shore marine (delta-front and inner-shelf) sandstones disconformably overlain by crossbedded (active) to deformed (abandoned) distributary-channel sandstones and conglomerates. The sequence is capped by delta-plain mudstones and silty sandstones.

Tight-gas sandstone reservoir facies are nonhomogenous and include crevasse splay, abandoned and active distributary channel, shoreface, foreshore, and inner shelf sandstones. Distributary-channel facies represent 80% of perforated intervals in wells in the southern part of the Moxa area, but only 50% to the north. Channel sandstone bodies are occasionally stacked, occur on the same stratigraphic horizon, and are laterally discontinuous with numerous permeability barriers. Percentage of perforated intervals in upper shoreface and foreshore facies increases from 20% in the south to 50% in the north. These sandstones thicken to the north and east and are more laterally continuous than channel facies. The lower Frontier contains strike-oriented shoreface (delta front) and dip-oriented distributary channel sand bodies in approximately equivalent amounts. Delta-plain mudstones thin to the north and east and are an important stratigraphic seal. Highest gas production rates are from distributary-channel sandstones closer to the axis of Moxa arch. However, there appears to be little correlation between the thickness of any reservoir facies and net production.

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Geology and Major Oil Plays, Coastal Margin Basins, Brazil

Six major tectonic-depositional sequences, reflecting rift and passive margin evolution, variously characterize the filling of Brazilian coastal margin basins: (1) Late Jurassic prerift, (2) Early Cretaceous tectonic rift, (3) Early Cretaceous quiescent stage (evaporitic or calcilutitic), (4) middle Cretaceous initial drift carbonate platform, (5) Late Cretaceous platform/deltaic progradational and deep marine retrogradation, and (6) Tertiary main passive margin progradation.

Habitat of oil discovered to date meets two regional geologic conditions: (1) in tectonic rifts known to have basin core of starved, lacustrine shales, and (2) in basins which developed a quiescent phase during the transition from tectonic rift to passive margin.

Two major plays characterize the central core rifts, including (I) underlying prerift sediments in fault contact with the central core, and (II) sublacustrine fans overlying the central core. These plays, typified in the Recôncavo basin, constitute about half the recoverable oil found to date.

A structurally related variation of type II play and a third regional play exist where the quiescent condition occurred, including reservoirs of the rift below evaporitic or calcilutitic regional seals and carbonate platform and turbidite reservoirs in the passive margin above the quiescent episode. The subevaporitic-calcilutitic subplay is prominent where overlying regional seals are structurally unmodified, contains about 15% of the discovered oil, and has typical development in the Sergipe (evaporitic) and Potiguar (calcilutitic) basins. Where regional seals of the quiescent phase have been mobilized, structurally modified, or cut by subsequent submarine canyons, carbonate platform and turbidite reservoirs of the overlying passive-margin fills are the prominent play (type III). This play, with typical development in Campos basin, in Mosqueiro low in Sergipe basin, and onshore Espirito Santo basin accounts for 35% of the discovered oil.

Exploration implications of the established plays are: (1) source is from tectonic or quiescent stage fill (Aptian or older); (2) structural integrity of the quiescent stage seals is critical to oil migration; and (3) tectonic rifts are productive when a core of deep lacustrine shales was developed.

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Diagenetic Relationships and Hydrocarbon Resource Implications, Nanushuk Group and Torok/Topagoruk Formation, National Petroleum Reserve, Alaska

Petrographic, X-ray diffraction, and scanning electron microscope investigations of Nanushuk Group and Torok/Topagoruk formation (Brookian) sandstones and siltstones from 9 wells in the National Petroleum Reserve in Alaska resulted in recognition of features of interest regarding the diagenetic development of these rocks. Several kinds of labile materials are present, and secondary dissolution porosity has been developed to various degrees. Mineralogic, geochemical, and textural characteristics indicate the potential for development of appreciable porosity of this type in equivalent horizons and/or similar materials within the northern Alaska Cretaceous basin.

Known regional geologic, geochemical, and geophysical relationships are consistent with this view. Considerations of hydrocarbon resource potential should include concern for these relationships as integral to appreciation of the overall diagenetic evolution of the region.

Heretofore, the potential for the occurrence of significant reservoir rocks in these horizons has been considered to be rather low, based on primary petrologic characteristics. However, this should be reappraised in light of increased knowledge and understanding of the principles and realities regarding diagenetic events, inorganic and organic, including secondary porosity development, clay mineral relationships, and maturation of organic material.

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Late Cenozoic Pull-Apart Graben Development, Big Bend Region, Texas

The Big Bend region is a giant rhomb-shaped structure with the Presidio (west) and Black Gap (east) pull-apart grabens marking the north-northwest-trending ends and the north and south branches of the Texas lineament (TL) marking its west-northwest-trending strike-slip ends. This large rhomb is broken internally by many faults (west, west-northwest, and north-northwest trends) that have generated numerous small to large pull-apart grabens.

