style of thin-skinned overthrust deformation, which occurred north of the lineament, to the foreland basement-involved thrust deformation, which occurred to the south. The differential motion of the basement was absorbed by small amounts of left-lateral transform motion.

This lineament may also have created a weak zone in the crust into which the Boulder batholith intruded during the early stages of the Laramide. The voluminous volcanic material associated with the batholith created a supracrustal load which downwarped the adjacent lithosphere. If the batholith itself slid eastward, as advocated by Hyndman in 1979, the load was enhanced. Decoupling of the lithosphere along the southernmost elements of the Lewis and Clark lineament localized and accentuated the load-induced subsidence, creating the Crazy Mountains basin and localizing the accumulation of the thick volcaniclastic sediments of the Livingston Group.

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Foreland Detached Deformation

In an area having perhaps more relief on the top of the Precambrian surface than any other structural province in the world, attention understandably has been focused on the basement-cored structures of the Rocky Mountain foreland. Deep-seated compression interpreted as responsible for the shortened basement features has also created detached structures in the overlying sedimentary cover. These latter structures have never been the object of systematic study, yet they provide important additional evidence of a compressional origin for the Rocky Mountain foreland and other forelands, and are also prospective for oil and gas.

Detached structures can be attributed to at least two types and stages of deformation. First, compression operating early in the development but prior to the differentiation of the foreland created small-scale fold and thrust structures. Probable examples of early compressional structures include those formed on what are now the gentle tilted flanks of the Owl Creek Range in Wyoming and the Cara Cura Range in Argentina. Second, after differentiation of the foreland into blocks, the flexural slip mode of folding in competent sedimentary layers dictates that space problems in both anticlines and synclines be accommodated by the creation of decollement surfaces and associated detachment structures. Examples have been documented from virtually every Rocky Mountain foreland basin. Specifically cited are the North Park basin in Colorado, Elk Mountain area, northwestern Wind River basin, and Big Horn basin in Wyoming, and the Cara Cura mountains in Argentina. Prominent detachment horizons in the Rocky Mountain foreland are shales of Cambrian, Triassic (Chugwater), and Cretaceous (Mowry, Cody, and equivalent) age.

Oil and gas have been produced from detached folds. A negative aspect is that otherwise prospective beds beneath a completely detached structure do not have closure unless they are affected by deeper faults. More optimistically, closures related to local detachment are prospective.

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Lineaments and Their Tectonic Implications in Rocky Mountains and Adjacent Plains Region

Two orthogonal sets of lineaments in Phanerozoic rocks of the Rocky Mountains and adjacent plains region probably reflect recurrent structural movement along corresponding fractures in the underlying igneous and metamorphic rocks. The lineaments seem to have been primarily paleotopographic features that affected the depositional and erosional margins, thicknesses, and the distribution of lithofacies of Phanerozoic strata. One set is oriented near the cardinal points of the compass, approximately N5°-15°E and N75°-85°W;the other set is oriented diagonally, about N50°-60°E and N30°-40°W.

At small scales, the crosscutting lineaments of either set suggest primarily vertical movements of rectangular blocks along through-going rectilinear fractures in the basement rocks. At larger scales, the differential movement of these blocks apparently was propagated upward through the strata and formed a variety of structures, many of which are en echelon. Blocks in the region moved at different times, and they commonly rotated about horizontal axes, as indicated by lateral differences in rates of associated sedimentation and by structural features along the lineaments. Throughout most of the Phanerozoic, the movements seem to have been mainly along the diagonal set (northeast, northwest) of lineaments, but the cardinal set (north-south, east-west) also influenced the development of Laramide structures and the present landscape in the Rocky Mountain region. The structural stresses, which were released along the two sets of lineaments, may reflect plate movements, and they probably are related to orogenies caused either by plate collisions or by rifting and continental fragmentation.

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Depositional Environment of Leo Sands, Middle Minnelusa Formation, Niobrara County, Wyoming

The Upper Pennsylvanian middle Minnelusa Formation "Leo Sands" in the north half of Niobrara County, Wyoming, and southwestern South Dakota, may have been deposited in a nearshore eolian sabkha environment. Cores reveal sedimentary features which support this hypothesis, such as deflation lags, avalanche-produced strata, probable interdune deposits, and nodular anhydrites.

The "Leo Sands" have proven to be excellent reservoir rocks. Associated anhydrites provide the seal for hydrocarbons which may have been generated from organic-rich interdunal shales.

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Sedimentary Facies and Reservoir Characteristics of Cretaceous "J" Sandstone at Torrington Field (North), Goshen County, Wyoming—Exploration and Development Implications

Torrington field (North) is productive from the Lower Cretaceous "J" sandstone in the Wyoming portion of the Denver basin. The trapping mechanism is stratigraphic, with reservoir sandstones enveloped laterally and updip by shale-dominated lithofacies. The field has produced 13,000 bbl of oil from two wells since its discovery in late 1981. However, production can be increased by development based on recognition of features comprising the "J" sandstone depositional system.

Three major sedimentary environments and their associated facies, characteristic of a meandered fluvial system, occur within the "J" interval in the area: abandoned channel, point bar(s), and interfluvial plain. Production at both Torrington (North) and Torrington is from reservoir development within point bar deposits. Cores of the "J" point bar at Torrington (North) show that it is comprised primarily of very fine to fine-grained quartzarenites and sublitharenites. Dominant framework grains are quartz and lithic fragments which are cemented by quartz overgrowths and authigenic clays (primarily kaolinite). Sedimentary structures observed in the cores include burrowing and bioturbation, high-angle plane-parallel cross-bedding, discontinuous wavy shale laminae, climbing ripples, and truncated laminae. Although excellent hydrocarbon shows occur from the base to the top of the point bar, production appears to be confined to thin intervals of medium-grained quartzarenite found near the middle of the vertical sequence. This may be due to flow regime size sorting which affected differential clay diagenesis within the point bar.

Petrophysical reservoir characteristics of the "J" sandstone were established through examination of X-ray diffraction, scanning electron microscopy, thin-section petrography, and conventional core analysis data. Microporosity development and geometry also affect production.

Field extension locations and an exploratory drill site have been established as a result of this study.

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Pennsylvanian Tyler Stratigraphic Seismic Concepts

Recent drilling in the Rattler Butte area of central Montana has renewed interest in the Pennsylvanian Tyler Formation as a drilling