and most apparent, production trend, results from the Opeche Shale infilling of northwest-southeast-oriented stream valleys. Most production to date has been from sandstones following this alignment juxtaposed downdip of these impermeable shales.

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Origin and Significance of Surface Occurrences of Natural Gas, Northern Denver Basin, Colorado

Natural gas commonly occurs in ground water and has been venting to the surface from abandoned water wells in the northern part of the Denver basin near urban areas of LaSalle and Greeley. Because these gases pose an explosion and fire hazard, our studies are aimed at determining their origin and source in an effort to help prevent these dangers.

Two types of gases have been distinguished on the basis of chemical and isotopic composition. Some of the gases are chemically dry ($C_1/C_{1-5} > 0.99$) and enriched in the light isotope ^{12}C ($\delta^{13}C$ values range from -73 to -67 ppt). These gases are interpreted to be of biogenic origin; they are being, or have been, generated in an anoxic, sulfate-free environment by decomposition of organic matter within Upper Cretaceous Laramie-Fox Hills aquifer.

Other gases contain significant amounts of heavier hydrocarbons (C_1/C_{1-5} values range from 0.76 to 0.88) and are isotopically heavier ($\delta^{13}C_1$ values range from -49 to -44 ppt). The chemical and isotopic compositions of these gases suggest that they are of thermogenic origin and were generated during intermediate stages of thermal maturity in the deeper part of the Denver basin. In addition, these thermogenic gases are almost identical in both chemical and isotopic composition to those produced from the underlying Cretaceous "J" sandstone and Codell Sandstone Member of the Carlile Shale at depths ranging from about 2,100 to 2,300 m (6,888 to 7,544 ft). The surface gases of thermogenic origin have probably migrated from these deeper reservoirs, and this migration may be related to recent drilling activity in the area.

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Evidence for Extension of Lake Basin Fault Zone from Coal Bed Correlations in South-Central Montana and Implications for Hydrocarbon Exploration

The Lake Basin fault zone is a structural lineament that extends west-northwest across central Montana. The lineament consists mainly of en echelon northeast-striking normal faults that are surface expressions of left-lateral movement along a basement wrench fault. Information gathered from the recent field mapping of coal beds and from shallow, closely spaced drill holes in the northwest part of the Powder River basin, Montana, permit detailed coal bed correlations, which revealed another linear zone of en echelon faulting directly on the extended trend of the Lake Basin fault zone. The faulted area, herein named the Sarpy Creek area, is located 48 km (30 mi) east of Hardin, Montana. It is about 13 km (8 mi) long and 10 km (6 mi) wide and contains 20 en echelon normal faults that have an average strike of N65°E. The Lake Basin fault zone is therefore extended 32 km (20 mi) farther southeast than previously mapped to include the Sarpy Creek area.

The Lake Basin oil field, Montana, and the Ash Creek oil field, Montana and Wyoming, produce from faulted anticlinal structures that have been interpreted to be genetically related to primary wrench-fault systems—the Lake Basin fault zone and Nye-Bowler fault zone, respectively. Therefore, the faulted area of Sarpy Creek (as yet unexplored), and areas southeastward from there along the trend of the Lake Basin fault zone are possible sites for hydrocarbon accumulation.

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High-Resolution Stratigraphic Correlations and Geochemical Analyses, Cretaceous Niobrara Formation, Northwestern Denver-Julesburg Basin

The middle Santonian–lower Campanian part of the Smoky Hill Member of the Niobrara Formation represents a fourth-order regressive-transgressive cyclothem. Studies of this interval have improved our understanding of the influence of depositional environments and structural setting on distributions of organic matter in epicontinental marine strata. Geochemical analyses of fresh quarried sections at Lyons and LaPorte, Colorado, show that, in general, C_{org} (organic carbon) levels are highest between mid-regression and mid-transgression. Rhythmic fluctuations of C_{carb} (carbonate carbon) and C_{org} correspond to limestone-marlstone bedding couplets at a scale of 15-20 cm (6-8 in.). Pronounced lateral variations between Lyons and LaPorte exist in C_{org}, HI (pyrolytic hydrogen index), sediment accumulation rates, and T_{max} (temperature of maximum pyrolytic yield). Comparisons of geochemical averages at Lyons ($C_{org} = 2.5\%$, $C_{carb} = 9\%$, HI = 100, $T_{max} = 445°C$) and LaPorte ($C_{org} = 4\%$, $C_{carb} = 9.5\%$, HI = 450, $T_{max} = 422°C$) indicate an elevated thermal maturity at Lyons and depositional conditions more favorable for preservation of marine organic matter at LaPorte. In both sections, C_{org} and C_{carb} show strong negative correlations, possibly reflecting cyclic climatic controls on the development of bedding couplets. High-resolution stratigraphic correlations of 100,000-year or smaller intervals between Boulder and Owl Canyon, Colorado, based on widespread bentonites and bedding couplets, reveal a paleostructural high near Lyons. Shallow-water conditions and increased turbulence over this high are reflected in sediment accumulation rates only 60% of those at LaPorte. Increased amounts and hydrogen richness of organic matter at LaPorte may reflect a deeper water, more quiescent depositional setting.

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Structural Development and Oil Occurrence on Northeast Flank of Uinta Mountains near Irish Canyon, Northwestern Colorado

The study area is located along Vermillion Creek, 1-3 mi (1.6-5 km) east of Irish Canyon, in northwestern Colorado. The exposed stratigraphic section consists of steeply dipping to vertical Upper Cretaceous Almond Formation, Ericson Sandstone, and Mancos Shale along the toe of the Sparks Ranch thrust fault, and of lesser dipping older Mesozoic and Paleozoic formations in distant parts of the thrust plate. In most places, the Almond Formation is in contact across the thrust fault with the Eocene Wasatch and Green River Formations, and all of these formations are unconformably overlain by the Oligocene Bishop Conglomerate and the Miocene Browns Park Formation. The structural development of the area has involved three major events: (1) Late Cretaceous uplift of the Uinta Mountains; (2) Paleocene and Eocene thrust movements of the Sparks Ranch fault; and (3) late Tertiary normal faulting associated with a collapse of the eastern Uinta Mountains. Oil-saturated sandstones are present in outcrops of 10 Paleozoic, Mesozoic, and Tertiary formations adjacent to several of the late Tertiary normal faults. Oil is escaping to the surface along these faults, probably from a large, deep-seated reservoir located below the Sparks Ranch thrust fault.

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Solution of Devonian Prairie Formation Salts: Implication, Seismic Recognition, and Interpretation

Evaporite deposits of the Devonian Prairie Formation in the Williston basin have undergone episodic dissolution, creating many types of hydrocarbon traps. Removal of the salt has resulted in collapse breccias, drape structures, local thickening of potential reservoir rock by sink infill, and enhanced migration paths. Recognition of the presence and absence of the salt section assists an interpreter in avoiding the pitfall, of salt-related velocity phenomena. Keys to recognizing salt solution on seismic data include abrupt terminations of salt reflectors, rootless structures, and isochron thickening and thinning. Comparisons of sets of isochron maps, to identify areas of superimposed thicks and thins, help determine the timing of solution.

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Paleozoic Paleotectonics and Sedimentation in Southern Rocky Mountain Region

During the Paleozoic, the southern Rocky Mountain region included most of New Mexico and Arizona and at least the northern parts of adjacent Chihuahua and Sonora. It was particularly stable part of the North American craton during the Cambrian through Middle Devonian. Slow