ment. In many projects, the final product is a combination of manual drafting, computer drafting, and "standard" computer application techniques.

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Contourite Anticlines as Exploration Objectives

Regional seismic profiles off the east coast of the United States gathered by the University of Texas Marine Science Institute and Woods Hole Oceanographic Institute have crossed three types of contourite anticlines. They are symmetric, asymmetric, and half-anticlinal forms and have up to 3,000 ft (1,000 m) of relief. Off the east coast, contourite anticlines have been found in sections of Paleocene to recent age. They are the result of erosion, transport, and deposition by bottom currents that flow along the break between the continental slope and the continental rise. Because of the relation to deep-water currents flowing along this break in slope, the resulting deposits have been named "contourite anticlines." Explorationists should be alert to the presence of contourite anticlines and realize the limited exploration potential of this type of anticline. Recognition of their true nature early in exploration programs may save millions of dollars.

Seismic reflections from Wilcox (lower Eocene) deep-water sediments of south Texas show that large—more than 10 × 5 mi (16× 8 km), 2,000± ft (600± m) closure—anticlinal features were developed by deposition basinward from submarine fans. Texaco 1 Rodriguez was drilled in 1968 to 17,752 ft (5,326 m) on one of these contourite anticlines. The section within closure (below a drill depth of 8,700 ft; 2,610 m) penetrated by this test was entirely shale.

Available data on present-day contourite anticlines indicate that the currents that form them are capable of moving only clay-size material. Until stronger currents are documented, sandstones or any other type of reservoir, with the possible exception of fractured chalk, would not be expected in these features. Drape crestal grabens are present over some of the Wilcox contourite anticlines of south Texas. Production has been obtained from the median-depth (9,000 ± 1,000 ft; 2,700 ± 300 m) upthrown fault traps associated with these grabens.

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Depositional Environments and Their Relation to Porosity in Upper Smackover Formation (Jurassic), Paup Spur Field, Miller County, Arkansas

Cores from 13 upper Smackover wells in the Paup Spur field, Miller County, Arkansas, and adjacent areas have been studied to define depositional facies from sedimentary structures and carbonate textures. A depositional model is developed from these data. Petrographic studies of thin sections show the relation of diagenetic events to facies, and help unfold the history of porosity development.

The vertical succession of facies in the upper Smackover Formation may be interpreted as an upward-shoaling sequence. From the base, burrowed and oncolite-bearing pelmicrite is overlain by burrowed and bimodally cross-bedded oosparite and pelsparite. These in turn are overlain by algal biolithite and pelsparite. Shale and anhydrite of the Buckner Formation overlie the upper Smackover. Contacts between all facies are gradational.

A depositional model based on this vertical sequence consists of low-energy peloidal carbonate mud deposited seaward of a moderate to high-energy oolite and pelletal-shoal complex. Bimodal cross-bedding indicates tidal influence on the shoal. Landward of the shoal complex, algal mats and peloidal mud were deposited in a low-energy intertidal environment. Farther landward, sabkha evaporites of the Buckner Formation were deposited.

Porosity is highest in the cross-bedded oosparite and pelsparite facies (greater than 25%), where molds of oolites and pellets are the principal pore types. In the algal biolithite facies, porosity reaches 15% and is principally moldic, interparticle, and fenestral pore space. Some interparticle porosity in the algal facies may result from dissolution of anhydrite cement.

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Downcurrent Change in Miocene Canyon-Channel Systems in Indus Submarine Fan

Multichannel seismic profiles with excellent resolution reveal the internal morphology of Miocene canyon-channel-levee systems in a part of the Indus submarine fan. Individual canyon-channel-levee systems may be correlated from profile to profile in a down-canyon direction for at least 160 km. Each canyon or channel complex consists of numerous smaller canyons or channels which have migrated, avulsed, and aggraded during a long complex history to produce the morphology observed in the seismic profiles.

Detailed examination of seismic lines over two canyon-channel-levee systems has resulted in the recognition of degradational, transitional, and aggradational zones, respectively, in a distal direction. The distribution of these zones and their associated processes is controlled by canyon-channel gradient. The degradational zone is characterized by an erosional base and is dominated by bank migrational deposits. The processes responsible for these deposits are poorly known. The transitional zone also has an erosional base but is marked by the presence of small levees. Deposition in this zone results from bank migration followed by channel-current and overbank processes. The aggradational zone is characterized by a depositional base and large levees resulting from channel-current and overbank processes which may include both sediment and fluid density flows. In each of the two canyon-channel-levee systems studied, aggradation has resulted in the gradual proximal displacement of the degradational, transitional, and aggradational zones.

