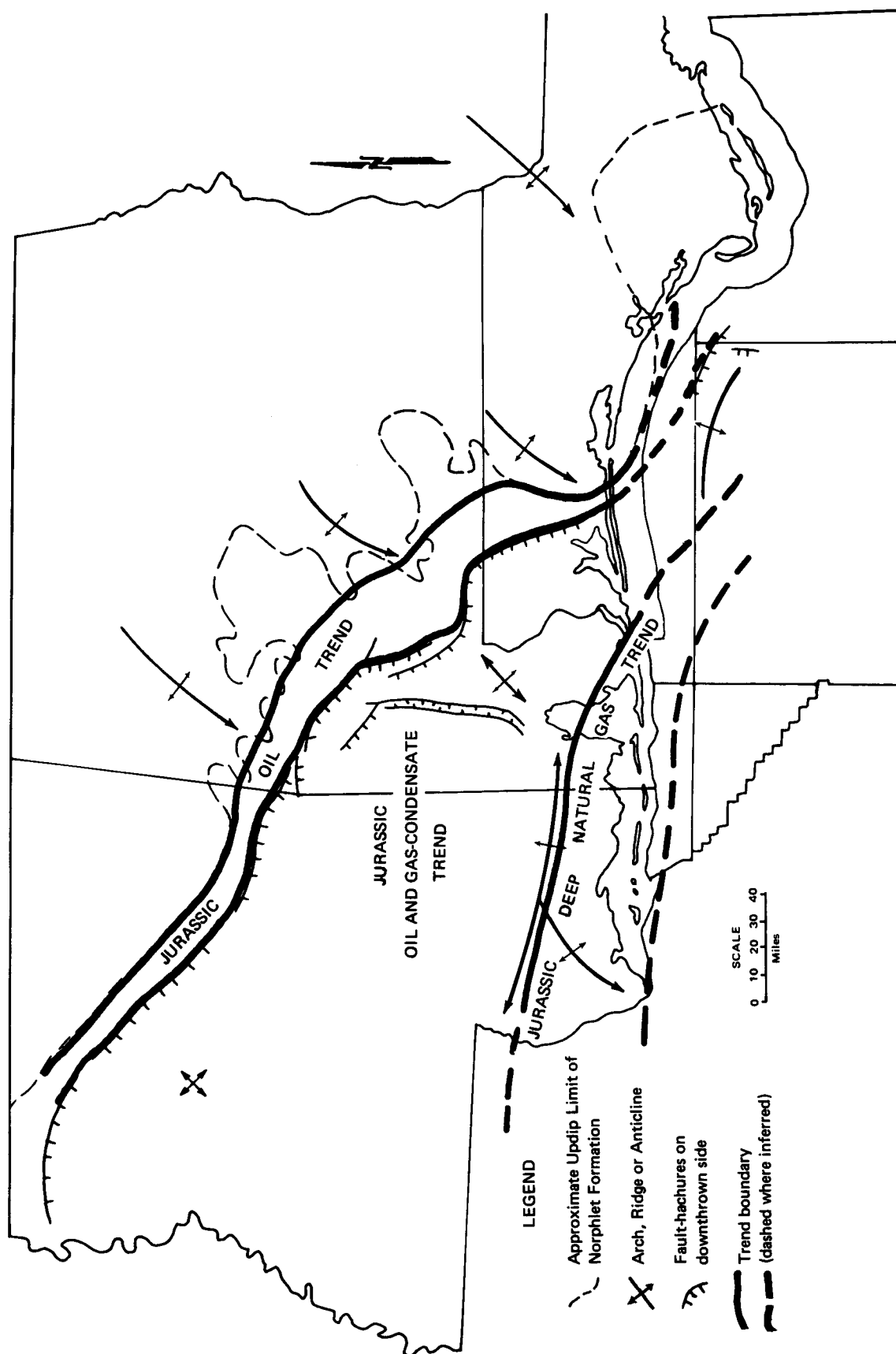


Figure 25.--Jurassic hydrocarbon trends of the study area.

