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Existing commercial petroleum deposits occur primarily in lacustrine and marginal lacustrine facies of the Green River and Wasatch Formations; hydrocarbon production occurs only locally from the more mountainward alluvial facies. However, it can be shown that oil migrated northward as early as late Eocene time, probably before complete compaction and cementation of Eocene sediments. Numerous rocks of Mesozoic and Tertiary ages that are impregnated with Tertiary oil are evidence of extensive northward oil migration. Potential petroleum traps along the Uinta Basin–Mountain boundary include pre-Tertiary strata above the fault, upturned strata against the fault, and structures in Tertiary and pre-Tertiary strata on the downthrown fault block.

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Well-Log Analysis in Cretaceous Gas Sands in Northern Montana

The fact that the responses of neutron and density logs in gas-bearing formations differ from those in oil- and water-bearing formations has prompted the acceptance of these logs in many areas as standard for the analysis of clean or shaly gas sands. Using these two logs, with gamma-ray and resistivity logs, the various permeable beds in a well can be evaluated accurately.

One approach to gas-sand interpretation, which can be done at the well site, involves a plot of the log data on ordinary graph paper. For each level the difference, apparent porosity from the neutron log minus apparent porosity from the density log, is plotted versus the reading from the gamma-ray log. If there are known water- and gas-bearing levels within the beds of interest or within the same geologic interval, then a liquid line can be determined on the plot. Gas-bearing levels are identified by the location of the corresponding plotted points relative to the liquid line.

A more complete interpretation of the reservoir is provided by the SARABAND (trademark of Schlumberger) computer-oriented technique. Results provided by this analysis include formation porosity, saturation, permeability index, and shale-, clay-, and sand-volume fractions. Experience indicates that good interpretation results are achieved, and that the subsequent completions are therefore improved.

Examples illustrate the applications of these two techniques in clean and shaly formations of northern Montana.

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Geologic Controls Over Hot Water Migration at Selected Hot Springs, Southwestern Montana

Development of models for thermal water circulation in areas away from active volcanism is needed. In southwestern Montana, 27 hot springs (discharges above 35°C) are under geologic investigation for geothermal potential. Many springs are on or near faults or major fractured zones. Preliminary investigation suggests several models for thermal-water circulation; permeable joint-shear zone intersection, graben-block, and synclinal controls are exemplified by Potosi, Wolf Creek, and New Biltmore hot springs, respectively.

Potosi hot springs waters issue as numerous seeps from N85°W permeable joints where intersected by a N5°E shattered zone in quartz monzonite of the Tobacco Root batholith. Water evidently percolates to depth along the permeable joints and rises where they intersect the relatively impermeable shattered zone. This model, with modifications, may apply to Boulder and other hot springs in fractured crystalline rock.

Wolf Creek hot springs issues from a N5°W recently active fault which displaces bench gravels in the upper Madison Valley and may form the west edge of a deep sediment-filled graben in Precambrian metamorphic rocks. The Madison Range frontal fault bounds the graben on the east. Water may circulate to depth beneath the graben or within the valley-fill sediments and may rise along the bounding fault. Chico and Bozeman hot springs also may illustrate graben or hinged fault-block control.

New Biltmore, Renova, and LaDuke hot springs waters may have risen along Paleozoic carbonate aquifers from depths of synclines located beneath the Big Hole, Jefferson, and upper Yellowstone Valleys respectively.

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Petroleum Geology of Fort Union and Mesaverde Formations—its Relation to Fracture Stimulation Results in Rio Blanco Unit, Rio Blanco County, Colorado

The Upper Cretaceous Mesaverde and Paleocene Fort Union-Wasatch Formations in the area of the Rio Blanco Federal Oil and Gas Unit, northern Piceance basin, Colorado, contain natural gas reserves exceeding an average of 30 Bcf per sq mi. The rocks comprise an alternating lenticular nonmarine sandstone-siltstone-shale complex with a combined thickness of approximately 6,000 ft (1,829 m). The formational boundaries within the sequence and between it and the overlying and underlying rocks are transitional.

Cores and excellent drill cuttings from recent wells have corrected the widespread impression that the Late Cretaceous-Paleocene depositional environment here was primarily nonhydrocarbon generating. Most of the sedimentary sequence was deposited in a hydrocarbon-rich paludal and lacustrine environment.

Upper Cretaceous shales are uniformly carbonaceous, firm to fissile, dark gray-brown to black, commonly calcareous and fossiliferous. Paleocene shale colors tend to lighter shades of gray and, particularly in the upper part of the formation, are locally varicolored and waxy.

The light-gray, variably clay-filled and calcareous sandstones of the Late Cretaceous are generally fine grained. They rarely exceed 50 ft (15 m) in thickness. Paleocene sandstones commonly exceed 50 ft in thickness, tending to be coarser grained and conglomeratic. The sandstones in the entire sequence are lenticular; however, certain of the arenaceous zones in the Late Cretaceous appear to be areally continuous.