erals and enhanced by the development of dissolution porosity in silicate grains and carbonate cement.

Upward-coarsening sandstone sequences, 3 to 30 m thick, contained in the Eagle-Telegraph Creek-equivalent Gammon Shale, accumulated tens to hundreds of kilometers seaward (eastward) of the strand. These sandstones are transitional between conventional reservoirs and low-permeability reservoirs. Near the bottom of each sequence, porosity averages 15% and permeability averages 1 md. Upward through each sand accumulation, loss of allogenic clay and increasing sand content and grain size enhance reservoir properties. Porosity and permeability attain 25% and 150 md near the top of each sequence. Reservoir quality is controlled by allogenic clay content, intensity of bioturbation, precipitation of authigenic minerals, and the dissolution of cements and detrital grains.

The greatest volume of natural gas occurs in low-permeability mudstones of the Gammon Shale, which are identical to offshore equivalents of the Milk River Formation in southeastern Alberta. The reservoirs are silty shales containing discontinuous lenses and laminae of silt or very fine sand, a few millimeters or less in thickness. Effective porosity is confined to passageways within the laminae or to spaces among loosely packed clay platelets between clastic grains. Porosities range between 10 and 20%, permeabilities are commonly less than 0.1 md, and pore-entrance diameters are normally 0.1 μ or less. Because of the amount and composition of allogenic clay, the reservoirs are highly water sensitive and display very high water-saturation values. Although economic flow rates are only achieved through fracturing, subsequent production has been predictable and profitable.

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Diagenesis in Shallow Conventional and Low-Permeability Biogenic Methane Reservoirs of Eagle Sandstone, Montana

The Upper Cretaceous Eagle Sandstone and equivalent rocks in north-central and eastern Montana provide an excellent opportunity to investigate postdepositional effects in gas reservoirs that have never attained thermal conditions sufficient for the generation of petroleum.

Investigations reveal that these reservoirs display inorganic diagenetic features similar to those of rocks having a burial history suitable for the formation of oil or thermogenic gas. These features are observed in both high-permeability and low-permeability reservoirs. Complex paragenetic sequences such as the following are common: (1) authigenic clay formation, (2) quartz overgrowth, (3) calcite cement and replacement, (4) carbonate dissolution, and (5) additional authigenic clay formation. Exotic phases, such as authigenic tourmaline, are observed locally. More importantly, there is widespread evidence of former calcite cementation and replacement, especially of plagioclase, followed by carbonate dissolution. The distribution of these features suggests that calcite has at various times occupied virtually every pore in many of the Eagle reservoirs. However, several lines of evidence, including the timing of gas generation and entrapment and the distribution of calcite in the Eagle Sandstone, suggest that the reservoirs have never been completely sealed by carbonate rock.

Thermal maturation of organic matter is not a prerequisite for the development of secondary porosity, nor for the development of minerals potentially hazardous to well-completion and treatment procedures. In addition, unequivocal evidence demonstrates that dissolution porosity can be produced without a previous period of total destruction of reservoir quality.

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Facies and Depositional Tectonics of Middle Jurassic Carmel Formation, Southern Utah

The Middle Jurassic Carmel Formation of southern Utah is divided into two informal members deposited during a major transgressive-regressive cycle. The relatively thin lower member was deposited in a shallow, subtidal, marine to coastal, sabkha environment that advanced southeastward, onlapping and reworking coastal dunes of the Navajo and Page sandstones. Lithofacies of the lower Carmel include calcareous mudstone, bivalve micrite, oolitic grainstone and packstone, ostracod pelletal micrite, dolomicrite, algal stromatolites, aphanitic dolomite, and minor nodular gypsum and sandstone.

The sporadic northwest retreat of the Carmel Sea and progradation of coastal sabkha and continental sabkha and dune sediments is recorded in the thick upper member of the Carmel. Lithofacies include algal stromatolites, aphanitic dolomite, calcareous mudstone, nodular gypsum, horizontal to gnarly-bedded sandstone, and cross-bedded sandstone.

The lower Carmel undergoes rapid west to east thinning and facies changes, indicating that during the early Middle Jurassic (late Bajocian) the Hurricane fault was a tectonic hinge line that separated a westward tilting unstable shelf slope to the west from an unstable shelf to the east. Furthermore, lower Carmel facies, isopach anomalies, and regional stratigraphic and structural correlations indicate that anomalous subsidence and sedimentation in the present Sevier-Paunsagunt fault zone were contemporaneous and genetically related to initial deformation of the Middle Jurassic San Pete-Sevier rift of the hinge-line region of central Utah.

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Carbonate Facies of Peñas Altas Formation, Venezuela—Case Study of Cretaceous Shallow-Marine Shelf

The Peñas Altas Formation, deposited in a shallow-marine shelf environment, forms the lower part of a Cretaceous transgressive sequence. Starting with a basal conglomeratic clastic wedge, the formation passes upward into a shelf facies and culminates in the basinal Luna Formation. The important carbonate lithofacies include (1) algal wackestones with trace fossils of *Pla-*