have been more active in exploiting these properties than have sedimentary petrologists interested in understanding the processes of diagenesis and lithification of calcareous and siliceous sediments.

Lithologic criteria indicate very small volumes of oceanic biogenous sediments of post-Jurassic age are exposed on land, and it is questionable if any but relatively tiny amounts of any age have ever been added to the continents.

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Deep-Sea Drilling in Antarctic—Late Tertiary Paleoclimatic History

Bold efforts by *Glomar Challenger* to drill in little explored regions of the southern ocean and its environs have considerably advanced knowledge of the earth's paleoclimatic history despite notable logistic problems encountered in working at high latitudes. Of special interest has been the discovery of evidence for the initiation of Southern Hemisphere glaciation during the Oligocene (DSDP Site 270) and the documentation of a particularly severe late Miocene glaciation of Antarctica which may have exceeded all others in intensity. Paleontologic evidence for reduced sea levels and sea temperatures associated with late Miocene glaciation was early noted among foram assemblages from New Zealand, and subsequently confirmed by oxygen isotope analysis (DSDP Site 284). Closer to the continent, late Miocene deep-sea sediments are characterized by strong bottom-current winnowing and multiple hiatuses; contained microfossils are highly fragmented and of low diversity (DSDP Sites 266 and 274). Farther away on the Falkland Plateau, the upper Miocene section is more complete but separated from the overlying Pliocene by a marked disconformity produced by a climatically intensified Antarctic Circumpolar Current (DSDP Site 329), whereas in an adjacent basin, the unconformity was probably produced by accelerated Antarctic Bottom-Water flow (DSDP Site 328).

Equally important to the definition of major climatic events has been the establishment of high-latitude biostratigraphic zonations based on prevalent microfossil groups, particularly diatoms, radiolarians, and silicoflagellates. Keyed into paleomagnetics and the less well-represented calcareous microfossil zones, these new high-latitude biostratigraphies set the stage for future exploration in this area.

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Stratigraphic Models for Modern Back-Barrier Environments

Kiawah Island, South Carolina, is a mesotidal barrier island composed of prograding beach ridges backed by extensive salt marshes, tidal creeks, and muddy tidal flats. The salt marsh–tidal creek complex is well developed along the length of the island and between bifurcating beach ridges. The major subenvironments of the back barrier are sandy high marshes adjacent to relict beach ridges, rooted and burrowed low marshes, tidal flats and associated oyster bars, active tidal creeks with sandy point bars, and inactive tidal-creek channels (cutoffs) being filled with fine-grained sediment.

Four stratigraphic models based on examination of 60 vibracores penetrating up to 6 m, 20 box cores, numerous channel cutbanks and surficial sediment distributions have been developed to describe the relations of Kiawah's back-barrier environments. (1) The active tidal-channel model consists of a coarse, cross-bedded shell lag underlying muddy-sand point-bar deposits. Bioturbated muddy sand containing shell hash and organic material commonly overlies the point-bar deposits and is capped with rooted, highly burrowed, fine-grained low marsh deposits. The basal unit of this entire sequence and of most cores is a lagoonal-bayfill mud containing *Rangia*. (2) The cutoff channel model contains a fining-upward sequence developed as a result of decreasing flow through the abandoned channel. Low marsh may also cap this sequence. (3) The tidal-flat model is best developed in shallow, open lagoonal areas. In this sequence, active channel-fill and point-bar deposits are capped by thick tidal-flat sediments. (4) The "mature" marsh model is developed where beach ridges are absent and low marsh is predominant. This sequence consists of channel-fill, fine-grained point-bar deposits, tidal-flat deposits, and very thick, rooted and burrowed low marsh sediments. The predominance of sandy point-bar and channel-fill deposits in this low-energy back-barrier area is significant and can be related to the reworking of beach ridges by meandering tidal creeks.

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Utility of Diatoms in Petroleum Exploration

Within the past decade diatoms have played a new and important role in the multidisciplined biostratigraphic approach to the search for petroleum. Diatoms have characteristics unique to the microfossil world. They are microplants; their tests are composed of silica; they live as sessile and vagile benthic and planktonic organisms; their optium environment is in the cool to cold water in the middle and high latitudes in addition to areas associated with nutrient-rich upwelling oceanic waters; and they are widely distributed geographically. Therefore, diatoms have been used biostratigraphically to date and correlate Mesozoic and Cenozoic rocks in various geographic areas where they occur to the exclusion of other microfossils. They also serve as a check on other microfossils where they do occur together. They can be used to determine whether rocks are of marine, brackish, or nonmarine origin and to determine if these rocks were deposited in shallow or deep water. One of the most important biostratigraphic uses of diatoms is in dating various sparker lines on a sparker profile. They can also be used to define the limits of various types of zones and to determine important datum levels.

