developed Bouma sequences. Few sequences exceed thicknesses of 1 ft (0.3 m) in distal channels.

Canyon sandstones are low-permeability reservoirs, with mean porosity and permeability of 10% and 0.2 md, respectively. Isoporosity and isopermeability maps indicate that porosity and permeability are greatest in turbidite channels and decrease laterally. Interchannel sandstones have limited lateral extent and make poor reservoirs.

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Prediction of Oil or Gas Potential by Near-Surface Geochemistry

Recent development in surface geochemical prospecting have enabled this age-old seep-detection technology to be used to determine the gas versus oil character of a potential fairway. Extensive field work has demonstrated that the chemical compositions exhibited by near-surface hydrocarbon soil gases are strongly coupled to the chemical compositions known to exist in the nearby underlying reservoirs. By using the compositions and ratios of the light hydrocarbons (methane, ethane, propane, and butane), it is possible to predict whether oil or gas is more likely to be discovered in the prospect area. Histograms which represent average soil gas compositions are observed to be strongly correlative with reservoir gas analysis histograms and with compositions from gas shows recorded in downhole mud logging. This correspondence with the actual formation gases suggests that the upward migration of reservoired light hydrocarbons into near-surface soils represents a viable mechanism, allowing surface geochemical exploration techniques to be utilized for regional hydrocarbon evaluations.

Geochemical investigations indicate that seep magnitudes depend on tectonic activity to aid migration along the fault and fracture avenues which appear to provide the major migration pathways. This fault association suggests the diffusion process to be of secondary importance. Geochemical prospecting must be used with caution, and only in conjunction with geologic and geophysical tools, because the location and shape of geochemical anomalies are commonly governed more by the local tectonic structure of the region rather than by the actual physical shape of the deposit. Thus geochemical prospecting, when used alone, cannot predict whether or not a particular soil gas anomaly is associated with a commercial deposit. It can only be used to verify the existence of petroleum hydrocarbons and to predict whether a potential structure is likely to contain gas or oil. Geochemical prospecting yields excellent regional evaluations of hydrocarbon potential.

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Geologic Interpretation Based on Dipmeter Data—Field Study

The Lambert Granite Wash field was discovered in Oldham County, Texas, in 1979. With the exception of the discovery well, every well in the field was logged with a 4-arm high-resolution dipmeter, and the log data were processed by computer. The data interpretation identified the paleoenvironment of the field and determined the source of the granite wash and how it was transported.

Log data indicated that a subsea distributary-channel system transported the detrital granite, and that the deposition was influenced by the remnants of a small Precambrian ridge. The channels were diverted around the ridge until it was eventually buried. The deposition continued, from the west, until the source of granite was depleted.

Through analysis of the dipmeter data, the Bravo dome was identified as the source of the granite, and it was determined that the channel system was located on the north side of the dome in Oldham County.

During Late Pennsylvanian time, a horst formed in the area as a result of basin subsidence. Log data indicate this horst is a suitable structure for the accumulation of hydrocarbons and has overlying shale which forms a stratigraphic trap.

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Carbonate Cementation of Gulf Coast Barrier-Island Sands and Formation of a Stratigraphic Trap

Field investigations in the area of Grand Isle, Louisiana, indicate the presence of active carbonate precipitation. Modern shoreline facies are being cemented by high-magnesium calcite, ranging from 10 to 50 mole % magnesium carbonate. Cementation occurs between the beach and marsh environments as surface crusts or laminae. The environment is characterized by seasonal high temperature (up to 50°C), high salinity (40 to 90° /₀₀), supratidal stromatolites and organic decomposition.

After burial, lithified crusts undergo chemical alteration, as indicated by a decrease in magnesium carbonate content (20 to 35 mole %). The cement eventually undergoes dissolution and reprecipitation, forming a well-cemented sandstone. Rip-up clasts of these sandstones are found along Gulf Coast beaches where a transgressive sequence occurs. These clasts are typically cemented by high-magnesium calcite with 10 to 15 mole % magnesium carbonate. Carbon isotope analyses of rip-up clasts indicate that dissolution and reprecipitation processes are methane-derived due to organic decomposition.

Buried crusts may be preserved in the subsurface and form an effective barrier to fluid migration. Where cementation is extensive, porosity is occluded on the marsh-side of the barrier-island sequence. Cement distribution is, therefore, a primary controlling agent of hydrocarbon migration and subsequent entrapment. Migration of hydrocarbons from organic-rich marsh sediments would be prevented by the early formation of the permeability barrier. Cementation, then, would account for accumulation of hydrocarbons on the marsh side of the barrier-island sequence and the formation of a stratigraphic (or "diagenetic") trap.

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Principles of Dipmeter Interpretation in Fluvial Systems

Identification of fluvial reservoirs has become increasingly more important in exploration. Stratigraphic information provided by dipmeter data is useful in defining the fluvial facies and reservoir morphology.

Field studies utilizing dipmeter data indicate that the middle Bartlesville sandstones in southeast Kansas and northeast Oklahoma are fluvial in origin and are composed of point-bar and longitudinal-bar facies. Dipmeter patterns within composite bedsets of each facies display a decrease in dip upward. This pattern indicates an upward decrease in the scale of sedimentary structures from cross-laminated to ripplelaminated sandstones as displayed in cores. The composite bedsets of the point-bar facies are significantly thicker than the bedsets of the longitudinal-bar facies. The thinly stacked nature of the longitudinal-bar composite bedsets produce an apparent random dip pattern. However, individual bedsets within the sequence show a decrease in dip upward.

