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Structural Complexities that Control Localization of Mississippian Shale-Generated Oil Prospects in Eastern Great Basin, Utah and Nevada

Mesozoic anticlinoria and synclinoria determine gross regional surface and subsurface distribution of Mississippian source rock shales. The original thicknesses of the shales are preserved only in the synclinoria. Over anticlinoria and on their flanks, shales were not deposited or were thinned by Late Jurassic to Early Cretaceous younger-over-older denudation thrusting. The Chainman decollement is a widespread stratigraphic zone of shearing, which, in extreme cases, caused the Triassic, Permian, and Pennsylvanian sequences to be rotated and dropped down in a systematic "chaos" upon the Devonian Guilmette Limestone (e.g., Ferguson Flat, Ferber Flat, Copper Flat). The Pilot, Joana, Chainman, and lower Ely Formations were eliminated either entirely or partly by shearing. The Chainman decollement zone is intruded by 110 m.y.-old quartz monzonite and 35 m.y.-old quartz latites within many mining district areas.

In the synclinoria areas, post-Oligocene block faulting has produced a mosaic of horsts and grabens. In many places on the horst blocks, the Oligocene volcanics and the late Paleozoic sequence are removed by erosion, but in the graben blocks the entire Paleozoic and volcanic sequences are preserved in the subsurface. These graben blocks still contain complete subsurface sections of the Mississippian source rock shales. The block-faulted mosaic is outlined by an older northeast fault set that displaced the sub-Miocene volcanic terrane in the valleys and refracted through the Paleozoic bed rock of the ranges. A younger set of normal faults outlines the geomorphology of the mountain blocks, bajadas, and playas. Geomorphology, gravity, and magnetic surveys help define the suballuvial pattern of the fault mosaic.

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Potential Precious and Strategic Metals as By-Products of Uranium Mineralized Breccia Pipes in Northern Arizona

The development of caves within the Mississippian Redwall Limestone, accompanied by later upward stoping of overlying Paleozoic and Triassic rock, resulted in the formation of breccia pipes. Despite the depressed uranium market, some of these pipes are presently being mined for uranium. The pipes apparently formed prior to the Jurassic, as no pipes have been observed to penetrate Jurassic strata, and U-Pb determinations on the Hack I and II pipes by K. R. Ludwig suggest the uranium mineralization occurred around 200 Ma. No brecciated rock within pipes has been observed above its normal stratigraphic position, nor is any volcanic rock associated in space or time with these pipes. Mineralized rock transects any strata from the Redwall Limestone to the Triassic Chinle Formation.

Over 400 collapse structures, believed to represent breccia pipes (many with exposed breccia), have been mapped. Those with gamma radiation exceeding 2.5 times background (57 pipes) have been sampled (155 samples). Of these oxidized surface samples collected solely on the basis of radioactivity, 30% have Ag exceeding 10 ppm, some with up to 1,150 ppm. The Copper Mountain Mine, located near Parachant Canyon on the Sanup Plateau has long been known for its "Au adit." Two samples of brecciated, oxidized sandstone with radioactivity exceeding 20 and 40 times background from this adit, and another sample of hematite-, malachite-, and chalcocite-impregnated sandstone from a higher level adit contained high concentrations of Au, Hg, Cd, and W, along with many elements commonly anomalous in mineralized breccia pipes from northern Arizona: Ag, As, Co, Cu, Mo, Ni, and Pb.

Preliminary oxygen isotope ratio data suggest that samples mineralized strongly with Au and Ag have $\delta^{18}O$ of 0.9 to 1.5 ‰ lighter than non-mineralized or less mineralized samples. The strongly developed epithermal suite (Au, Ag, Hg, and As) and ^{18}O depletion of originally detrital quartz is suggestive of at least moderately high temperature hydrothermal fluids involved in the mineralization of the Copper Mountain system.

Co and Ni concentrations in these breccia pipes are also of interest as a by-product to U; 10% of the above samples contain greater than 100 ppm Co (300 times average crustal abundance for sandstones) and 23% of the samples contain greater than 100 ppm Ni (50 times the average crustal abundance). The potential for economic recovery from breccia pipes of elements other than U, such as Ag, Au, Co, and Ni, should not be ignored, as their concentrations are even more enhanced in unoxidized samples.

