ing pyrite concentrations in the laboratory. Furthermore, the R_t-ϕ plot may confirm the presence of pyrite in a sandstone where core samples are not available.

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Pleistocene Meander-Belt Ridge Pattern near Houston, Texas

Meander-belt ridges are the most enduring depositional features of the Pleistocene outcrop near Houston, where those on the Beaumont Formation (seaward from Buffalo Bayou) are evident on most early aerial photographs and soils maps, especially the U.S. Geological Survey 1-ft contour-interval topographic sheets of Galveston and Harris Counties, surveyed in 1915-1926. These show the meander-belt ridges as drainage divides between the modern streams, which developed later on the intervening lowlands (except for upper Mustang Bayou). This systematic transposition of the drainage makes it possible to identify the eroded older ridges farther inland as well as those near the Gulf of Mexico.

In the coastal sector from the Brazos River east to Galveston Bay and the San Jacinto River, the meander-belt ridges deflect eastward from successive fluvial terraces along the Brazos Valley and repeatedly branch downslope to the southeast. They belong to four major systems (one of which consists of three subsystems), within each of which the ridge pattern is internally consistent and distinct from contiguous systems. The major systems are separated by the sector's four longer streams, which head just outside the Brazos Valley and flow nearly east: Cypress Creek is the simplest example, and Buffalo Bayou the most complex. These streams flow almost parallel with the nearest meander-belt ridges on their south sides, whereas the ridges from the north approach at much higher angles and are cut off abruptly by the stream. Each such stream evidently formed along the landward edge of an eastward-prograding increment of coastal plain, where it gathered the blocked drainage off the older plain to the north. As a result, these streams closely follow the unconformable contacts between successive coastal-plain increments, and so mark the approximate landward edges of a succession of distinct unconformity-bounded sequences of strata, each of which is expressed at the surface by its meander-belt ridge system.

Substantially greater ages of the sequences farther inland are indicated by successive increases in the average slope of the ground and amount of erosion and weathering and, for the Beaumont units, by contrasting directional rates of meander-belt slope and quality of channel preservation. However, the boundaries of these formations as shown on the *Geologic Atlas of Texas* maps are not closely related to the corresponding eastward-flowing streams that fairly well define the stratigraphic sequences. Also, immediately west of the Brazos River and along the San Jacinto River some of the equivalent ridge systems are elongated in the dip direction, which makes the larger regional outcrop pattern much more complex than that described between these rivers.

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Regional Organic Geochemistry of Offshore Louisiana

Geochemical analyses of well cuttings from offshore Louisiana reveal trends in organic matter characteristics that mimic thermal alteration effects, but are in fact related to depositional environments. Sediments deposited on the continental slope contain organic matter that is considerably higher in hydrogen content than organic matter from adjacent environments. These chemical variations are reflected in headspace composition of canned cuttings. Slope sediments, at or near the top of the oil window over a widespread area, are commonly encountered near the base of the penetrated section, leaving the greater part of the principal zone of oil generation unsampled. Active petroleum generation must occur deeper than 8,000-15,000 ft, depending on local geothermal gradient. Model calculations of thermal maturity, used in conjunction with burial history analysis, are consistent with our empirical observations of the maturation of organic matter based on vitrinite reflectance and geothermal gradient.

In the absence of direct evidence from the source beds of Gulf of Mexico oils, detailed biomarker analysis can provide information on the nature and thermal history of the organic matter from which the oils were generated. Thermal maturity of the oils increases from west to east, indicating that source beds of eastern oils are older than those of western oils. Oils produced from the eastern offshore region were probably generated from early to middle Miocene sediments. The depocenter was located to the northwest, and deposition of oil-generating sediments enriched in marine organic matter occurred in deep water. Oils produced from the western offshore region were probably generated from Pliocene sediments. The depocenter was located close to where the oils are found today; hence, the oils are enriched in components derived from land plants deposited in oxygenated sediments. Oils produced from two locations close to the present-day shelf edge are significantly different from the other offshore oils. These were probably generated from middle to late Miocene sediments deposited in anoxic basins with high bacterial input.

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Thermal Regimes of Balcones-Ouachita Trend, Central Texas

Local ground-water temperatures and bottom-hole temperatures for oil and gas wells present two lines of evidence indicating regional high geothermal anomalies along the Balcones-Ouachita trend in central Texas. Analysis of the variables in the heat-flow equation, however, indicates that these anomalies are probably not due to conductive heat flow; most of the rock units for which data exist are limestones and sandstones, and thus, should have high thermal conductivities and low geothermal gradients. Measurements of heat flow are few along this trend, but because the strata for which bottom-hole temperature data exist generally contain fluids, it is reasonable to assume that hydrodynamics also is a factor in creating these apparent thermal anomalies. In short, Darcy's law, not the heat-flow equation, may control thermal conditions: rocks having high thermal conductivities generally also have high hydraulic conductivities, so upwelling warm waters may account for the observed thermal anomalies. Since upwelling waters also may be important conveyors of hydrocarbons, these geothermal and/or hydrodynamic anomalies also indicate promising areas for petroleum exploration.

