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Stratigraphy and Paleontology of Bisti Badlands, San Juan County, New Mexico

Study of 29 stratigraphic sections of the Upper Cretaceous Cliff House Sandstone, Lewis Shale, Pictured Cliffs Sandstone, Fruitland Formation, and Kirtland Shale in the Bisti Badlands of northwestern New Mexico suggest deposition in deltaic environments. Cliff House Sandstone littoral, Lewis Shale prodelta and delta-front, Pictured Cliffs strand-plain, levee, and distributary-channel, Fruitland Formation paludal, estuarine, and delta-plain, and Kirtland Shale flood-plain facies document the transgression and regression of the last epeiric seaway for the San Juan basin.

Littoral and strand-plain paralic facies, respectively, delineate transgressive and regressive sequences, whereas prodelta and delta-front facies reflect deposition in offshore open-marine waters. Late Campanian fossils represented by marine mollusks, sharks and dinoflagellates, pelagic foraminiferids, benthic ostracods, littoral and shallow-neritic *Ophiomorpha* burrows, and terrestrial palynomorphs illustrate that marine conditions prevailed but were contaminated by terrestrial biotas. Deposition of delta-front sandstones 1 km or more from shore is substantiated by the hypopycnal inflow formula.

Terrestrial environments, represented by levee, distributary-channel, paludal, delta-plain, and flood-plain facies, exhibit the deposits of vertically accreted shale, laterally accreted channel sandstones, and coal. Overbanking of distributary channels formed natural levees on the periphery of interdistributary marshes, thereby preserving a coal to shale to sandstone vertical sequence. Local transgression due to channel abandonment and delta-lobe subsidence deposited estuarine shale and upward-coarsening, crevasse-splay sandstones. Delta-plain to flood-plain facies shows the transition from thick commercial coals and shale, to shale and channel sandstones, to shale which contain local coal, bentonite, and channel sandstones. The transition represents, respectively, poorly drained swamps, well-drained delta-top tracts, and riverine with lacustrine regions. Aquatic bivalves and gastropods plus fish, turtle, crocodile, and dinosaur bones occur as lag deposits to channel sandstones. Locally, articulated dinosaur, turtle, and crocodile bones are present in the vertically accreted shale.

Nine hundred million metric tons of coal from four coal seams of the lower Fruitland Formation represent a major energy resource for New Mexico. Western Coal Co., Albuquerque, intends to strip mine 80 million metric tons of coal found within the study area.

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Geology of Espinaso Formation (Oligocene), North-Central New Mexico

In the Hagan basin of north-central New Mexico, Espinaso Ridge contains the largest and least deformed exposures of the Espinaso Formation (Oligocene). The Espinaso primarily consists of 430 m of volcanic detritus eroded from eruptive centers in the Ortiz Mountains and Cerrillos Hills. The Espinaso appears conformable and gradational with the underlying Galisteo Formation and is overlain unconformably by the Santa Fe Group.

Sedimentary structures, facies relations, and upward coarsening sequences indicate that the Espinaso was deposited on prograding alluvial fans by braided streams and laharic flows.

Clasts in the conglomerates range from andesitic near the base of the formation to latitic near the top. A chemical analysis from an interbedded lava flow in the upper half of the section shows a normative composition of nepheline latite. The sandstones are composed mostly of feldspar and lithic fragments. The most distinctive petrologic characteristics of the Espinaso are high P/F ratios, low quartz, lack of any lithic fragments other than volcanic fragments, and high percentages of microlitic volcanic fragments.

The sedimentary record suggests that the commencement of volcanic activity in late Eocene time coincided with deposition of upper Galisteo sandstones. By Espinaso time, significant volcanic activity caused the progradation of coalescing fans over a region of low physiographic relief. The fine grain size of uppermost Espinaso sediments suggests the waning of volcanic activity in the latest Oligocene.

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Effects of Physical and Chemical Diagenesis on Low-Porosity, Low-Permeability Sandstones, Mesaverde Group, Uinta Basin, Utah

Examination of sandstones from core samples spanning a 110-m interval of Upper Cretaceous Mesaverde Group indicates that physical compaction of labile rock fragments and chemical diagenesis greatly modified the original lithology. These modifications reduced porosity (to less than 10%) and permeability (generally to less than 0.5 md at surface conditions). Local silty lamina further reduce vertical permeability.

The sandstones are predominantly feldspathic litharenites composed of monocrystalline and polycrystalline quartz, igneous, metamorphic, and fine-grained sedimentary rock fragments, and small amounts of potassium and plagioclase feldspars. Cementing agents include quartz overgrowths, authigenic low-albite on plagioclase, intergranular calcite and dolomite, and authigenic clays (kaolinite, illite, and minor chlorite). Quartz overgrowths are more common than in the Mesaverde Group sandstones previously examined, and undoubtedly reduce porosity. The overgrowths are sometimes separated from the detrital-quartz host by an iron oxide-stained dust ring or by a thin ($\pm$ 2 μ) film of chlorite. Locally, early formed intergranular calcite occupies as much as 40% of volume and, in addition to virtually eliminating porosity, has largely prevented compaction of labile rock fragments. Chert and fine-grained sedimentary rock fragments are commonly compacted between more competent framework grains. Following compaction and deformation, leaching of feldspars and rock fragments produced secondary porosity, which includes most measured porosity in these sandstones.

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Hydrology of Strippable Coal Deposits, San Juan Basin

Commercial coal deposits of the San Juan basin are associated with intertonguing Cretaceous marine and nonmarine deposits. Sandstone units in this stratigraphic sequence act as ground-water aquifers that may be affected by mining operations. Sandstone aquifers can be classified as areally extensive with significant potential for ground-water development, or as discontinuous aquifers of limited potential.

Coal deposits in the lower part of the stratigraphic sequence generally are associated with areally extensive sandstones.