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Oil Source Beds and Oil Prospect Definition in Upper Tertiary of Gulf Coast

Data on the origin and migration of oil in the highly productive Gulf Coast Tertiary are sparse. What is known with some certainty is that crude oil (1) is most commonly found in old salt-related structures, (2) probably migrated vertically a considerable distance through fault-associated fracture systems, and (3) most likely originated in deeply buried high-pressure marine-slope shales. All other conclusions are highly speculative. Oil compositions suggest multiple sources with mixed type II and type III kerogens. Although many migration modes have been suggested, most oil movement probably took place as a continuous oil phase or as a solute in a supercritical gas phase. Accumulation occurred most readily in structural closures within or just above the "soft" geopressure zone where pressure gradients are high and seals are effective.

Because of their location in the "hard" geopressure zone, oil source beds are rarely penetrated, and the lack of adequate samples has made practical application of geochemical data in the Gulf Coast difficult if not impossible. Nearly all published information defines only thermally immature, organic lean, gas-only source beds. Consequently, until appropriate samples can be collected and analyzed, it is important to develop conceptual models based on geologic history and seismic-stratigraphic methods to predict distribution of oil source beds.

A model for oil source bed deposition in anoxic, salt-controlled intraslope basins has been developed. Most modern, silled basin analogs, however, are oxic and do not contain oil-generating kerogens. Reduced bottom circulation and resulting anoxia could have existed better during periods of global warmup and high sea level stands that occurred during the Pliocene and middle Miocene. Definition of these oil source bed sites, either directly by geochemical analysis or indirectly through seismic investigations, can greatly enhance our ability to predict oil occurrences and to separate oil from gas prospects. It should also stimulate collaboration among Gulf Coast geologists, geophysicists, geochemists, biostratigraphers, and petroleum engineers, which will result in improved geologic models and exploration successes, quite possibly including the discovery of oil in obscure and subtle traps.

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Exploration and Development of Gulf Coast Tertiary, 1983

Total well completions in the Texas Gulf Coast portion of the Tertiary trend registered a marked decline during 1983, with gas completions experiencing the largest drop. The overall success rate, however, remained almost unchanged at 62%. Wildcat drilling declined by about 14%, but the success rate increased to 23%. The Wilcox, particularly the deep Wilcox and Lobo trends of south Texas, was the most popular exploration target and resulted in 40 new field discoveries. The Frio provided the largest number of new discoveries in 1983 with 55 recorded, as well as most of the new pays and extensions. Drilling for Yegua pay was also brisk and resulted in 18 new fields.

In south Louisiana, a similar decline occurred in overall completions and wildcats drilled, with the respective success rates of 46% and 8% being markedly lower than for the Texas Gulf Coast. Here the most significant new trend was the downdip Wilcox, centered in Lockhard Crossing and Livingston fields in Livingston Parish, and originated by Callon Petroleum in 1982. The Miocene, however, attracted the greatest amount of wildcat drilling in 1983 and constituted the pay in most of the new fields discovered with 12 listed.

Several prolific extensions to existing Miocene fields were also reported. The Wilcox play in the central Louisiana parishes resulted in four new field discoveries, and its extension into southwestern Mississippi opened nine new fields there. The shallow Miocene play continued in Baldwin and Mobile Counties, Alabama.

Offshore Texas and Louisiana, the bulk of exploration was directed at Miocene targets—including several tests drilled in water depths up to 3,450 ft (1,050 m)—and resulted in 19 new Miocene field discoveries.

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Thermal and Diagenetic History of Pleasant Bayou-Chocolate Bayou Area, Brazoria County, Texas

Studies of the Pleasant Bayou 1 and 2 test wells and of data from the Chocolate Bayou oil and gas field have yielded the most complete picture of a geopressured geothermal aquifer system yet obtained from the Texas Gulf Coast. The principal geothermal reservoir, the "C" (Andrau) sandstone, has outstanding porosity and permeability owing to (1) initially high porosity resulting from deposition in a winnowed distributary-mouth bar complex, (2) enhancement of porosity by secondary leaching by acid waters, and (3) isolation from late carbonate cementation. The maturity profile obtained for the test well is anomalous, but can be modeled using various time-paleotemperature and burial-history configurations. These models fall into two groups. The first assumes the present geothermal gradient, modified by cooling of the lower Frio section by water flow. In the second, anomalously cool paleogeothermal gradients must be enhanced by the passage of warm waters through the middle Frio section. Both models indicate a fairly late origin of secondary porosity.

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Microfacies and Porosity in Vivian Field, Caddo Parish, Louisiana

Approximately 1 million bbl of oil and 2 bcf (5.7×10^7 m^3) of gas have been produced from the Vivian field since its discovery in June 1981. Ultimate recoverable reserves after water flooding are estimated to be 5.1 million bbl of oil and 8.3 bcf (2.4×10^8 m^3) of gas. The field is a stratigraphic trap resulting from porous, permeable grainstones pinching out into muddy limestones and shale. It is located on the northwestern flank of the Caddo-Pine Island structure in Caddo Parish, Louisiana, and has 56 productive wells, 52 of which produce from one or more reservoirs in the Pettet "B" interval. (The Pettet "B" is a term used by the operator of the field to denote the second of four limestone units encountered when drilling through the Lower Cretaceous Sligo Formation in the vicinity of Vivian field.) The reservoir rock is primarily skeletal-rich grainstone (rarely oolitic). The occurrence of these high-energy deposits at this location indicates that the broad Sligo platform was divided by an oolite-shoal complex into a platform lagoon on the landward side of the grainstones and an outer platform on the basinward side. A similar situation was described for the Sligo of south Texas.

The Pettet "B" interval contains eight microfacies: oolitic grainstone, skeletal grainstone, skeletal-oolitic grainstone, skeletal packstone, oolitic packstone, skeletal-oolitic packstone, skeletal wackestone, and shale. Three depositional environments (high, moderate, and low energy) are represented by these microfacies.

Reservoir grade permeability of 0.5 md or greater is restricted to the grainstone microfacies in the Pettet "B." Normally, this occurs in the skeletal and skeletal-oolitic grainstone microfacies where permeabilities can be as high as 80 md. A portion of the lower B2, however, does have lower limit reservoir permeability in a medium-grained oolitic grainstone. Porosities associated with reservoir-grade permeabilities range from 9 to 21%.

The Pettet "B" represents an oolite-shoal complex which built up on the broad Sligo platform. An apron of skeletal grains, primarily aragonite mollusc shells, accumulated in a narrow belt on the seaward flank of the oolite-shoal complex. Porosity and permeability are highest in this skeletal grainstone, which has both primary and skeletal-moldic porosity.

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Transmission Electron Microscope Study of Illite/Smectite, at GCO/DOE 1 Pleasant Bayou Geopressured Geothermal Test Well, Brazoria County, Texas

Six shale samples, two from core and four from hand-picked cuttings, were examined by transmission electron microscopy (TEM) techniques to study the effects of burial metamorphism on mixed-phase illite/smectite (I/S). TEM lattice fringe images from shallower samples show mixed-