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Laramide and Neogene Structure of Northern Sangre de Cristo Range, South-Central Colorado

The Sangre de Cristo Range, from Blanca Peak northward to the Arkansas River in Colorado, is composed mostly of Precambrian crystalline rocks and upper Paleozoic clastic sedimentary rocks. These rocks were folded and faulted by Laramide compressional forces from the Late Cretaceous to Eocene. Laramide structures are large arcuate thrust plates that intersect and overlap one another to form a northwest-trending belt that extends across the range from Huerfano Park to Valley View Hot Springs. All of the thrust plates within the range are bounded by west-dipping faults, some of which extend into the basement of Precambrian crystalline rocks. Along the east side of the range, the Alvarado fault is interpreted tentatively as an east-dipping thrust, bringing Precambrian crystalline rocks west over Paleozoic rocks. Thrust plates were folded internally before and during thrusting; some plates of Paleozoic rock contain folds that tighten and decrease in amplitude toward the leading edge of the plate. Stacked plates consisting of Precambrian and Paleozoic strata have been folded concordantly after thrusting. Thrust faults are mainly high to medium-angle reverse faults along the leading edge of thrust plates, but they flatten to about 30° at depth. Total shortening within the range is at least 8 km (5 mi) at the latitude of Westcliffe and at least 14 km (9 mi) farther south near the latitude of the Great Sand Dunes.

During the Neogene, the Sangre de Cristo Range was uplifted, and the adjoining San Luis and Wet Mountain Valleys were downdropped by extensional rift faulting. Rifting followed late Oligocene intrusion of stocks, sills, and dikes of mafic to felsic igneous rock into the Precambrian and Paleozoic rocks of the range. The horst of the Sangre de Cristo Range probably began to rise in the late Oligocene, rose rapidly in the early Miocene, and rose rapidly again in the late Miocene and Quaternary. Flows of mafic lava were erupted from faults along the southwest side of the Wet Mountain Valley and in the San Luis Valley. Zones of Laramide thrusts along the east and west sides of the range were reactivated to form the Sangre de Cristo and Alvarado normal faults, respectively. The floor of the Neogene sedimentary and volcanic fill of the San Luis Valley has been downdropped 2,000-7,000 m (6,600-23,000 ft) below the top of the range, and the floor of the Wet Mountains Valley has been downdropped about 2,000 m (6,600 ft) below the range. Rifting is still in progress in the San Luis Valley, west of the range, but may have ceased in the Wet Mountain Valley.

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Tectonic Development of Southwestern Montana and East-Central Idaho

The region of southwestern Montana and east-central Idaho, north of the Snake River plain and east of the Idaho batholith, has been affected by a complex sequence of orogenic events from the Proterozoic through Holocene time.

Deposition of Proterozoic Belt Supergroup rocks and rocks of similar age in east-central Idaho occurred in basins that were clearly fault controlled. Many of these faults were reactivated repeatedly at later times and controlled or affected the development of younger tectonic features.

This study encompasses the entire width of the Sevier orogenic belt in this part of the Cordilleran fold and thrust belt. The thrust belt comprises several major eastward-transported thrust plates that are successively younger to the east. These plates juxtapose distinct stratigraphic packages that were deposited in eugeoclinal, miogeoclinal, and continental platform settings. As a consequence, the thrust plates can be distinguished on the basis of facies and thickness distribution as well as, to some extent, structural style. In southwest Montana, Sevier-type structures overlap with, and butt against, basement-involved Laramide structures. The extension of southwest Montana basement trends into Idaho suggests that this overlap may extend into east-central Idaho.

Superimposed on these older structures are mid-Tertiary to Holocene normal faults that formed present-day basins and ranges. Many of these are reactivated older fault zones, some of which can be shown to have Precambrian ancestry.

The region has excellent oil and gas potential, because reservoir and source rocks and trapping mechanisms are all clearly present. However, an understanding of the effect of overlapping tectonic elements is necessary to predict accurately where favorable rock packages are preserved.

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Cyclic Deposition and Sea Level Changes: Record in Twin Creek Limestone (Jurassic), Northern Utah

The Twin Creek Limestone in northern Utah was deposited in a shallow sea during the Middle Jurassic. Paleocurrent patterns determined from study of ripple marks and cross-stratification, and the distribution of facies, indicate that the average shoreline orientation was northeast-southwest.

