IP of 2,254 BOPD and 21.8 MMCFGD. Three wells are testing and only two wells are known dry holes.

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Structural Pattern of Eastern Part of Disturbed Belt of Montana

The eastern part of the disturbed belt of Montana is in the foothills east of the northern Rocky Mountains. The area studied extends about 190 km from Wolf Creek north to Browning, Montana. It is about 30 km wide in the northern and southern parts, narrowing to about 10 km in the central part. The eastern margin is bounded by a thrust fault or folds.

The eastern part of the disturbed belt contains four structural-stratigraphic subdivisions which are, from west to east: (1) thrust-faulted Jurassic and Lower Cretaceous mudstone and sandstone; (2) folded and locally thrust-faulted Upper Cretaceous mudstone; (3) Upper Cretaceous sandstone and mudstone that are imbricately thrust faulted in the northern part, complexly folded near the central part, and folded and thrust faulted in the southern part; and (4) folded and locally thrust-faulted Upper Cretaceous thin sandstone and thick mudstone. The latter is absent in the central parts.

Structural trends change from northwest in the northern part of the area, to due south in the central part, and southeast in the southern part.

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Geology and Structural Control of Geothermal System at Roosevelt Hot Springs KGRA, Beaver County, Utah

The Roosevelt Hot Springs KGRA is located in the Basin and Range province along the western flank of the Mineral Mountains. It is within the Wah Wah–Tusher mineral belt which has been the locus for rhyolitic intrusive and extrusive activity through Tertiary and into Quaternary time. The area is just east of the Sevier (Cretaceous) thrust belt and is near the margin of the Intermountain seismic belt. Geologic mapping has identified three metamorphic and plutonic units of Precambrian age, nine intrusive phases of the Tertiary Mineral Mountains pluton, three Pleistocene rhyolitic extrusive phases, and siliceous hot spring deposits of relatively recent age. Cuttings from exploration holes indicate that the Precambrian and Tertiary crystalline rocks host the present geothermal system.

The structure of the area is dominated by low-angle normal faults (denudation faults) which dip to the west. The hanging wall of the principal denudation fault was intensely brecciated during the fault episode forming steep fault zones which generally strike northwest. Both these low- and high-angle fault zones show the development of intense, silicified mylonites. Adjacent to these mylonite zones, the crystalline rocks are highly fractured. East-west and northeast-trending high-angle faults cut the denudation faults and channel much of the recent hot-spring activity.

The geothermal system is a high-temperature, water-dominated resource which is probably related to an igneous heat source. The low primary permeability of the reservoir rocks and the location of the geothermal field indicate structural control of the system. The reservoir geometries and permeabilities result from the intersections of the principal fault systems.

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Petrology of Tertiary Sandstones of Southern Piceance Creek Basin, Colorado—Implication for Provenance and Depositional Processes

Comparative petrographic analyses of channel-form and tabular sandstone bodies in the upper Wasatch Formation (Paleocene-Eocene) and lower Green River Formation (Eocene) in the southern Piceance Creek basin show that compositional and textural variability is primarily a reflection of provenance and the environment of deposition.

Sandstones from the upper Wasatch Formation and lower Green River Formation are generally similar in texture and composition and have varying concentrations of (1) angular to well-rounded monocrystalline quartz grains, some with abraded overgrowths; (2) fresh and slightly altered potassic and sodic feldspars; and (3) volcanic lithic fragments, mostly andesite. Wasatch sandstones contain slightly more lithic fragments than those of the lower Green River, which are more quartzose. This difference is attributed to the fluvial mode of deposition of the Wasatch in contrast to the marginal-lacustrine nature of the Green River sandstones. Lacustrine sandstone also commonly contains accessory analcime and pyrite.

The sampled intervals of the Green River Formation permit an evaluation of the source terrane and its evolution during development of Lake Uinta. Paleocurrent data suggest that the sources for most of the sediment were on the south, southwest, and southeast. Petrographic similarities among the samples imply a relatively constant source terrane during deposition of the Green River Formation that was composed of Mesozoic and Paleozoic sedimentary rocks and late Mesozoic and early Cenozoic silicic volcanic and plutonic rocks.

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Petroleum Exploration in Younger Over Older Thrust Plates in Southeastern Idaho

West of the Paris and Putnam faults (Bear River and Portneuf Ranges, Idaho), thrust plates of younger strata overlie older with tectonic omissions as great as 7 km, in contrast to eastern foreland thrusts of older over younger strata with repetitions of about 6 km. Folds in the western plates are broad, open, and upright in contrast to tight asymmetric folds in eastern plates.

