subparallel with a mean strike of N25°E. Changes in thickness of coal lithotypes and the coal seam itself commonly occur across the rolls.

Though a reliable model is not known which fully explains rolls, enough information exists to suggest a likely explanation. The rolls parallel the thickest portion of the Storrs Sandstone Tongue of the Starpoint Sandstone, an ancient littoral sandstone system. This and roll morphology suggest rolls are the steep sides of accretion ridge troughs which comprise the upper surface of the Storrs Sandstone tongue.

Study of the rolls has increased the reliability of their prediction, enabling the engineering staff to make appropriate changes in the mine plan in order to minimize the adverse effects on mineability.

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Red Beds of Middle Pleistocene Olorgesailie Formation, Kenya

Middle Pleistocene lake sediments of the Olorgesailie Formation from the East African Rift Valley of Kenya contain red beds, with colors ranging from moderate orange pink to dark reddish brown (Munsell color chart). Two distinct mechanisms of hematite formation, distinguished by thin section and scanning electron microscope study, have produced the red sediments.

In the first mechanism, hematite was formed in situ by dehydration of limonitic minerals. The limonitic minerals formed in soils of the source area and were transported to the depositional site mainly by adhering to clay particles. The elevated pH of the depositional environment accelerated the rate of hematite formation, producing ultrafine red coating on the clays. Red sediment formed by this mechanism occurs both as an undisturbed bed and as a reworked intraclast conglomerate.

In the second mechanism, hematite is precipitated from ground water, possibly at elevated temperatures produced by the interaction of basaltic magma with water-saturated sediment. The hematite occurs in three forms: as cement within diatomaceous clay, as replaced or stained plant material, and within siliceous sinters. The sinters are red, have a pumice-like texture, and include diatoms that show effects of dissolution. These characteristics indicate formation of the sinters by boiling of near-surface water-saturated sediment. Red beds formed by this mechanism are redeposited and each of the three hematite forms dominates in specific localities.

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Lateral Accretion Channel Deposits in Athabasca Delta: Potential Modern Analog to McMurray Formation

"Epsilon cross-stratification" refers to large-scale, alternating sand and mud couplets that dip at right angles to the paleocurrent direction. This feature is of major concern when producing oil from ancient meandering river point-bar deposits. Mud epsilon cross-strata act as impermeable barriers to the movement of hydrocarbons within the reservoir. This and other related problems have been prevalent in steam enhanced recovery from the bitumen-rich middle member of the McMurray formation.

Research on epsilon cross-stratified lateral accretion deposits has been focused for the most part on the study of ancient deposits. Investigation into the modern occurrence of these features has been limited in scale (0.5 m or 1.6 ft deep channels) and numbers of observations. Many unanswered questions remain as to the location of depositional environment (meanders in fluvial, tidal, or deltaic systems) and detailed sedimentologic characteristics.

A recent investigation has found mud epsilon cross-strata in lateral accretion point-bar deposits in the Athabasca upper delta plain in northeastern Alberta. The overall sedimentologic trends of these particular lateral accretion deposits, including the variability, continuity, thickness, and geometry of the mud epsilon interbeds, has given new insight into the complex nature of these deposits and occurrence of depositional setting.

Many aspects of the lateral accretion in the Athabasca upper delta plain appear very similar to the ancient lateral accretion deposits of the middle McMurray. Comparative sedimentology of the modern and ancient deposits may lead to a better understanding of these deposits. This may in turn allow for optimum site selection for in-situ steam injection and recovery wells as well as prediction of potential fluid movement patterns.

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Economic Potential for Upper Cretaceous and Lower Tertiary Rocks Near Helper, Carbon County, Utah

Exceptionally good exposures of Late Cretaceous and early Tertiary rocks in the western Book Cliffs area near Helper, Utah, allow detailed study of nearshore clastic sediments. The Mancos Shale is an organic-rich, silty shale, interrupted regularly by tongues of fine to medium-grained sandstone that thin to the east. The Garley Canyon and Emery Sandstones, which are the two main sandstone members in this area, exhibit a prograding clastic shoreline sequence from open-marine and lower shoreface to upper shoreface environments. Thinner sandstones also crop out in the area that indicate minor pulses of deltaic progradation and exhibit one or more of these facies. These sandstones pinch out eastward, and are offset by normal faults to the west; therefore, hydrocarbon accumulation is likely to occur in areas to the west.

The coal-bearing Blackhawk Formation is also well exposed within the study area, and is interpreted as a wave-dominated delta complex. Coal-forming swamps were situated directly on beach ridges. Several of these economically important coal seams pinch out westward (landward) within the study area. This stratigraphic interplay between terrestrial sedimentation and the coal-forming swamp environment provides details for refining coal exploration models.

Upon completion of regional stratigraphic analyses, thickness variations in Upper Cretaceous and lower Tertiary formations may provide a more precise indication for the time of crustal uplift associated with the San Rafael swell.

