Areal distributions of clay suites of the central Gulf of Mexico area have been studied mainly by X-ray diffraction, using peak-height ratios as an index to the nature of clays. This approach alone yields little information regarding effects of depositional environments. The present study couples geochemical techniques with analysis of other environmental indicators and emphasizes effects of organic and inorganic processes associated with deposition and early diagenesis. Undisturbed samples from both active environments and deep borings were utilized. Samples from fresh-water alluvial valley and upper deltaic-plain environments were compared with others from brackish and saline environments of the lower delta. Laboratory techniques included X-ray radiography, X-ray diffraction, X-ray spectrography, atomic absorption spectrophotometry, and microsteam distillation.

Clays deposited in channel and natural levee environments show little modification from the basic transported suite carried by the Mississippi (predominantly montmorillonite with appreciable amounts of illite and kaolinite). Minor differences attributed to seasonal fluctuations in flow regimes of major tributaries are detectable in suspended load and bottom samples. Percent organic C and cation-exchange capacities tend to decrease toward the river mouth.

In the lower delta, properties of delta-front and prodelta clays show distinct gradients, reflecting velocity decrease, water-depth increase, salinity increase, and mixing with shelf clays. Clays become more kaolinitic, less calcium saturated, and more sodium saturated seaward from distributary mouths. In these environments high soluble salt content is associated with a distinct texture and lamination produced by salt flocculation.

Integrated intensity ratio logs of montmorillonite-plus-illite/kaolinite from deep lower-delta borings not only exhibit trends related to delta progradation, but also show clay-mineral zonation resulting from shifting delta lobes. This zonation has been useful particularly in solving stratigraphic problems associated with diapiric mud-lump structures.

Clays are introduced into upper deltaic plain fresh-water basins largely by overbank flow from the main distributaries. Paludal and lacustrine environments are characterized by low rate of detrital introduction, high rates of organic and inorganic chemical deposition, high pH (>8.0), and warm, stagnant water. Despite the fact that secondary minerals (siderite, calcium carbonate, pyrite, vivianite, *etc.*) in the form of nodules and cementing agents are abundant and form rapidly, the basic nature of the clay remains unaltered even after burial for several thousand years.

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Anatomy of a Giant—Oklahoma City Field

Oklahoma City field, Oklahoma County, Oklahoma, was discovered in 1928 by the drilling of a wildcat well on a mapped 100-ft surface closure. Today this field ranks among the largest 10 oil fields in the United States. Its structural growth is allied closely to the stages of evolution of the Anadarko basin. Growth probably commenced in Cambrian time, and definitely took place from Ordovician through Early Pennsylvanian time as a result of subsidence in the Anadarko basin. This subsidence caused faulting and compressional folding, the most pronounced of which took place near the northeast rim of the basin. In that area, folds and faults in the Anadarko basin intersected the southern end of a buried mobile basement feature, the Nemaha ridge. The presence of this ridge not only influenced the position of the Oklahoma City field structure, but also its size, shape, and structural complexity.

The structure was folded, faulted, and truncated more or less contemporaneously. Approximately 2,000 ft of Ordovician-Pennsylvanian sediments was removed from the top; Pennsylvanian sediments above the unconformity overlie rocks as old as Ordovician. The trap is big—12 mi long, and having 1,000 ft of closure. A 2,000-ft, down-to-the-east fault prevented lateral migration of oil from the fold. The Pennsylvanian above the unconformity allowed only limited upward migration. Relief was so prominent and growth so continuous, even after truncation and burial, that the fold provided an ideal environment for development and trapping of oil and gas in the numerous shallow Pennsylvanian sandstones on the irregular surface of the fold. Traps within the Pennsylvanian sandstones include pinchouts, fault traps, and channel deposits.

The discovery well produced from Ordovician Arbuckle dolomite, the oldest pre-Pennsylvanian rocks on the crest of the structure beneath the unconformity. The most prolific production has been from the Wilcox Sand (basal Simpson) on the lowest part of the structure along the west flank, nearest the common water table. More than 20 different zones are productive from Ordovician Arbuckle to Late Pennsylvanian. Arbuckle and lower Simpson oil zones have a water drive.

Production from the Wilcox Sand was 350 million bbl of oil and 820 Bcf of gas through 1939, at which time the pressure in the Wilcox zone was reduced to atmospheric. Since 1939 the natural water drive has not been effective and natural gravity drainage has resulted in the production of an additional 186,370,000 bbl of oil. Estimated Wilcox oil in place is 1,072,000,000 bbl.

This field is unique in that it has been for 40 yr a model and proving ground for exploration techniques and producing technology; for modern proration rules and laws; for drilling and testing techniques in deep rotary wells; and for establishing the standards for formation evaluation and reserve estimates. Developments within a major city furnished the excitement caused by many "wild" wells like "Wild Mary Sudik," but joy accrued to the economic infusion which came during the worst days of the depression.

It is a billion-barrel field, having already produced more than that amount of oil and oil-equivalent gas. Of additional importance is the influence which this field has had in the finding and development of great quantities of oil and gas in adjacent areas of Oklahoma and throughout the world.

