Hatter's Pond field: anhydritic mudstone, skeletal-peloidal packstone or grainstone, oolitic grainstone, microcrystalline dolomite, finely crystalline dolomite, and coarsely crystalline dolomite. The microcrystalline dolomite is commonly associated with bedded and nodular anhydrites and is interpreted to represent early replacement in a sabkha environment. Both the finely and coarsely crystalline dolomites are secondary in nature and represent replacement of low-energy skeletal-peloidal packstones and high-energy oolitic grainstones, respectively.

The majority of the reservoir porosity in the Smackover is late stage vuggy and/or moldic and is facies-selective and preferential to the coarsely crystalline dolomite. This porosity, which commonly ranges from 4 to 22% with permeabilities of 2 to over 100 md, is a product of mesogenetic leaching related to migration of carbon dioxide-charged fluids during the early stages of hydrocarbon maturation. The porosity is facies-selective to the coarsely crystalline dolomite, as this lithology possessed the greatest porosity and permeability at the time of migration of the carbon dioxide-charged solutions.

Evidence suggests the oolitic grainstones, which were the precursors of the coarsely crystalline dolomites, were deposited as a series of linear bars along the flanks of the Wiggins uplift. If this is the case, and more study is needed to document this definitively, the coarsely crystalline dolomite should occur in elongate mappable trends. Hydrocarbon exploration in this area and all along the flanks of the Wiggins uplift should involve location and mapping of these trends, with the greatest success occurring in areas where the trends are superimposed over structural highs produced by faulting and/or salt diapirism.

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Abnormal Pressures in Lower Vicksburg, McAllen Ranch Field, South Texas

The Vicksburg Formation consists of an upper shale member about 2,000 ft (610 m) thick and a lower member of interbedded sandstones and shales about 4,000 ft (1,220 m) thick. The entire section is abnormally pressured, and gradients reach 0.94 psi/ft (21.2 kPa/m). Pressures within the section were established by extrapolation of shut-in buildup pressures and by estimation of pressures from conductivity logs. Hydrostatic heads were then calculated and displayed in a vertical potentiometric profile. Head distributions suggest that hydrodynamic flow is taking place from areas of high pressure to an underlying major, listric normal fault and then updip along the fault plane. There is also upward flow from Jackson Shale below the fault. The top of abnormal pressures occurs at a depth of 7,500 ft (2,286 m) and at a temperature of about 210°F (99°C) where there is an abrupt decrease in smectite within the mixed-layer illite-smectite clays. Pressure increase with temperature does not follow isodensity lines for water as in the case of aquathermal pressuring. Therefore, it is concluded that abnormal pressures are largely the result of clay transformation, perhaps accompanied by pressuring caused by hydrocarbon generation.

A second zone of abnormal pressures with gradients to 0.74 psi/ft (16.7 kPa/m) occurs at about 6,000 ft (1,829 m) in the lower Frio Formation. In this zone, pressure increase with temperature follows isodensity lines for water, and it is concluded that aquathermal pressuring is the major cause of abnormal pressures. Shale densities suggest that nonequilibrium compaction may have played a minor role in creating abnormal pressures in the Frio.

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Geometry and Mechanisms of Folding Related to Growth Faulting in Nordheim Field Area (Wilcox), De Witt County, Texas

The Nordheim area in western De Witt County, Texas, has produced over 121 bcf of gas, of which over 53 bcf has come from the deep lower Wilcox. Consequently, a better understanding of folding in the Nordheim area should aid future exploration efforts, especially in the deeper (greater than 10,000 ft, 3,000 m) Wilcox. The folding mechanisms recognized are: mechanical folding, or folding due to faulting; drape compaction; and differential compaction. As a consequence of separating the various folding mechanisms, important geometric aspects of folding were recognized at Nordheim. They include: (a) the upward movement of folds relative to regional dip, (b) the shift of fold crests along dip and strike at various depths, and (c) the role of compaction in the final fold geometry. Upfolding is the term used to define the upward movement of folds relative to regional dip. Upfolding is recognized where intervals thicken off a fold crest in all directions, not just in the direction of the growth fault. For example, the deepest interval in the lower Wilcox, the Migura, has over 200 ft (60 m) of isopach relief and about 250 ft (76 m) of closure. Shallower intervals and zones show similar relationships between structure and isopach, but with less relief. Upfolding is the dominant mechanism of folding in the Nordheim area. Most of the folding not explained by upfolding is explained by either drape or differential compaction.

Previously proposed mechanisms of folding related to growth faulting have only incorporated two dimensions. Upfolding is a three-dimensional concept, and it is believed to be caused by material moving down a concave listric normal fault. The concave shape may cause a volume problem, which is overcome by the upward movement of material.

Three specific exploration concepts have been developed as a result of this study.

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Relation of Smectite-Illite Transformation and Development of Abnormal Fluid Pressure and Structure in Northern Gulf of Mexico Basin

Water expelled from smectite into the pore system of the host shale during the process of diagenesis may migrate out of the shale early, or may be totally or partially trapped and released slowly through time. In areas such as the northern Gulf of Mexico basin, where much of the water is partially trapped, clay diagenesis data indicate a close relation between high fluid pressure build-up and the smectite-illite transformation process.

Abnormal pressures affect, in part, the type and quantity of hydrocarbons accumulated, as pressure controls the direction of fluid flow and partially controls the geometry of structures formed in basins where shale tectonism is the primary mechanism for structural development. In basins of these types, contemporaneous faults and related anticlines are the most common types of productive structures found. The depth to which faults can penetrate and the angle of dip that faults assume at depth is dependent largely on fluid pressure in the sedimentary section at the time of faulting. Some faults, formed in the overpressured Tertiary section of Texas, have been observed to flatten and become bedding plane types at depths near or above the temperature level required for thermal generation of hydrocarbons. This observation suggests faults of these types are minor factors in draining hydrocarbons from deep shales within basins where thick overpressured sedimentary sections are present at shallow depths and where shale tectonism is the primary mechanism for structural development.

