and silts up to 7 m thick. The configuration and pattern of deposition suggest that this area could be used as a petroleum exploration model. The model consists basically of a reservoir-size porous carbonate-sand ridge surrounded downdip by organic-rich carbonate muds, which could serve as source beds. Reversing tidal currents and bed forms are identical to those of oolitic areas in the Bahamas, however, the Quicksands area does not contain ooids.

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Fractured Devonian Shale Reservoir, Appalachian Basin

Detailed structural analysis along the west flank of the Appalachian basin in Kentucky and West Virginia demonstrates the importance of detached and basement deformation in developing fracture permeability within Devonian shales. A porous fracture facies of regional extent within the organic-rich lower Huron Member of the Devonian shale partially relates to unique physical properties of the organic sediments, but an important factor for widespread gas production is fractures caused by differential shortening of sediments above a detachment surface in the lower Huron Member. Mineralized, uniquely oriented, and slickensided fractures, and increased fracture intensity within the organic lower Huron shales perpendicular to Alleghanian stress support this interpretation. The porous fracture facies is most permeable (commercial) beyond the region of major tectonic transport where permeability is only local in extent. Linear trends of abnormally high final open flows in the producing area relate to trends of intensely fractured organic shale. These fracture zones seemingly reflect unique, complex, and perhaps more intense shear stress within organic shale found in flexures above basement faults. Gas migrated updip along open fractures placing the best wells slightly updip along the fracture trend or on the flank of adjacent low-relief flexures. This unique reservoir forms its own source and seal, and the lithologically restricted fracture facies imparts the permeability. Tailoring completion techniques which limit the vertical extent of induced fractures and which enhance recovery in the more common orthogonally fractured shale of the mid-continent region will be important for future development of this huge resource.

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Mechanism for Framework Grain Dissolution (Secondary Porosity in Sandstones)

We propose that organic and clay maturation in concert are responsible for much framework grain dissolution (secondary porosity). Petrographic observations indicate a pulse of porosity formation near the top of the oil-generation window and that there is often not enough authigenic clay to account for the aluminum removed from the dissolved grains. Geochemical considerations indicate that H+ ions are required for aluminosilicate dissolution and that the aluminum must be complexed to concentrations greater than 100 ppm in order to transport aluminum out of the sandstone using water volumes available in most basins. The smectite to illite conversion, which is coincident with early organic maturation, produces additional pore water and can desorb organic molecules from the smectite interlayers. The early stages of organic-matter maturation generates H+ (as carbon dioxide), volume-change pressures to move fluids, and water-soluble organic matter. The soluble organic matter can contain ligand compounds (e.g., short-chain fatty acids) which complex aluminum. The organic ligands in the shale complex aluminum at relatively low concentrations because aqueous aluminum activity is depressed by the formation of illite from smectite. The H+ and organic ligand-bearing solution is expelled into sandstones where the aluminum activity is buffered at higher levels by feldspar, thus allowing higher levels of complexed aluminum. The solution dissolves the feldspars and other aluminosilicate components and complexes much of the resulting aluminum for transport out of the sandstone.

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Evolution of Floating Drilling Systems

Offshore exploration over the past 30 years has progressed from mud flats to almost 5,000 ft (1,500 m) of water. Exploratory systems for obtaining geologic information have progressed from scuba divers and small ships outfitted for grabbing rock and soil samples from the ocean floor to drill ships over 600 ft (180 m) long capable of maintaining station without anchors. Specialized subsea equipment has been developed from elementary drilling bases with wire rope guidelines to blowout preventer systems weighing over 400,000 lb (181,000 kg) and standing 40 ft (12 m) high which utilize acoustic and television reentry methods. Motion compensation systems are now available which make drilling from a floating vessel as similar to land drilling as is possible from a continuously moving platform. Engineers and the supplier industry continue to develop drilling systems to meet ever-changing environmental conditions.

