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REGIONAL STRATIGRAPHY AND PETROLEUM POTENTIAL OF GULF COAST LOWER CRETACEOUS

Lower Cretaceous sediments were deposited throughout the Gulf Coast during the Neocomian, Aptian, Albian, and early Cenomanian Epochs. Basal sandstones extend across the entire region, onlapping Upper Jurassic terrigenous strata. Following the initial stage of detrital rock deposition, a shallow epicontinental sea covered the western coastal plain and regions on the south and west. In this area, and also in the seaward parts of the eastern coastal plain, shallow-shelf carbonates were deposited contemporaneously with subsidence. In East Texas and adjacent areas, periods of peneplanation of the bordering land and deposition of carbonates alternated with regressive periods when the hinterland was uplifted and deposition of the land-derived material exceeded subsidence. The southern Appalachians rose at irregular rates throughout Early Cretaceous time, and furnished sediments (sand and clay) to the Mississippi embayment and the eastern Gulf Coast.

Lower Cretaceous rocks are the most widespread and have the greatest volume of any major Gulf Coast stratigraphic division. They are believed to underlie an area of about 340,000 sq mi and have a volume of more than 200,000 cu mi. The area presently productive of oil and gas, extending from Mexico to southwestern Alabama, has an area of 83,000 sq mi, and a volume of 60,000 cu mi. In this proved belt, 1½ billion bbl of oil and 10½ Tcf of gas have been produced from Lower Cretaceous sandstone and carbonate rock. Landward from the productive belt in Texas and Arkansas is a narrow belt that is considered to be nonprospective. This belt widens eastward across central Mississippi, southern Alabama, Georgia, and northern Florida, where continental "redbeds" with thicknesses to 4,000 ft are present. A prospective belt and a speculative belt are gulfward from the proved area.

Depositional conditions of the extensive and thick Lower Cretaceous sediments were favorable for the development and preservation of vast amounts of hydrocarbon source materials and for the formation of many reservoir rocks and stratigraphic-structural traps. An environmental analysis of each stratigraphic unit indicates a very large petroleum potential for this group of rocks. Many hydrocarbon accumulations will be found in the prospective belt, on land as well as under the continental shelf of Mississippi, Alabama, and Florida. The undiscovered accumulations are in deltaic sandstone, carbonate reefs, and shell mounds. In the speculative belt of coastal and offshore Louisiana and Texas, the objectives are limestone reefs which developed on the landward side of positive blocks. Many new fields will be found in the productive belt, and there will be lateral and deeper extensions of producing fields.

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STRATIGRAPHY AND PETROLEUM POTENTIAL OF PENINSULAR FLORIDA AND SOUTHERN GEORGIA

Cretaceous and Tertiary sediments, with a maximum thickness of about 8,000 ft in southwestern Georgia and 18,000 ft in the South Florida basin, are present under all of the area south of the Appalachian Piedmont belt of Precambrian (?) crystalline rocks. In addition, flat-lying early Paleozoic sandstone and shale underlie northern Peninsular Florida and southernmost Georgia; Triassic continental deposits, with diabase sills and dikes, are in grabens under parts of the Georgia coastal plain and northern Florida; and Jurassic terrigenous clastics, carbonates, and evaporites probably are present on the western and southern flanks of the Peninsular arch.

Limestone and dolomite comprise most of the Cretaceous and Tertiary section. Anydrite is abundant in the Lower Cretaceous and Paleocene deposits, and sandstone and shale are present throughout the section in Georgia near the northern edge of the coastal plain. Deposition was in shallow-marine environments on an extensive, slowly subsiding shelf. The southern Appalachians were of low relief and, after Early Cretaceous time, little sediment from this bordering land was transported to the shoreline of the shallow sea. There were, however, several minor marine transgressions and regressions in southern Georgia during the Late Cretaceous and Tertiary, because of changes in the rate of uplift of the bordering land and downwarp of the coastal plain and adjacent marine areas. The regressive deposits, with sands, were deposited slowly, and they were reworked during the succeeding advances of the sea.

Many wells have been drilled in nearly all parts of Peninsular Florida and southern Georgia in search for petroleum. Therefore, data are available for deciphering the depositional and tectonic history of the area and assessing its petroleum potential. Only 4 small oil fields, all in southern Florida, have been discovered.

Lower Cretaceous carbonates and quartzose sandstones of the continental shelf off western Peninsular Florida, and of the northern flank of the South Florida basin have the greatest petroleum potential. Upper Jurassic carbonates and quartzose sandstones, which are probably present in the South Florida basin and the inner part of the Gulf continental shelf, may have many accumulations, and Paleocene carbonates of northwestern Peninsular Florida and adjacent continental shelf are potentially productive.

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CHANGE OF BATHYMETRIC DISTRIBUTION OF GENUS *Cyclammina*

Disparities between ancient and modern occurrences of *Cyclammina* spp., both in abundance and in the nature of the associated fauna, indicate that the bathymetric distribution of the genus *Cyclammina* in the Gulf of Mexico has changed with time. An examination of Gulf Coast fossil assemblages reveals that this distribution became more restricted during the late Pliocene, normal occurrences in the younger sediments being limited to upper bathyal and deeper zones. In the older section, the distribution extended into the neritic environment. This change was accompanied by a marked decrease in the relative and absolute abundance of *Cyclammina* spp. in the younger sediments.

