proposed that these cohesive sediments have moved downslope, and that folds developed in response to increasing lateral confinement as sediments converged within bathymetric lows. The general style of deformation, preservation of bedding, and absence of faults suggest that movement occurred at a slow rate, probably as creep.

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Influence of Transcontinental Arch on Cretaceous Sedimentation and Petroleum Occurrences in Western Interior

A regional thinning of the marine Niobrara Formation and equivalent strata, trending northeast across Colorado and adjacent states, reflects movement on the Transcontinental arch during the Late Cretaceous. The isopach pattern reflects low rates of deposition on the arch, a regional unconformity at the base of the Niobrara with onlap onto the broad structural high, and other unconformities within or at the top of the formation.

Isopach maps of the Lower Cretaceous and of four time-stratigraphic intervals in the lower part of the Upper Cretaceous (approximating the Graneros, Greenhorn, Carlile, and Niobrara Formations) were prepared from surface and subsurface data. These maps suggest that tectonic movement of the Transcontinental arch affected the seafloor during times of worldwide changes in sea level. The major movement occurred during deposition of the upper Carlile and Niobrara Formations (late Turonian to early Santonian).

This structural movement on the Transcontinental arch may have been significant in early stratigraphic entrapment of petroleum in high structural positions in the Dakota sandstones at two of the largest gas fields in the area: Wattenberg field in the Denver basin and the Blanco field in the San Juan basin. The downwarping of the traps into their present low structural positions occurred during the Laramide orogeny in latest Cretaceous and early Tertiary time.

The Transcontinental arch is but one of several northeast-trending cross-basin arches that influenced sedimentation and petroleum occurrences in Cretaceous of the Western Interior of North America.

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Comparison of Pore-Filling Material in Some Pennsylvanian and Cretaceous Reservoir and Nonreservoir Sandstones

SEM and thin-section study of core samples from producing sandstones and associated fine-grained facies from several stratigraphic intervals of Pennsylvanian and Cretaceous age in the Rocky Mountain region show different processes of pore-size reduction relating to: (1) original pore-fluid composition; (2) grain size and texture; (3) depositional environment; (4) timing of diagenesis; and (5) depth of burial.

The sandstones studied and depositional environments are: Tyler Sandstone, southwestern North Dakota, shoreline (barrier island); J sandstone, northeastern Colorado, distributary channel and channel margin; Frontier Sandstone, northeastern Wyoming, offshore marine bar; Almond Sandstone, southwestern Wyoming, shoreline (barrier island or tidal channel); Terry and Hygiene sandstones, northeastern Colorado, offshore marine bar; and Raton Formation, southeastern Colorado, fluvial channel and channel margin.

All the reservoir sandstones were deposited by relatively high-energy transport processes in fluvial, brackish, or marine depositional environments, and represent initially "clean" sandstones with relatively good porosity and permeability. Pore space in five of the six reservoir sandstones has been initially reduced by precipitated kaolinite or chlorite. The Tyler Sandstone, a nearshore sandstone which underwent early near-surface diagenesis, exhibits reduced porosity related to precipitation of caliche.

Associated fine-grained, nonreservoir facies show a pore-filling composition that differs from the reservoir facies in both the marine and nonmarine sequences.

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Influence of Basement Tectonics on Depositional Systems and Seismic Stratigraphy

The new field of seismic stratigraphy has focused attention on the reconstruction of depositional models in which seismic responses can be evaluated and interpreted. In many exploration programs, geologists and geophysicists limit their work to processing data from relatively thin petroleum-productive sequences. Amplitude and other seismic anomalies and porosity variations are studied in search for the elusive stratigraphic trap without concern for what geologic conditions are present at the deeper basement level.

Current research in oil-productive basins indicates that recurrent movement on basement fault systems during deposition may have had an important influence on the distribution of "reservoir rock," on early fracture systems controlling petroleum migration, and on other subtle trapping mechanisms. The concept of drape folding over basement faulting can be related to the concept of fault control of facies changes. Therefore, establishment of fault trends in the basement may aid in predicting stratigraphic traps. Using this approach, success in exploration may be improved by developing exploration models which incorporate basement level tectonics with stratigraphic and seismic anomalies occurring at shallower depths.

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Sediment Suspension, Dewatering, and Mass-Movement Processes in Coastal Fluid Muds

Large, northwestwardly migrating mud shoals, parts of which are composed of fluid mud (bulk density 1.05 to 1.25 g/cc), front the shoreline every 30 to 60 km along the 1,600-km-long Guiana coast. The rather spectacular density variations that occur in these soft, gellike silts and clays have provided considerable insight into the dynamics of sedimentary and mass-movement processes. Time-series measurements taken along the coast of Surinam using pressure-sensitive instruments indicate that periodic density variations may range in frequency from that of waves (~10 sec) to that of the tide (~12.4 hour). The density fluctuations are the result of sediment suspension, loss and gain of pore waters, and subaerial and subaqueous mass-movement processes.

