organic matter, whereas for blanket peats, 14% of the section has more than 70% organic matter.

Mineralogic data collected on low-temperature ashes indicate that major minerals in brackish peat consist of kaolinite, quartz, and water-soluble salts, whereas minerals from freshwater samples are primarily kaolinite and quartz. X-ray diffraction and electron microscopy show the presence of smectite, illite, abundant siliceous spicules, framboidal pyrite, biotite, pyroxene, and rutile in the insoluble fraction.

Suitability of these deposits as coal precursors has been discussed by several workers. Superficial examination of data generated so far suggests that only thin coal seams with high ash would be produced. However, the presence of decomposing siliceous sponge spicules in the ash and the possibility of ash being leached by fresh ground water, suggest that much ash may be lost during early diagenesis. Hence, this environment may have more potential as a modern coal-forming model than it first appeared.

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Deep Wilcox Structure and Stratigraphy in Fandango Field Area, Zapata County, Texas

The Fandango field in Zapata County, Texas, is a new deep Wilcox trend extension. The deep Wilcox sands are commonly found at depths of 15,000 to 20,000 ft (4,500 to 6,100 m). Enough well log and seismic control now exists to make an accurate integrated interpretation of regional deep Wilcox structure and stratigraphy.

Deep Wilcox structure and stratigraphy are controlled by regionally extensive shale anticlines. These shale uplifts control deep Wilcox sand distribution, create large anticlines, and cause regional growth faults which commonly influence local structure. Each regional uplift presents a new exploration frontier holding the promise of vast reserves in the deep Wilcox.

The history of Frio-Vicksburg exploration is an analogy to the deep Wilcox trend today. It took 40 years to expand Frio exploration from shallow stratigraphic traps down into the enormous reserves in the Gulf of Mexico, because each new fault-block extension was considered to mark the downdip limit of Frio production. This was, of course, not true and is not true in the deep Wilcox today. The deep Wilcox trend remains virtually unexplored and it is my belief that continued work will prove the existence of much more deep Wilcox potential than is currently thought to exist.

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Tidal Inlet Variability in Mississippi River Delta Plain

Stratigraphic sequences of deltaic and shallow marine origin commonly contain sand bodies transgressively overlying lower delta-plain and delta-front deposits. Although generally ascribed to barriers formed during the destructive phase of the delta cycle, most of this sand is probably of tidal-inlet origin because of the high preservation potential for sediment deposited below the base of the retreating shoreface in deep migratory tidal channels and their associated tidal deltas. To facilitate the identification of such units, this paper reviews the temporal evolution of the inlet sand bodies found along the rapidly transgressive shoreline of the abandoned Holocene Mississippi River deltas. This study also reveals that tide dominance or wave dominance of a coastline is not simply a function of tide range and wave height; it depends largely on the tidal prism, an inlet parameter which, in Louisiana, changes rapidly over time.

Three distinct stages can be identified in the evolutionary sequence for Louisiana tidal inlets: (1) wave-dominated inlets with flood-tidal deltas, (2) tide-dominated inlets with large ebb deltas, and (3) wide, "transitional" inlets with sand bodies confined to the throat section.

Stage 1.—Tidal inlets ranging in age from 50 to a few hundred years are associated with flanking barrier systems attached to erosional deltaic headlands. The barriers enclose restricted interdistributary bays. Small inlets occur at the entrance to abandoned distributary channels within the headland section proper. The tidal prism being exchanged through either of these inlet types is small; the morphology of the inlets and adjacent coastline is wave-dominated, and most of the inlet sand is associated with a flood-tidal delta. The inlets are generally shallow.

Stage 2.—The Holocene Mississippi River deltas are subject to rapid subsidence and consequent local sea level rise. One gage at Grand Isle indicates a sea level rise of 30 cm (12 in.) over the past 20 years; however, the long-term average is somewhat less. Subsidence leads to an expansion of back-barrier open water environments, an increase in tidal prism, and an evolution of the inlet into a tide-dominated morphology with a deep main channel and large ebb-tidal delta. The recent evolution of Pass Abel and Quatre Bayou Pass represents the transition from wave dominance to tide dominance. Sand bodies developed in stage 2 inlets have the greatest preservation potential because they generally lie below the base of the retreating shoreface.

Stage 3.—Further subsidence generally leads to development of an open sound, permitting efficient tidal exchange with the gulf along the sound margin (Chandeleur Sound). As a consequence, the inlets play only a minor role in the tidal exchange pattern. At this stage, the inlet sand bodies evolve along two distinctly different paths, apparently controlled by sediment supply. Barriers with adequate coarse sediment produce many small well-defined inlets with large flood-tidal deltas (washover fans) and only transient, post-storm ebb deltas. The island shore is distinctly wave dominated. Along coastal segments where coarse sediment is scarce, one finds rapid island deterioration, shoaling of the inlet channel, and reworking of the ebb-tidal deltas into a "transitional" configuration with the sand tied up in throat section shoals.