Black Gap graben is divided into segments by west-northwest faults that drop each segment deeper (250-1,050 m, 820-3,450 ft, structural relief) and southeastward in the United States part. The continuation into Mexico has not been studied.

Presidio graben also has a complex bounding fault pattern of north-northwest-, west-northwest-, and west-trending segments. Depth of the graben in unknown, although outcrop and well data give a minimum of 800 m (2,600 ft). The internal shape is poorly known because of widespread pediment gravel cover.

The Presidio and Black Gap grabens are the southeastern continuation of the Rio Grande graben system that terminates southward against the north-branch of the TL (that extends from El Paso to Valentine Black Gap across Texas). The south-branch of TL extends east-southeast from near Presidio across Mexico to the Gulf of Mexico near the mouth of the Rio Grande.

Right slip along the west-northwest trends is demonstrated in the Sierra del Carmen by slickensides and by a first-motion study of the Valentine earthquake. Strike-slip displacement is presumably modest across the region (under 10 km, 6 mi, ?), but actual slips are indeterminate with the present data set.

The Presidio graben lies along the eastern boundary of the Laramide Chihuahua overthrust belt. The Black Gap graben lies along the eastern boundary of the Laramide Rocky Mountain front.

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Magnetotelluric Sounding Method as Applied in Ouachita Thrust Belt, Central Texas: A Case History

A 25-station magnetotelluric (MT) traverse across central Texas has been recorded and analyzed. The 84 line-mi (135 line-km), northwest-southeast-trending traverse begins 13 mi (21 km) southeast of Lampasas and ends 6 mi (10 km) north-northeast of Lexington, Texas. Geologic elements crossed are the Ouachita foreland facies, frontal and interior zones, and the rimming gravity high described by Flawn et al, Nicholas and Rozendal, and others.

Interpretation of the MT data, supported by 1- and 2-dimensional modeling, borehole data, and previously published gravity data, suggests northwest transport on the order of 22 mi (35 km) for the allochthonous Ouachita frontal zone.

A shallow resistive zone in the Precambrian and the overlying autochthonous Ouachita foreland facies is traced southeast 46 mi (74 km) from the sites nearest Lampasas, but become indeterminate north of Taylor, Texas. Data from the Shell 1 Purcell (Williamson County) suggest the shallow Precambrian resistor to be correlative with granites outcropping in the Llano uplift. While indeterminate southeast of Taylor, autochthonous Ouachita foreland facies is interpreted to overly Precambrian basement of similar resistivity at least as far southeast as the rimming gravity high.

Several other resistive and conductive zones are indicated in the Precambrian basement, including a resistive zone which rises to the southeast from a depth of approximately 50,000 ft (15,240 m) near Georgetown to 10,000 ft (3,050 m) into the core of an antiformal basement structure coincident with the rimming gravity high.

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Control of Accretion Processes on Tiran Strait Sill by Evaporation-Driven Current Dynamics

The Strait of Tiran (~4.5 km, 2.8 mi, wide), linking the Red Sea and the Gulf of Aqaba, is characterized by 4 small, shallow carbonate platforms separated from the Sinai coast by the deep (≈280-m, 920-ft) Enterprise passage and from the Saudi Arabia coast by the shallow (≈75-m, 250-ft) Grafton passage.

Intense evaporation (3.5-5.0 m/yr, 11.5-16.5 ft/yr) in the interior basin of the Gulf of Aqaba suggests the presence in the strait of an inverse stratified flow, similar to the Strait of Gibraltar. As no direct observations of currents existed, 12 current meters were deployed for 5 weeks across the 2 deep passages in winter 1982. Other physical data included salinity-temperature-depth (STD) transects and wind and tide measurements.

The deeper Enterprise passage shows a remarkably steady, strongly developed 2-layered flow structure, with upper layer net inflows of 30-40 cm/sec (12-16 in./sec) and lower layer net outflows of 55-60 cm/sec (22-24 in./sec); the shallow Grafton passage is completely in the upper layer, with net flows of 30-40 cm/sec (12-16 in./sec) directed northerly into the Gulf against the wind.

High-resolution seismic profiles, side-scan sonar data, echo-sounder profiles, and direct observations of the bottom indicate morphological responses in sill geometry and sedimentation patterns that reflect controlling dynamics. For example, morphological features associated with the shallow sill channels are controlled by the upper-layer gulfward flow. Current and salinity data in the deep passage suggest outflow-oriented features that are as yet unconfirmed by seismic profiles. Bottom samples suggest that sill accretion is accomplished primarily by the buildup of coralline algae, as well as stabilization of coarse bottom sediments by both organic and inorganic cements. Another striking feature is the occurrence of large and numerous patch reefs on the windward (northern) slope of the shallow platform margins. Storm wave forces on the platform front apparently dislodge carbonate blocks that function as substrates for thriving patch reefs. These processes are likely characteristics of entrances to tectonic troughs in early stages of ocean-basin formation.