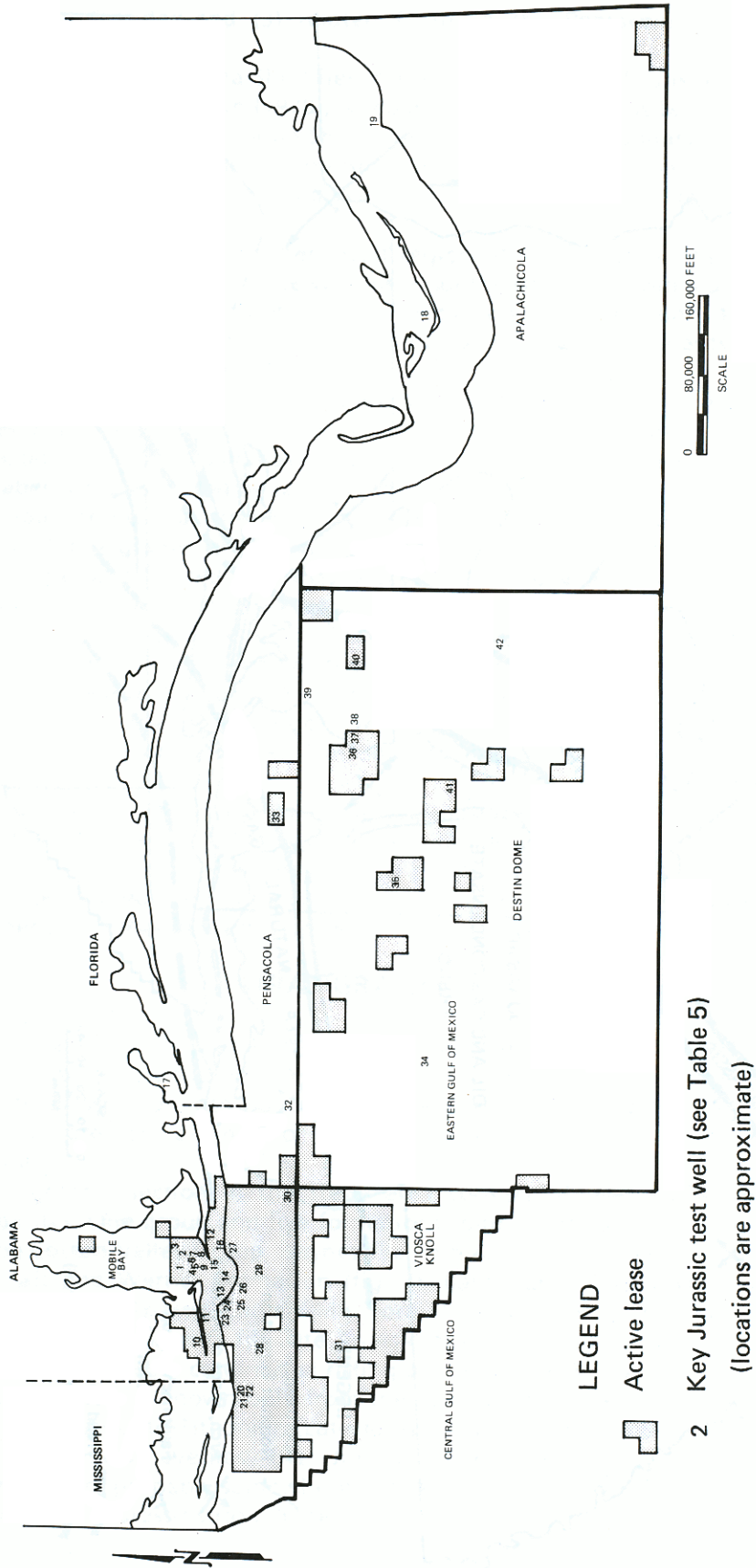


Figure 26.--Leased areas and offshore Jurassic test wells in the study area.

