shortcomings, which reflect mostly the state of the art, calcareous nannofossils are increasingly important in Gulf Coast Early Cretaceous exploration.

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ATCHAFALAYA BAY, LOUISIANA—REGIONAL SUBSIDENCE AND CONTEMPORARY DELTA FORMATION

Approximately 30% of the lower Mississippi River presently is diverted into the Atchafalaya distributary. As a consequence, lacustrine deltas rapidly are filling Atchafalaya basin lakes, increasingly coarse-grained sediments are entering Atchafalaya Bay, and a new delta—though probably geologically short-lived—is beginning to form. Understanding the geologic and hydrologic processes giving rise to this newly born delta might provide a clearer insight into the evolution of deltas as recorded in ancient sediments.

In the initial subaqueous phase of deltaic development (between 1952 and 1962) more than 120 sq km of Atchafalaya Bay had been covered by at least 0.5 m of new sediment. Local filling near the delta apex exceeded 2 m. The following phase, an estimated 50-year period of rapid subaerial expansion and shoreline accretion, has just begun. Comparison with modern Mississippi River subdeltas suggests the Atchafalaya delta eventually will deteriorate because of subsidence, compaction, and probable abandonment of the lower river course for a more direct, higher gradient route to the sea.

Analysis of tide records from Eugene Island and other Louisiana coastal stations indicates that in the last 30 years the rate of sea-level rise in Atchafalaya Bay ranged from 0.80 to 1.32 cm/year, almost exclusively because of regional subsidence. This exceeds even the rapid glacio-eustatic sea-level rise 6,000–10,000 years ago—an estimated 0.07 cm/year. Despite deposition into this rapidly subsiding trough, the Atchafalaya delta is still prograding; its ultimate internal form will reflect an interaction of sediment supply, wave energy, and regional tectonism. Unless modified by man, the Atchafalaya delta will expand across its bay 14.2 to 16.9 sq km/year until about the year 2020, creating approximately 950 sq km of new coastal land.

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CALCAREOUS NANNOFOSSIL APPLICATIONS IN GULF OF MEXICO–CARIBBEAN REGION

Preliminary investigations of the stratigraphic utility of calcareous nannoplankton in the Gulf of Mexico–Caribbean region were begun prior to 1954. Most of the applications of these minute forms, however, have been published during the last decade. Their stratigraphic occurrences have been documented for the Late Cretaceous and younger sections of the region, but, insofar as is indicated through publication, they have not gained the status of routine application in onshore and nearshore subsurface studies.

However, the stratigraphic value of calcareous nannofossils has been demonstrated amply. They are second to no group for the rapid evaluations needed routinely in the shipboard work connected with geologic oceanographic studies. Their worldwide applications, particularly in the Joint Oceanographic Institutes Deep Sea Drilling Program, include the Caribbean and Gulf of Mexico. Late Cretaceous through Holocene species occurrences have been calibrated for the Gulf region with the planktonic foraminiferal-based zonation scheme on Leg X of the Deep Sea Drilling Project. Current work in or applicable to the Gulf of Mexico–Caribbean region is summarized in this symposium volume.

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ERRORS IN PRE-HOLOCENE CARBON-14 SCALE

Carbon-14 dates more than about 10,000 years old are subject to at least one serious error, which is (at the moment) not amenable to correction.

Wood pebbles from a single thin clay layer, in western Florida, give C-14 dates which range from 22,000 to 29,000 years, with no assurance that either of these dates is correct. C-14 dates from different wood fragments and other material in coastal zones appear to provide a data for a high stand of mean sea level during the Wisconsin at almost any time desired from 20,000 to 40,000 years ago or more. Not all of these dates can be correct, or there would have been no Wisconsin glaciation. For reasons having to do with the growth and decay mechanisms affecting continental glaciers, it is unlikely that any of these dates are correct. Regardless, there is no standard by which "good" dates can be distinguished from "bad" dates.

A suite of samples which has been dated by both C-14 and K-Ar methods yields dates which differ by 1 order of magnitude or more; either the "young" C-14 dates represent much older materials, or the "older" K-Ar dates represent much younger material. With no additional method of dating, one cannot be certain which type of date—if either—is correct. The likelihood of contamination is higher for the C-14 results, however, and therefore this suite of dates may include mid-Wisconsin numbers for mid-Pleistocene events.

Mörner has reported that a small contamination of late Wisconsin or Holocene carbon may provide mid-Wisconsin dates for pre-Wisconsin materials.

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WEST LOUISIANA CHENIER PLAIN HISTORY

The "a-b-c . . ." model, which is based on littoral transport of sand, provides a powerful method for coastal analysis. Where long-parallel beach ridges are present, however, it may not be applicable: the two-dimensional map-view model requires that dq/dx (a numerical evaluation of changes in the littoral drift load) not be zero, except at 3 sharply defined points, whereas long-parallel beach ridges were built under conditions where dq/dx was essentially zero at all points.

