longer distances within the San Diego trough. Parallel and current-ripple cross-lamination, as well as imbricated mud pebbles, reworked from the underlying old clay, are more abundant than distinct grading. Study of grain fabrics (imbrication) by the use of magnetic susceptibility anisotropy and evaluation of cross-lamination foresets generally show downslope direction of sediment transport, confined to the canyon-fan valley system. Current measurements and observations from deep submersible vehicles indicate that bottom currents capable of transporting medium to coarse sand have a pulsating (tide-related?) flow (maximum velocity, 10–25 cm./sec.) both up and down La Jolla Canyon. These data suggest that probably most of the sand in water depths up to 1,100 m. was transported, or at least reworked, by ordinary tractive bottom currents (or diluted "steady" suspension currents), rather than by occasional "spasmodic" turbidity currents.

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Relation of Hydrocarbon Accumulation to Deltaic Sedimentation in Western Kentucky

Deltaic and fluvial sedimentation processes are recognized as primary dispersal mechanisms that operated to contribute sediments to the Chesterian depositional area in Illinois, Indiana, and Kentucky.

As the fluvial cycle was initiated, erosion channels were incised into the underlying strata. Clastic sediments were delivered to the depositional area by the Michigan River system. The channel fill may be traced from its outcrop into the subsurface and across Kentucky more than 300 miles. The fill may be projected, with considerable success, into areas where few tests have been drilled. Successful projections have been accomplished by making isopachous maps of the channel fill. Once the distributary network is outlined, a direct relation is apparent between the channel system and hydrocarbon accumulation within the Bethel Sandstone. The recently discovered Midland, St. Charles, Barnsley, Luzerne, and Sharon School fields occur within the distributary network.

All of these fields are combination traps. They are restricted to the channel fill and are localized by subsequent structural deformation.

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Compaction Tests on Aragonitic Sediment

Microcrystalline aragonite from the Bahama Banks was compacted in the laboratory at pressures from 10^{-1} to 10^5 psi. at room temperature; the effects of heating were explored. The important conditions affecting the maximum compaction were total pressure, rate of loading, rate of removal of water, grain-size, and cohesion of grains. Conditions having a minor effect were initial water content, time period of compaction (for periods of more than 3 hours), and temperature (for water-saturated samples).

A new parameter is proposed to characterize compaction: grain proportion (g), which is equal to the volume of grains divided by the bulk volume; g is equal to one minus porosity expressed as a decimal fraction. Grain proportion is a useful index of compaction because it is also the ratio of the dry bulk density to the grain density of the sediment, and thus is a linear measure of the approach to solid rock.

The effect of raising the pressure from 1 psi. to 10^5 psi. on Bahaman aragonitic sediment is to increase the compaction from $g = 0.3$ to $g = 0.8$. Rapid loading of the sediment (at 10^4 psi./min.) results in differential compaction ranging from $g = 0.85$ under the moving piston to $g = 0.65$ at the stationary piston; differential compaction also seems to occur at very slow loading rates (10^{-6} psi./min.). Constricted egress of water as the sediment is compressed can reduce the amount of compaction by $\Delta g = 0.1$. Sediment of 1μ median grain-size compacts to $g = 0.5$ under 500 psi., but sediment of 200μ median grain-size compacts only to $g = 0.4$ under the same pressure; furthermore, the compacted coarse sediment falls apart, but the fine sediment is relatively coherent.

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Biostratigraphy of Blake Plateau (Atlantic) Drill-Hole Samples

Paleontological study of cored sediments from six drill holes on the continental margin off eastern Florida, in water depths ranging from 25 to 1,030 m., has made possible the reconstruction of faunal successions of planktonic Foraminifera through most of the Tertiary. The oldest assemblage cored includes species characteristic of the middle Paleocene *Globorotalia pusilla pusilla* Zone. With the exception of the Oligocene, the foraminiferal sequences present beneath the continental shelf, Florida-Hatteras slope, and Blake plateau are in general accordance with those established in the Caribbean region for marine beds now exposed on land. The Oligocene interval is identified on the basis of foraminiferal faunas found in the Vicksburg Group of the Gulf Coast, this equivalent being absent from the otherwise well-developed Tertiary of Venezuela and Trinidad. Miocene sections are best developed in J-3 hole in the southeastern part of Blake plateau, where approximately 49 m. of lower Miocene, 16 m. of middle Miocene, and 10 m. of upper Miocene consist entirely of *Globigerina*-ooze facies.

A marked contrast in sedimentary facies, *i. e.*, shallow-water calcarenite and silty phosphatic clay in nearshore holes, versus *Globigerina*-coccolith ooze in offshore holes, appears to have persisted from Eocene through Miocene times. Eocene and Oligocene sediments from nearshore sites contain assemblages of planktonic Foraminifera mixed with the benthonic species characteristic of Gulf Coast stratigraphy, thus enabling clear correlation of the Gulf Coast stages with established planktonic foraminiferal zones.

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Role of Kinetics in Early Diagenesis of Carbonate Sediments

Because most modern carbonate sediments are a mixture of several metastable carbonate phases, studies of such deposits necessarily represent instantaneous observations of disequilibrium systems which may be undergoing slow but significant change. Conventional thermodynamic (equilibrium) models may be of little value in interpreting such observations, but kinetic and steady-state models promise to afford a clearer understanding of depositional and early diagenetic processes in natural environments.

