changes in environmental conditions and/or oil characteristics.

Isobath maps show a displacement to the southwest (approximately 2.5 km) of the top of the anticline from deeper horizons to surface. In the upper and shallow zones, hydrocarbons are found in the south block only, divided into smaller blocks by an east-west fault pattern. Daily production is 160,000 bbl. Cumulative production is 125 million STB (October 1978).

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Grondin Oil Field, Gabon

After deposition of thick Aptian salt while the Atlantic Ocean was opening, the Gabon sedimentary basin was filled with mainly sandy continental and littoral deposits on the eastern margin and marine deposits on the west. The marine formations are mainly shaly, but a few sand layers, some thick, may be intercalated. Grondin oil field is related to one of these sands—the Batanga sandstone of Maestrichtian age. The sandstones are generally clean with good porosity, but some shales are interbedded. Gross thickness may reach more than 150 m.

The trap is an anticlinal salt structure, without noticeable piercing, though a median fault is obvious at the top. The producing sandstone is reduced by an internal unconformity. Nevertheless, the oil field, with a small gas cap, consists of a unique pool with a unique oil-water contact. Source rocks are post-salt marine shales, particularly in the Turonian. Migration probably occurred during the Miocene.

Grondin oil field, situated 40 km offshore, was discovered in 1971 by Elf Gabon and was rapidly developed. The initial recoverable reserves are estimated at 30 million tons (approximately 200 million bbl).

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Great Carbonate Bank of Yucatan and Its Petroleum Potential

Since 1972, numerous large and giant fields have been discovered in Chiapas and Tabasco States, southern Mexico, and in the offshore platform west of Campeche. Most of these fields produce from fore-bank talus, now largely dolomitized, of Late Jurassic and Early to middle Cretaceous ages. Drilling depths to the tops of the reservoirs generally are 3,800 to 4,500 m. Offshore discoveries include fields which also are productive in fore-bank talus of Paleocene age. The petroleum source materials for the Jurassic-Cretaceous fields are believed to be mainly Jurassic. Proved reserves in these new fields are 20 billion bbl.

Although some porosity and permeability are primary, most is secondary—the result of solution, dolomitization, and intense microfracturing. The original trap for the Late Jurassic–middle Cretaceous fields was stratigraphic, but the present traps are fractured, faulted, domal salt pillows created during the Laramide orogeny.

The basis for the discovery of the fields was the widespread presence on the Yucatan Peninsula, and in the states of Campeche, Chiapas, and Tabasco, of Cretaceous through Tertiary back-reef or lagoonal facies—carbonates, anhydrites, and some halite. In addition, more than 200 oil seeps were known in a linear zone along the foot of the Sierra Madre, adjacent to the coastal plain. By analogy with the Golden Lane, it was concluded that a great fore-bank talus deposit should lie gulfward from the lagoonal facies. With this geologic concept in mind, seismic work was commenced, and drilling during 1971-72 led to the dual discoveries of the Cactus and Sitio Grande fields in 1972.

The great carbonate bank of Yucatan is believed to continue northwestward into Veracruz State, where several discoveries have been made in carbonate rocks of Early to middle Cretaceous age in thrust sheets buried beneath the coastal plain. We believe that large, subthrust, anticlinal structures underlie the thrust sheets of the Veracruz basin and that, when drilled, these also may be the sites of giant-field discoveries.

Although the potential for this large area is great, it is too early to speculate on the potential reserves of the numerous but still untested structures of the region.

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Controls on Late Cretaceous–Paleocene Sedimentation in Wyoming

Recent developments in the time-stratigraphic interpretation of seismic record sections have indicated the need for separating tectonic and eustatic processes. The combination of a eustatic rise with a major orogenic episode during the Paleocene in Wyoming resulted in a stratigraphic sequence of economic importance. This sequence was deposited during a period of worldwide onlap, and a period of thrusting and foreland uplift. More than 5,000 ft (1,500 m) of stratigraphic fill of intermontane basins record these processes. Lithologic, environmental, and petrographic observations indicate sea-level changes, strandline positions, paleocurrent patterns, and areas of provenance.

Authigenic glauconite suggests an area of brackish to marine transgression within the "Cannonball sea." Supporting this observation, specific vertebrate faunas indicate that central Wyoming was inundated by the worldwide post-Danian transgressive onlap. Other environmental criteria support the paleogeographic reconstruction of a broad interior sea invading an area of rising uplifts, encroaching thrust plates, and subsiding basins. These boundary conditions provided the framework for the development of commercial hydrocarbon and coal accumulations.

Lacustrine and marine source and reservoir rocks, coastal swamps, and thick subbituminous coals were developed in response to the climatic, tectonic, and eustatic history. These aspects are interpreted from the mineralogy, palynology, petrophysical responses, and the facies patterns in outcrop and subsurface sections.

