deposition and dewatering. Deposits above the basal sand accumulated in broad, anastomosing channels 10 to 15 m deep with variegated fill; some still contain sand and conglomerate, but most were evacuated and filled with lower energy thin-bedded sands and muds or massive hemipelagic muds, indicating significant volumes of bypassed sand.

At the base of slope, a major 100-m deep leveed channel was floored with conglomerates and large canyon-wall clasts, and filled with massive to convoluted sandstone. The channel fed a system of shallow, crosscutting, conglomeratic channels, interpreted as inner fan that extended into the canyon mouth.

Paleobathymetric relief exhibited across this ancient shelf break is minimally 600 m (outer shelf to mid-bathyal or deeper) within a lateral outcrop distance of 3,000 m.

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Comparison of Eogenetic and Mesogenetic Porosity-Diagenetic Trends in Deeply-Buried Limestone Reservoir in West Texas

Stratigraphically trapped gaseous hydrocarbons occur in porous limestones of Atokan (Middle Pennsylvanian) age in the Chapman Deep field, along the northern shelf edge of the Delaware basin in Reeves County, Texas. These rocks were deposited as a shallow-water mosaic of cyclic algal bioherms, grainstone shoals, and low-energy interbank facies. A relatively uninterrupted sequence of porosity evolution related to early and burial diagenesis is recognized in these rocks. Syndepositional subaerial exposure resulted in the formation of a secondary pore system, including biomolds, non-fabric-selective vugs and channels, and solution-enlarged fractures. However, most of this porosity was occluded rapidly in the vadose and phreatic environments by calcite cementation, dolomitization, and internal sedimentation. Progressive burial to minimum depths of 13,000 ft (3,962 m) was accompanied by bulk-volume reduction via physical and chemical compaction. However, simultaneous fabric-selective dissolution rejuvenated a pore system of relatively low permeability which, enhanced by natural fractures and the presence of open stylolites, comprises the principal reservoirs in the field. Pore types include ooid and cement-solution molds; although not recognized in these rocks, burial-solution channels and vugs are reported to be relatively abundant in Smackover carbonates of the Gulf Coast region. Such tertiary porosity is easily misinterpreted as of meteoric origin, and its occurrence attests to a possible parallel evolution of eogenetic and burial-diagenetic processes and products.

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Tectonic Effects on Meandering River Deposits, Carboniferous, Nova Scotia, Canada

Sediments of the Boss Point, Port Hood, and Parrsboro Formations (Carboniferous) of Nova Scotia were deposited on alluvial plains in tectonically active basins bounded by strike-slip faults. Some basins contain over 1 km of strata of this age. Fining-upward fluvial channel sandstones are about 20 m thick and are composed of a vertical sequence of basal conglomerate, trough cross-beds, ripple lamination, and siltstone. Large-scale lateral accretion surfaces are present and the sandstones are interpreted as meandering river deposits. Floodplain sediments include crevasse splay sandstones, rooted mudrocks, thin coals, and lacustrine deposits.

The channel sandstones are stacked vertically and many form thick sandstone packages. One 1-km thick sequence, for example, consists of over 75% channel sandstone. There are similarly thick, laterally equivalent, sequences of flood-plain sediment with few or no channel sandstones. It appears, therefore, that meander belts were restricted in their positions for long periods, allowing the unusually thick sequences of channel and coeval overbank sediment to accumulate. The variation from the classic meander-belt model, in which avulsion randomly distributes the meander belts across the alluvial plain through time, was presumably due to differential subsidence rates which caused the meander belts to be restricted to the areas of higher subsidence, thus retarding avulsion frequency.

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Depositional Model of Sand-Dominated Mesotidal Estuary

Depositional environments were surveyed in a large sand-dominated estuary on the south-central South Carolina coast. The estuarine system is characterized by abrupt lateral variations in sediment texture, composition, and physical and biogenic sedimentary structures. Sand-dominated intertidal environments include point bars, ebb sand spits trailing seaward from marsh headlands, tidal sand ridges, and sandy tidal flats. Morphologically, point bars, trailing spits, and tidal ridges are in a continuum of linear to sinuous depositional forms 1 to 3 km long.