Two major transgressive-regressive cycles, which are correlated with sea level curves proposed by P. R. Vail and others for the Jurassic, are delineated. The lower cycle in the Twin Creek Limestone unconformably overlies the Lower Jurassic Nugget Sandstone. The Twin Creek Limestone is represented by deposits of the Gypsum Springs, Sliderock, Rich, and Boundary Ridge Members. Lithofacies in this cycle sequence grade upward from reworked Nugget Sandstone at the base into oosparite, micrite, and silty ripple-marked micrite, to an overlying discontinuous red siltstone unit. The cycle is correlative with the J2.1 global cycle of relative change of sea level.

The upper cycle is separated from the lower one by a hiatus of unknown duration. This boundary is recognized on the basis of the thin discontinuous red bed at the top of the Boundary Ridge Member. The cycle consists of the Watton Canyon, Leeds Creek, and Giraffe Creek Members. Lithofacies grade from oosparite at the base up into micrite, silty micrite interbedded with sandy oosparite, and sandstone. The upper boundary is marked by the base of the Middle Jurassic Preuss Sandstone. The cycle is correlative with the J2.2 global cycle.

Duration of these global cycles is about 8-10 m.y. Recognition of the cycles leads to improvement in stratigraphic and structural interpretation incorporating the effects of sea level changes.

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Gravity and Magnetic Survey of Portneuf River Valley Between McCammon and Lava Hot Springs, Idaho

The study was made to determine the subsurface shape and extent of faulting in the section of the Portneuf River valley between Lava Hot Springs and McCammon, Idaho. A series of roughly north-south-trending faults cuts the valley, leading to a stepped bed-rock surface. These steps are downdropped going west from Lava Hot springs to McCammon. Gravity readings were taken on a Worton Gravimeter and adjusted to latitude, terrain, and free air corrections. These final values were plotted and contoured on a 1:24,000-scale topographic map. Cross sections through the contours were then made and the resulting picture interpreted using Nealson's method. Magnetics were conducted to determine the extent of the valley-filling basalt.

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Post-Burn Mineralogic and Trace Element Relationships from an In-Situ Oil Shale Experimental Retort

Twenty post-burn and two control (unburned) core holes were drilled into a horizontal in-situ oil shale retort at the Geokinetics field site, Uinta basin, Utah. The object of the investigation was to study the mineralogic changes and trace element partitioning resulting from a true in-situ burn of Green River oil shale under field conditions. Minerals were examined by x-ray diffraction and optical microscopy; elemental determinations were performed utilizing x-ray fluorescence, neutron activation analysis, and other analytical chemical techniques. The complex mineral assemblage created was a result of rapid intense heating coupled with fluctuating temperatures, gas and fluid pressure, cooled at a shallow depth, composed primarily of solid solutions of silicates plus cations, primarily Ca^{2+}, Mg^{2+}, and to a lesser degree Fe^{2+}. Distinct zones observed correspond to temperature thresholds, which can be distinguished by increasing degrees of silicification of the carbonate-rich raw oil shale. Trace element partitioning parallels closely the mineral assemblages, with the synthesis of insoluble minerals in the hottest most intensely altered zones, minimizing the extractability of potentially detrimental materials from the residue of in-situ combustion.

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Sedimentology and Depositional Environments of Emery Sandstone, Emery and Sevier Counties, Utah

From a sedimentologic study of the Emery Sandstone Member of the Mancos Shale (Upper Cretaceous) in southern Castle Valley, Utah, it is possible to determine depositional environments, paleogeography, textural and mineralogical characteristics, and possible sediment sources.

Tidal-flat deposits are dominant in the Emery, but subtidal (shoreface) and offshore deposits also occur. The paleotidal range is estimated to have been 1.3-1.7 m (4.3-5.6 ft). Many asymmetric, transgressive-regressive cycles of two different magnitudes and periods are present. They formed in response to minor fluctuations in sea level combined with slight variations in the subsidence rate.

The Emery Sandstone was deposited in the foreland of the Sevier orogenic belt. The average orientation of the paleoshoreline, as determined by paleocurrent analysis, was N9°W. Sediment was probably transported southward from the Utah-Idaho-Wyoming border area by longshore currents.

Well-sorted, subrounded to subangular, very fine-grained subarkose is the dominant rock type in the Emery. Dolomite and calcite are the major cements. Average porosities, based on thin section analysis, are less than 2%.

Abundant chert grains and reworked authigenic quartz overgrowths suggest a sedimentary source terrane. The observed amounts of feldspar could have been derived from Mesozoic sedimentary rocks exposed in the Sevier orogenic belt.