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IPOD Drilling on Convergent Ocean Margins

Active ocean margins have been drilled by the *Glomar Challenger* to test the conceptual subduction-accretion model of convergent-plate tectonism. In this model, subduction results in accretion of oceanic and trench sediment to the margin and a general buildup of the upper plate. The results of pre-IPOD drilling confirmed some general aspects of the model such as compressional strain, folding, deformation of young sediment, and periods of arc volcanism. However, the results of IPOD drilling along the Japan and Mariana Trench transects indicate that much of the oceanic sediment is subducted rather than accreted if the rates of convergence derived from global considerations are assumed. Off Japan, massive subsidence of the outer continental shelf during subduction suggests some erosion and disposal of the leading edge of the upper plate. Thus the conceptual subduction-accretion model cannot be applied in these two areas without major modification.

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Effects of Source Material and Thermal Maturation on Chemical Composition of Gulf Coast Crude Oils

Variations in the chemical composition of crude oils in the Gulf Coast of the United States are related to the depositional environments of the rock successions from which they are produced (a measure of source type), and to the temperature to which the oil has been subjected (a measure of maturation). The chemical composition of 2,105 Gulf Coast crude oils was calculated from physical properties determined by the U.S. Bureau of Mines. The relative proportions of paraffin, naphthene, and aromatic compounds in these oils revealed two clusters of crude oil composition. The first cluster contains an average of 70% paraffin, 20% naphthene, and 10% aromatic compounds and is the most common type of crude oil produced from Mesozoic reservoirs. The second cluster contains an average of 43% paraffin, 45% naphthene, and 12% aromatic compounds and is the most common type of crude oil produced from Cenozoic reservoirs.

The importance of source material in determining crude oil composition is demonstrated by (1) the close association of high-wax crude oils with Mesozoic and Cenozoic rocks formed in deltaic environments; (2) the association of crude oils rich in aromatic compounds with rocks formed in interdeltaic environments; and (3) the occurrence of high-sulfur oils in Mesozoic reservoirs which are not associated with delta systems. Deltaic environments provide greater sources of terrigenous organic material versus interdeltaic areas, which contain more marine organic material.

The effects of thermal maturation are shown by the relation between reservoir temperature and the relative proportion of naphthenes in the crude oil. Oils having greater than 55% naphthenic compounds are produced from Cenozoic reservoirs which have lower temperatures than those which produce paraffin-rich oils.

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Role of Physical Sedimentation in Carbonate-Bank Growth

Carbonate mud banks of central Florida Bay contain three types of sediment wedges which provide evidence that pulses of rapid physical sedimentation are a dominant cause for bank growth and migration.

Most dramatic are layered to laminated wedges of carbonate mudstone flanking eastern, southern, or western bank margins. Depositional units are 0.5 to 1.5 m thick and compose up to 70% of the existing bank. Units have erosional basal contacts; basal shelly sand grades upward to a layered to laminated mudstone containing no pellets, no burrowing, no seagrass rootlets, and few sand-size skeletal grains. Three features suggest rapid deposition: vertical escape burrows extending upward from the basal sand, vertical smooth-walled water-escape fractures in the lower part, and abundant seagrass blades incorporated into the layers.

The second type of wedge is a layered, pelleted mudstone to packstone otherwise similar to that described above.

The third type of wedge is a bioturbated, soft-pellet wackestone to packstone as much as 1 m thick and flanking only southern bank margins. It contains horizontal to inclined seagrass rhizomes throughout and has minor autochthonous mollusks.

The layered wedges are interpreted to record rapid subtidal sedimentation during rare superstorms (extreme hurricanes), the first type from storms of sufficient violence to destroy most pellets. The third wedge type records persistent lee-side accumulation from lesser hurricanes and winter storms. This deposition, although rapid, is slow enough to be in continuous association with a seagrass-community influence.

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Lower Cretaceous Carbonate Shelf in Southeastern Arizona and Northeastern Sonora, Mexico

The Mural Limestone (Bisbee Group, Lower Cretaceous) in southeast Arizona and northeastern Sonora exposes a broad carbonate shelf and an irregular, migrating shelf margin at the northwest end of the Chihuahua trough. The upper Mural represents the culmination and initial regressive phases of an Aptian-Albian transgression. It is underlain by nearshore clastic strata and limestones of the lower Mural and the Morita Formations, and overlain by clastic beds of the Cintura Formation. Study of the narrow outcrop belt from the Mule Mountains in Arizona to where the Mural disappears beneath Quaternary volcanics, 70 km to the south in Sonora, reveals an overall pattern of southward-deepening water. The upper Mural thickens from 50 to nearly 300 m over this distance. Facies present in Arizona are, from north to south: (a) shallow lagoonal packstones and wackestones; (b) a broad oolite and pelletoid-sand shoal; and (c) a muddy, open shelf with small, isolated reefs in waters at least 10 m deep. In Mexico,