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Source Areas and Paleotectonic Implications of Upper Cretaceous Ohio Creek Member of Mesavarde Group, Piceance Basin, Colorado

The Ohio Creek member of the Mesaverde Group consists of massive or a series of massive conglomeratic sandstones deposited by several large braided stream systems that drained into the Piceance basin during Campanian-Maestrichtian time. Channel forms and internal bedding features are similar to those in the underlying Mesaverde. However, the Ohio Creek weathers to form a conspicuous white band above the brown sandstones of the Mesaverde and is further distinguished by an increase in pebble content. The distinctive color is due to extensive kaolinization caused by post-Ohio Creek weathering.

Paleocurrent data, pebbles, and sandstone lithologies indicate at least two distinct source areas. A western sedimentary source area, probably central Utah, is indicated by deposits along the western margin of the basin. A contribution from the Uncompahgre highland area cannot be ruled out as yet. A sedimentary source area is also indicated to the east and/or southeast. The Sawatch Range area seems to have been the major contributor of coarse material, but a change in pebble lithology could be due to an influx from the southern Park Range.

Approximate ages of the Ohio Creek member in published literature are derived from palynomorphs. Scattered data by separate workers indicate that the Ohio Creek in the southern part of the basin is conformable with the underlying Mesaverde, whereas the member could be as young as middle Paleocene in the northeastern basin.

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Geology and Energy Resources of Southwest Sego Canyon Quadrangle, Grand County, Utah

The Southwest Sego Canyon 7½-minute quadrangle is located in the Book Cliffs of eastern Utah and contains an exposed sequence of Upper Cretaceous through Eocene rocks. Exposed units include rocks from the upper Mancos Shale through the undifferentiated Wasatch Formation and were deposited during the final regressive phase of the Mancos sea. They represent shallow open-marine, wave-dominated deltas, and lower through upper flood-plain depositional environments. Coal has been produced from seams up to 8 ft (2.5 m) thick, but reserves are largely undeveloped. Hydrocarbons have been produced from adjacent areas, and similar structural and stratigraphic traps may exist in the quadrangle.

The area is crossed by low-profile, north-northwest-trending folds. The Thompson anticline is a faulted, salt-movement produced fold. The Cisco dome is caused by minor Laramide adjustment on the Uncompahgre fault. The quadrangle overlies the Paradox basin margin and may have deeper Paleozoic related traps.

Evidence of several structural events exists within the stratigraphic sequence. The Farrer Formation thins over the nose of the Cisco dome and documents Campanian movement on the Uncompahgre fault. Tuscher Formation current directions shift from east to northeast, indicating initiation of uplift on the San Rafael swell. Overlying conglomerate beds follow a 15-m.y. erosional hiatus and show sufficient uplift on the Uncompahgre fault to expose Mississippian rocks. Ratios of sandstone to shale in Wasatch Formation show derivation from the Uncompahgre uplift and a gradual reduction of the Uncompahgre highland.

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Stratigraphy and Structural History of Salina Quadrangle, Sevier County, Utah

Detailed mapping in the Salina 7½-minute quadrangle has provided new data on the stratigraphic and structural history of the area. Exposed strata range from Middle Jurassic to Holocene, including one of the most complete early Tertiary sections in Utah. The rocks have undergone several episodes of faulting and folding, resulting in complex and often puzzling geologic relationships. At least seven factors have been important in development of the present structural configuration of the area: (1) relationship to the Utah hinge line, (2) position in relation to the Colorado Plateau, (3) effects of Sevier orogenic deformation, (4) effects of Basin and Range faulting, (5) effect and timing of the Wasatch monocline, (6) possible effects of older faults, and (7) results of evaporite flowage of the Arapien Shale. Extent of Sevier faulting and evaporite movement are the most controversial of these. Previous interpretations in the area range from control primarily by Sevier deformation to control primarily by evaporite flowage. Recently acquired data support an interpretation based on the combined effects of evaporite flowage and faulting to produce the features now present in the quadrangle.

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Laramide History of Northwestern Wind River Basin and Washakie Range, Wyoming

A complex history of Laramide tectonism, erosion, and deposition is recorded in lower Cenozoic rocks of the northwestern Wind River basin and Washakie Range, Wyoming. These rocks include the Indian Meadows Formation (lower Eocene), Wind River Formation (middle to uppermost lower Eocene), and Aycross Formation (middle Eocene), separated by unconformities.