Azimuth-frequency plots of cross-bed dip directions yield valuable information on the reservoir morphology. A unidirectional azimuth pattern indicates a predominant paleocurrent direction characteristic of point-bar deposition. Longitudinal-bar sandstones produce a multidirectional azimuth pattern due to stream bifurcation. However, the general paleocurrent direction can be determined from a weighted average of the azimuths. The local sandstone trend of each facies is in the direction of the paleocurrent. Azimuth-frequency plots of the overlying shale drape are 90° out of phase with the paleocurrent direction, indicating that the thicker sandstones of the trend lie in the opposite dip direction of the shale drape. Paleogeographic reconstructions based on paleocurrent and shale-drape data show that the point-bar facies has a broadly arcuate, dip-trending morphology of high sinuosity, and the longitudinal-bar facies has a gently curving, dip-trending morphology or low sinuosity.

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Atokan Clastics of Fort Worth Basin—Depositional Environments in a Foreland Basin

The sedimentary evolution of the Fort Worth basin may be explained by tectonic movement within the basin and bounding features. This tectonic activity was the primary constraint on the depositional environments and distribution of the clastic sediments from the basin's margins.

Previously, the lower Atoka Big Saline (Bend) conglomerates of the Fort Worth basin have been interpreted as a part of the larger Atokan clastic sequence derived from the Ouachita orogene. However, the distribution, progradation of depositional environments, and reservoir qualities of these sediments suggests an alternative interpretation. The Big Saline (Bend) conglomerates appear to be derived from the Muenster-Red River arch complex to the north and transported into the basin through a series of prograding, high-constructive deltas.

Seven primary deltaic facies are recognized for the Big Saline (Bend) sediments. The facies include (1) point bar; (2) distributary-mouth bar and bar finger; (3) distributary-channel fill; (4) meander-channel fill; (5) crevasse splay; (6) backswamp marsh; and (7) undifferentiated delta front and prodelta deposits.

Contemporaneous with Big Saline (Bend) deposition, clastics derived from the Ouachita orogene were deposited in the deeper, eastern part of the basin. Deposition occurred primarily in fan-delta complexes; however, deep-water sedimentation in the form of submarine-fan deposits is also recognized. This eastern influx of sediments continued after the cessation of Big Saline (Bend) deposition.

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New Method for Determining Paleocurrent Direction

A new technique has been developed for determining paleocurrent direction for siliciclastic formations. Development of an efficient and accurate technique for determining this has been a recurring problem in both industry and university research labs for the past 20 years. The new technique measures variations in the intensity of a beam of coherent light reflected from a polished horizontal surface on an oriented core. These variations indicate the orientation of the resultant vector for the optic axes of the quartz grains in the surface. Since the optic axis of a detrital quartz grain is statistically subparallel to its long axis, determination of the orientation of the optic axes is equivalent to determining the orientation of the long axes. In most noneolian siliciclastic deposits, the orientation of the long axes of the sand grains are parallel with the flow direction of the depositing fluid. Paleocurrent data from oriented cores have two uses in the mature oil field. First, they would aid in development drilling by providing accurate sandbody trends. Second, since the permeability of a sandstone is greater parallel with the grains than across them, the data should be useful in designing secondary and tertiary recovery programs.

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Types and Controls of Facies-Stratigraphic Traps in Permo-Pennsylvanian Carbonates in Permian Basin—Exploration Models

Many existing and undiscovered hydrocarbon reservoirs in Permo-Pennsylvanian carbonates of the Permian basin are stratigraphic traps in various shallow-marine depositional facies. Paleoenvironmental interpretations and an understanding of the causal relations among facies occurrence, mappable paleogeologic features, and regional stratigraphy provide predictive models in the exploration for similar traps in the Permian basin.

Some of the depositional environments recognized in shallow-shelf carbonates in this area include strandline beaches, tidal channels and barrier bars, lagoonal and inner-shelf patch reefs, and shelf-marginal oolitic or bioclastic grainstone shoals and organic buildups. The areal occurrence, geometry, and reservoir-trap configurations of each of these facies and, hence, the strategy and model-approach toward their exploration, are dictated by an understanding of the interplay between several factors, including paleobathymetry, relative rates of subsidence and sedimentation, regional stratigraphy and history of transgression or regression, and complexities of diagenesis. The coincidence, or lack thereof, of preexisting structure or bottom topography and the predictability of occurrence of a given depositional facies are probability potentials dependent on the nature of regional sedimentation patterns and the types of sediments and/or organisms present during deposition.

Porosity evolution in these facies may or may not be related to and mappable together with depositional facies. Porosity formation or occlusion may occur in a spectrum of diagenetic environments from eogenetic (submarine and meteoric exposure) to mesogenetic (deep burial). Porosity types and reservoir permeabilities are dependent on original facies textures and timing of porosity formation.

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Dipmeter Interpretation of Cherry Canyon Reservoir Sandstones, Delaware Basin, New Mexico

Stratigraphic interpretation of high-resolution dipmeter logs can provide important information concerning the mor-