As the inlets migrate during the transgression, they will leave behind on the continental shelf, tidal sand bodies with a landward succession of facies changing from those characteristic of wave dominance, into tide dominance, and back again to "transitional" or wave-dominated inlets.

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Harmony Field, Clarke County, Mississippi: A True Stratigraphic Trap

Harmony field in Clarke County, Mississippi, has produced approximately 2 million bbl of oil since its discovery in 1968. Production has been from oolitic grainstones in the upper Jurassic Smackover Formation.

The trapping mechanism at Harmony field is a complex stratigraphic trap. Porous oolitic grainstones pinch out updip into tight carbonates and anhydrite. Structure contour maps on top of the Smackover Formation indicate a low relief structural nose associated with the field. Additional structure maps contoured at the top of the Haynesville anhydrite, approximately 500 ft (150 m) above the top of the Smackover, reveal only regional southwesterly dip. An isopach map of the interval between the two structural markers shows a thinning of Haynesville section coincident with the field area. Evidence suggests, therefore, that the porous Smackover in Harmony field was deposited with depositional relief above the surrounding sediments. This relief had been completely masked by the time the Haynesville anhydrite was deposited.

Stratigraphic and structural cross sections using the Haynesville anhydrite as datum indicate the Smackover in Harmony field consists of not one, but multiple, thin oolitic zones which are productive in various portions of the field. These zones grade laterally as well as updip into nonporous anhydritic carbonates.

The Smackover Formation is often considered to be a chronolithologic unit. In the Harmony field area it is a lithostratigraphic unit, i.e., a unit defined not by time but by a particular rock type, in this case a porous limestone.

During the Late Jurassic, the Harmony field area was near the updip limits of the Mississippi salt basin. Porous oolitic grainstones are interpreted as washovers or storm deposits into lagoons containing tight carbonate muds. Such a model can provide excellent exploration targets in similar areas within the Mississippi salt basin. As Harmony field demonstrates, we are looking for features with little structural expression and great variations in rock type—true stratigraphic traps.

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Marginal Marine Evaporites, Lower Cretaceous of Arkansas

The mixed evaporite/carbonate/terrigenous clastic sediments of the DeQueen formation, in southwestern Arkansas, were deposited at the landward margin of a broad shallow lagoon formed behind the Glen Rose reef. About 60% of the sedimentary volume consists of mudstone, silt, and sand, with brackish-water to hypersaline ostracod faunas believed to result from influx of flood waters from the Ouachita highlands a few miles to the north. The lower part of the formation contains discontinuous beds of gypsum, ranging in thickness from a few centimeters to composite beds > 3 m (10 ft), and displaying mosaic structure with vertically oriented, elongate nodules. These beds, which are lenticular, are interpreted to result from subaqueous precipitation of vertical selenite crystals (subsequently recrystallized) in discrete ponds and pools on microtidal-range mud flats. Intrastratal growth of gypsum nodules and displacive halite occurred at the margins of the pools.

The upper part of the formation contains no gypsum beds, but halite pseudomorphs at the base of and within some of the thin limestones suggest the presence of supratidal brine pools. Several minor unconformities exist, of which one has a regional extent and is underlain by red-brown mudstones. Algal-mat lamination, lenticular gypsum pseudomorphs (an intrastratal growth form), and syneresis cracks occur in the limestones, and a supratidal environment is envisaged for a significant proportion of the time of deposition.

The limestones generally have a restricted fauna of ostracods, bivalves, cerithid gastropods, serpulid worms, and miliolid Foraminifera, and range in texture from lime mudstones to grainstones. The most abundant grain types are pellets, superficial ooliths, and terrigenous quartz. A paucity of dolomite is a striking feature. Some of the thinner bedded units are rippled, and some ripples were truncated during periods of emergence. The limestones are believed to represent periods of shallow water, slightly hypersaline to slightly hyposaline conditions of variable energy. The regressive trend displayed by these two divisions continued with deposition of the overlying formation. The uppermost 3 m (10 ft) of the DeQueen consists of mudstone with a thin marl at the top. A conformable contact exists with the overlying Antlers formation, which has basal mudstones becoming more silt- and sand-rich upwards and finally giving way to the typical Antlers (Paluxy) sands.

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Depositional Setting and Characterization of Deep-Basin Oak Hill Lignite Deposit (Middle Paleocene) of Southwest Alabama

In southwest Alabama, deep-basin lignite with economic potential occurs in the Oak Hill Member of the Naheola Formation. This middle Paleocene lignite is the thickest (2 to 11 ft, 0.6 to 3.3 m) and most extensive lignite in the southwest Alabama region. The Oak Hill lignite deposit accumulated in lower delta plain coastal marshes located in interchannel areas behind of a barrier system. The source area for the deltaic sediments was probably to the west and/or northwest of Choctaw County, Alabama. The lignite occurs in a clay-dominated sequence. Oak Hill interdistributary bay ripple-laminated clays are interbedded with ripple-laminated, crevasse splay sands generally < 15 ft (5 m) in thickness. The glauconitic sands of the overlying Coal Bluff Member of the Naheola Formation represent marine encroachment into the interchannel basin area.