CHAMBERLAIN, ALAN K., Placid Oil Co., Salt Lake City, UT

Shallow-Water Clastic Sediments of Great Blue Formation and Manning Canyon Shale, Oquirrh Basin, Utah

An east-west belt of clastic sediments in the Mississippian Great Blue Formation and Manning Canyon Shale thickens and coarsens westward and contains terrestrial plant and palynomorph assemblages. These clastic sediments were derived from the Antler highlands in central Nevada. The depositional axis of the clastic belt or proto-Oquirrh basin is probably related to a basement weakness that controlled the east-west-trending Uinta basin. The geometry of the belt is illustrated by isopach maps and cross sections. An isopach map of the total Mississippian clastics in eastern Nevada and Utah and an east-west cross section through the Oquirrh basin demonstrate that the clastics thicken and coarsen westward and indicate a western source. A north-south cross section illustrates how the clastic sediments were restricted to the east-west clastic belt. In contrast to previous interpretations that assumed that the clastic sediments were shed westward from the craton into deep water, field evidence suggests that they were shed eastward from the rising Antler mountains into very shallow water.

Terrestrial plants preserved in shales and sandstones of the Great Blue Formation and the Manning Canyon Shale suggest that the clastic sediments were deposited in a transitional environment such as lagoons, distal flood plains, and deltas. Palynomorph assemblages in the shales lack marine forms and also indicate shallow-water deposition. In addition, surface gamma-ray patterns of measured sections are typical of transitional facies sequences such as deltas and nearshore environments.

CHAN, MAJORIE A., and JACQUELINE F. HUNTOON, Univ. Utah, Salt Lake City, UT

Complex Interaction of Eolian and Marine Sedimentation in Permian White Rim Sandstone, Elaterite Basin, Southeast Utah

Two depositional units distinguished in the Permian White Rim Sandstone of the Elaterite basin indicate episodes of both eolian and marine sedimentation. The lower unit is a thick section of large-scale, high-angle, cross-bedded quartzarenite. The tabular cross-bed sets average 2.6 m (8.5 ft) in height and contain inversely graded translatent strata and small ripple trains with high ripple indices. Some exposures reveal large barchan dune forms. This lowest unit comprises most of the formation and is sharply cut and scoured by the overlying unit. The upper unit is a thin veneer that ranges from 1 to 5.3 m (3 to 17 ft) in thickness and possesses

characteristic marine structures.

An idealized vertical sequence within the veneer consists (in ascending order) of a laminated sandstone facies (in places containing chert pebbles), cross-stratified (0.3-m or 1-ft sets) sandstone facies, and an oscillation ripple sandstone facies. The upper part of the oscillation ripple sandstone facies may contain 6-sided polygonal structures filled with coarse-grained sandstone and chert pebbles, or it may be covered by a massive facies that contains abundant fluid-escape structures. Variations on the idealized veneer stratigraphy exist where some facies are absent, but the vertical sequence order is maintained.

Most of the formation is interpreted to be eolian in origin. Northerly winds deposited the large cross-bed sets in an extensive dune field. This event was followed by a period of marine transgression that reworked the uppermost part of the formation and formed the thin veneer. The abundance of fluid-escape structures and oscillation ripples in the veneer indicates rapid deposition by marine processes. The distinctive stratigraphy within the veneer reflects a deepening trend with the rising transgression.

CHIDSEY, THOMAS C., JR., Celsius Energy Co., Salt Lake City, UT

Hydrocarbon Potential Beneath Paris-Willard Thrust of Utah and Idaho

The Paris-Willard thrust trends in a north-south direction parallel with the eastern edge of the Bear Lake plateau of north-central Utah and southeastern Idaho. In places along the leading edge of the thrust, formations as old as the Cambrian Brigham Quartzite have overridden the Jurassic Nugget Sandstone and various Triassic formations. Movement on the Paris-Willard thrust began in latest Jurassic or earliest Cretaceous time, displacing rocks from the west to the east over 10 mi (16 km).

Seismic surveys indicate that from the leading edge to approximately 6 mi (10 km) west, the Paris-Willard thrust is relatively thin skinned. Detailed structural cross sections suggest that shales in the Triassic Woodside or Ankareh Formations, acted as "sled runners" for Cambrian quartzites moving on the overlying Paris-Willard plate. The thickness of this overlying thrust plate is believed to range between 3,000 and 8,000 ft (900 and 2,400 m), with a complete Paleozoic section present on the underlying Crawford thrust plate. With the exception of two wells drilled on the edge of the Paris-Willard thrust, 600 mi^2 (1,500 km^2) of potential Paleozoic reservoirs beneath the thrust have never been tested. Seismic interpretations indicate the presence of several large structures in the subthrust where formations such as the Phosphoria (which tested gas on the Crawford plate at Hogback Ridge field to the east), Weber, and Madison would be the primary objectives. Recent studies by several workers suggest units in the Phosphoria and other Paleozoic formations are excellent potential source rocks.

