ly festooned and planar-cross-bedded tidal-channel sandstone and festooned, burrowed washover sandstone. The beach-bar sandstones are very fine to medium grained, quartz rich (54%), and commonly burrowed by *Ophiomorpha.*

Differentiation of Pictured Cliffs Sandstone depositional environments led to recognition of deltaic and back-barrier coal deposits of the overlying Fruitland Formation.

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Ancestral Delta Lobe of Santee River Near Charleston, South Carolina

The Santee River of North Carolina and South Carolina emptied into the sea 75 km west of its modern mouth when the shoreline was 15 to 21 m above present sea level in early Pleistocene time. For a short time, the river deposited a fluviomarine delta lobe (volume 5 cu km) that covered 400 sq km near Summerville, South Carolina, 35 km northwest of Charleston. The Summerville lobe was abandoned before the late Pleistocene, and the sea has not covered the area since then. The original wave-constructed ridge-and-swale topography is still visible; drill holes have revealed the subsurface lithofacies relationships. In the modern Santee delta and the chenier plain of Louisiana, similar topography and patterns of lithofacies reflect alternating dominance of flood-plain deposition and shoreface redistribution.

Paleontology, paleomagnetic stratigraphy, and sediment mineralogy contribute to the age determination of the Summerville lobe. On the basis of fossil pollen and invertebrates identified by U.S. Geological Survey paleontologists, the Summerville lobe deposits are tentatively believed to be equivalent in age to the Waccamaw Formation (late Pliocene and early Pleistocene) of northern South Carolina. Surficial heavy- and light-mineral suites are more mature, and thus older, than paleontologically dated late Pleistocene shoreline deposits nearby. Less weathered mineral suites below the water table in the Summerville lobe reflect the Piedmont (Santee River) source of the sediment. Preliminary paleomagnetic data are compatible with this age determination.

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Oceanic Crust

The model presented is based on the interpretation of marine geophysical data, studies of dredged rocks, theoretical modeling, geologic investigations of ophiolite complexes on the continents, and results of deep-sea crustal drilling by JOIDES/IPOD.

Along the axis of the midoceanic ridge system a zone of upwelling asthenosphere extends from the base of the lithosphere at 50 to 70 km to the base of the oceanic crust. Within this prism, which narrows upward, adiabatic decompression of asthenospheric material results in partial melting, forming basaltic melt. The basaltic liquid coalesces into pockets of magma at shallow depths, forming magma chambers typically located a few kilometers beneath seafloor and centered beneath the axis of the ridge crest. Crystal fractionation takes place within these chambers, but generally never evolves too far because of the periodic addition of fresh magma from below and loss of magma to the seafloor. Profound complications exist, however, because several primitive magma types have been clearly defined which cannot be related to each other by crystal fractionation in shallow, crustal magma chambers, but must reflect different mantle compositions and/or melting processes. Either several zones of melting and magma ascent in the asthenosphere or a compositionally heterogeneous mantle is implied. Furthermore, drilling results demonstrate that distinct magma types occur in units of variable thickness (50 to 200 m), implying generation and fractionation of distinct batches of magma. This suggests that magma generation and emplacement is an episodic rather than a steady-state process, and argues for the coexistence of several magma chambers of restricted size, rather than a single, large, continuous magma chamber. In time, cooling of the magma chamber leads to a lower oceanic crust composed of gabbroic rocks and cumulates. The plutonic foundation of the oceanic crust is overlain by an assemblage of sheeted dikes which are capped by a chaotic extrusive carapace of pillow basalts, massive and thin flows, sills, and intercalated sediments. Seawater percolates down through the brittle carapace of the oceanic crust along permeable pathways, reacts with the hot rock at depth, and leads to metamorphism of the lower crust. Furthermore, the high thermal gradients at the ridge crest lead to the development of convective circulation of seawater through the shallow intrusive and extrusive lid of the crust, causing widespread low-temperature alteration. The water is heated and leaches material from the rocks; these dissolved constituents are either deposited along voids within the crust or are deposited on the seafloor as metallic sulfides, manganese and iron oxides, or metal-enriched sediments.

This model is still a working hypothesis, and much of it is based on circumstantial evidence. The model will change as a function of the evolving, accreting-plate-margin mosaic.

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Geology of Southeast Georgia Embayment

Computer-generated lithology-porosity calculations based on corrected sonic, density neutron, and gamma-ray logs can aid greatly in interpreting the rock record. Percentage shale calculations averaged over uniform intervals show one-to-one correlation with environmental interpretations derived from micropaleontologic data for Upper Cretaceous rocks in the COST GE-1 well. For the marine section percentage quartz parallels percent shale and both follow the general trend of transgressions and regressions suggested by P. Vail et al.

The transgressive pulses at the GE-1 site are quite similar to those at the B-2 site. The depositional sequence is similar at the two sites, with both containing Upper Cretaceous shelf carbonates, Lower Cretaceous nonmarine clastics, and a decreasing rate of deposition with time.