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POSSIBLE FUTURE PETROLEUM PROVINCES OF GULF COAST—UPPER MIOCENE-PLIOCENE

During the Miocene and continuing through the Pliocene, great volumes of sediment were delivered rapidly to an eastward-shifting depocenter in southernmost Louisiana. Sediments were introduced to the basin by rivers and were distributed farther by marine currents gulfward and laterally across persistently broad shelf areas; the amount and grain size of the sediments decreased with distance from the deltas. At any depositional moment, three gradational facies (sand, sand-shale, and shale) were being developed in bands mainly parallel with the shoreline. This depositional pattern persisted through the late Miocene and Pliocene so that in the total geometry of this net-regressive sedimentary wedge, the facies may be grossly viewed as having developed a sand, a sand-shale, and a shale *magnafacies*.

The sand magnafacies has been productive. However, the majority of hydrocarbons have been found in the inner- and middle-neritic zones of the sand-shale magnafacies in structural traps formed by salt diapirs and growth faulting. The gulfward limits of their exploitation can be determined reasonably from present data and should be confined largely to water depths up to 600 ft. Any significant discoveries are likely to be in the offshore. Louisiana is approaching maturity in its development of these facies but there is room for limited extension. Offshore Texas is largely unexplored but results of drilling through 1969 appear to have been disappointing. The volumes of sediments in the sand and sand-shale magnafacies remaining to be exploited are estimated as follows:

Pliocene	*cu mi*	*Reservoir Rocks*
Texas	3,000	30%
Louisiana	14,000	20%
Upper Miocene		
Texas	13,000	30%
Louisiana	16,000	20%

A possible future source exists in the shale magnafacies, where turbidite sands can reasonably be expected on the updip flanks of salt structures and in the lows between them. The search for reservoirs of this type, particularly in the younger sections, will involve operations beyond the edge of the continental shelf in water exceeding 600 ft in depth. Exploration in the older sections can be accomplished in shallower waters, but will require increasingly deeper drilling. Turbidite exploration demands a considerable sophistication of seismic techniques and the best efforts of geologists, paleontologists, and geophysicists. No reasonable estimate of favorable sediment volume in the shale magnafacies can be made at this time.

Present economics barely have justified the oil industry's endeavor in the prime sand and sand-shale magnafacies in water less than 600 ft deep. The same economics hardly can be expected to support operations beyond the edge of the continental shelf, particularly in the face of deteriorating or conjectural objectives. Increased incentives are necessary to encourage the costly risk-taking that will be required to find and develop any future trends in the upper Miocene and Pliocene shale magnafacies. Instead, it appears that current political attacks on existing incentives will be successful to some degree, and incentives will be lessened. Without substantial compensating factors, economic considerations may jeopardize all future explorations in the Gulf.

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Origins of Abnormal Fluid Pressures

This paper was prepared by the Houston Geological Society Abnormal Pressure Study Group Subcommittee on Origins, to serve petroleum geologists who may be responsible for planning and executing drilling programs.

The normal compactional process produces a stress system in sedimentary rock. A stress system is in equilibrium when the overburden pressure on a given rock equals the sum of the fluid pressure and the grain pressure within the rock. Processes which impose changes in the stress system may generate abnormal pressures, and there are several different modes of origin. Abnormal pressures may be generated if changes in overburden pressure result from vertical compression, horizontal compression, or uplift. Abnormal pressures also may result if changes in fluid pressure result from fluid density contrast or recharge, or if mechanical or physical processes (such as faulting, adsorption, osmosis, or diagenesis) inhibit the expulsion of fluid from compacting rocks.

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Application of Paleobathymetry in Exploration

Ecological studies of living Foraminifera provide an accurate framework for paleobathymetric interpretations. Exploration for hydrocarbons can be improved greatly if these interpretations, together with standard stratigraphic and structural methods, are used by the geologists.

Paleobathymetry can be used in (1) interpreting the geologic history of an area, (2) demonstrating seafloor topography and establishing the time of growth and burial of topographic highs, (3) determining the presence of faults and unconformities, and the amount of uplift or subsidence, (4) correlations, and (5) determining the interrelations among sand deposition, abnormal pressure, and accumulation of hydrocarbons. These relations can be derived by plotting paleobathymetric data on cross sections and constructing bathymetric, tectonic, structural, and isopach maps.

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Future Petroleum Provinces of United States Western Gulf Basin—Lower Miocene-Oligocene

Future lower Miocene-Oligocene discoveries will be found under conditions similar to those controlling present production. Reservoirs are typically sandstone, and traps are usually structural, associated with salt domes, fault closures, anticlines, or residual highs. Depositional environment is critical for accumulation of hydrocarbons, the ideal habitat being a thick section of deltaic or shallow-neritic sandstone interbedded with marine shale. This relation limits the extent of production downdip where deeper shale replaces sandstone.

The lower Miocene section appears to be prospective both downdip from and on strike with the present producing trend over a 9,600 sq mi (24,900 sq km) area in Louisiana and Texas. The prospective area contains 9,200 cu mi (38,300 cu km) of sedimentary rock and lies largely on the sparsely drilled continental shelf offshore from southwestern Louisiana and south Texas. This future province may be divided into two parts: a probable producing area of 4,700 sq mi (12,200 sq km) containing 4,800 cu mi (20,000 cu km) of sediments, and a possible producing area of 4,900 sq mi (12,700 sq km) containing 4,400 cu mi (18,300 cu