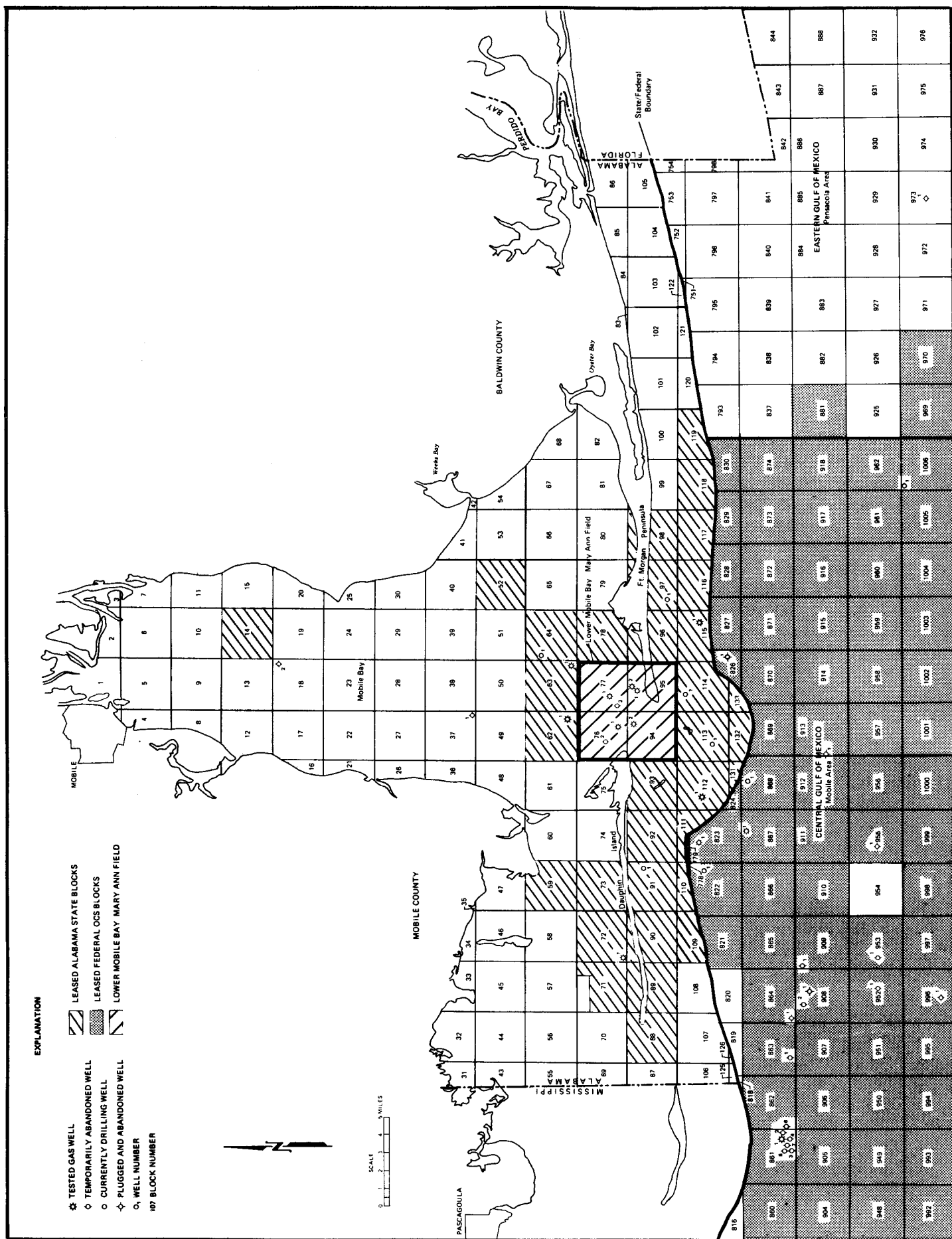


Figure 27.--Oil and gas leases in Alabama state waters and adjacent federal waters.

lease terms of 5 years. Four blocks were leased in October 1969 for total bonuses of \$78,822.35 with 16.67 percent royalty and a \$1.00 per acre rental. Following the discovery of natural gas in Mobile Bay in 1979, the March 1981 sale produced \$449,178,059.00 in total bonuses with rentals of \$5.00 per acre and royalties ranging from 25 to 28 percent. A sale in September 1982 resulted in the leasing of one block for a total bonus of \$3,117,000.00 with \$5.00 per acre rental and 25 percent royalty. The August 1984 sale resulted in \$347,483,000.00 in bonuses being accepted for 19 blocks with \$5.00 per acre rental and royalty rates ranging from 16.67 to 20 percent (which revert to 25 percent after payout).

