the ideal situation in which enhanced porosity is created immediately before migration. Later in the burial history, after thermal decarboxylation of organic fluids produces CO_2, a second opportunity exists to create enhanced porosity. Using these diagenetic concepts, it may be possible to predict enhanced reservoir porosity within tripolitic chert.

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Lithofacies and Diagenetic Controls on Reservoir Development and Production, Goose Lake Field, Eastern Montana

Goose Lake field is located on a north-northwest–oriented structural nose on the western side of the Williston basin and produces from carbonate island facies in the Mississippian Ratcliffe zone. Island facies are concentrated on the structural nose and include low-energy, fenestral, pisolite-algal lime boundstones (supratidal) and high-energy, evenly laminated, pellet-oolite lime grainstones (beach and storm deposits). These beach grainstones occur preferentially along a narrow zone on the western side of the field, suggesting that major wave and wind approach was from the west.

Development of distinct porosity systems within these rocks and in encasing offshore facies accounts for variations in permeability, oil and water production ratios, and overall cumulative production. Both reservoir facies contain porosity as high as 20%, whereas permeability is highly variable. In wells with high cumulative production (i.e., above 200,000 bbl), permeability is normally 10-20 md. Grainstones are typified by primary intergranular, oomoldic, and microvuggy porosity, whereas algal boundstones have micro-intercrystalline, fenestral, and microvuggy to mesovuggy porosity. Porosity occlusion in these facies is due to a variety of early calcite cements, late-stage anhydrite, and baroque dolomite. The encasing offshore marine facies may contain high micro-intercrystalline porosity but lack effective permeability and serve as the updip seal. Porosity in these fine-grained facies and supratidal units is probably due to an early freshwater leaching episode that affected islands situated on paleohighs during rising sea level and less arid climatic conditions.

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Hydrocarbon Potential in Paradox Basin: an Overview

The petroleum-rich Paradox basin of southeastern Utah and southwestern Colorado remains an exploration frontier. With current production and exploration programs focusing on "algal mound" limestones in the Pennsylvanian Paradox Formation and deeper Mississippian structures, numerous other zones with hydrocarbon potential exist. Floored by a complexly faulted Precambrian basement, there is ample evidence suggesting that both source beds and reservoir rocks comprise much of the Cambrian section underlying the region. Although successfully developed at Lisbon field, Devonian sandstones and Mississippian carbonates have only been peripherally explored in other parts of the basin and much remains to be learned about deeper evaporite sequences in the Paradox Formation where turbidite deposits are known or inferred to exist between source bed shales and dolomites. Migration reservoirs exist in the Laramide structures that rim and occupy parts of the basin. Permian tar sand deposits estimated to hold 4-8 billion bbl of oil in place remain to be developed where an exhumed stratigraphic trap in the White Rim Sandstone is exposed west of the confluence of the Colorado and Green Rivers. Additionally, carbon dioxide gas deposits associated with Tertiary intrusives in the region require further delineation and development for coal slurry and enhanced oil recovery projects. Accordingly, the basin is expected to continue being developed for its resources for several decades.

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Paleotectonic Implications of Arkose Beds in Park Shale (Middle Cambrian), Bridger Range, South-Central Montana

The Cambrian System in the Bridger Range, south-central Montana, is represented by the Sauk sequence, a transgressive-regressive package of fine-grained clastic sand carbonates. In ascending order, the sequence consists of the Flathead Sandstone, Wolsey Shale, Meagher Limestone, Park Shale, Pilgrim Limestone, and Snowy Range Formation.

Regionally, the Park is a green, micaceous shale with interbedded siltstone at the base and intercalated limestone at the top. However, in the northern Bridger Range, the lower 30 m (98 ft) is a prominent interval of interbedded arkosic sandstone and shale. A quartz- and/or orthoclase-rich facies and a biomicritic, arkosic, glauconite-rich facies comprise this interval. Individual sandstone beds, 5-17 cm (2-7 in.) thick, are characterized by sharp contacts, scoured surfaces, load structures, and weakly developed cross-stratification. Gneissic, quartzofeldspathic pebbles and biomicritic cobbles occur in sharp contrast to adjacent shales. The arkosic sandstones were deposited in a nearshore island environment adjacent to an areally restricted source of clastic detritus. Variations in environmental energy regime and tectonic stability resulted in the two facies.

The abundance of basement-generated grains in the basal Park Shale, their absence in the upper Wolsey Shale and Meagher Limestone, and the localized occurrence of arkose indicate late Middle Cambrian tectonism and exposure of Precambrian crystalline basement. Subsequent weathering resulted in an easily erodable source of coarse-grained clastics.

Due to its unique mineralogy and stratigraphic setting, the Park arkosic interval may provide a key stratigraphic marker for refining estimates of displacement along Laramide structures within the study area.

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Radiometrics for the Petroleum Explorationist

Ground radiometrics provide the petroleum explorationist with an economical means of gathering large volumes of data in a short time. Profiles generated by a radiometric survey delineate prospective acreage and permit judicious use of the exploration dollar. Observations and techniques presented in this paper represent the acquisition and interpretation of over 100,000 mi (160,000 km) of radiometric data.

Radiometric and geochemical anomalies reflect surface and near-surface alteration by vertically migrating hydrocarbons. The observed decrease in natural radiation background over a petroleum reservoir is the result of several interactive factors: (1) the adsorptive capacity of hydrocarbons for radioactive particles, (2) the decrease of surface and near-surface porosity and permeability due to secondary mineralization, and (3) the increase of relatively low-radiation, secondary carbonates in the soil. High radiometric anomalies can be associated with faults, fracture systems, unconformable surfaces, or radioactive deposits that terminate in the near-surface.

Radiometric survey design and acquisition require a thorough knowledge of instrumentation, calibration, window aperture, integration time, background level, temperature drift, survey accessibility and positioning, and targeted anomaly size and shape. The advent of data processing and the need for repeatable data necessitate proper annotation of surface changes and development of production analogs. Processing permits quantitative analysis and enhancement of radiometric data. Normalization and Rad-Stack processes correct profiles to an average-background level and enhance the signal-to-noise ratio by attenuating random events (e.g., cosmic radiation). The science of radiometrics is applicable in a fully integrated exploration program.

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Geologic Development, Origin, and Energy Mineral Resources of Williston Basin, North Dakota

The Williston basin is a major producer of oil and gas, lignite, and potash. Located on the western periphery of the Phanerozoic North American craton, the Williston basin has undergone only relatively mild tectonic distortion during Phanerozoic time. This distortion is largely related to movement of Precambrian basement blocks.

Sedimentary rocks of cratonic sequences Sauk through Tejas are present in the basin. Sauk, Tippecanoe, and Kaskaskia sequence rocks are largely carbonate, as are the major oil- and gas-producing forma-