source of hydrocarbons in the Lower Cretaceous Muddy Sandstone of the Powder River basin. This sandstone has a geographic distribution similar to that of the Mowry and much of the Skull Creek.

Illite/smectite mixed-layer clay in the Mowry and Skull Creek Shales of eastern Montana and western North Dakota is unaltered. No significant amounts of hydrocarbons have ever been found in the Muddy Sandstone of this area. Hydrocarbons in the Muddy Sandstone occur within or immediately adjacent to areas in which the smectite component of the illite/smectite in the Mowry and Skull Creek Shales has undergone alteration to illite during burial diagenesis. Anomalous decreases in the total organic carbon content of the Mowry and Skull Creek Shales lie within areas of illite/smectite alteration and coincide with the deeper parts of structural basins which developed after deposition of the Mowry and Skull Creek. These regional variations in illite/smectite alteration and total organic carbon content reflect thermal maturation and are not provenance controlled. They are useful indicators of areas where the potential source rocks have been subjected to temperatures adequate to generate hydrocarbons. The degree of illite/smectite diagenesis in the Mowry and Skull Creek of the northern Rocky Mountains-Great Plains region is thus of exploration significance in the search of hydrocarbons in this area.

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Permian Upper Yates Formation Carbonate/Siliciclastic Depositional Patterns, Northwestern Shelf, Guadalupe Mountains, New Mexico

Sedimentological field study of the upper three sandstones of the upper Yates Formation (Permian, Guadalupian), Guadalupe Mountains, New Mexico, has shed considerable light on the shelf depositional environment, morphologic profile, and temporal relationships of alternating carbonate and siliciclastic deposition. Outcrops were examined in detail, and 31 stratigraphic sections were measured, described, and correlated within the region 5 km (3 mi) shelfward of the Capitan reef and encompassing an area of 180 km^2 (69 mi^2).

The three sandstones in the upper 15 to 30 m (49 to 98 ft) of the Yates are continuously traceable across the study area as thin, nonchanneled sheet sandstones 0.5 to 8 m (1.6 to 26 ft) thick. They exhibit no deepening or "shoaling-upward" sequences; no beach or tidal sedimentation features; and no vertical repetitive sedimentation patterns. Primary sedimentary structures are rare, obscure, small scale ($\leq$ 20 cm; 8 in., height), and discontinuous. All structures indicate subaqueous deposition. From the sandstones nearest the Capitan, the shelfward progression of sedimentary structures indicates shelfward diminution of hydraulic energy. Sandstones are largely abiotic suggesting maintenance of inhospitable marine conditions (mesohaline?) during siliciclastic deposition.

Evidence for a marginal mound shelf profile during sandstone deposition is inconclusive. A localized area of fenestral porosity in the lowermost sandstone unit, and a narrow region of probable fossil caliche along the Yates/Tansill formational contact of the upper sandstone, both suggest local emergence of a paleotopographic high located 1.5 to 3.0 km (.9 to 1.8 mi) and 1.5 to 3.25 km (.9 to 2 mi) respectively, shelfward of the Capitan. All three sandstones continuously overlie the area of the marginal mound as inferred from the underlying carbonate facies, hence a marginal mound was not present or had no affect on transport of siliciclastics across the outer 5 km (3 mi) of the shelf.

Each sandstone is characterized by a sharp, subplanar erosional base, and typically grades upward into peritidal carbonates, which exhibit along the shelf crest of the marginal mound one or more 1 to 2 m (3 to 6 ft) shoaling-upward hemicycles which commonly built up to depositional fill-level in response to episodic shelf subsidence of 1 to 2 m (3 to 6 ft). The eroded fill-level carbonates of the shelf crest underlying two of the three sandstone intervals were diagenetically micritized analogous to incipient pedogenesis prior to subsidence and burial by subaqueously deposited siliciclastics. Local emergence of 1 to 2 m (3 to 6 ft) relief could explain the inferred pedogenesis, with siliciclastic deposition being favored by subsidence and greater water depth which governed siliciclastic transport processes.

The following depositional sequence is repeated twice in the study interval: subaqueous deposition of siliciclastics across the eroded surface of the underlying carbonate unit; upward siliciclastic gradation into peritidal carbonates characterized by one or more 1 to 2 m (3 to 6 ft) shoaling-upward hemicyclic deposits which proceeded to fill-level; local emergence with concomitant subaerial erosion and micritization; subsidence and renewed subaqueous siliciclastic deposition. Reconnaissance observations from the middle Yates and lower Tansill reveal numerous analogous sandstone/carbonate relationships.

The sandstone intervals interbedded with shelf crest carbonate facies comprise sandstone/carbonate shoaling-upward hemicycles; contrary to current interpretation the sandstone represents the basal "deeper" water deposition, the carbonates represent the "shoal water" deposition.

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Importance of Radar Look Direction in Petroleum Exploration

Structural features which can be readily mapped from radar imagery are those features which are represented by some elements of physical relief. These structural features are usually fractures or physical discontinuities in the rock materials, which can be seen because of the effects of selective or differential erosion. These effects are seen on radar imagery in two distinct manners. First is the linearity of physical features, and second is the discontinuity of tone, shape, texture, and/or pattern. The discontinuity of tone, shape, texture, or pattern is created by differential erosion of the terrain on one side of a fracture in respect to the other side.

The ability of a remote sensing system to enhance minor physical features is the most important aspect in mapping structural features. The available tonal contrast is of secondary importance. The direction of illumination is also important in the mapping of structural features as determined by studies on the Alaskan Peninsula.

Maps showing the major structural features of the study area were compiled from real aperture radar imagery, synthetic aperture radar imagery, and Landsat MSS imagery. Three simple frequency diagrams were produced from maps of the study area showing the major structural features. The frequency diagram of the linear features taken from real aperture radar imagery, shows a strong bimodal distribution. The two major directions indicated are approximately 50°W and 50°E. The frequency diagram of the linear features taken from synthetic aperture radar imagery also shows two major directions of orientation. The two major directions are approximately 70°W and 20°E. The frequency distribution for Landsat MSS imagery is trimodal showing major orientations of approximately 60°W, 10°E, and 60°E. All three frequency diagrams are strikingly different.

What is shown in the frequency diagram is preferential enhancement of linear features by a particular direction of illumination. Field reconnaissance indicated three major directions