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Geologic History of Deep Gulf of Mexico Based on Regional Multifold Seismic Lines

Four annotated regional multifold seismic lines across the deep Gulf of Mexico illustrate details of many of the major geologic features. The thick sedimentary section (up to 9 to 10 km) underlying the deep gulf is subdivided into six major sequences or units whose boundaries are major unconformities along the southern margin of the basin, tentatively dated as middle Cenomanian, early Tertiary, middle Oligocene, late Miocene, and the Pliocene-Pleistocene boundary. These units provide a framework for analyzing and discussing the stratigraphy, structure, and geologic history of the deep gulf. A northeast-southwest line 1,000 mi (1,600 km) long from the Florida Escarpment to the Mexican Shelf shows the following major geologic features: (1) the Mexican Ridges foldbelt as a decollement and possible large gravity slides; (2) details of salt deformation in the Campeche-Sigsbee salt dome province; (3) a smooth subsalt basement reflector that possibly represents a major unconformity on top of an attenuated continental crust; (4) an irregular acoustic basement beneath the central Gulf of Mexico that possibly represents some type of oceanic crust; (5) a cross section of the thick Pleistocene Mississippi fan; and (6) a thick Jurassic to Lower Cretaceous sedimentary section thickening beneath the northern Florida Escarpment. Some of the geologic features seen along three north-south seismic depth sections include: (1) unusual salt or shale wedges beneath the upper Mississippi fan; (2) evidence for Jurassic sedimentation and early salt deformation in a basin just northwest of the Campeche Escarpment; and (3) details of the basement structure and the overlying Jurassic to Lower Cretaceous sedimentary sequences in the deep gulf between the northeastern Campeche Escarpment and the Florida Escarpment.

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Structure-Contour Maps Computer Constructed from Orientational, Stratigraphic, and Positional Outcrop Data

The manual of computer-based methods currently employed in exploration to produce structure-contour maps of coal seams requires numerous drill holes to provide the necessary three-dimensional control. The following method, illustrated by maps of coal seams from the Rocky Mountain foothills of Alberta, uses only orientational, stratigraphic, and positional data from outcrops. It has four steps: (1) establishment of structural domains within which the coal is approximately cylindrically folded; (2) construction of the coal seam's profile in each domain; (3) projection of each profile parallel with its fold axis in order to generate the coordinates of a set of points on the seam in each domain; (4) computer contouring of the resulting elevations. The first and fourth steps use known procedures. The second step can be carried out graphically using a computer plot showing the geographic location, stratigraphic position, and bedding trace of each outcrop projected onto a plane normal to the fold axis. Alternatively, where the stratigraphic positions of the outcrops are known precisely enough and the structure is not too complex, the computer can be instructed to interpolate the coal seam between the various projected outcrops. The third step involves using the appropriate digitized profile and fold axis to predict the coal seam's depth beneath each outcrop and saving these values for the contouring stage.

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Carbonate Mud Mounds from Lower Ordovician Wah Wah Limestone, Ibex Area, Western Millard County, Utah

Four carbonate lenses in the upper Wah Wah Limestone, western Utah, were core drilled. Thin sections and peels show that the lenses are mud mounds consisting primarily of micrite matrix, with some bioclastic debris, and minor (< 1%) intraclasts, pellets, iron minerals, and calcite fillings. Bioclastic debris consists of sponges, echinoderms, shell fragments (brachiopods and trilobites), and an encrusting problematic organism. Porosity is less than 1%; dolomitization averages less than 10%. The lenses are extremely burrowed. These fragments were transported to the buildups by currents which varied from fairly low energy to moderately high energy. The absence of frame-building organisms in growth position indicates that these buildups are mud mounds rather than reefs. Formation of the mud mounds could have resulted from sediment trapping by some organism, from sediment heaping by currents, or by a combination of both processes. The mud mounds are similar to those of other geologic periods. The mud mounds, although similar to reefs in external appearance, could have significance in that they serve as examples of what reefs are not. They also demonstrate that not all reeflike carbonate bodies offer potential for petroleum. Analysis of the interiors of carbonate lenses is required to distinguish reefs from mud mounds.

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Immanitas Bed, Paso del Rio, Colima, Mexico

Immanitas is a rudist bivalve genus of the family Caprinidae described by Palmer in 1925. With one possible exception described by Coogan from the subsurface of south Texas, the genus has been reported from only one locality—at Paso del Rio, which is the old ford on the Rio Armería, just below the village of Periquillos, Colima, Mexico.

The *Immanitas* bed itself is a single carbonate cycle starting at the base with about 2 m of wackestone, overlain by packstone and perhaps grainstone for a total thickness of 4 m. In the packstone and grainstone the clasts are nearly all rudists, of which there are many giant specimens of species of *Immanitas*.

The single cycle represents a shoal area in a thick sequence of volcaniclastic rocks, at least part of which are marine. On the high-energy side of the shoal area, to the east, the carbonate bed gives way to dirty quartzarenite. Toward the low-energy side, on the west, the