pore anisotropies of tight sandstones. Several analysis methods were used; each indicated that little anisotropy was present in the pore structure.

Statistical-shape parameters, derived from the measured perimeters and areas of the pores, suggest that most of the pores within each sample are tabular rather than tubular in shape. Knowledge of the pore structure suggests that the pores should be treated as oblate rather than prolate spheroids in modeling the electromagnetic or fluid-flow properties of these rocks.

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Cretaceous-Tertiary Boundary, San Juan Basin, New Mexico and Colorado

The Cretaceous-Tertiary boundary in the San Juan basin, New Mexico and Colorado, has been variously placed at the base, at the top, and somewhere within the Ojo Alamo Sandstone. New evidence bearing on the location of this boundary includes palynologic analyses, vertebrate paleontology, paleomagnetism, and trace-element analyses.

The Ojo Alamo Sandstone is a series of fluvial, high-energy, braided stream deposits consisting of from one to several conglomeratic sandstone sheets separated by overbank or floodplain shales. The conglomerates contain pebbles and cobbles of quartzite, jasper, and andesite on the west side of the San Juan basin. The pebbles and cobbles diminish in size eastward and are rare to nonexistent on the east side of the basin. There is a major unconformity at the base of the Ojo Alamo.

The Cretaceous-Tertiary boundary, as determined earlier from palynologic criteria, is below the base of the Ojo Alamo Sandstone in the uppermost part of the underlying Kirtland Shale on Mesa Portales. New evidence from the Star Lake area, New Mexico, tends to confirm that boundary location. Other new data based on vertebrate remains, also from the Star Lake area, indicate that the boundary is within the Ojo Alamo Sandstone. Recently published paleomagnetic data and trace element studies now underway may also help in solving the Cretaceous-Tertiary boundary problem.

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Upper Cretaceous Tocito Sandstone Lentil of Mancos Shale, San Juan Basin, New Mexico—Is There Any Oil Left?

The Upper Cretaceous Tocito Sandstone Lentil of the Mancos Shale consists of a series of northwest-trending linear sandstone bodies in the San Juan basin of New Mexico. This sandstone unit, which has produced most of the basin's crude oil (more than 125 million bbl to date), was referred to as the "Gallup" Sandstone for many years. Recent stratigraphic studies of the Tocito by several authors clearly demonstrated that the Tocito Sandstone Lentil is a totally different stratigraphic unit from the Gallup; thus, the Tocito name was reinstated as a lentil of the Mancos Shale. (Actually, the "Tocito" was thought to be part of the Gallup years ago and the Tocito name was dropped in favor of the "Gallup" name.) Even though hundreds of holes drilled to produce natural gas from the deeper Dakota Sandstone have penetrated the Tocito, these holes cannot be thought of as Tocito dry holes because, for many of them, no attempt was made to test the Tocito for its possible oil potential. There is still a good chance that significant amounts of oil remain to be found in the Tocito.

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Facies Distribution and Reservoir Quality of Biogenic Gas Reservoirs of Northern Great Plains—Example From Eagle-Telegraph Creek (Upper Cretaceous) Interval

The quality of reservoirs containing biogenic gas in the northern Great Plains is predictable on the basis of facies distribution. Rocks of the Upper Cretaceous Eagle Sandstone-Telegraph Creek Formation stratigraphic interval include excellent examples of several reservoir types.

Conventional reservoirs of the Eagle Sandstone are restricted to a north-south trending band of coastal sandstones in central Montana. These reservoirs are highly porous and permeable and display evidence of extensive diagenetic alteration. Conventional Eagle reservoirs are exemplified by gas fields in the vicinity of the Bearpaw Mountains, where gas is found in structural traps.

Coarsening-upward sequences of the Shannon Sandstone Member of the Gammon Shale were deposited on a shallow shelf seaward (eastward) of the coastal sandstones. Reservoir quality improves upward through each sequence, and depends upon the distribution and amount of sand accumulation. The Shannon reservoirs are transitional between conventional reservoirs of the Eagle Sandstone and low-permeability (tight) reservoirs in the Gammon Shale. The Liscomb Creek field, in southeastern Montana, produces gas from the Shannon in a structural-stratigraphic trap.

Gas reservoirs in offshore marine mudstones of the Gammon Shale consist of thin, discontinuous lenses and laminae of siltstone enclosed in silty shale. The reservoirs are tight with permeabilities of 0.1 md or less. They have high irreducible water saturations ($>$80%; however, they produce little free water). The reservoirs are extremely susceptible to formation damage when exposed to water-based fluids used during drilling and hydraulitc fracturing. The Gammon reservoirs have low productivity but volumetrically make up the greatest part of rocks equivalent to the Eagle-Telegraph Creek sediments, and they probably have the greatest potential for reserves of shallow gas in the northern Great Plains. Examples of low-permeability reservoirs include pay zones in the Little Missouri field in southwestern North Dakota and in Gammon-equivalent rocks of the Milk River pool in southeastern Alberta.

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Progress in Modeling Natural Fracture Distributions

Recent interest in the influence of rock fractures on fluid movement through rock has created a need for modeling techniques which can predict fracture geometry, spacing, and opening in large, heterogeneous rock bodies. A suggested approach involves the simultaneous development of (1) a rock body model which represents the distribution of rock physical properties and the boundaries between property domains; (2) an empirical model representing fracture geometry, distribution, and opening for as much of the rock body as is feasible; and (3) a theoretical strain model which allows the strains indicated by the empirical model to be generalized over the body model. The theoretical model is based on the analysis of strain mechanisms during field work for the empirical model. This methodology has been applied to a complex nearshore sedimentary rock sequence in an area having widely spaced basement-rooted faults of the Laramide type. The resulting model was sufficiently powerful to predict acceptably fracture aperture size and spacing in the strata of interest. These predictions provide input for the existing geohydrologic models for fracture flow which is significantly less variable than permitted by the models' sensitivity to this parameter.

