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 SW ¼, 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. Secondary dolomite porosity has been destroyed by the precipitation of secondary minerals.

Porosity development and reduction by cementation can be explained by near-surface geochemical conditions which are thought to have existed in and around these topographic highs. Dolomitization occurred as meteoric waters were introduced into the subsurface from partly exposed tidal flats. Microcrystalline dolomite was precipitated as waters with high Mg/Ca ratios percolated down from the tidal flats. Rapid nucleation precluded the formation of sucrosic dolomite and porosity. As the Mg/Ca ratio dropped owing to dolomite crystallization, nucleation rates dropped and sucrosic dolomite and porosity developed downdip from the crests of the topographic highs.

In this manner, a "ring-shaped" zone, of reservoir quality porosity formed surrounding paleotopographic highs. Application of this proposed model to petroleum exploration in the Williston basin provides a significant guide for the drilling and accurate development of Ordovician Red River prospects.

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Middle and Upper Ordovician Paleogeography of Region Bordering Transcontinental Arch

Following a period of Whiterockian erosion, Middle Ordovician seas transgressed into the North American continental interior, and a diachronous sheet of clastic sediments (St. Peter, McLish, Winnipeg) lapped onto the margins of the Transcontinental arch. The arch served as a major clastic source region during subsequent deposition (especially Decorah). Middle Ordovician clastic sediments adjacent to the Transcontinental arch and in the Williston basin were probably deposited in a humid climatic regime, and carbonate deposition predominated in an arid belt that included Wisconsin, southeastern Iowa, Missouri, and Illinois, where carbonate oolites and evaporites are noted. Clastic source areas on the Transcontinental arch were inundated, as the marine transgression continued, and a continuous sheet of carbonate sediments (Galena, Viola, Red River, Bighorn) spread across most of the continental interior by the close of the Edenian. Migration of North America across latitudinally-related climatic belts brought the Williston basin area into an arid climatic regime by middle-Late Ordovician as evidenced by the deposition of upper Red River evaporites.

Widespread carbonate deposition was replaced by Dubuque-Maquoketa and Stony Mountain carbonate-clastic deposition as source regions emerged on the Transcontinental arch and Ozark uplift. The lower Maquoketa is conformable with the underlying Dubuque over most of the eastern Mid-Continent, and the joint occurrence of organic-rich shales and phosphorites is attributed to a low-oxygen, phosphate-rich water mass in the Maquoketa sea. The Ordovician closed with red clastic deposition, intermixed with carbonates and/or ironstones, adjacent to the arch.

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Model of Autocementation of Quartz Sands as Suggested by SEM Study of St. Peter Sandstone

Autocementation of quartz sand commonly involves growth of α-quartz in crystallographic continuity with the host grain (overgrowth). This mechanism is not well understood, but SEM examination of quartz grain surfaces from the St. Peter (Ordovician) sandstone suggests that overgrowths develop by recrystallization of a precursor matte or druse which covers much of the original grain surface. However, the matte is always absent along grain contact, and commonly exhibits foliation concentric with the host surface. A cyclic process is thereby suggested for the matte, but one which does not permit deposition between grain contacts. Alternating wetting and drying episodes in which dissolved material is deposited on the sand grain during each cycle is a possible mechanism. Numerous small (1 to 2 μm) euhedral kaolinite crystals scattered over and embedded in the matte are evidence of this mechanism. In the St. Peter sand, it appears that a pore fluid saturated with quartz and kaolinite, and containing numerous kaolinite crystallites, repeatedly came into contact with the sands and evaporated leaving a residue of SiO_2 and kaolinite during each cycle. Whether these cycles were diurnal, annual, or reflect rises and falls in the water table is not known, but it is likely that the cementation involved stages requiring complete removal and reinjection of pore fluid, but not as an uninterrupted process in a permanent, continuous pore fluid.

In this process, the driving forces (e.g., evaporation and a changing water table) are easy to identify and quantify. However, a static situation involving a stationary pore fluid does not present any obvious driving force for either mass transfer or recrystallization.

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Thrust Geometry of Northern Absaroka Sheet, Idaho and Wyoming

Seven major thrusts comprise the Absaroka-St. John thrust system in the Snake River Range southwest of Jackson Hole. The Absaroka thrust forms the base of this system in which earlier, higher thrusts are folded by later, lower thrusts. Shortening within the system is 17 km, excluding the basal detachment. Recent mapping requires a revised nomenclature for the thrusts to recognize that thrust sheets substitute for one another along strike.

There are three different thrust geometries in the area: (1) upward opening wedge-shaped imbricates; (2) horses; (3) complex systems of horses and imbricates. The St. John, Elk, Ferry Peak, and Baldy thrust sheets are wedge-shaped, thickening from about 700 m in the west to 800+ m in the east. These sheets all carry Cambrian limestones and their fault surfaces merge with the basal Absaroka detachment to the west. The Absaroka thrust sheet is isolated as a large horse between the Absaroka and St. John thrusts, which merge at depth to the west and on the surface to the east. The Thompson thrust lies at the base of a complex fault-zone of horses and imbricates resulting from the partitioning of fault slip throughout a well-developed karst and solution breccia zone in the upper Mission Canyon formation.

The Absaroka-St. John thrust system was uplifted and partly eroded as a result of later deformation asso-