Detailed investigations, however, demonstrate that these regional anomalies have high-frequency perturbations; local areas within a regional high may have anomalously low temperatures. Local faulting not discernible on a regional scale may control detailed hydrodynamic conditions, and in effect, these faults may form structural traps for hydrothermal fluids as well as for hydrocarbons. However, they can also localize downwelling recharging waters that impart a low thermal anomaly. Clearly, a radius of influence exists within which any well "senses" the ambient thermal regime. Within a fault zone, this radius is probably small, dictated by detailed stratigraphic dislocations. Although complex perturbations affect the prevailing thermal regime in ways not yet completely understood, some of these geothermal anomalies indicate general loci of long-term upwelling from deep within the Gulf Coast basin. Studied in detail, thermal anomalies may prove to be indicators of economic geothermal resources. They also may indicate hydrodynamic traps, in which warm waters might have filtered through a trap zone during the process of petroleum accumulation. In this way, these thermal anomalies may point toward hydrocarbons in a downstructure direction.

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Evidence for Large-Scale Vertical Migration of Dissolved Fatty Acids in Louisiana Oil Field Brines: Iberia Field, South-Central Louisiana

Interest in the origin and distribution of dissolved volatile fatty acids (VFAs) in oil field brines has developed as a result of the recognition of the role these compounds may play: (1) in subsurface acid attack and porosity enhancement, (2) as precursors of natural gas, and (3) as possible proximity indicators of hydrocarbon accumulations. The detailed study of the distribution of dissolved VFAs on a field scale provides useful information on processes of generation, transport, and degradation of these compounds.

At Iberia oil field, in the Tertiary section of south-central Louisiana, spatial variations in pore-water compositions and temperatures indicate the presence of an ongoing, dynamic, subsurface circulation system.

Deep brines with VFA levels exceeding 150 mg/L are migrating up the south flank of the Iberia salt dome, a vertical distance of at least 2 km (6,000 ft). The VFAs in these waters are dominated by acetate and propionate. As these waters ascend, they mix with an ambient mass of water having total VFA concentrations of 20 mg/L or less and dominated by n-butyrate. Preferential decarboxylation of acetate and propionate relative to isobutyrate and n-butyrate and isovalerate and n-valerate are occurring in this system. The by-products of these decarboxylation reactions should be methane, ethane, and bicarbonate. Temperatures are cool enough (< 80°C) in the shallower parts of the sequence to allow bacteria that could break down acetate through fermentation.

The spatial distribution of individual dissolved VFAs is complex but systematic, and must ultimately be related to the rates of advective transport, dispersive mixing, and chemical reaction. We believe that a potential new application of the study of these dissolved organic compounds lies in helping to unravel the dynamics of some types of subsurface flow systems.

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Shelf-Margin Deltaic Sediment Deposited on Diapir-Controlled Slope: Pleistocene of Garden Banks Area, Northwestern Gulf of Mexico

Pleistocene sediment in the Texas-Louisiana outer shelf and upper slope salt basin (including the outer West Cameron and Garden Banks offshore lease areas) can be related to glacial and interglacial events. Integration of well logs, biostratigraphic data, cores, and conventional two- and three-dimensional seismic data demonstrates that depositional patterns are inseparably linked to the timing and style of structural deformation associated with delta progradation onto a diapir-controlled slope.

Sediments of the Garden Banks field (Blocks 192, 193, 236, and 237) were deposited in an upper slope salt-withdrawal basin located 15 mi (24 km) downdip of a late Pleistocene (glacial stage) shelf-margin delta complex. Reservoir sands are deltaic sediments redistributed to the slope by slumping and sediment gravity flows. Two genetically related sand-body types are recognized: (1) channelized gravity flow sequences characterized by elongate sand bodies oriented parallel with paleoslope, and (2) progradational lobes deposited adjacent to channels that offlap in a basinward direction. Sand bodies stack vertically and onlap the flanks of the salt ridge that encloses the field to the east, west, and south. The overall retrogressive vertical sequence indicates salt-ridge growth coeval with deposition of the sequence. The rapid lateral variations in reservoir sand thickness and sequence character are related to deltaic deposition in an unstable basin, where mass transport deposits are diverted or blocked by salt-controlled bathymetric highs. The complex geometry and the restricted size of salt-withdrawal basins and submarine troughs in the Garden Banks slope area contrast sharply with deep-sea fans that spread sediment across broad, unrestricted basin plains (e.g., Mississippi Canyon and Fan).

In any one portion of the study area, the vertical succession of facies and structural styles indicates an evolution from (1) relatively stable slope to (2) unstable shelf margin to (3) increasingly stable (shelf) environments as fault-bounded basins filled and the shelf-margin prograded through time. This evolution controlled the distribution and geometry of Pleistocene sediments, as well as the position and character of potential reservoir intervals. Regional shifts in depocenter position created dramatic differences in sequence character and depositional history along the shelf margin. This study indicates that sand development in Pleistocene slope environments is best in structural lows along the flanks of penecontemporaneous salt features and residual shale masses. However, details of sedimentation history and basin evolution vary with geographic location and stratigraphic position in the basin.