Microfracturing resulting from increased fluid pressure is indicated to be a primary mechanism for flushing fluids from deep basins where thick abnormally pressured sedimentary sections are present. This flushing process would be enhanced by clay diagenesis since water supplied from smectite would cause the processes to continue for longer periods of time and to extend to greater depths than could be attained if only remnants of the original pore water were present in the section. Large volumes of diagenetic water present within the microfracturing interval could also act as a vehicle for primary hydrocarbon migration, provided hydrocarbons are present in sufficient quantities to be transported.

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Late Eocene to Early Oligocene Calcareous Nannofossils in Alabama and Mississippi

The Eocene-Oligocene boundary in the central Gulf coastal plain has been placed traditionally at the contact of the Shubuta Member of the Yazoo Formation and the Red Bluff Formation, or the contact of the Shubuta and the facies equivalents with the Bumpnose formation. Calcareous nannofossils were examined from six upper Eocene to lower Oligocene localities in Alabama and Mississippi. The Shubuta, Red Bluff, and equivalents have a very similar calcareous nannofossil flora, and both are in Martini's Zone NP21. However, from the base of the Shubuta up through the Red Bluff, 10 calcareous nannofossil extinction horizons can be used to subdivide the lower part of Zone NP21. *Discoaster saipanensis* Bramlette and Riedel, *D. barbadiensis* Tan Sin Hok, and *Reticulofenestra reticulata* (Gartner and Smith), which become extinct at or near the top of Zone NP20, are only rarely present in the 27 Shubuta samples examined, are poorly preserved, and are assumed to have been reworked. Below the Shubuta lies the Pachuta Marl Member of the Yazoo, which was examined at one locality in Mississippi and two in Alabama, and although the flora is poorly preserved, contains significant numbers of all three Eocene species.

If the Eocene-Oligocene boundary is assumed to correspond to the Shubuta-Red Bluff contact, this boundary, at least in the Gulf coastal plain, cannot be recognized using traditional calcareous nannofossil markers, because of its inclusion within Zone NP21. This contact, however, appears to coincide with the last occurrence of the planktonic foraminifer *Globorotalia cerroazulensis* s.l.; the extinction of *Hantkenina* spp. may occur slightly below the contact. The extinction of *Discoaster saipanensis* below that of the planktonic foraminifers has also been observed on several legs of the Deep Sea Drilling Project, where this offset is no more than a few meters. At the Red Bluff type locality, the separation approximates 65 ft (20 m). Clearly, in the study area, the extinctions of *G. cerroazulensis* and *D. saipanensis* do not define the same horizon.

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Hydrothermal Mineralization Within Balcones and Luling Fault Zones of Texas

Occurrences of precious and base metals, in anomalous concentrations, have been reported for more than 100 years from sites within the Balcones and Luling fault zones. Recent field investigations supported by geochemical studies have corroborated some of these reports while casting others in doubt. Whole-rock and groundwater analyses confirm claims of cobalt, zinc, and lead mineralization, but reputed gold, silver, and mercury concentrations have not been substantiated. Although some metals are present at high levels in selected samples, the mineralized fraction of the host rock is minute, and there is no evidence to encourage hopes for a viable resource.

The source of these metals is problematic. Throughout the region, Lower Cretaceous limestones serve as the hosts and mineralization is clearly secondary. Late Cretaceous igneous activity was extensive in this area, including the vicinity of most sites of mineralization. However, none of the sites are directly associated with volcanic or intrusive bodies, and the bulk composition of these igneous rocks suggests that they would have been unsuitable as a source for these metals. Current evidence favors mineralization from hydrothermal fluids expelled, by compaction, from sedimentary basins nearby. Metallogenesis has occurred along faults and joints which may have served as conduits for the mineralizing fluids. In addition, formation waters are actively mineralizing porous Cretaceous limestones at depth in major fault zones of south Texas; these limestones contain traces of secondary galena, sphalerite, fluorite, and strontianite, and the waters are high in the corresponding solutes. This modern analog is the most suitable model for the known occurrences of mineralization.

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Polycystine Radiolarian Distribution and Enhancements Related to Oceanographic Conditions in a Hypothetical Ocean

Radiolarian data from Holocene sediments of the world oceans were fitted to a hypothetical ocean exhibiting characteristics of all oceans. Warm-water sphere radiolarians exhibit major poleward boundaries to their distributions at subtropical and polar convergences. They exhibit poleward extensions in the westward boundary currents. Collosphaerids are enhanced in sediments under the anticyclonic gyres and eastern tropical regions. The *Dictyocoryne profunda-truncatum* group appears to be indicative of warm-water sphere mesotrophic conditions. Cold-water sphere radiolarians dominate sediments poleward of the polar convergences and occur in significant percentages under the eastern boundary currents and equatorial divergences. Intermediate and deep-water radiolarians appear to be enhanced under the polar cyclonic gyres, eastern boundary currents, and the oceanic divergences and convergences. These radiolarian indices of present oceanographic conditions (currents, divergences, convergences, and oligotrophic to eutrophic conditions) should aid in deciphering similar paleo-oceanographic conditions.

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Productive Lower Wilcox Stratigraphic Traps from Entrenched Valley in Kinkler Field, Lavaca County, Texas

Subsurface data around Kinkler field define a shale-filled valley (lower Wilcox A delta), which causes multiple stratigraphic traps in the incised strata, the fill, and the overlying beds.

The channel is 1.5 mi (2.8 km) wide, 4 mi (7.4 km) long, and