objective. New production in this area, coupled with the surrounding well density, provides an ideal situation for further development of Tyler stratigraphic-seismic exploration concepts and methods.

Both geologic and geophysical Tyler thickness maps have proven to be useful tools in delineating eroded Heath and subsequent lower Tyler deposition. Seismic modeling has revealed a series of possible Tyler-Heath erosional edge characteristics, providing another tool for Tyler-Heath boundary definition. In modeling specific seismic sand signatures, it was found that seismic character and amplitude are dependent upon both formation thickness and lithology.

Detailed mapping of the study area also revealed a new environmental interpretation of the Tyler. Unlike the fluvial system to the north, the Tyler regime in the Rattler Butte area appears to have fluctuated among fluvial, deltaic, and marine systems.

Two hydrocarbon occurrence patterns have been noted within the Tyler: (1) although reservoir quality sands are present throughout the Tyler, those within the lower Tyler are more likely to contain hydrocarbons, and (2) close proximity to the Tyler-Heath erosional edge increases the chances of discovering oil-filled Tyler sands.

Combined use of these exploration tools should greatly enhance the chances for successful lower Tyler exploration.

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Fault Control of Channel Sandstones in Dakota Formation, Southwest Powder River Basin, Wyoming

The Dakota Formation is an important oil reservoir in the southwestern Powder River basin and adjoining Casper arch. Two fields, Burke Ranch and South Cole Creek, are used as examples to show the depositional environments of the Dakota and to indicate the influence of tectonic control on the distribution of the environments.

Burke Ranch field is a stratigraphic trap which produces oil from the upper bench of the Dakota. The environment of deposition of the reservoir, determined by subsurface analysis, is a channel sandstone. South Cole Creek field is a structural-stratigraphic trap which produces from the lower bench of the Dakota. Two distinct facies, a channel and channel margin sandstone, exist at South Cole Creek.

At both Burke Ranch and South Cole Creek it can be shown that the Dakota channels were deposited on the downthrown side of faults, which were present during Dakota time and which now are reflected on the surface by drainage patterns. An understanding of the environments of deposition of the Dakota and control of the environments by paleotectonics is necessary for exploration for these prolific reservoirs.

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Facies in Upper Part of Madison Group, Sawtooth Range, Northwestern Montana

Portions of the Mississippian Madison Group are gas reservoirs in the plains adjacent to the Sawtooth Range, northwestern Montana, and are equivalent to Mississippian carbonates that are major gas producers in the Canadian Foothills. In the Sawtooth Range, three facies are recognized in the upper 125 m (410 ft) of the Madison Group; they comprise a carbonate shelf sequence that is several hundred meters thick, shoals upward, and is unconformably overlain by Jurassic strata. Economically significant porosity may occur in the upper part of the Madison Group, controlled by the eogenetic secondary dolomitization of a conspicuous crinoidal grainstone unit within it.

This dolomitized crinoidal grainstone unit (termed facies C) is the lowest of three facies in the upper part of the Madison Group, and it abruptly overlies lagoonal limestone that forms the major part of the group. Facies C is massively bedded and exhibits large-scale planar cross-stratification suggestive of its origin as a subaqueous dune field. Measured porosity in surface samples of the dolomitized grainstone of facies C is a maximum of 18% and consists of vuggy, intergranular, and intercrystalline pores. The upward transition from limestone to secondary dolomite commonly occurs in the lower part of facies C. The thickness of facies C ranges from 35 to 75 m (115 to 250 ft) and is inversely proportional to the thickness of the intertonguing and overlying facies B.

The uppermost two facies, termed B and A, reflect the upward transition from and open platform to a restricted platform environment. Facies B ranges in thickness from 25 to 75 m (80 to 250 ft) and is a nonporous, dolomitized mudstone and wackestone sequence generally containing some 1 m (3 ft) interbeds of porous dolomitized grainstone. This sequence is capped by < 10 m (30 ft) of intertidal rocks of facies A, which are thin-bedded, partly algally laminated, dense dolomites.

Locally, facies A and parts of B have been removed as a result of pre-Jurassic folding and erosion in the Sawtooth Range. However, all lateral thickness changes in facies C reflect its intertonguing with B. Although original facies patterns are greatly telescoped by thrusting, the porous grainstones of facies C are best developed in the vicinity of Blackleaf Canyon, Montana, the site of a recently developed commercial gas field in dolomite of the Madison Group.