Nineteen wells have been completed or are now being drilled in Alabama state waters. Sixteen of these wells (table 5) have tested or will test the Jurassic section. Following the drilling of MOEPSI's 1979 discovery well on Alabama Block 76, five wells were drilled to confirm and further define the Lower Mobile Bay-Mary Ann field. Three wells were completed as natural gas wells (testing between 10.5 and 19.4 million cubic feet of gas per day) on Alabama Blocks 77, 94, and 95; and two wells drilled on Alabama Blocks 76 and 77 were temporarily abandoned to be tested at a later date. MOEPSI made a natural gas discovery on Alabama Block 72 in the Norphlet Formation. This well tested 21.2 million cubic feet of gas per day. Exxon has made four natural gas discoveries in the Norphlet Formation in Alabama state waters. Exxon's Alabama Block 62 well north of the Lower Mobile Bay-Mary Ann field tested 20.5 million cubic feet of gas per day. The drilling of this well was followed by another Exxon discovery on Alabama Block 63. The Block 63 well tested 28.12 million cubic feet of gas per day. Exxon tested 21.17 and 1.394 million cubic feet of gas per day from a well drilled on Alabama Block 112 which is south of the Lower Mobile Bay-Mary Ann field. Exxon also tested 9.045 million cubic feet of gas per day from a well drilled on Alabama Block 115. Five wells are being drilled in Alabama state waters. Exxon is drilling Jurassic test wells on Alabama Blocks 64, 91, 97, and 114, and Shell is drilling a well on Alabama Block 113.

Production of natural gas from the Lower Mobile Bay-Mary Ann field is expected to begin in late 1986 or early 1987. This production will probably be the first production of hydrocarbons from the Jurassic in the northern Gulf of Mexico region.

Three wells have tested the Jurassic section in Florida state waters (table 5) in the study area. Two wells were drilled in the vicinity of Apalachicola Bay and one well was drilled in East Bay. All three wells were plugged and abandoned.

FEDERAL WATERS AREA

A total of 198 federal OCS blocks are currently under lease in the Mobile (81 blocks), Viosca Knoll (north) (60 blocks), Pensacola (7 blocks), and Destin Dome (50 blocks) Areas. These blocks were leased as a result of OCS Lease Sale 67 (February 1982), OCS Lease Sale 69 Part II (March 1983), OCS Lease Sale 72 (May 1983), OCS Lease Sale 79 (January 1984), OCS Lease Sale 81 (April 1984), and OCS Lease Sale 98 (May 1985).

Twenty-three wells have tested or probably will test the Jurassic section in the federal waters area encompassed by this study (table 5). Three of these wells have been reported to have tested natural gas from the Norphlet Formation. MOEPSI's Mobile Block 823 well tested 26 million cubic feet of gas per day. This discovery was followed by an Exxon discovery on Mobile Block 867, which tested 32.9 million cubic feet of gas per day. More recently, Chevron tested 11.2 million cubic feet of gas per day on Mobile Block 861.

Table 5.--Offshore Jurassic test wells in the study area

<u>Alabama State Waters¹</u>						
Key number	Operator	Block number	Well number	Permit number	Total depth (feet)	Well status
1	Exxon	62	1	3632-OS-15	20,822	Gas-SI ²
2	Exxon	63	1	4068-OS-21	21,000	Gas-SI
3	Exxon	64	1	4576-OS-27	NA ³	Drilling
4	MOEPSI	76	2	3614-OS-14	20,981	TA ⁴
5	MOEPSI	76	1	2543-OS-3B	21,113	Gas-SI
6	MOEPSI	77	2	3840-OS-19B	21,710	TA
7	MOEPSI	77	1	3548-OS-11	20,984	Gas-SI
8	MOEPSI	95	1	3127-OS-5	20,949	Gas-SI
9	MOEPSI	94	2	3135-OS-6B	21,859	Gas-SI
10	MOEPSI	72	1	3802-OS-18	21,315	Gas-SI
11	Exxon	91	1	4553-OS-26B	NA	Drilling
12	Exxon	97	1	4600-OS-28B	NA	Drilling
13	Exxon	112	1	4131-OS-22	21,965	Gas-SI
14	Shell	113	1	4477-OS-25B	NA	Drilling
15	Exxon	114	1	4435-OS-24	NA	Drilling
16	Exxon	115	1	4266-OS-23	21,678	Gas-SI

