(Meramecian) in age and therefore had no influence on the earlier deposition of Mississippian sediments. The Mississippian system in this region is represented by the Madison, Leadville, Redwall, Humbug, and Manning Canyon formations. The Humbug and Manning Canyon formations are present only in the northwestern part of the area, due to erosion of the Humbug and the fact that the Manning Canyon was deposited only in the area of the Oquirrh basin of central Utah. At the close of Humbug time, strata of the Mississippian system formed the eastern shelf of the Cordilleran miogeosyncline, and was exposed over the positive area of the Southern Colorado Plateau, now known as the Paradox, Black Mesa, and San Juan basins.

The possibilities of finding oil and gas accumulations in the thick, commonly porous, carbonate sediments of Mississippian age are favorable along the Cordilleran shelf, or hinge area. Both stratigraphic and structural conditions are favorable in this area. The only Mississippian oil production in Utah is in the Paradox basin at the Big Flat unit, discovered in 1957 by the Pure Oil Company. The complex, subsurface, structural conditions of the Mississippian strata, in the Paradox basin, imply excellent possibilities for oil accumulation in structural traps.

It is concluded that there is a Cordilleran shelf or hinge area in south-central Utah and that the Mississippian formations can probably be correlated throughout the Four Corners region.

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Dakota Stratigraphy in San Juan Basin

Subsurface stratigraphic study of the Dakota formation in the San Juan baisn area of northwestern New Mexico and southwestern Colorado has been facilitated by (1) published stratigraphic sections along its outcrop, (2) good distribution and density of well control, and (3) presence of a persistent, superjacent marker—the Greenhorn limestone (zone of *Inoceramus labiatus*).

The Dakota formation is the basal sandstone of an early Late Cretaceous transgression that probably reached its maximum extent in this area during latest Greenhorn time. It overlies a rather even erosion surface developed on the Morrison and Burro Canyon formations.

The Dakota may be divided into three units in the San Juan basin area. The lower unit is predominantly non-marine and generally consists of a basal conglomeratic sandstone overlain by carbonaceous shales that commonly contain thin coal beds and lenticular sandstones.

Overlying the basal Dakota and grading upward into the Graneros shale is a 30–100-foot-thick transgressive middle unit, predominantly sandstone, that becomes progressively younger from east to west. These middle Dakota sandstones probably were deposited as nearshore sands along the westward margin of the advancing Cretaceous sea during Belle Fourche and early Greenhorn time. Careful correlation in the subsurface and between the subsurface and outcrop sections shows the interval between the base of the Greenhorn and the top of the middle unit to be more than 200 feet in thickness in the southeast part of the basin, about 150 feet in the southwest and northeast part, about 100 feet in the west-central part, and less than 50 feet along the west and northwest margins. These and other relationships suggest that regionally middle Dakota strand lines, unlike those of succeeding Upper Cretaceous strata, trend northeast-southwest in the southern part of the basin and north-south in the northern part.

The sandstones of the upper unit of the Dakota intertongue with the Graneros shale and are developed in one or more correlative intervals below the Greenhorn limestone. They commonly occur as lenses, are early Greenhorn in age, and have been referred to as "Tres Hermanos sandstone" in outcrop sections along the southern border of the basin and as "Graneros sands" in the subsurface. These sandstone tongues probably represent minor regressive phases resulting from local increase in sand supply during the major Dakota transgression. The uppermost interval of widespread sandstone development occurs about 30 feet below the base of the Greenhorn and locally is more than 50 feet thick in the southwest part of the basin. Its distribution and northeast pinch-out suggest the source of the sand was at the southwest and that by the time of its deposition regional northwest-southeast "trends" had been established.

Present Dakota production is largely from stratigraphic accumulations in the San Juan basin and from structural accumulations in the platform area along its northwest margin. The variations in shoreline trend during Dakota deposition suggest diverse orientation of trends for new Dakota discoveries.

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Marine Redbeds in Central Colorado Basin

Considerable, difference of opinion is reflected in geologic literature concerning the environment of deposition of redbeds. Many geologists apparently assume that red coloration (hematite) in sediments can be preserved only under conditions of subaerial deposition, and they therefore assume that all redbeds are continental sediments. These assumptions are not valid. If an adequate source of hematite is available, redbeds can originate in any environment, continental or marine, in which

oxidizing conditions exist below the depositional interface, or in which the reducing capacity of the bottom sediments is inadequate to destroy the volume of hematite present.