An idealized vertical section through these sand bodies is a fining upward sequence beginning with channel lags of coarse sand and gravel followed by interbedded and bioturbated sands and muds interpreted as channel-fill deposits. A gradation between high-angle, large-scale cross-bedding and low-angle, small-scale cross-beds is typical of bar platform and vertical accretion bar sands. Capping the sequence are muddy sands to laminated muds grading into salt-marsh deposits.

Sand flats that prograde from marsh islands typically display a fining-upward trend beginning with shell material concentrated in medium to coarse sand where high-angle cross-bedding is the dominant sedimentary structure. In the upper part of the tidal-flat sequence, biogenic structures increase and disrupt low-angle, small-scale cross-bedding. Wave-deposited laminated sands, capped by rooted, bioturbated marsh muds, top the idealized sequence. Delta-like deposits within the estuary are morphologically gradational between tidal-sand ridges and true flood-tidal deltas and include physical and biogenic structures common to both.

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Nonmarine Carbonates of Neogene Lake Idaho in Utah

Nonmarine carbonate sequences are not well known in Neogene rocks. Best known, perhaps, are two lacustrine sequences recently described in the Pliocene of western North America. One, in the Ridge Basin of southern California, contains numerous beds about one meter thick of stromatolitic and oolitic limestone interbedded with non-carbonate clastic rocks. The other, in southern Idaho, is the Glenns Ferry oolite, a 10-m thick carbonate sand unit exposed for 45 km along the western margin of the Snake River Plain. The latter unit is a deposit of the extensive Miocene-Pliocene lake system called Lake Idaho, and is considered the largest freshwater lacustrine oolitic carbonate sequence known in the rock record. New

evidence from fossil fishes indicates that Lake Idaho extended into northern Utah, where it is recorded in an uninterrupted sequence 60 m thick of diverse carbonate facies in the fluviolacustrine Salt Lake Formation.

In Utah, the lake carbonates are best exposed in a landslide scarp in the Junction Hills, near the northern end of the Wasatch Range. Distinctive carbonate facies in the scarp and nearby exposures include: (1) cross-stratified oolitic calcarenite, in which ooids range from 0.1 to 4.0 mm in diameter, in foreset units from a few cm to 17 m thick; (2) algal stromatolites in cabbage-shaped heads and laterally linked hemispheres as high as 50 cm; (3) skeletal carbonate beds composed predominantly of tests of ostracods and mollusks; (4) convoluted bodies of contemporaneously slumped carbonate sand up to 3 m thick; and (5) a 55-m thick unit of lithographic limestone overlying the scarp sequence. These lake beds appear to represent the thickest and most diverse succession of nonmarine Neogene carbonates known in North America.

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New Surface-Sediment Distribution Maps for Pacific Ocean

New surface-sediment distribution maps at 1:10,000,000 have been compiled as part of the Circum-Pacific Map Project. These maps represent the first depiction of such sediments on a systematic and uniform scheme for the entire ocean basin. The primary data used were the qualitative analysis of all Pacific cores in the Lamont-Doherty Geological Observatory collection (3,710 at last count) using smear-slide analyses by petrographic microscope combined with laboratory determinations of $CaCO_3$ content for quantitative control; additional data were taken from published smear-slide descriptions by others, and secondarily from the World Data Bank and the published literature. Ten dominant sediment types are depicted, with three minor types, in a classification based upon calcareous-biosiliceous biogenic components and conventional textural attribution. Base maps for the new maps, including bathymetry, are the five, 1:10,000,000 sheets produced by the Circum-Pacific Map Project on an equal-area projection. The maps depict unconsolidated sedimentary deposits exposed on the Pacific Ocean floor, at least those presumably at the sediment-water interface recovered by coring and dredging, and do not necessarily represent Holocene or recent material. The Circum-Pacific Map Project is a cooperative international endeavor intended to summarize the relation of known hydrocarbon and mineral resources to the major geologic features of the Pacific basin and surrounding continental areas.