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Great Falls Lineament, Idaho and Montana

The name "Great Falls lineament" is given to a northeast-trending zone of diverse geologic features that can be traced northeastward from the Idaho batholith in the Cordilleran miogeocline of the United States, across thrust belt structures and basement rocks of west-central and southwestern Montana, through the cratonic rocks of central Montana, and into southwesternmost Saskatchewan, Canada. The zone is well represented in east-central Idaho and west-central Montana where geologic mapping has outlined northeast-trending, high-angle faults and shear zones that: (1) extend more than 150 km (93 mi) from near Salmon, Idaho, northeastward toward Anaconda, Montana; (2) define a nearly continuous zone of faulting that shows recurrent movement from middle Proterozoic to Holocene time; (3) controlled the intrusion and orientation of some Late Cretaceous to early Tertiary batholithic rocks and early Tertiary dike swarms; and (4) controlled the uplift and orientation of the Anaconda-Pintlar Range. Recurrent movement along these faults and their strong structural control over igneous intrusions in this region suggest that northeast-trending faults represent a fundamental tectonic feature of the region.


Geologic features that are similar to those mapped in the Salmon-Anaconda region are present to the southwest and the northeast. In central Idaho, these structures include numerous northeast-trending faults and pronounced topographic lineaments that cut across the southern part of the Idaho batholith, and a northeast alignment of Tertiary igneous rocks that cut the Idaho batholith and adjacent rocks. East and southeast of the Anaconda-Pintlar Range, subparallel, high-angle faults and topographic lineaments are present in the Highland, Pioneer, Ruby, and Tobacco Root Mountains. High-angle faults may have in part controlled the orientation of the northeast-elongate Boulder batholith. Northeast-trending structures are not easily traced across the thrust belt of western Montana or across the Lewis and Clark line. In the central Montana plains, northeast of the disturbed belt, however, a broad zone of colinear, northeast-trending structures is present, and includes: parallel, buried basement highs that in part controlled depositional patterns of some Paleozoic and Mesozoic sedimentary rocks; major physiographic features, such as the remarkably straight, 175-km (109-mi) long segment of the Missouri River, and equally long, buried river channels in southwestern Saskatchewan; a northeasterly alignment of highly differentiated igneous rocks and a belt of ultrabasic intrusions and related diatremes;

and a well-defined pattern of northeast-trending gravity and aeromagnetic anomalies underlying this part of central Montana and southwesternmost Saskatchewan.

Taken together, all these geologic features define a broad, northeast-trending zone at least 150 to 200 km (93 to 125 mi) wide and more than 1,000 km (620 mi) long. The zone is approximately colinear but not demonstrably continuous with the well-exposed boundary in eastern Saskatchewan and Manitoba between the Archean Superior and the Proterozoic Churchill provinces of the Canadian Shield. This boundary is also characterized by: high-angle faults, shear zones, and topographic lineaments; pronounced linear gravity and magnetic anomalies; igneous intrusions; and fault controlled depositional patterns and mineralization. That the Great Falls lineament is controlled by a similar Precambrian boundary between the Archean Wyoming province of southwestern Montana and early Proterozoic terrane to the north is speculative; however, the geologic features found along the Great Falls lineament share many common characteristics with features present along the Archean-Proterozoic boundary in Canada.

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Erosional History of Big Horn Basin: Mackin Revisited

The classic study of the erosional history of Big Horn basin is by Mackin in 1937. In it he studied the terrace levels which ranged in age from Late Tertiary to late Pleistocene. He postulated that the terraces were the product of stream captures or intervals of interglacial stability alternating with glacial incision. More recent studies have revised Mackin's classically simple model.

Detailed studies have increased the number of terrace levels, changed the timing of their stability episode, and estimated their ages. The number of terrace levels has been increased to nine along the Greybull and Bighorn Rivers and to six along the Shoshoni River. Because some of the different levels occur along each river, the number of unique levels within the basin is 12. The occurrence of a 600,000 and a 100,000 year old ash on two terrace levels allows the ages of the terraces to be estimated. The estimated ages range from 3 m.y. for the Tatman to 49,000 years for the Himes, which is the lowest level along the Bighorn River. Both ashes were deposited during river stability intervals and indicate that the Bighorn River and its eastern tributaries were stable late in the interglacial episodes. In contrast, the glaciofluvial gravels along the Shoshoni River at Cody indicate a late glacial stability episode for the western tributaries. The terrace cycles along the Bighorn River and its western tributaries are therefore out-of-phase. This relationship fostered the numerous stream captures recognized by Mackin, as well as some unusual terrace geometries. Comparison of the estimated terrace ages to termination in the marine isotopic record indicates that not all of the Pleistocene climatic cycles are preserved in the Big Horn basin terrace chronology. The present chronology is currently more complete than that of Mackin's pioneering work of the 1930s, but it has not changed his basic story.