Reaction rates for a wide variety of reactions involving carbonate phases and aqueous solutions have been investigated by monitoring pH changes as the reactions proceed. Rate constants are available for the escape of CO_2 from solution, for the dissolution of a wide range of calcium and calcium-magnesium carbonate minerals, and for growth rates of aragonite and calcite. Preliminary studies of nucleation energy and nucleation induction time have been carried out, but these studies have limited applicability to natural systems where abundant nuclei already are available. In certain cases where carbonate deposition is assumed to occur, tetracycline marking techniques have been employed to test the validity of the kinetic models.

On the basis of the experimental results, kinetic theory allows the following predictions: (1) in the presence of organisms, surface waters will appear oversaturated with respect to both CO_2 and dissolved carbonates during daylight hours; (2) the composition of a solution in contact with mixed carbonate phases will be determined by the more rapid of the simultaneous dissolution and precipitation reactions, with dissolution generally being the controlling process; and (3) in the absence of a continuing supply of metastable phases, equilibration will be approached more rapidly by the removal of metastable phases (either by solution or by replacement) and much more slowly by interstitial carbonate precipitation. Each of these observations is supported by field evidence.

The observations made suggest the need for caution when applying the results of field study of modern carbonate environments to the interpretation of ancient carbonate rocks.

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Early Post-Depositional Preservation of Paleosalinity, a Mathematical Approach

Early alteration of interstitial water can appreciably hasten sediment diagenesis; this is especially true for calcareous deposits. Thus, from a theoretical standpoint, it is of interest to determine if "original" interstitial water can be preserved as a paleosalinity in areas where post-depositional bottom-water salinity changes characteristically take place, *e.g.*, coastal swamps and deltas.

A model based on the coastal mangrove swamps of southwest Florida, an area where marine swamps recently have replaced fresh-water swamps, was constructed and an equation derived to evaluate the effect of long-term and short-term salinity variations in swamp water on the salinity of water entrapped in the 1–3 meters of sediment underlying the swamps. The model considers ionic diffusion in a homogeneous sediment column overlying an impervious basement and underlying swamp water that seasonally (short term) fluctuates in salinity and that systematically decreases or increases in mean water salinity over periods measured in years (long term).

The model predicts that, in areas where the bottom water has an annual sinusoidal-salinity fluctuation with an amplitude of 35 ‰ (parts per mil), the interstitial water will be affected significantly (more than 0.2 ‰) in the upper 35 cm. of the underlying sediment. This prediction is borne out by field data. If the mean water salinity about which the short-term fluctuations take place is increased or decreased, most of the effect of the drift in the mean is transmitted to the bottom of the sediment column within a few hundred years. Normal sedimentation rates in the swamps have little effect on the rate at which the interstitial water is modified.

Preservation of paleosalinities in the coastal swamps of southwest Florida, or in similar environments, evidently requires special condition, *e.g.*, a recent change in mean bottom-water salinity combined with rapid deposition of sediment. Deposition of sediment isolates underlying deposits from diffusion contact with the changed bottom water.

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Diagenesis and Geochemistry of Sediments in Marine Environment

Diagenetic alterations were induced in sediments in a model representing a shallow-marine shelf by injecting synthetic sea water under partial pressure of carbon dioxide. The sediments from the model were then removed and studied under the petrographic microscope. The study included (1) the interrelation of the chemistry of the interstitial fluid and the mineralogy of sediments, (2) the factors controlling the formation of silica and calcite cements, (3) the processes responsible for transforming sediments into hard rocks, and (4) the sequence of these processes.

The precipitation of silica and calcium carbonate as cements in the model sediments was detected under the petrographic microscope and is shown on photomicrographs. The petrographic analyses indicate that during early diagenesis cements formed in intergranular space only. The calcite cement crystallizes as small fibrous crystals around the grains extending into the pore space and subsequently results in rim cement. Silica cement is formed simultaneously both as overgrowths and in optical continuity around sand grains.

The silica and calcite precipitated as cements in the model seem to be derived from the interaction of clays and sea water. Geochemical environments for such reactions and environments which enhance the cementation of sediments were interpreted from the studies.

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Outline of Geology of Niger Delta

The coastal sedimentary basin of Nigeria has been the scene of three depositional cycles. The first started in middle Cretaceous time with a marine incursion and was terminated by a mild folding phase during Santonian time. The second began with the growth of a proto-Niger delta during Late Cretaceous time and ended in a major Paleocene marine transgression. The third cycle, lasting from Eocene to Recent, was the continuous growth of the main Niger delta.

A new three-fold lithostratigraphic subdivision is introduced for the Eocene-Recent Niger delta subsurface, comprised of an upper sandy unit called the Benin Formation, an intervening unit of alternating sandstone and shale named the Agbada Formation, and a lower shaly unit called the Akata Formation. These three units extend throughout the delta and each ranges in age from early Tertiary to Recent. A separate member of the Benin Formation is distinguished in the Port Harcourt area. The Afam Member is interpreted as an ancient valley fill formed in Miocene sediments. Subsurface structures are interpreted