An estimated 8 billion short tons of hypothetical Oak Hill deep-basin lignite may be available in southwest Alabama. The lignite is of good quality and is characterized on an "as determined basis" as having 20 to 27% moisture, 8 to 10% ash, 0.8 to 3.0% sulfur, 0.1 to 1.0% pyritic sulfur, 30 to 39% volatile matter, and 28 to 36% fixed carbon. The calorific value of the lignite is 9,070 to 9,970 Btu/lb and averages 9,530 Btu/lb. Presently, this deep-basin lignite resource is beyond the depth for effective surface mining and, therefore, must be recovered by underground mining or in situ gasification or liquefaction recovery methods.

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Recognition of Sandstone Depositional Environment: A Grain-Shape Approach, With Example from North Padre Island

The shapes of 8,000 fine quartz sand grains from Malaquite Beach, North Padre Island, were analyzed with the Fourier shape technique. It was found with this technique that dune sands can be differentiated easily from beach sands on the basis of both their gross and fine (roundness) shape characteristics.

The analysis of samples from transects across the beach and dunes also reveals a high degree of grain-shape variation within these environments. This variation is due to the effects of hydrodynamic and aerodynamic sorting by swash and wind currents respectively.

The Fourier technique provides a rapid and objective manner to discriminate between beach and dune sands, and can be applied to ancient as well as modern sands with equal facility.

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Hydropressure Tongues Within Regionally Geopressured Lower Tuscaloosa Sandstone, Tuscaloosa Trend, Louisiana

A regional study of the Tuscaloosa Formation in Louisiana, undertaken to assess geopressured-geothermal potential, revealed lobate, downdip extensions of the hydropressured zone in lower Tuscaloosa massive sandstone facies below the regional top of geopressure. Normal pressure zones within geopressured section were identified by drilling-mud weights less than 13 lb/gal on electric logs of massive lower Tuscaloosa sandstone; cross sections demonstrated updip continuity of these zones with the regional hydropressured zone. These hydropressure "tongues" are permitted by the anomalously high permeabilities reported from the deep Tuscaloosa trend, and they are attributed to both primary and secondary porosity by investigators of Tuscaloosa sandstone petrography. The hydropressure tongues correspond with lobes of thick net sandstone, principally in Pointe Coupee, East Feliciana, East Baton Rouge, and Livingston Parishes in the central Tuscaloosa trend. Limited control suggests at least one hydropressure tongue in the Chandeleur Sound area to the east.

Dimensions of hydropressure tongues range up to 27 km (17 mi) parallel to strike and 17 km (11 mi) oblique to strike. In many places, tongues are terminated downdip by faults, which, by acting as pressure seals, prevent the tongues from extending to the downdip edge of the massive sandstone in the expanded sections of the downthrown blocks. The areal extent of geopressured Tuscaloosa sandstone is controlled updip by these fault zones, and downdip by pinch-out of the sandstone units basinward. Local hydropressure tongues diminish the geopressured-geothermal potential of the Tuscaloosa trend, but show no discernible relation to gas-productive areas.

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Unusual Calcite Cementing of Quartz Grains on Chandeleur Island Beach, Offshore Louisiana

A very unusual calcite cement was found in some beachchips from an unconsolidated beach surface of Chandeleur Island offshore approximately 35 nmi (65 km) south of Mississippi in the Gulf of Mexico. The beachchips are irregularly shaped and are well cemented by this unusual calcite. This calcite crystal structure has not been reported previously as existing in a marine environment. A similar cement has been found in freshwater lake beachrock and in some travertine samples. The calcite crystals are elongate parallel to the c-optic axis, and are composed of bunches of crystallite blades. The crystallite blades of each crystal bunch are pointed and are more bladed than freshwater cement crystals. The intercrystallite pore space contains no fine calcite silt as was observed in the lake samples. Fresh water provided by rainfall may be held in the pore spaces and bounded to the quartz-grain surfaces by ionic attraction. Marine spray above and saline water concentrated underneath form a sandwich effect at the micropore level, allowing rapid growth and precipitation of these very unusual calcite crystals in a single-phase low-salinity fluid.

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Regional Patterns of Diagenesis, Porosity Evolution, and Hydrocarbon Production, Upper Smackover of Gulf Rim

The exploration fairway of the Upper Jurassic Smackover, from the Rio Grande to the Panhandle of Florida, consists of a rather simple carbonate ramp depositional system characterized by thick, widespread blanket ooid sands. The ooid sand belt gives way landward to quartzose