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Gravity Interpretation of Northern Overthrust Belt, Idaho and Wyoming

A gravity interpretation of the northern Overthrust belt of eastern Idaho and western Wyoming was made to determine the structural configuration of the Precambrian basement and overlying sedimentary veneer. Two east-west gravity models of geologic cross sections were constructed along lat. 42°30′N and 43°N and one north-south section was constructed along long. 110°30′W. Two-dimensional analysis of the models reveals the presence of two basement highs—one beneath the leading edge of the Prospect fault and one beneath the Absaroka plate. Limited data also suggest another basement uplift may be present beneath the Meade thrust.

The location of the easternmost basement high suggests that it may have formed prior to the completion of thrusting and acted as a buttress to movement along the Prospect, causing the thrust to climb toward the surface. The uplift beneath the Absaroka was probably formed after thrusting, and lifted the overlying Absaroka plate toward the surface, as is evidenced by the exposure of Cambrian, Ordovician, and Devonian sole rocks within the Salt River Range. The uplifts appear to have influenced the subsurface structural geometries of the overlying sedimentary rocks, but not the depositional thicknesses of the Triassic, Jurassic, and Lower Cretaceous units. It may therefore be concluded that the uplifts of the Precambrian basement were formed after the deposition of the overlying sedimentary rocks.

Gravity modeling has also indicated the presence of high-density masses within the Precambrian basement, both beneath the Green River basin at lat. 43°N, and along lat. 42°45′N.

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Geologic Controls of In-Situ Processing of Tar Sands, N.W. Asphalt Ridge, Utah

The Laramie Energy Technology Center completed three in-situ oil-recovery experiments from tar sands at N.W. Asphalt Ridge, Utah. The 10-acre (4 ha.) tract is part of the Sohio Shale Oil Co. "D" tract located west of Vernal, in Uintah County. Asphalt Ridge, lying on the northern boundary of the Uinta basin, is a northwest-southeast-trending ridge. The area on the northwest is structurally a monocline dipping southwest. The 3.28 to 14.75 m thick experimental tar-sand zones are in the Rim Rock Sandstone Member of the Mesaverde Formation of Cretaceous age. The beds dip 28°SW, and overburden thicknesses range from 89 to 164 m. Two known faults, with throws up to 66 m, bound the tract.

Three experiments were performed at the tract on varying partial acreages from 1975 to 1980. Two combustion tests using reverse combustion and a combination reverse and forward combustion were completed in a tar-sand bed 3.28 to 3.93 m thick. Recovered oil and water for the experiments ranged from 65 to 580 bbl and 167 to 600 bbl, respectively. The third test used steam injection on a 14.75 m thick bed. Production was 1,150 bbl of oil and 6,250 bbl of water. Tar-sand analyses yielded the following range of data for the three tests: extracted porosity, 26.1 to 31.1%; absolute air permeability, 651 to 2,175 md; oil saturation, 62 to 75% pore volume; water saturation, 2.4 to 7.9% pore volume. Various geologic controls can determine the effectiveness of the extraction process. These include the dip of the beds, reservoir thickness, water and oil saturation, porosity, permeability, vertical and horizontal continuity of section, confinement of zone, and potential fractures and faulting in area.

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Early Cretaceous Depositional and Structural Development of Wyoming-Idaho-Utah Foreland Basin

Early Cretaceous deposition in the western Wyoming, eastern Idaho, and northeastern Utah region reflects the interplay of tectonic and eustatic controls during the early development of the thrust belt in this area. A major marine withdrawal at the close of the Jurassic was closely preceded by initial movement of the Paris-Willard thrust. Two subsequent pulses of eastward movement along this thrust occurred: a poorly dated event in Early Cretaceous time and a final movement during Late Cretaceous (Turonian). These periods of uplift on the western margin of the foreland basin are reflected by the eastward progradation of coarse fluvial clastic wedges into the Cretaceous seaway.