CLAYTON, JERRY L., U.S. Geol. Survey, Denver, CO, and ROBERT T. RYDER, U.S. Geol. Survey, Reston, VA

Petroleum Source-Rock Potential of Pennsylvanian Black Shales in Powder River Basin, Wyoming, and Northern Denver Basin, Nebraska

We analyzed 70 black shale samples from the middle member of the Minnelusa Formation (Pennsylvanian) in the Powder River basin of Wyoming and South Dakota, and from equivalent rocks of Desmoinesian age in the northern Denver basin of Nebraska. Organic-carbon content of these shales ranges from less than 1 to 26 wt. % (average = 5.4 wt. %). The shales contain predominantly type II organic matter and yield an average of 27,000 ppm hydrocarbons upon pyrolysis (S_2 yield, Rock-Eval). These data indicate that the shales are excellent potential source rocks. Thermal maturation data (vitrinite reflectance, pyrolysis, hydrocarbon geochemistry) indicate that some hydrocarbon generation has occurred, although complete generation of available hydrocarbons has not occurred for the samples analyzed in this study.

We analyzed 12 oil samples from fields producing from the Minnelusa Formation, for comparison with extracts from the black shales. Two, and possibly three, genetic oil types are produced from sandstone reservoirs in the Minnelusa Formation. One type is produced from sandstone reservoirs in the upper member (Permian), and a second type is produced from the middle member Leo sandstones (Pennsylvanian). This second oil type can be subdivided into two subgroups based on chemical composition, although we cannot determine from our data whether these are genetically distinct oils. Extracts from the black-shale samples correlate well with the two or three oil types based on stable carbon isotope composition and detailed molecular hydrocarbon composition determined by gas chromatography-mass spectrometry (C_{9+} alkanes and biomarkers). These results suggest that oil produced from the upper and middle members of the Minnelusa Formation in the Powder River basin is derived locally from the Pennsylvanian black shale and is not a product of long-range migration from the Phosphoria Formation in western Wyoming.

CLAYTON, JERRY, U.S. Geol. Survey, Denver, CO, ROBERT T. RYDER, U.S. Geol. Survey, Reston, VA, and FRED MEISSNER, U.S. Geol. Survey, Denver, CO

Geochemistry of Black Shales in Minnelusa Formation and Desmoinesian Age Rocks (Permian-Pennsylvanian), and Associated Oils, Powder River Basin and Northern DJ Basin, Wyoming and Colorado

No abstract available.

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Petroleum Geology of Greater Altamont Area, Uinta Basin, Utah

The Greater Altamont area consists of a group of major, naturally fractured, overpressured petroleum reservoirs situated on the gently northward-dipping flank of the asymmetric Uinta basin. This area produces approximately 17,000 BOPD and 29 MMCFGD—one-half the petroleum production in the Uinta basin. It presently consists of three contiguously producing designated fields: Altamont, Bluebell, and Cedar Rim.

The Tertiary Uinta, Green River, Wasatch, and North Horn Formations and the Tertiary-Cretaceous Flagstaff Limestone are the source and reservoir rocks. The low-porosity sandstones and siltstones form the stratigraphic traps within the interbedded shales. Vertical fractures provide the necessary permeability in these formations. Producing intervals occur at depths between 3,700 and 18,613 ft (1,128 and 5,673 m), each with an average thickness of 311 ft (95 m).

Average recovery is expected to be approximately 12%. Completion techniques play an important role in the primary production of oil from the area. Several extraction methods used in the area have resulted in variation of longevity of the wells. Secondary recovery is not deemed feasible owing to the type of reservoir; repressuring would result in channeling along fractures, bypassing most of the oil in place. In the near future, the Greater Altamont area is envisaged to extend farther south, as indicated by Sonat's recently completed producing wells in T3S, R1-2W.

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Tar Sand Triangle—Largest United States Tar Sand Deposit

Estimates of 4-8 billion bbl of oil in place make the Tar Sand Triangle the largest known deposit of tar sand in the United States. At present, 14 different companies or individuals hold leases in the area, most of which are for in-situ development of the tar sand resource.

In the summer of 1982, the DOE/LETC drilled four core holes, three of which penetrated the principal bitumen-bearing sequence—the White Rim Sandstone. The locations of the core holes were selected to fill obvious gaps in the data available from previous holes drilled into or through the deposit.

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Seismic Facies and Reservoir Distribution in a Prograding Shelf-Slope-Basin Plain System: Chandler and Torok Formations, North Slope, Alaska

The Chandler-Torok sequence is one of several Cretaceous-Tertiary clastic wedges shed north and east from the ancestral Brooks Range hinterland into a rapidly subsiding foredeep trough. Each wedge consists of a