<u>Florida State Waters⁵</u>						
Key number	Operator	Block number	Well number	Permit number	Total depth (feet)	Well status
17	Getty	NA	1	1097	18,011	P&A ⁶
18	Mobil	NA	1	387	14,369	P&A
19	California Coastal	NA	1	293	10,560	P&A

Table 5.--Offshore Jurassic test wells in the study area - Continued

Mobile Area (OCS)⁷

Key number	Operator	Block number	Well number	Permit number	Total depth (feet)	Well status
20	Chevron	861	1	OCS-G 5062	NA	TA
21	Chevron	861	3	OCS-G 5062	NA	TA
22	Chevron	861	6	OCS-G 5062	NA	TA
23	MOEPSI	822	1	OCS-G 5056	NA	Drilling
24	MOEPSI	823	1	OCS-G 5057	21,736	TA
25	Exxon	867	1	OCS-G 5066	22,422	TA
26	Exxon	868	1	OCS-G 5067	NA	Drilling
27	Placid	826	1	OCS-G 5747	21,728	P&A
28	Shell	909	1	OCS-G 5072	NA	TA
29	Exxon	913	1	OCS-G 6856	NA	P&A
30	Texaco	1006	1	OCS-G 6867	NA	Drilling

Viosca Knoll Area - North (OCS)⁷

Key number	Operator	Block number	Well number	Permit number	Total depth (feet)	Well status
31	Tenneco	117	1	OCS-G 6872	NA	Drilling

Pensacola Area (OCS)⁷

Key number	Operator	Block number	Well number	Permit number	Total depth (feet)	Well status
32	MOEPSI	973	1	OCS-G 3886	23,264	P&A
33	Sohio	948	1	OCS-G 63491	NA	Drilling

Table 5.--Offshore Jurassic test wells in the study area - Continued

Destin Dome Area (OCS)⁷

Key number	Operator	Block number	Well number	Permit number	Total depth (feet)	Well status
34	Gulf	360	1	OCS-G 2468	20,960	P&A
35	Exxon	284	1	OCS-G 6428	NA	Drilling
36	Shell	160	1	OCS-G 6417	NA	TA
37	Shell	160	2	OCS-G 6417	NA	P&A
38	Exxon	162	3	OCS-G 2486	17,938	P&A
39	Amoco	31	1	OCS-G 2502	18,338	P&A
40	Sun	166	1	OCS-G 2490	17,608	P&A
41	Chevron	422	1	OCS-G 6438	NA	Drilling
42	Sohio	563	1	OCS-G 3890	21,068	P&A

¹Data derived from the State Oil and gas Board of Alabama.²SI = Shut in.³NA = Not available.⁴TA = Temporarily abandoned.⁵Data derived from the Florida Department of Natural Resources.⁶P&A = Plugged and abandoned.⁷Data derived from the Minerals Management Service.**SUMMARY AND CONCLUSIONS**

Study of the available stratigraphic, structural, and hydrocarbon data for onshore Mississippi, Alabama, and Florida and for Alabama state waters demonstrates that these data can be used to establish a regional geologic framework for the Jurassic for the onshore tri-state area and for the state coastal waters and adjacent federal waters areas. Establishment of a regional Jurassic geologic framework along with interpretation of the hydrocarbon data for the tri-state area indicates that at least three Jurassic hydrocarbon trends are present in the region. An oil trend is defined onshore north of the regional peripheral fault trend and extends into the offshore area north of the Destin anticline. An oil and gas-condensate trend is delineated onshore between the regional peripheral fault trend and the Wiggins arch and extends into the offshore area of the Destin anticline and north of the DeSoto Canyon salt basin. A deep natural gas trend is identified along the Wiggins arch extending into the offshore area in the Mobile Area. The oil and gas-condensate and deep natural gas trends appear to be prospective for Jurassic hydrocarbons in state coastal waters and federal waters areas of portions of the Central and Eastern Gulf of Mexico. Substantial natural gas reserves are expected to be present in the northern portion of the Mobile Area, and significant accumulations of oil and gas-condensate may be encountered in the Pensacola, Destin Dome and Apalachicola Areas.

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