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Cretaceous Transgression of Coahuila Peninsula, Potrero de la Mula and Sierra del Fuste, Coahuila, Mexico

Exposures of the Late Jurassic to Early Cretaceous Coahuila peninsula have been reported at three localities northwest of Torreon and at Potrero de la Mula in central Coahuila. Exposures also occur at Sierra del Fuste, about 25 km northwest of the La Mula outcrops. At Potrero de la Mula, granites to granodiorites containing xenoliths are cut by dikes of six ages. Deep pre-Cretaceous weathering, thin transgressive arkose, and overlap by the Padilla Formation confirm these as basement rocks.

In early Neocomian time the basement was a source of detritus for the basinward San Marcos Formation. Subsequently, seas partly covered the La Mula area, depositing the lagoonal facies (Oballos Member) of the Padilla Formation, which thins to a featheredge against the higher parts of the basement. A 1 to 2-m arkose, which seems restricted to paleotopographic lows, is present at the base of the Padilla. Overlying the Padilla, marine shales and a progradational sequence of fluvial and marginal-marine sandstones compose the La Mula Formation. Upper La Mula shales grade upward into sabkha deposits of the lower La Virgen Formation. Normal-marine shelf conditions existed at Potrero at several different times, causing carbonate tongues to be deposited in the La Virgen Formation and ultimately forming the Cupido Formation. Possible subaerial exposure of the Cupido preceded deposition of the La Peña shales and calcareous mudstones, which grade upward into calcareous mudstones of the Aurora Formation.

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Movement of Subsurface Waters Under Sabkha, Abu Dhabi, United Arab Emirates, and Its Relation to Dolomite Genesis

Field work was carried out during the years 1971-73 to investigate the hydrology of the Abu Dhabi sabkhas with the purpose of determining (1) the source of subsurface water inducing the diagenesis of Holocene sediments and (2) the directions and rates of hydrologic movements. The ionic ratios of Cl/Br and K/Br and the stable isotope contents of the subsurface brines of the sabkha separated them into three distinct categories according to their origin: (1) coastal sabkha zone, of evaporated marine waters from supratidal flooding (a) daily near the coast from the lagoon and (b) occasionally farther inland from the open sea; (2) intermediate sabkha zone, a mixture of marine waters with meteoric groundwaters which are isotopically altered by capillary evaporation and/or diagenesis, that is, the oxygen-18 content increases while the deuterium content remains relatively constant; and (3) continental sabkha zone, of meteoric groundwater with variable isotopic composition as a result of evaporation and sporadic addition of rainwater.

The intermediate sabkha zone is the site of extensive diagenesis, precipitation of gypsum and anhydrite, and formation of dolomite. Unusual winter storms in conjunction with spring tides produce high supratidal flooding in the intermediate zone by open seawater. The groundwater table rises nearly to the surface. Floodwaters dissolve and transport away interstitial salts, which are carried seaward surficially or downward through the aquifer at an average rate of 11 cm/year. Subsequent secular evaporation tends to lower the groundwater table and induce Darcy flow under a vertical hydraulic gradient of evaporative pumping, that is, upward movement of water through the saturated zone to replace water lost by capillary evaporation. An appreciable vertical groundwater gradient is induced by the presence of a cemented crust which serves as an aquiclude about 1 to 2 m below the surface.

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Massive Marine-Sandstone Facies, Mackerel Field, Gippsland Basin, Australia

The Esso-Hematite Mackerel oil field in the Gippsland basin, Australia, is in a high-quality Paleocene sandstone section and has been delineated by four exploratory wells.

A predevelopment stratigraphic model of the field was constructed from detailed analysis of high-quality seismic data. Although the sandstone section initially appeared to be massive and homogeneous, seismic data quality was sufficient to separate 11 discrete depositional units, each with an apparent marine progradational character. The boundaries of these seismic units were then tied back to minor variations in log and core lithologic characteristics, providing facies and depth control for the model.

It was possible, therefore, to construct a detailed geologic picture—with emphasis on the vertical and lateral extent of facies distribution. petrographic character, and reservoir properties—in a section which initially appeared to be generally ambiguous in its stratigraphic and paleoenvironmental position in the depositional framework of the surrounding area.

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Test-Tube Pyrolysis—Simple Technique for Identifying Yield and Maturity of Source Rocks

When small samples (i.e., well cuttings) of kerogen-rich rock are pyrolyzed in a test tube placed over a propane torch, oil-like material may be generated and condense as a brown residue around the walls of the tube. This simple technique may be used to identify source rocks capable of generating liquid oil. The artificial test-tube-generating process is believed to be similar to that associated with natural time- and temperature-dependent processes accompanying rock burial in depositional basins. The relative amount of oily residue pyrolytically generated in a test tube is therefore a semiquantitative measure of the natural oil-generating capacity of the rock. Source rocks which have been subjected to advanced stages of thermal maturation are not capable of generating liquid hydrocarbons and there-