

a water block similar to that described by J. A. Masters in the Deep Basin of Canada and the San Juan basin of New Mexico and Colorado. Recent work suggests that the formation of the water block in the Greater Green River basin is related to a dewatering process associated with the thermal generation of gas.

Data from reference wells indicate that in the deeper parts of the basin, the relatively closed nature of this system imposes severe restrictions on the ability of gas to migrate appreciable distances from the interbedded source rocks. Consequently, the temporal relationships of hydrocarbon generation and migration with respect to the development of structural and stratigraphic traps are not as important in these unconventional reservoirs as in more conventional ones. The more important factors related to gas generation and occurrence are source-rock quantity and quality, organic maturation, thermal history, formation pressure, porosity and permeability variations, and the nature of formation-water occurrence.

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Evolution of Fluvial Style—Lower Devonian Battery Point Formation, Gaspé Peninsula, Quebec, Canada

The Battery Point Formation (Emsian) forms part of a broadly upward-coarsening alluvial suite. The formation is 2,300 m (7,550 ft) thick, rests unconformably on shallow marine sandstones of the York River Formation, and is transitional upwards into a proximal braid-plain sequence of the Malbaie Formation.

A lower, 110 m (360 ft) thick, sequence from the Battery Point was previously interpreted as braided-fluvial based mainly on the recognition of laterally migrating, shallow transverse bar deposits and on a paucity of vertically accreted fine-grained sediment.

Between Cap-aux-Os and Penouille, Gaspé Peninsula, these braided-fluvial facies are succeeded by quite different fluvial deposits mainly comprising 30–40 m (100–130 ft) multistory channel sandstone complexes, often thinning laterally to 15–18 m (50–60 ft), and separated by 6–10 m (20–33 ft) of laterally persistent mudrock sequences. The latter can be traced laterally up to 6.5 km (4 mi), allowing the geometry of the sandstones to be evaluated in great detail.

Within the sandstones, medium-scale trough cross-bedding is dominant, with subordinate, isolated (0.8–3 m or 32 in.–10 ft thick) planar-tabular sets and parallel laminated units. Mudclast-lined erosion surfaces commonly define individual channel-fill events.

The scarcity of cut-bank phenomena, and lack of lateral accretion surfaces suggest laterally unstable channels of fairly low sinuosity within large (possibly up to 15 km or 9 mi wide) stable channel belts. These were rapidly abandoned, accumulating the mud-rock sequences, which are exceptionally up to 50 m (165 ft) thick. The paucity of desiccation features and lack of mature calcretes, together with abundant plant activity and much wave rippling, suggest that large areas of standing water existed on the flood plain.

Extrinsic controls, such as climatic change, are proposed for this evolution in fluvial style.

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Uranium Occurrence in Major Rock Types by Fission-Track Mapping

Microscopic occurrence of uranium has been determined in about 50 igneous rocks from various locations, and in a genetically unrelated sandstone from south Texas.

Precambrian granites from the Llano uplift of central Texas contain from a few ppm uranium (considered normal) to over 100 ppm on a whole-rock basis. In granite, uranium is concentrated in: (1) accessory minerals including zircon, biotite, allanite, Fe-Ti oxides, and altered sphene, (2) along grain boundaries and in microfractures by precipitation from deuteric fluids, and (3) as point sources (small inclusions) in quartz and feldspars.

Tertiary volcanic rocks from the Davis Mountains of west Texas include diverse rock types from basalt to rhyolite. Average uranium contents increase from 1 ppm in basalts to 7 ppm in rhyolites. Concentration occurs: (1) in iron-titanium-oxides, zircon, and rutile, (2) in the fine-

grained groundmass as uniform and point-source concentrations, and (3) as late uranium in cavities associated with banded, silica-rich material.

Uranium in ore-grade sandstone is concentrated to more than 3%. Specific occurrences include (1) leucocoxe and/or anatase, (2) opaline and calcite cements, (3) mud clasts and altered volcanic rock fragments, and (4) in a few samples, as silt-size uranium- and molybdenum-rich spheres. Uranium content is quite low in pyrite, marcasite, and zeolites.

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Mid-Continent Rift System—A Frontier Hydrocarbon Province

The Mid-Continent rift system can be traced by the Mid-Continent geophysical anomaly (MGA) from the surface exposure of the Keweenaw Supergroup in the Lake Superior basin southwest in the subsurface through Wisconsin, Minnesota, Iowa, Nebraska, and Kansas. Outcrop and well penetrations of the late rift Keweenaw sedimentary rocks reveal sediments reflecting a characteristic early continental rift clastic sequence, including alluvial fans, deep organic-rich basins, and prograding fluvial plains.

Sedimentary basins where these early rift sediments are preserved can be located by upward continuation of the aeromagnetic profiles across the rift trend and by gravity models. Studies of analog continental rifts and aulacogens show that these gravity models should incorporate (1) a deep mafic "rift pillow" body to create the narrow gravity high of the MGA, and (2) anomalously thick crust to account for the more regional gravity low. Preserved accumulations of rift clastics in central rift positions can then be modeled to explain the small scale "notches" which are found within the narrow gravity high.

Indigenous oil in Keweenaw sediments in the outcrop area and coaly partings in the subsurface penetrations of the Keweenaw clastics support the analogy between these rift sediments and the exceptionally organic-rich sediments of the East African rift. COCORP data across the rift trend in Kansas show layered deep reflectors and large structures. There is demonstrable source, reservoir, and trap potential within the Keweenaw trend, making the Mid-Continent rift system a frontier hydrocarbon province.

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Estimation of Oil Potential of Beaverhill Lake Group, Alberta

The Devonian Beaverhill Lake reefs in the subsurface of central Alberta are among the most prolific oil-producing reservoirs in Canada. More than 1,600 exploratory wells have penetrated into the Beaverhill Lake beds in the area. Nineteen oil pools have been discovered, and make up a reserve of  $848 \times 10^6 \text{ m}^3$  ( $5.3 \times 10^9$  bbl) of oil in place. Subsurface studies reveal that episodic growth of reef occurred on the Swan Hills platform. The questions for petroleum resource evaluation are: (1) how many undiscovered pools may exist, and (2) what are their possible sizes?

This talk will use the Beaverhill Lake data to discuss the following questions. (1) What is the role of play definition in resource evaluation? (2) What types of geological data or information are required to construct a pool-size distribution scheme? (3) What geological information can and cannot be inferred from pool-size distribution data? (4) What types of procedures are available for determining the number of pools? (5) How can pool sizes by rank be estimated? (6) What types of uncertainty can be handled and reduced by the present method? Finally, the number of possible undiscovered pools and their sizes in the Beaverhill Lake Group also will be addressed.

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Deep Wilcox Structure and Stratigraphy in Fandango Field Area, Zapata County, Texas

The Fandango field in Zapata County, Texas, is a new deep Wilcox trend extension. The deep Wilcox sands are commonly found at depths of 15,000–20,000 ft (4,500–6,100 m). Enough well log and seismic control exists to make an accurate integrated interpretation of regional deep Wilcox structure and stratigraphy.