Between pulses of thrust movement, tectonic quiescence was coupled with a decrease of clastic influx into the subsiding basin. During periods of marine regression, broad marl-dominated lacustrine depositional systems developed in the foreland basin. In contrast, during transgressive periods, depositional environments were characterized by mixed fluvial and lacustrine systems bordered down paleoslope by extensive marsh-dominated systems. Basin subsidence, instigated by tectonic loading of the Paris-Willard thrust allochthon and further enhanced by sediment loading of the coarse clastic wedges, controlled the distribution of lacustrine systems during periods of marine regression.

The Paris-Willard thrust allochthon throughout the Early Cretaceous was dominated by upper Paleozoic strata. Subsequent to the final movement of the thrust, the allochthon was carried passively eastward and uplifted by ramping along steps of the more eastern Absaroka thrust. This uplift resulted in the exposure of upper Precambrian and lower Paleozoic strata which dominate the allochthon today.

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Geometry of Modern Anastomosed Channel Deposits and Potential Hydrocarbon Traps

The anastomosed fluvial model, interpreted from modern deposits in the upper Columbia River valley between Radium and Golden, British Columbia, consists of aggrading, multiple, low-gradient, low-sinuosity, thick, sand-filled channels laterally contained by levees, crevasse splays, and various wetland deposits. While active aggrading cross-valley alluvial fans controlled sedimentation in the upper Columbia valley, basin subsidence and/or regional tilting were controls for probable ancient anastomosed fluvial rocks, such as in the Cretaceous Western Interior molasse basin. The uniqueness of anastomosed fluvial style compared to that of meandering rivers is attributed to regional rapid aggradation, which subsequently favors anastomosed deposits for deep burial and preservation.

In the Columbia valley, the cross-valley profile of anastomosed channel deposits consists of vertically and laterally multiple stringers of channel sand, longitudinally interconnected at different stratigraphic levels. Individual channel cross sections consist of mud-contained, thick channel fills with multistoried textural cycles dominated by planar, tabular cross-bed structures. The upper ¼ to ⅓ of each channel fill consists of either mud or sandy point bar, contained laterally by mud resulting from waning river discharge.

Several different trapping processes may account for hydrocarbon accumulations in ancient anastomosed fluvial sandstones, based on core observations from modern deposits in the Columbia valley. The most common trap occurs in upper channel fill point-bar sands contained laterally and above by mud. A less common trap is a sand-filled channel segment plugged at both ends with a mud-filled master channel and capped with lacustrine mud. Two other traps result from differential compaction of mud versus sand: (1) deep scour holes at the downstream confluence of two channels allow the thicker sand-filled scour to form a domelike "compaction high" when capped with mud; and (2) a cross overlap of two stratigraphically different channels results in an anticline of the upper channel where it crosses over the lower channel.

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Anastomosed River Deposits—Modern and Ancient Examples in Western Canada

Depositional facies of two Canadian modern anastomosed river systems, the upper Columbia River and lower Saskatchewan River, occur in intermontane and plains settings, respectively. Both systems contain low-gradient, multiple, interconnected, laterally stable sand-bed channels, with adjacent splay, levee, and shallow wetland deposits, all aggrading in accordance with channel sedimentation. While aggrading cross-valley alluvial fans or subsidence tend to control sedimentation rates in intermontane valleys, basin subsidence and/or regional tilting controls deposition rates in plains settings.

Deposits in the upper Columbia River valley (120 × 1.5 km) consist of low-sinuosity multistoried stringers (textural cycles) with planar tabular cross-bed sets of channel sands and numerous sandy crevasse-splay deposits. Channel deposits are laterally contained by deposits of levee silt and lacustrine mud, and when buried are vertically mud encased. Aggrading at an average rate of 60 cm/100 years over the past 2,500 years, the anastomosed system is very dynamic, exhibiting many avulsions and channel