In muds where density is less than 1.20 g/cc and water depth is less than 5 m, clouds of sediment are suspended as shallow-water waves propagate shoreward. Although suspended-sediment concentrations may reach 50,000 ppm under wave crests, rapid settling takes place before the next wave arrives. Wave-by-wave suspension is superimposed on a lower frequency process whereby accumulations of fluid mud up to 80 cm thick are suspended and redeposited during a tidal cycle.

In muds where density exceeds 1.20 g/cc, less than 1 cm of the bottom is suspended by incoming waves or by tidal currents. Measurements indicate that cyclic density variations result from pore-water loss during a falling tide followed by pore-water gains during a rising tide.

Spectral analysis shows the presence of a third frequency of density perturbation, typically 1 to 5 minutes, which we hypothesize to be the result of mass movement of fluid mud offshore. Observations on mud flats at low tide reveal well-formed shear planes bounding linear mudflow failure chutes. Sediment-flux determinations indicate that most of the estimated 2×10^8 m^3/year of sediment moved onshore by waves can be roughly balanced by a slow, periodic mass-movement offshore. The result may be a sawtoothed pattern of sediment movement to the northwest.

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Pore Systems in Jurassic Carbonate Reservoirs, United States Gulf Coast

Common pore types in Jurassic carbonate reservoirs in the Gulf Coast include lime grainstones of the Smackover Formation in southern Arkansas and northern Louisiana with interparticle and grain-moldic pore systems, dolomitized pelletal packstones, and grainstones from the Jay field in Alabama and Florida with mainly pelmoldic porosities, and Haynesville oolitic grainstones from east Texas with partial grain-moldic pores. Reservoir quality in all these examples is a function of both primary depositional and secondary diagenetic processes.

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Correlation of Subsurface Middle and Upper Devonian Rocks in Appalachian Basin

Widespread, highly radioactive Devonian shales in the Appalachian Basin contain abundant organic matter and commonly contain hydrocarbons that are sources of natural gas. The shales are gas-productive in eastern Kentucky and southwestern West Virginia. Correlation of subsurface shale units in the basin is difficult because of unconformities and complicated facies changes, but such correlation may lead to the location of additional amounts of gas.

A series of stratigraphic cross sections through the western half of the Appalachian Basin depicts the subsurface relations between tongues of dark shale on the east and massive thick shale units farther west.

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Effect of Biogenic Methane on Sediment Instability in Modern Delta Sediments

Biogenic methane is produced in rapidly deposited Mississippi delta sediments in concentrations sufficient to create excess pore pressures. These excess pressures, interacting with underconsolidated clays, can induce submarine mudslides and other phenomena which are hazardous to offshore platforms and pipelines. By utilizing a geochemical model for methane production, an estimate can be made of the total amount of gas that could be generated. Calculations of theoretical in-situ CH_4 were made on the basis of the concentrations of pressure-independent species, that is, dissolved SO_4^{2-} and dissolved inorganic carbon, in the pore waters of modern Mississippi delta sediments. The maximum theoretical CH_4 value was 4.65×10^5 ppm. Depth profiles of observed and theoretical CH_4 values were similar. From theoretical CH_4 concentrations and the pressure-solubility relationship, a maximum gas-pressure expression was developed. Gas pressures, P_0, attained a maximum value of 57.8×10^4 dynes cm^{-2} (8.5 psi) at the depth of 20.4 m below the sediment-water interface. Because of surface tension, in-situ P_0 decreases with bubble size. However, near-maximum gas pressures may be released during storm waves, mudslides, or other changes in hydrostatic pressure, where bubble combination can occur. Gas pressures are important in decreasing the effective stress, especially in regions of rapid sediment deposition, and should be considered when implanting bottom-mounted structures.

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Early Pleistocene Submarine Canyon, Boso Peninsula, Japan

The Boso submarine canyon was one of the first "fossil" canyons to be described. It is also one of the best exposed, because careful quarrying of the economically useful gravel fill has exposed the noneconomic marly rocks into which the canyon was cut. These country rocks (Umegase Formation) are gently dipping, cream-colored siltstones and mudstones. In contrast, the canyon fill (Higashi-higasa Formation) consists of brown to yellow sandstones with marked lenses of polymodal and polymictic conglomerates (with small pebbles of granites, basalts, cherts, and basic tuffs from the Chichibu terrane and much larger clasts of marlstone up to 1 m in diameter). There are also some boulder beds and armored mud balls and many early Pleistocene shelly fos-