ly dominated deltaic and shallow-marine sands and muds of the Graneros Shale. These deposits completed the filling of pre-Cretaceous valleys and buried the predepositional topography. By early Turonian time, the eastern edge of the seaway had transgressed far to the east, leaving western Iowa far from siliciclastic source areas. The result was the deposition of the carbonate muds of the Greenhorn Limestone. Renewed introduction of siliciclastic muds, probably from the northeast, resulted in deposition of the Carlile Shale.

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Relations Between Stromatolites and Burrowing Organisms

The activity of burrowing organisms seems to be of great importance in limiting the occurrence of stromatolites. Profiles of Callovian and lowermost Oxfordian of the Cracow-Wielun Upland, central and south Poland, are very useful for studies of relations between stromatolites and burrowing organisms. Many burrows, with up to 20 burrow apertures/sq m, of the *Thallasinoides* type occur in sandy crinoid limestones of early Callovian age. They are sublittoral deposits without stromatolites. However, stromatolites occur in stratigraphically condensed limestone sequences of middle and late Callovian age, and indicate deeper-water deposition. The associated fossils are pelagic forms: ammonites, belemnites, and coccoliths. Also present are iron-manganese nodules with a red or brown color. Probably these deposits accumulated on a submarine swell at a depth of several tens of meters. They pass laterally into deeper water marls which do not show any features of stratigraphic condensation. The latter deposits are without stromatolites, but contain numerous *Zoophycos* burrows.

Stromatolites of condensed sequences occur as beds of various thicknesses, up to 40 cm. Interstitia and pockets in stromatolites are filled by highly bioturbated red limestones. The limestones and marls above the stromatolites contain numerous burrow structures of the *Chondrites* type. Such relations suggest competition for space between blue-green algae and burrowing organisms. Probably the instability of the sediments caused by the activity of the burrowing organisms was an important factor limiting the spread of algal mats.

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New and Developing Techniques in Coal Exploration

New techniques in coal exploration develop slowly. Most of the current work being done in this field relies heavily on the techniques and practices in common usage about 20 years ago. Developments in three areas are improving the geologist's ability to better quantify available information and to better predict the position and distribution of coal seams between and beyond drill holes: (1) improved geophysical techniques; (2) modeling of the deposition environments; and (3) manipulating available information with computer programs.

Several new geophysical techniques are proving useful. These include improved resolution of downhole logging probes that more accurately indicate depth and thickness of seams and give coal quality information. High-resolution seismic equipment and techniques are now defining better the discontinuities in seams. Faults can be identified readily, but sedimentary cutouts are more difficult to define. New instrumentation in gravity and magnetic technology show some promise. These new geophysical methods lean heavily on manipulation of data by computers.

Modeling of depositional environments is gradually becoming more accepted as a better means of predicting what happens to the coal seam and adjacent rocks beyond the outcrops and drill holes. Not only does it allow the geologist to extrapolate the presence and thickness of seams, but also to predict the rock type that overlies and underlies the coal. All of this information is important for mine planning.

Increased use of computers and accessories provides rapid handling of large amounts of data. Once the data are entered, the computer will construct a variety of maps, do statistical calculations, and tabulate requested information.

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Potential Petroleum Reservoirs on Deep-Sea Fans Off Central California

A variety of potential petroleum reservoirs are indicated in subbottom siesmic profiles or implied by the depositional history of the deep-sea fans off central California. The size and extent of both the stratigraphic and tectonic traps off California are large compared to terrestrial analogs as seen only through the crude filter of acoustic profiling. Stratigraphic traps such as buried deep-sea channels, sand lobes, and updip pinch-out sands are produced as a normal consequence of the formation of deep-sea fans. Such stratigraphic traps can be expected on any submarine fan if the sand budget and porosity are sufficient. Slumps of sediment from the continental slope cover large areas of the deep-sea fans, and slumped sediment may isolate and bury channel segments and associated sand bodies. Tectonic traps resulting from folding or faulting are rare in deep-water fans. Faulting and folding are more commonly observed in fans from slope basins and from the California borderland and produce both tectonic traps and stratigraphic traps by altering configuration of the basin.

Large deep-sea fans are built over irregular oceanic crustal topography that has as much as 2 km of relief. As a result, many localized basins on the middle and outer fan are substantially thicker than much of the adjacent fan. On Monterey fan, for example, these local basins include valleys between abyssal hills and a large fracture-zone trough.