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Geologic Setting of Petroleum Source Rocks in Permian Phosphoria Formation

The Permian Phosphoria Formation in the northwestern interior United States contains two phosphatic and organic-carbon-rich shale members—the Meade Peak Phosphatic Shale Member and the Retort Phosphatic Shale Member. These rocks were formed at the periphery of a foreland basin between the Paleozoic continental margin and the North American cratonic shelf. The concentration, distribution, and coincidence of phosphorite, organic carbon, and many trace elements within these shale members probably were coincident with areas of optimum trophism and biologic productivity related to areas of upwelling. Upwelling is indicated to have occurred in the Phosphoria sea by the presence of sapropel that was deposited adjacent to shoals near the east flank of the depositional basin.

Maximum organic-carbon concentration is as much as 30 wt. % in the organically richest beds in the shale members and the maximum average in each member is about 10 wt. %. A close association occurs in the distribution of the organic carbon, silver, chromium, molybdenum, nickel, titanium, vanadium, and zinc. Phosphorous differs slightly from the distribution of organic carbon and by contrast seems typically associated with copper, lanthanum, neodymium, strontium, yttrium, and ytterbium.

Burial of the sapropelic muds by Triassic and younger sediments and the consequent rise in ambient temperature has led to catagenesis of hydrocarbons from the kerogen in these rocks. In some areas of southwestern Montana, hydrocarbons have not been generated; however, burial has been minimal and temperatures have remained low. Consequently, these rocks remain organic-rich shales that have the potential for producing synthetic oil and gas.

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Stratigraphic Relationships and Distribution of Hydrocarbon Source Rocks in Greater Rocky Mountain Region

"Hydrocarbon Source Rocks of the Greater Rocky Mountain Region " is the title of the Rocky Mountains Association of Geologists 1984 contribution to its annual symposium–guidebook series. This volume is comprised of over 25 papers that describe Precambrian through lower Tertiary source rocks and their associated maturation, migration, and accumulation patterns.

Placement of source rocks within a regional depositional framework indicates that they are generally associated with specific depositional environments associated with recognizable cycles of transgression and regression. When placed in a framework of depositional sequences, the source rocks can easily be related to the geometry of the associated reservoirs that they charge and to the seals that restrict hydrocarbon migration and control accumulation.

A series of maps shows distributions of source rocks for each critical stratigraphic sequence, and places the data and concepts of individual symposium papers in a regional context.

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Applied Depositional Modeling for Developing Western Coal Deposits

Geologic data from Mesaverde Group (Upper Cretaceous) strata in the Rocky Mountain region indicate that two major depositional models can be used to evaluate the geology and mining conditions of many western coal deposits. Marine and continentally deposited strata that enclose coal seams are characterized by physical and chemical characteristics which, if recognized, will permit more efficient mine planning and development. These characteristics impact selectively and differently on underground coal mining including longwall and room-and-pillar methods.

Continentally deposited strata in the roof and floor of coal seams require closely spaced data points for predicting geologically related mining conditions due to the lenticularity of the component beds. Fluvial sandstones are commonly associated with "wants," rolls, water inflows, and thinned coal. Channel-margin strata are notorious for roof control problems. Mudstones deposited in interchannel areas are prone to rapid decomposition with the introduction of water, humidity, and stress release.

Marine-deposited strata enclosing coal seams require less closely spaced data points than continentally deposited strata for predicting mining conditions because of the lateral continuity of such strata. Roof and floor strata and mining conditions are characteristically uniform over wide areas except near the termination of strata. Shoreline sandstones form very competent roofs and floors although they are locally associated with reduced seam thicknesses. The immediate association of marine-deposited strata and coal commonly results in higher sulfur values at the contacts of these strata.

Where marine and continental strata interfinger, the prediction of mining conditions becomes complex and requires an understanding of the depositional and erosive capabilities of the associated facies.

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Geology of Scipio Pass Quadrangle, Millard County, Utah

The Scipio Pass quadrangle is comprised of three separate packages of stratigraphy: (1) the Canyon Range Precambrian and Cambrian allochthonous section, (2) the Pavant allochthon of Paleozoic carbonates and quartzites, and (3) a thick Cretaceous to Quaternary blanket of coarse clastics that unconformably overlies the other packages. A fourth package, the Pavant autochthon, is inferred in the subsurface. Mesozoic rocks of this package crop out farther south where the Jurassic Navajo Sandstone is overlain in thrust contact by the Cambrian Tintic Quartzite.

Based on lithology and biostratigraphic evidence, the heretofore undivided Cambrian section of the Pavant allochthon correlates well with the