Major structures developed during latest Cretaceous through earliest Eocene time, prior to deposition of preserved Tertiary rocks. During this interval, the Washakie Range arched upward and thrust southwestward over the basin axis and erosion stripped more than 5,000 ft (1,500 m) of upper Mesozoic rocks from the area, forming the basal Tertiary unconformity.

During the Eocene, the Indian Meadows Formation accumulated as alluvial fans spread from deep mountain valleys southward across the basin. Large Paleozoic masses slid southward off the oversteepened range front. Near the end of Indian Meadows deposition, a new fold arched and thrust southward, depressing and downfaulting the older range front and disturbing rocks in the basin.

During the middle early Eocene, the Wind River Formation accumulated as new alluvial fans spread southward from canyons of the rejuvenated range. Erosion had breached the Precambrian core of the range, flooding downstream areas with granitic debris.

During the early middle Eocene, the range collapsed along normal faults. The Aycross Formation accumulated in flood plains in the basin and in broad valleys that developed along normal fault traces in the range. During this time, the Absaroka volcanic field to the north became the dominant local source. By the end of Aycross deposition, the basin and all but the highest parts of the collapsed, deeply eroded range were buried by volcaniclastic debris.

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Meeteetse Field, Bighorn Basin, Wyoming

Lower Cretaceous Muddy and Upper Cretaceous Frontier sandstone reservoirs remain popular objectives for new energy reserves in the Bighorn basin of northwestern Wyoming. Predominantly structural reserves approximate 1 million bbl of oil and 20 bcf of gas from six Muddy fields, and 210 million bbl of oil and 100 bcf of gas from 16 Frontier fields. Newly established structural-stratigraphic gas production from these reservoirs is at Meeteetse field (T48-49N, R99W) on the west flank of the basin where Muddy Frontier bar sandstones trend across a long, narrow, horst-associated anticline.

Terra Resources 1-33 Federal (Sec. 33, T49N, R99W) established the shallower pool discovery in 1979. Ten wells are now drilled along or near the axis of the structure. Production history is only now beginning because wells were shut in during field development due to absence of a gas line.

The Frontier is productive in the middle two of its four units. Most initial production rates are between 1 and 2 MMCFGD; small amounts of oil, condensate, and water have been produced from some wells. The Muddy is a discrete sandstone unit with thin shale interbeds. Most initial production rates are between 1 and 3 MMCFGD; small amounts of oil, condensate, and water are also produced. Some production is from commingled Frontier zones and from commingled Frontier and Muddy.

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Boise Geothermal System, Western Snake River Plain, Idaho

The Boise geothermal system lies in an area of high heat flow along the northern margin of the western Snake River plain. Exploratory drilling for petroleum and geothermal water, seismic reflection profiling, and regional gravity data permit construction of a detailed structure section across the western plain. A faulted acoustic basement of volcanic rocks lies at depths of 2,400 to 6,000 ft (730-1,830 m) beneath late Cenozoic lacustrine and fluvial deposits in the center of the plain. Volcanic rocks of the acoustic basement are typically basalt out in the plain, but the acoustic basement along the north margin in the vicinity of Boise is largely silicic volcanic rock. Geologic mapping and geothermal well data have provided information on the late Cenozoic geologic units and structures important to the understanding of the Boise geothermal system. The main geothermal aquifer is a sequence of rhyolite layers and minor arkosic and tuffaceous sediment of the Miocene Idavada Volcanics. The aquifer is confined by a sequence of impermeable basaltic tuffs. The aquifer has sufficient fracture permeability to yield 150°-170°F (65°-76.6°C) hot water for space heating at a rate of 600 to 1,200 gpm from wells drilled in the metropolitan area, north of the Boise River. In this area the rhyolite lies at a depth of 900-2,000 ft (274-610 m). Artesian pressure typically lifts water to an elevation of about 2,760 ft (840 m). A conceptual model of recharge assumes percolation driven by the topographic head to a depth of more than 7,000 ft (2,135 m) beneath the granitic highlands northeast of the city. Heated water convects upward through northwest-trending range-front faults.