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Seismic Data Acquisition Parameters, Northwest Montana

The Montana Overthrust area and adjacent Disturbed Belt are characterized by extremely complex geology and rugged topography. To date, several hundred miles of high quality seismic data have been acquired in this area. The first step in obtaining this data quality was to understand the physical characteristics of the rock properties for seismic signal and noise, then to apply this information in designing our data acquisition parameters.

At the commencement of each seismic specification program, a complete suite of experimental tests were run over carefully selected areas. These tests generally included noise and reflection analysis, geophone patterns, energy input patterns, offsets, expanding spreads, and specific problems (i.e., traffic, freezing, thawing). From these tests, appropriate field parameters were selected for various surface and subsurface geologic environments.

It is the scope of this paper to discuss the results of these tests and the subsequent fine tuning of both acquisition and processing parameters of this data.

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Late Jurassic Tectonism on West Side of Colorado Plateau, Utah and Arizona

Detailed sedimentologic studies in south-central Utah and north-central Arizona indicate that several major basins and uplifts as well as many smaller folds within them were actively growing during deposition of the Salt Wash Member of the Morrison Formation. The region lies outside that part of the Colorado Plateau underlain by thick Pennsylvanian halite deposits so the structures are not related to salt deformation. Tectonic activity in the region is inferred from several types of sedimentologic features which include thickness variations, facies distribution, cross-bedding parameters, and bedding ratios. Distribution of the various features studied indicates the Emery, Circle Cliffs, Echo Cliffs-Kaibab, Cow Springs, and Monument uplifts, as well as the Henry and Kaiparowits basins, were active during the Late Jurassic. In addition, several anticlines and synclines that were active at the same time can be delineated in or near the Henry and Kaiparowits basins.

The apparent absence of local angular unconformities in the Salt Wash near the positive structures suggests that most of the tectonic movements were the result of differential subsidence rather than uplift of the positive structures. It could not be determined if the San Rafael swell near the Emery uplift was active during Late Jurassic time. Also, the relationships are not entirely conclusive but suggest that the Cow Springs uplift may have extended southeast across Black Mesa and that downwarping may not have occurred there in the Late Jurassic.

Late Jurassic folds have essentially the same northwest to north-northwest trend as many of the Laramide and possibly younger folds in the region although the older folds tend to be less sinuous. Vertical repetition of lacustrine strata, deposited under conditions especially sensitive to slight tectonic movements, suggest that the movements were episodic. Comparison of the present amount of structural relief with the Late Jurassic structural relief indicates that approximately 3 to 7% of the present-day relief between several of the major basins and uplifts can be attributed to tectonic movements during deposition of the Salt Wash. Thus, it is erroneous to assume that all of the structural deformation in the region occurred during or after the Laramide orogeny.

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Mesozoic and Early Tertiary Paleostructure and Sedimentology of Central Wasatch Mountains, Uinta Mountains, and Uinta Basin

During latest Cretaceous-Eocene time, 5,000 m (16,000 ft) of beds were deposited in central and northeast Utah. In the Late Cretaceous, sediment derived from the Sevier-Laramide thrust belt was transported to the east and southeast. Southerly paleocurrent directions in the base of the Currant Creek Formation (Maestrichtian) raise the possibility that uplift of the Uintas may have begun by then. The thrust belt continued as a major highland during the early Paleocene, and major uplift of the Uintas occurred. By the middle Paleocene there was an extensive lake which regressed during the late Paleocene as uplift of the Uintas continued. Lake Uinta reached its maximum size during the middle Eocene. During the late Eocene, Lake Uinta regressed and, near the end of the epoch, the lake expired. Major sediment influx was from the east and southeast. Lower (early Duchesnean) and upper (Late Duchesnean) conglomeratic intervals record major episodes of uplift in the Uintas during latest Eocene.

Structurally, the Wasatch Mountains are part of a marginal foreland fold and thrust belt. In the northern Wasatch Mountains, pre-Late Cretaceous thrust fault plates were folded in part of a large, ramp-anticline that is cored by allochthonous, crystalline basement. Foreland thrust belt structures in the central Wasatch Mountains were folded about the east-trending Uinta axis as the Uinta Mountains formed. Eastward movement on the Hogsback thrust during the Paleocene was transferred onto the adjacent Uinta axis and Uinta Mountains structure, causing about 20 km (12 mi) of sinistral slip in the western Uinta Mountains. Deformation in the Uinta Mountains continued following cessation of movement on the Hogsback thrust system. A south-dipping fault ramp was located beneath the Uinta Mountains and extended to depths of 15 to 20 km (9 to 12 mi).