Three major thrust plates are recognized from extensive but incomplete mapping. (1) An uppermost and most extensively exposed plate of Oquirrh strata (Pennsylvanian and Permian) with Manning Canyon Shale (Mississippian and Pennsylvanian) at its base lies discordantly on middle Paleozoic units and extends from the Albion Range 100 km east to the Bannock Range. (2) A middle plate of mainly Ordovician to Middle Cambrian strata lies on upper Precambrian quartzite and argillite of the Brigham Group in the Bannock Range between Pocatello and Utah. Ordovician strata in the Raft River and Albion Ranges lie on schist and quartzite of unknown age. (3) A lower plate of mainly upper Precambrian (Mutual and Camelback Mountain) quartzite in the Bannock Range overlies Precambrian rocks of the Scout Mountain Member of the Pocatello Formation, 3 km lower in the stratigraphic sequence. The middle plate locally overlaps the lower, placing Ordovician limestone directly on Scout Mountain strata. Scout Mountain rocks are more intensely sheared, mylonitized, and metamorphosed (greenschist) than any east of the Raft River Range, which poses the problem of whether they are autochthonous.

Prolific Mesozoic hydrocarbon reservoirs of the foreland belt are thus unlikely to be encountered by drilling farther west. Moreover, these thrust plates are cut by younger basin-and-range faults that have enormous apparent stratigraphic throws, further complicating local structure and hydrodynamic history. Reported moderate to high paleotemperatures reflect a complex thermal history with undefined implications for maturation. Nevertheless, regional stratigraphic relations suggest the presence of Paleozoic hydrocarbon source beds and reservoirs, although exploration will be difficult.

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Sedimentary and Tectonic Controls of Uranium Mineralization in Morrison Formation (Upper Jurassic) of South-Central Utah

Sedimentologic studies in the Henry basin of south-central Utah indicate that uranium deposits in sandstones of the Morrison Formation are related to the depositional environment in which the host sandstone bed and nearby mudstones were deposited and to the tectonic setting at the time of deposition. Thus, an understanding of environments of deposition and contemporaneous tectonism may be helpful exploration guides for uranium deposits in sandstones.

Discontinuous tabular uranium orebodies are present in fluvial and marginal lacustrine sandstone beds that lie just above, below, or a short lateral distance from offshore lacustrine gray mudstone beds. The mudstones are present only in the distal part of the lowermost alluvial-plain sequence of the Morrison where fluvial energy regimes and rates of sedimentation were low, allowing lakes to form while the Henry basin was slowly subsiding. The lakes were restricted to the east side of the basin where the least amount of clastic sedimentation by streams occurred. Palynomorphs, carbonized plant debris, and scarce pyrite in the mudstones indicate that the lakes were sufficiently persistent and deep during most of their lifetimes for reducing conditions to persist in the offshore muds. They also indicate that the mudstones were originally gray and are not bleached red mudstones. The gray mudstones are not present in other alluvial-plain sequences of the Morrison because little or no basin subsidence occurred after deposition of the lowermost sequence.

Plant debris and palynomorphs in the gray lacustrine mudstones suggest deposition in humus-producing lakes in which humic and fulvic acids (degradation products of plant tissues) were generated in the lake sediments. The close spatial association of the ore-bearing sandstones and the gray mudstones suggests that pore fluids containing these organic acids were expelled by compaction or seepage from the mudstones into nearby sandstones where they were fixed as tabular humate deposits. Subsequently, uranium in groundwater passing through the sandstone was concentrated by the humate to form the ore deposits.

Gray mudstones which cannot be used as exploration guides are bleached red mudstones and primary gray mudstones containing the alga *Botryococcus*. Sandstone beds adjacent to these gray mudstones are barren of uranium because (1) the gray color in bleached red mudstones is an alteration feature and does not indicate primary reducing conditions, and (2) *Botryococcus* thrives in humus-free lakes whereas humus-producing lakes are considered necessary to form ore deposits.

Thus, the requisites for mineralization appear to have been active crustal downwarping to cause ponding of fluvial sediments, and formation of humus-producing lakes on the alluvial plain, in the most sediment-starved part of the area undergoing basinal downwarping.

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Stratigraphy of Lacustrine Deposits

The major stratigraphic aspects of lacustrine rock units are geometry (thickness and lateral extent), facies patterns, and vertical sequence. Sizes and shapes of modern lakes show wide ranges, but many large ones are subcircular to elongate. In cross section most thick lacustrine units are broadly lenticular with maximum thickness near the center of the basin where subsidence is greatest.

Bottom sediments of modern lakes encompass a wide variety of lithofacies. If clastic sediments dominate, there may be concentric belts of gravel, sand, sandy marly mud, and mud, which are controlled by wave base and overall energy gradients. Facies patterns in chemical and organic sediments are not so easily predicted. However, two carbonate models are recognized, one with increasing carbonate content toward the center of the lake and the other with higher carbonate concentrations near the margins. The former results from nearshore dilution by terrigenous sediment and the latter from greater carbonate productivity in shallower water. Similarly, two organic facies patterns predominate. Offshore increase in organic matter results from deposition and preferred preservation below wave base. In contrast, nearshore concentrations of organic matter are mostly caused by in-place accumulations of organic remains.

Few ancient lacustrine sequences are either suffi-