sinward (southerly) facies changes from supratidal to subtidal; facies exhibit many features of modern, low-relief, coastal sabkhas. Lithofacies include (1) salt formed in upper sabkha evaporating ponds, (2) lower sabkha anhydrite in bedded units, (3) supratidal to subtidal dolomite with nodular and bedded anhydrite, and (4) highly burrowed subtidal-shelf carbonates. Red beds occur as sheets (up to 300 ft or 100 m thick) of shale and fine sandstone, which intertongue basinward with evaporites and dolomite. It is suggested that these formed largely in tidal mudflats grading basinward into tidal sandflats. Clastic input was by eolian and/or low-energy alluvial processes. The genetic aspect of the stratigraphy is a general southerly facies shift through time.

Potential for potash minerals is best in the upper sabkha facies associated with salt, whereas anhydrite is abundant in the lower sabkha deposits. Copper may be present in the tidal-flat systems. Lack of large gamma ray anomalies suggests that ore-grade uranium concentrations are unlikely. Hydrocarbons are present in Guadalupian facies equivalents on the southern basin margin, and knowledge of facies relations will aid exploration.

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Active Submarine Landslide Processes, Mississippi Delta

A major project is in progress to map the entire submarine portion of the modern Mississippi delta using precision depth recorders, side-scan sonar, and subbottom profiling. The survey network is composed of north-south lines spaced at 140-m intervals and east-west crosstie lines 600 m apart. The object is a detailed documentation of seafloor changes resulting from bottom sediment and slope instability. Subaqueous slope failures are widespread and active, occurring on slopes with very low inclinations, ranging from 0.2 to 1.5°. They have resulted in damage and loss to offshore oil and gas structures. The types of features include collapse depressions, bottleneck slides, elongate slides and slumps, mudflow gullies, and overlapping mudflow lobes. The basic mechanism can be approximated as downslope translation of shallow slabs of debris. Stability calculations based on measured shear-strength properties and failure geometry indicate that very high excess pore-water pressures are needed to initiate failure, and there is some empirical evidence to suggest that such pressures exist and are related to rapid sedimentation, surface wave perturbation of bottom sediments, and in-situ methane gas generation.

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Cyclic Sedimentation of Cretaceous-Paleocene Reservoir Sandstones in West-Central Pakistan

The Upper Cretaceous and Paleocene sequence in the eastern Sulaiman Range of west-central Pakistan records continuous cyclic sedimentation in shallow-marine, shelf environments. These rocks are 800 m thick and are representative of at least 50 cycles of shoreface and fluvial to fluviotidal origin. Lithogenetic studies using sedimentary structures, trace fossils, and vertical sequences indicate that the shoreline orientation was northwest-southeast with the open shelf on the northeast. Shallow-marine carbonate rocks of the Cretaceous Mughalkot Formation grade abruptly into 26 shoreface cycles and 10 fluvial to fluviotidal cycles of the Cretaceous Pab Sandstone. Gradationally above this are 14 shoreface cycles of the Paleocene Khadro Formation, distinguished from the underlying Pab Sandstone by the increased amounts of argillaceous matrix and lower-shoreface shales.

The Mughalkot carbonate rocks and the lower-shoreface shale interbeds of the Pab and Khadro Formations may serve as hydrocarbon source beds for the Pab and Khadro sandstone reservoir beds.

This sequence suggests a rather uniform rate of subsidence with episodic transgressions and controlled-sediment-supply progradation. The abrupt increase in the amount of argillaceous detritus during the early Paleocene suggests a significant change in the source-area character.

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Carbonate Replacement of Sulfate—New Mechanism for Porosity Generation in Carbonate Rocks Marginal to Evaporite Basins

Production of macropores by gypsum replacement of carbonate, and of intergranular porosity by pervasive dolomitization constitute two important mechanisms for generating high porosity in carbonate rocks in and adjacent to evaporite basins.

Exposures of Upper Permian Capitan Group carbonate beds in Carlsbad Caverns and other caves of the Guadalupe Mountains, New Mexico, indicate that one of the earliest stages of speleogenesis was the massive replacement of carbonate by sulfate. Field relations indicate that replacement took place in a mixing zone between a meteoric freshwater lens and gypsum-saturated brines. Replacement is most pronounced along joints, indicating a possible correlation with the rate of freshwater input. Replacement probably began with the development of the lens following orogenic uplift of the Guadalupe Mountains, or solutional deflation of basinal evaporites. As uplift and deflation continued, hydrologic base level fell with respect to replacement gypsum pods, exposing them first to freshwater phreatic conditions, and later to vadose conditions, causing their partial or complete recrystallization or dissolution and creating enormous voids. These underwent limited enlargement in the freshwater phreatic zone, and collapsed following draining of the caves.

Replacement of the gypsum may be recognized by primary carbonate structures preserved as remnant inclusions. Replacement gypsum crystals are generally equant with complex boundaries, but may derive their size and shape from carbonate macrostructures re-