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Perspectives of Energy Development in New Mexico

New Mexico ranks fourth in the nation in natural gas and natural gas liquids production. It is seventh in crude oil and lease condensate extraction, has 55% of the country's uranium, and ranks first in providing this crucial energy fuel. Over 120 billion tons of coal lie between the surface and 3,000 ft (915 m) in northern New Mexico with 3 to 6 billion tons of low-sulfur coal accessible for relatively inexpensive strip mining. The U.S. Geological Survey estimates that the Valles Caldera of the Jemez Mountains alone contains geothermal fluids capable of sustaining 2,700 Mw of electrical generating capacity for 30 years. Solar insolation in southern New Mexico is within 10% of the maximum received anywhere in the world.

Energy in all its forms will be the major force in New Mexico's economic future. More than half of the state's gross product is now derived from energy-oriented activities. It is not unreasonable to expect that, just as a century or so ago major communities and industrial enterprises developed around transportation corridors of rivers and railroads, the new commerce of the next decades will locate where assured energy supplies exist. Massive service, social, financial, and environmental burdens and impacts must be addressed by industry, government, and citizens if the state is to provide orderly, stable, and beneficial development, to avoid the potential misfortunes of "boom and bust" cycles, and to preserve its unique environment and life style.

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Origin of Intraformational Folds in Jurassic Todilto Limestone, Ambrosia Lake Uranium Mining District, McKinley County, New Mexico

The Todilto Limestone of Middle Jurassic age in the Ambrosia Lake uranium mining district of McKinley County, New Mexico, is the host formation for numerous small to medium-size uranium deposits in joints, shear zones, and fractures within small to large-scale intraformational folds. These folds probably were formed as a result of differential sediment loading when eolain sand dunes of the overlying Summerville Formation of Middle Jurassic age migrated over soft, chemically precipitated, lime muds of the Todilto shortly after their deposition in a regressive, mixed fresh and saline lacustrine or marginal-marine environment of deposition.

Encroachment of Summerville eolian dunes was apparently restricted to relatively narrow beltlike zones trending radially across the Todilto coastline toward the receding Todilto body of water. Intraformational folding is believed to be confined to the pathways of individual eolian dunes or clusters of dunes within the dune belts.

During the process of sediment loading by the migrating dunes, layers of Todilto lime mud were differentially compacted, contorted, and dewatered, producing both small, and large-scale plastic deformation structures including convolute laminations, mounds, rolls, folds, and small anticlines and synclines. During the processes of compaction and dewatering, the mud, in localized areas, reached a point of saturation at which sediment plasticity was lost, causing shearing, fracturing, and jointing of the contorted limestone beds. These areas or zones within the limestone became the preferred sites of uranium mineralization because of the induced transmissivity created by sediment rupture during prolonged sediment loading.

Along the Todilto coastline adjacent to the eolian dune belts, both interdune and coastal sabkha environments dominated the Summerville on the margins of the Todilto body of water. Sediment in these areas consists mainly of claystone, siltstone, sandy siltstone, and very fine grained sandstone which was apparently derived from the winnowing of the finer grained fraction of sediment from adjacent eolian dune fields during eolian activity. Most of the sabkha sediments were probably carried in airborne suspension to the low-lying, ground-water saturated, coastal areas where they were deposited as relatively uniform blanketlike layers. Deposition of sabkha deposits was apparently slow and uniform over most of the Todilto coastal and interdune areas, and did not cause the formation of other than small-scale deformation features in underlying Todilto rocks. Large-scale deformational features as well as uranium deposits are notably absent in the Todilto where it is overlain by finer textured sabkha deposits in the Summerville.

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Mollusca from Upper Cretaceous Fruitland and Kirtland Formations, Western San Juan Basin, New Mexico: Review

Renewed interest in the development of substantial coal reserves in the San Juan basin has given new impetus to the determination of the potential impact of expanded mining on paleontologic resources and to a reconsideration of depositional environments of Fruitland coals.

Reanalysis of molluscan localities from the Fruitland and Kirtland Formations on lands of the Navajo Nation, in preparation for more extensive field studies, indicates that, of the 24 localities collected by C. M. Bauer in 1915, 12 are type localities for 17 species, representing a large percentage of the total fauna known from these formations. Differentiation of brackish and nonmarine environments on the basis of biostratigraphic distribution of species divides the Fruitland Formation into upper and lower units. Near the western margin of the San Juan basin, predominantly brackish environments are present near the base of the Fruitland, underlain by the littoral-marine Pictured Cliffs Sandstone, and extend up to 35.6 m in total thickness. Exclusively nonmarine sediments are present above this horizon to the top of the Fruitland and throughout the Kirtland Formation. Nonmarine molluscan diversity seems to increase markedly at approximately 35.6 m. Below this horizon, only 7 taxa indicate freshwater environments. At 35.6 m, 8 taxa are introduced, and of these 7 occur only at this level. Above 35.6 m, only 2 taxa are introduced: *Physa reesidei* at about 61 m and "*Unio*" *baueri* at 123.5 m (Kirtland Formation). The only terrestrial mollusk reported is *Planorbis chacoensis* from near the base of the Fruitland Formation.

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Overview of Geology as Related to Environmental Concerns in New Mexico