Sediments deposited in normal marine environments (those having normal salinity and open circulation) rarely are red because if hematite is present it normally is altered to non-red ferrous compounds by the reducing action of decaying organic matter in the bottom sediments. However, if sedimentation and subsidence are comparatively rapid, and if the volume of hematite present is large, red sediments can originate even in normal marine environments. Excellent examples of such redbeds are found in certain red shales, red arkoses, and red limestones in the Minturn formation (Des Moines) along the northeastern flank of the central Colorado basin near McCoy, Colorado. These red sediments contain well preserved marine fossils that reflect deposition under normal marine conditions. Mildly reducing conditions existed in the depositional environment causing some bleaching, but the sediments are predominantly red because they were deposited in an area of relatively rapid subsidence in which the volume of hematite was too great to be completely reduced in the time available.

Marine waters with abnormally high salinity, on the other hand, can be highly favorable for hematite preservation, a fact that has been pointed out by earlier writers. Because organisms are scarce in such waters the bottom sediments commonly lack the reducing influence of decaying organic matter. If good mixing of the overlying water is maintained by wave action or by convection currents, oxidizing conditions prevail below the depositional interface; any organic matter present is destroyed by oxidation and any hematite present is preserved. Redbeds originating under these conditions are nonfossiliferous but possess other characteristics of marine sediments, e.g., well sorted texture, uniform bedding, absence of channel structures, and association with primary dolomite and evaporites. Parts of the Pennsylvanian and Permian strata in the central Colorado basin provide convincing examples of redbeds of this origin.

In petroleum exploration, redbeds should be analyzed carefully for possible marine origin. Although such rocks are unfavorable as source beds of petroleum, they may serve as satisfactory reservoir rocks and may be closely associated with other marine sediments that are highly prospective for oil.

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Pennsylvanian Paleogeology and Search for Oil in Lucero Basin, Central New Mexico

The Lucero basin of central New Mexico was an area of Pennsylvanian sedimentation representing a significant widening of the central New Mexico seaway or accessway from the Paradox geosyncline on the north to the Sonoran geosyncline on the south. Several such basins along this accessway include the Lucero, San Mateo, and Orogrande, all of which have slightly different post-depositional geologic histories. This accessway, of which the Lucero basin is a part, ranged from 50 to 130 miles in width, and received up to 3,000 feet of Pennsylvanian sediments which form the Sandia, Madera, and Red Tanks formations. This seaway was in existence between Atokan and Virgilian time but was widest during Desmoinesian and Missourian time. Pennsylvanian marine sedimentation was limited on the west by the Zuni positive, on the east by a long sinuous platform west of the Estancia basin and the Pedernal positive, and on the northeast by the Penasco positive. Fine clastic sediments from the Zuni and medium to coarse sediments from the Penasco make up less than one-fourth of the Pennsylvanian section which is predominantly limestone. The sharp downwarp of the Estancia basin on the east, as a southerly basin of the central Colorado-Sangre de Cristo seaway, resulted in entrapment of westerly moving coarse clastics from the Pedernal uplift. The Sandia-Manzanita-Manzano-Joyita tectonic alignment (of Tertiary age) was a long narrow platform or "sill" which separated the thick clastic-filled Pennsylvanian section of the Estancia basin from the somewhat thinner but normal basinal and shelf carbonate section of the Lucero basin.

Bioherms grew on the gently shelving east sides of the central New Mexico accessway as indicated by outcrops of calcarenite mounds containing *Chaetetes* sp. corals in the Sandia and Manzano mountains. Inasmuch as the Pennsylvanian outcrops at Monte de Belen and Gray Mesa along the Lucero uplift show basinal lithologic character in Desmoinesian and early Missourian strata and the entire section thins to zero westward onto the Zuni positive, it is likely that similar reefoid masses will be found in the subsurface in the area surrounding the corner common to Catron-Socorro-Valencia counties.

Because of Laramide folding and Tertiary faulting, the eastern two-thirds of the Pennsylvanian Lucero basin is buried deeply beneath the valley fill of the Rio Grande trench, and parts of the platform between the Estancia basin on the east and the Lucero basin on the west now stand high as the Sandia-Manzano block-fault mountains.