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In-Situ Rock/Water Geochemistry of Holocene Marine Radial Ooid Environment, Lizard Island, Great Barrier Reef, Australia

Although most marine ooids have concentric structure and aragonitic composition, radial-structural aragonite ooids occur in Lizard Island. Radial ooids are confined to the lagoonal sediment south of Lizard Island in water depths of 0-7 m (0-23 ft). Primary bed forms vary from minor current ripples to nondescript. Ooids comprise up to 18% of the subarkosic sands and are found in an environment protected from open-ocean energy by patch and fringing reefs. Ooids are dark gray and are frequently bored by endolithic algae. Compound and asymmetric forms are common. Individual aragonite crystals may range up to 12 μm in length.

To assess the environment of formation, in-situ diurnal chemical measurements were made in the ooid and interstitial and ambient waters. Critical parameters examined in a 28-hr period were temperature, pH, P_{CO_2}, Cl ‰, $A_{Ca^{2+}}$, and $A_{CO_3^{2-}}$. Cyclic diurnal changes occur in both water systems, with the ambient water experiencing the greatest changes. Measured extremes for the ambient water are day = 25.3°C, P_{CO_2} of $10^{-5.08}$, and Alk_c of 2.52 meq; night = 22.3°C, P_{CO_2} of $10^{-4.98}$, and Alk_c of 4.31×10^{-3} meq. The $A_{Ca^{2+}}$ (2.6×10^{-3}) and Cl ‰ (19.24 ‰) are essentially time invariant. The P_{CO_2} ranges from atmospheric saturation in the day to supersaturation during the night. Both ambient and pore waters are supersaturated with respect to aragonite ($\Omega_{ARAG\text{-}ambient} = 2.8$ to 4.4; $\Omega_{ARAG\text{-}porewater} = 3.1$ to 4.1). Our findings suggest alkalinity consumption by carbonate precipitation occurs during the day and is greatest in the upper 10 cm (4 in.) of ooid sands.

This physical/chemical environment differs from other monitored classic ooid localities and is diagnostic of marine radial-structured aragonite ooid growth.

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Stratigraphy of Transgressive Barrier Island Arc

Isles Dernieres, a Holocene transgressive barrier island arc on the Louisiana coast formed as a result of dominant marine processes reworking deposits of the abandoned Caillou distributaries of the early Lafourche delta lobe. The island system exhibits a variable transgressive and regressive stratigraphy throughout its framework, which is discriminate from comparable Atlantic coast transgressive barrier sequences. Continuous subsidence and storm breaching divide the island system into 3 major island segments: Western, Central, and Eastern Isles Dernieres, each of which is separated by locally interjacent tidal inlets.

Vibracore data reveal that Western Isles Dernieres represents a series of accreting sand spits that resulted from the erosion and longshore transport of the abandoned distributary channel deposits from the central deltaic headland. This 3 to 4-m (10 to 13-ft) thick sequence of sand spits and associated marsh deposits overlies interdistributary silts and clays. Central Isles Dernieres is a fluvial-deltaic complex that exhibits marsh and tidal-flat deposits capping a relatively thick sequence of levee and interdistributary bay sediments. A relatively thin beach-ridge plain lies locally submerged beneath sand spit and marsh deposits of Eastern Isles Dernieres. This beach-ridge plain formed during a regressive phase of island evolution. Erosion of the beach-ridge plain above the effective wave base presently provides an active sand source for the downdrift accreting sand spit at the eastern end of Isles Dernieres.

A high preservation potential of the western and eastern transgressive sequences of Isles Dernieres is probably due to rapid subsidence and the consequent in-place drowning of the island segments. In contrast, Atlantic coast barrier counterparts often exhibit incomplete transgressive sequences owing to continued shoreface erosion.

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Estimating Reserve Growth: Opportunities and Challenges for Petroleum Resource Assessment

Historically, efforts at petroleum resource assessment have concentrated on assessing amounts remaining to be discovered in unknown fields. Today the most important methodological frontier in petroleum resource assessment is assessing reserve growth in known fields. During the past 10 yr, most of our reserve additions have come from the growth of old fields, not the discovery of new ones. In the contiguous United States, most of our recoverable resource potential of crude oil, and possibly of natural gas as well, is in known fields. To the conventional sources of reserve growth (extensions and new pool discoveries), recent improvements in economics and technology have added such diverse phenomena as infill drilling, well stimulation in tight formations, enhanced oil recovery, reduced abandonment pressures and production levels, and development of known but previously subeconomic areas and pools. The reserve appreciation models customarily used to estimate reserve growth fail to capture the effects of these and other recent developments. No single method will suffice in future assessment efforts, because the mechanisms of reserve growth have become too diverse. New methods must be tailored to the specific characteristics of each type of reserve growth. Economics must be considered explicitly. Improvements in field data bases are a fundamental prerequisite for the successful development and application of new methods.