Lower Cretaceous Albian anhydrite present at GE-1 is absent at B-2. Conversely Lower Cretaceous coal, abundant at the B-2 location, is absent at GE-1. Given the otherwise similar stratigraphic sections, these differences are believed mainly climatic in origin. Porosity in GE-1 Lower Cretaceous sands shows only slight decrease with depth.

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Environmental Studies at NOAA's Atlantic Oceanographic and Meteorological Laboratories

Two major current projects are focusing on processes and rates of marine sediment transport on the inner shelf, at the shelf edge, and on the continental slope. They are the Inner Shelf Sediment Transport Experiment (INSTEP) and the Marine Geotechnical Rational Use of the Sea Floor (RUSEF).

INSTEP is designed to investigate the rates and directions of sediment transport and the process by which sediments are resuspended from the bottom. Initial studies are on the inner Long Island, New York, shelf, a typical barrier-island coast. Suspended-sediment flux, bottom erosion versus deposition, and bottom characterization are integrated work units. The nucleus of the project is data collected from three "state of the art," bottom-boundary-layer sensing platforms which measure (1) suspended-sediment concentration and current 1 m off the bottom; (2) current-velocity and sediment-concentration profiles in the bottom 1 m of the water column, and (3) the current-velocity profile in the bottom 2 m and the suspended-sediment concentration 1 m above the bottom. The study is designed to measure, for the first time, the threshold of sediment transport with increasing current in the marine environment owing to the combination of unidirectional and wave-generated currents.

Marine Geotechnical RUSEF programs include seafloor-stability studies on the continental slope off the northeastern United States and on the shelf off the Mississippi delta, and a sediment-transport study along the northeastern United States shelf edge. Most of the northeastern continental slope north of Cape Hatteras has been mapped with shallow-penetration seismic reflection profiling and narrow-beam echo soundings. Extensive piston and hydroplastic gravity coring was done in both regional and site-specific areas. For the first time, several large slump blocks have been identified, one of which has been mapped in detail. A major effort is underway to identify by geotechnical methods the conditions (processes and mechanisms) leading to mass slumping and other types of seafloor instabilities.

The Mississippi delta research is a cooperative NOAA-Lehigh University seafloor-engineering study using in-situ instrumentation to determine and assess critical soil properties important in stability analyses.

Two other studies of interest to the petroleum industry are a geochemical study of hydrocarbon concentrations in the water column and in bottom sediments, and an extensive current-meter program, both in the New York Bight from the shelf edge to the inner shelf.

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Subaqueous Gravity-Displacement Products

All sediments deposited on subaqueous slopes are affected by the tangential component of the earth's gravity. Among the kinds of gravity-displacement processes are subaqueous rock falls, slumps, and debris flows. Turbidity currents are likewise processes affected by the slope, but are not a subject of discussion here.

Individual blocks of rock move down a slope from reefs and coastal cliffs; they result from bioerosion, the effects of storm, or ordinary gravity. Incoherent slumps generate a body of sediment so thoroughly mixed and churned that nearly all traces of stratification are obliterated. Debris-flow deposits containing large blocks are known as olistostromes. In places, such olistostromes have been mistaken for melanges, a mixture of huge blocks of diverse kind and provenance dispersed in pervasively sheared and fine-grained matrix which forms a special kind of tectonic breccia. Deep-water rubble of shallow-water carbonate rocks, usually angular, interstratified with dark deep-water marine shale is known as brecciola. Brecciolas accumulate at the toe of the slope. On the upper part of the slope accumulate sediments resulting from coherent slumps which have moved down a slope with their strata still preserved. Deposits of slope-influenced sediments may also result from contour-following currents (contourites) which travel along the lower parts of slopes.

Many examples of ancient gravity-displacement products have been reported from the rock record, among them the so-called melanges (in fact, olistostromes) of Turkey, slope-fan-basin-plain deposits of the Appalachians, and basinal deposits in the Delaware basin of west Texas. In the Taconic sequence of the Appalachians, as in many other hinge-line deposits, only the lower slope and base-of-slope portion of the early Paleozoic continental margin has been preserved.

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Dolomite is Evaporite Mineral—Evidence from Rock Record and from Sea-Marginal Pools of Red Sea

Despite recent pleas to consider dolomite a product involving fresh water, especially the reaction between fresh water and seawater, more recent work in the rock record and in sea-marginal pools of the Red Sea commands a return to the earlier hypothesis that most dolostones owe their origin to hypersaline brines and that dolomite is an evaporite mineral. Schizohaline dolostones, as well as other examples, commonly lack evaporites; yet these dolostones probably accumulated under hypersaline evaporitic conditions although the evaporite minerals have since vanished. However, the imprint of evaporite minerals and other evidence for hypersalinity have been preserved. Evidence includes (1) abundant authigenic feldspar; (2) calcitized anhydrite nodules; (3) euhedral quartz crystals; (4) solution-collapse breccias; (5) ghosts and pseudomorphs of former crystals of gypsum or anhydrite, now preserved as molds, calcite, or pyrite, in some places preserving the