MCCUBBIN, D. G., and J. W. PATTON, Marathon Oil Co., Littleton, CO

Burial Diagenesis of Illite/Smectite, a Kinetic Model

X-ray diffraction analysis of clay-rich sediments of Miocene and younger age from 14 wells in offshore Louisiana supports the published conclusion that diagenetic changes in the mixed-layer illite/smectite (I/S) clays involve a progressive downward increase in the proportion of illite layers, followed by a change from random to regular interstratification and a further increase to about 80% illite layers. We also found that the depth at which these diagenetic changes begin and the degree of alteration at any given depth vary substantially from well to well and are related to the age and burial rate of the sediments as well as to present-day subsurface temperatures.

This burial alteration was modeled using a first-order reaction equation with a term to describe a non-linear increase in temperature with time. For each of several wells where we had complete data, we solved this equation for values of activation energy (E) and frequency factor (a). The resulting values of (E) are fairly consistent among wells and are close to those determined experimentally by others. The calculated values of (a) are lower by two orders of magnitude than the reported experimental values, but range considerably. The same equations can be used to calculate the degree of reaction for different times and temperatures, assuming these or other values of (E) and (a). This kinetic model should be helpful in deciphering the influences of I/S reactions on interstitial fluid pressures, fluid and rock chemistry, and shale physical properties.

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Middle Tertiary Laumontite Isograd Offset 37 Km by Left-Lateral Strike-Slip on Santa Ynez Fault, California

The Santa Ynez fault is mappable for 133 km westward from its apparent truncation by the Agua Blanca thrust on the east, nearly to Point Conception on the west. Neogene dip separation is locally large, and substantial left-lateral strike-slip is suspected. Total slip, however, is undefined, and the movement history has been obscure, partly owing to the lack of recognition of any trustworthy piercing point or steep plane.

Some Paleogene and older strata along the fault contain laumontite. This mineral is a distinctive indicator of burial changes in mineralogically immature rocks that have been heated with dilute pore waters at above-average geothermal gradients. Laumontite crystallizes from the surface to more than 7,000 m (controlled by temperature, fluid pressure, and fluid composition); alteration fronts at intermediate depths are clearly defined and locally steep.

Preliminary results of a reconnaissance study suggest that a steeply inclined northeast edge (isograd) of laumontite alteration is offset by the fault 37 km left-laterally. Pervasive alteration south of the fault is conspicuous everywhere in susceptible lithologies of the lower Matilija Sandstone (Eocene) and all older strata west of lat. 118°57′W. Alteration north of the fault is conspicuously absent wherever the same units are visible (subsurface and surface) east of the alteration edge near lat. 119°20′W. Stratigraphic and structural reasoning suggests that the laumontite crystallized about 22 to 25 m.y.B.P. Santa Ynez fault left-lateral slip necessarily predates the inception of San Gabriel fault right-lateral strike-slip (10 to 13 m.y.?B.P.).

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Sandstone Tongue of Cherry Canyon Formation and Upper San Andres Formation (Permian), Last Chance Canyon Area, Southeast New Mexico

The sandstone tongue of the Cherry Canyon Formation and the overlying upper San Andres Formation, exposed in the Last Chance Canyon area, represent a progradational sequence of slope, shelf, and nearshore systems. Based on lateral and vertical lithofacies relations, a paleoenvironmental model in a landward to basinward transect consists of the following: a supratidal through subtidal mixed carbonate-siliciclastic tidal flat; a mixed carbonate-siliciclastic lagoon; a fusulinid shelf shoal or bank complex; a predominantly carbonate open-