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Oil and Gas Accumulation in Recôncavo Basin, Brazil

The Recôncavo basin, on the Atlantic coast near the city of Salvador, includes about 3,850 sq mi and is the principal petroleum province of Brazil. Since

1939, 255 wildcats have been drilled, resulting in the discovery of 43 areas of accumulation, accounting for 942 million bbl and 992 Bcf, respectively, of producible oil and gas. The API gravity of most of the oil ranges from 35° to 40°.

The Bahia Supergroup, the principal objective for petroleum exploration, has a maximum thickness of 20,000 ft. These sediments are nonmarine, and range in age from Late Jurassic to Early Cretaceous. The Late Jurassic deposits consist of a typical redbed association, which is overlain by the blanket Sergi Sandstone, the best reservoir rock of the basin. The Early Cretaceous (Neocomian) sediments are composed largely of dark-gray and grayish-green shale of the Itaparica, Candeias, and Îlhas Formations, which are considered to be the source rocks for the hydrocarbons. The "A" sandstone, the lenticular sandstone bodies of the Candeias Formation, and the São Paulo and Santiago Sandstones of the Îlhas Formation are the best reservoir rocks of the Neocomian section.

The present architecture of the Recôncavo basin is an intracratonic half graben, developed chiefly during the times of deposition of the Candeias and lower Îlhas, when the basin became a rapidly sinking trough. The accelerated growth of the Salvador and Mata-Catu uplifts, the most prominent structural features, were responsible for the two principal northeast- and northwest-trending normal fault sets. A late phase of tectonic movements occurred near the end of, or after, deposition of the São Sebastião, reactivating ancient faults and causing new ones to form. As a consequence, the tectonic pattern of the basin is a complex system of faulted blocks.

The six major fields, in which 96 percent of the total producible oil is concentrated, are related to the structural evolution of the basin. It is believed that the early period of faulting, contemporaneous with the deposition of Candeias and lower Îlhas, was a decisive factor in the control of petroleum migration and accumulation in Sergi and "A" sandstones. The horst blocks of Agua Grande, D. João, and Buracica fields, uplifted during this tectonic phase, trapped about 622 million bbl of recoverable oil in the two sandstones. Accumulation of Îlhas reservoirs was controlled mainly by the later phase of faulting. Folds, developed in the downthrown blocks of normal faults, but not related to compressional stresses, were the traps for accumulations in the São Paulo and Santiago Sandstones. Examples of such traps, which accumulated about 186 million bbl of producible oil, are Miranga and Taquipe fields. The genesis of the reservoir sandstone lenses in Candeias field, a stratigraphic trap, is related to syntectonic Candeias deposition. Fractured shale and limestone also constitute reservoir rocks in this field, where 94 million bbl of recoverable oil were trapped.

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Komia Banks (Pennsylvanian) of Southwestern San Juan Mountains, Colorado

Investigation of a Pennsylvanian limestone unit exposed near Molas Pass, southwestern San Juan Mountains, Colorado, reveals a distribution of carbonate materials similar to those on some modern banks of south Florida. Local thickenings of an interval containing the problematical red alga *Komia* suggest bank-like accumulation at shallow sites which were favorable especially for the prolific growth of this organism. The size and twig-like nature of *Komia* and its common association with pelleted micrite matrix suggest a comparison with the modern alga *Goniolithon* which inhabits the Florida banks. Such comparison leads to the interpretation of a very shallow-water environment for the Pennsylvanian counterpart. Micritic matrix is replaced by sparry calcite cement near the fringe of the *Komia* banks and demonstrates the slightly more agitated conditions of the seaward margin where carbonate mud was removed selectively from around *Komia* grains

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Considerations Regarding Formation of Potash Deposits

Commercially valuable potash salts usually occupy only minor parts of evaporite basins, whereas certain noncommercial potassium-bearing minerals have a more widespread distribution.

The processes of the concentration of these potentially valuable salts no doubt begin when salt first is precipitated within the evaporating basin. As brine concentration increases, highly complex solutions are formed which influence not only the chemical but also the physical factors of concentration. Environmental and geologic processes at this time further aid in restricting the depositionally favorable locations in which the potash-bearing solutions can precipitate.

On completion of evaporation and burial of the preserved complex salts, further concentration and enrichment of the potash salts may occur due to metasomatic processes.

Saline precipitation presently is taking place on a reduced scale in some locations along the continental margins of the ocean basins, inland seas, continental brine lakes, and salt pans.

Trace minerals, such as bromine, cesium, and rubidium are of special interest in saline studies, because they furnish much information on the genetic character of the salts. Argon, found commonly in salt sequences where a high concentration of potassium is present, aids in the determination of the age of the salt.

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Upper Devonian Reef Oil Field—Redwater, Alberta, Canada

The Redwater oil field discovered in 1948 has in-place reserves of 1,300 million bbl, about 64 percent of which will be recovered. The field is a single pool 58 sq mi in area along the updip edge of a large Late Devonian (Frasnian) limestone reef complex.

The complex is more than 800 ft thick, roughly triangular in plan and about 225 sq mi in area. More than 900 wells have been drilled in the field area where normal forereef, reef, and backreef facies are recognized. Porosity and permeability were influenced by diagenesis, but conform with the primary facies patterns.

The Redwater reef grew during a major subcycle within the Kaskaskian sequence. Transgression over shoal carbonate of the previous subcycle created a