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Reservoir Rock, Source Rock, and Trapping Mechanism of Permian Basinal Facies, Delaware Basin

The Delaware Mountain Group consists of a 1,000-m thick section of Permian siltstone and sandstone that was deposited in a euxinic, deep-water, intracratonic basin. More than 100 oil and gas fields produce from the upper part of the Delaware Mountain Group (Bell Canyon Formation) in western Texas and southeastern New Mexico. Stratigraphic traps occur where sandstone-filled channels are incised into less-permeable, interchannel siltstone. Subparallel, erosional channels are relatively broad, shallow features (0.5 to >8 km wide, 1 to >35 m deep) which trend at high angles to the basin margin and extend at least 70 km basinward. Channels are filled with siltstone and thick-bedded, moderately well-sorted, very fine sandstone. The sandstone contains abundant large- and small-scale tractive-produced stratification, generally lacks texturally graded sedimentation units, and shows no regular vertical sequence of stratification types. Channel erosion and sediment transport are interpreted to have resulted from long-lived, clay-free, density underflows of fluctuating flow strength. The flows may have originated by storm-ebb flushing of hypersaline shelf lagoons.

Reservoirs are subarkosic, poorly cemented sandstones with high intergranular porosity (15 to 25%) and relatively low permeability (<200 md). The presence of authigenic, pore-lining clay (principally chlorite) greatly affects reservoir properties in these sandstones. Source-rock analyses of the interbedded siltstones show large amounts of unstructured kerogen (TAI∼2) and extractable organic matter (1,120 to 2,550 ppm), with high concentrations of hydrocarbons in the extractable organic matter (515 to 1,560 ppm). Delaware Mountain Group siltstones are good to very good source facies and are the most likely source for oil in Bell Canyon reservoirs.

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Permian-Pennsylvanian of West-Central Nebraska Panhandle

Pennsylvanian and Permian sediments in the sparsely drilled western panhandle of Nebraska reflect a transition through time from shallow-marine to restricted environments. Middle and Upper Pennsylvanian and Lower Permian beds are cyclic; a typical cycle sequence includes black shale and carbonate mudstones, wackestones, packstones, and grainstones.

The cyclic sequences, particularly those in the Desmoinesian series, can be compared to productive sequences in the Midland basin, the Four Corners, and the Dodge City embayment. The black shales are excellent source beds. Diagenetic processes both enhance and inhibit porosity. Dense, intratidal dolomites are the norm but the porous, supratidal dolomites associated with a shoal and strandline assemblage of carbonate grainstones in the Continental 1-35 Duncan (NW¼ SW¼, Sec. 35, T25N, R57W) strongly imply that a few feet of added elevation is the difference between tight rocks and those with effective porosity.

Lack of structural leads and scant deep drilling put strong emphasis on the stratigraphic interpretation of seismic data and modeling. A synthetic trace derived from a sonic log can be systematically altered by replacing high-velocity tight rock with porous-rock low velocities. Ideally, the modeled porous synthetic trace will compare favorably to the actual seismic traces.

Other factors must be integrated. Low-velocity rocks can be other than porous. Assuming porosity, where is it effective? At what position is the hydrocarbon trap along the updip edge of the effective porosity?

In addition to the Permian-Pennsylvanian cycles, the Niobrara chalks and the Cretaceous "D," "J," and Codell sandstones are potentially productive in the Nebraska panhandle.

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Lower Wilcox Shelf Edge in Texas—Relation to Growth Faulting and Geothermal Reservoir Quality

Most geopressured sandstone reservoirs in the lower Wilcox (Eocene) of Texas occur along a narrow trend associated with the ancient shelf margin. Traps for geopressured fluids were created by early, rapid growth of down-to-the-basin faults as part of a large-scale instability of the continental slope. Basinward translation and rotation of upper-slope fault blocks over a decollement zone of geopressured shale (south Texas) or salt (east Texas) initiated fault movement near the shelf break. After the shelf edge had prograded farther basinward, continued movement of some of these faults at a much reduced rate created normally-pressured traps in post-lower Wilcox formations. In east Texas, the shelf-edge structural style has been overprinted by growth of salt dome. Faults that originate near the restricts the volume of potential geothermal reservoirs.

Lower Wilcox deposition was dominated by the Rockdale delta system in east Texas, similar in scale to delta system of the Quaternary Mississippi depocenter. Sand distribution reached its maximum extent when deltas prograded to the shelf edge. The thickest geopressured sands occur in De Witt County at the southern edge of the Rockdale system. Maximum permeabilities occur in distributary sandstones; these are laterally continuous with extensive delta-front sandstones of lower permeability. A proposed test-well site for the Cuero geothermal prospect in De Witt County has been located to intersect the greatest total thickness of distributary sandstones.

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Proposed Model for Development of Red River (Ordovician) Porosity, Eastern Montana and Western North Dakota

Analysis of lithologic and electric log data from the Ordovician Red River Formation of eastern Montana and western North Dakota has been utilized to propose a diagenetic model of the nature, extent, and position of porosity development in this stratigraphic unit.

Abundant evidence suggests that porosity of reservoir quality developed around the perimeter of small structures exhibiting slight topographic expression during Ordovician time. Porosity of less than reservoir quality developed on the crests of these Ordovician highs. Sec-