These parallel beach ridges, then, do not represent an important littoral-drift system. Study of many sets of such ridges shows that they were built by onshore movement of sand which came from deeper water. The equilibrium which they achieve, with the passage of time, must be considered primarily in a vertical plane, taken at right angles to the beach, rather than in the map plane. They represent a steepening, with time, of an initially very gentle slope offshore from the beach, and leading to the suggestion that the present steeper slope is closer to equilibrium than the original gentle slope.

The chenier plain of Cameron Parish, Louisiana, is composed mainly of parallel ridges. Because of the parallelism, as well as the large content of shell debris, it is thought that these cheniers were built of material which must be attributed to an offshore source. Because of local departures from parallelism, and the

presence of the Mississippi River heavy-mineral suite, these cheniers must have had a significant contribution from the littoral-drift system. It is concluded that much of the chenier plain, other than silt–clay mud swales, was built by onshore migration of sand which acquired its offshore location when sea level occupied a lower position.

A plot of position versus age of the Cameron Parish cheniers indicates that growth of the plain has been slowing down, especially in the western part of the area, and that it may be close to a maximum width. The shoreface slope also may be close to a maximum angle. Both of these inferences suggest that the depositional history of this part of the coast may be essentially over, being replaced—either now or in the near future—by long-term coastal erosion.

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ANOMALOUS BEACH RIDGES OF SANGAMON (?) AGE

Six large-amplitude ridges, about 35 km in length and 300–1,000 m in width, parallel the mainland of Gulf County, Florida. Associated troughs are from 0.5 to 2.0 m above sea level and have a maximum width of 200 m. The intercoastal waterway cuts the ridges exposing low-angle parallel beds dipping primarily south-southwest at less than 5°. The ridges differ in thickness and each displays 3 distinct zones of laminae. Virtually all bedding appears to be of beach origin, mostly of foreshore type but with some backshore features. Eolian and current bedding is absent.

Study indicates that systematic changes occur between the 3 zones of the ridges. Average-mean grain size and standard deviation decrease upward as skewness and kurtosis increase, a trend observed in profiles taken up the beach face of some Florida panhandle beaches. The ridges are composed mostly of white-quartz sand with humate lenses of decayed organic matter. Bedding and sediment parameters suggest that the ridges are ancient beach deposits, which locally coalesce to form larger ridges. A large cuspate foreland of Holocene age, the St. Joseph Spit, protects the ridges from wave action, thus suggesting a probable minimum Sangamon age for the ridges.

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LATE DEVONIAN–EARLY MISSISSIPPIAN SUBAQUEOUS DELTAIC FACIES IN PART OF SOUTHEASTERN APPALACHIAN BASIN

Evaluation of subsurface data in a part of the southeastern Appalachian basin permits paleoenvironmental reconstruction of a Late Devonian and/or Early Mississippian deltaic complex.

Electric logs and samples from 114 oil and gas wells were used to construct 21 stratigraphic cross sections through a 6-county area in southwestern Virginia and adjacent Kentucky and West Virginia. The study area covers approximately 2,100 sq mi.

Results obtained from petrographic analyses, grain-size determinations, studies of cross-sectional configurations, and inferred relation to regional paleogeography indicate that there are 3 essentially contemporaneous clastic facies in the study area. These are: siltstone and sandy siltstone (delta front); clayey siltstone (prodelta); and pyritic, carbonaceous black clay shale (offshore marine). Each of the lithofacies represents a different subaqueous environment of a north-northwest-trending progradational deltaic complex.

Siltstones and shales of the study area were deposited in a shallow, euxinic sea probably no deeper than 100 ft. A low-lying drainage area, stable source, and restricted-marine circulation explain the occurrence of predominantly fine-grained deposits. Abundant carbonaceous matter and pyrite imply anaerobic, reducing conditions.

Inadequate physical and paleontologic control and the fact that these facies intertongue laterally raise questions concerning the validity of traditional time-rock units in this area. Considering these facts, it appears unlikely that an exact Devonian-Mississippian boundary can be established in this part of the southeastern Appalachian basin.

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"HIGH-ENERGY" CARBONATES ON INNER SHELF OF NORTHEASTERN YUCATAN PENINSULA, MEXICO

The Bahama-Banks model, where "high-energy" carbonate-sand bodies are associated with shelf edges or pronounced shelf breaks, is often invoked in the interpretation of ancient limestones, but the Yucatan shelf provides another model which may be pertinent to the analysis of many Gulf Coast Mesozoic carbonates. Off the northeastern Yucatan Peninsula several types of bioclastic and lithoclastic carbonate sands and gravels have been deposited on the inner shelf, and longshore transport has produced a barrier island–lagoon complex adjacent to the coast.

A partly submarine, partly subaerial belt of oolitically coated sand parallels the coast from the Caribbean side of Isla Cancun northward to beyond Isla Blanca. This belt of Holocene ooids is thickest on its landward edge, where coastal dunes accumulate. The carbonate-dune deposits are rapidly lithified, enhancing their chance of preservation and creating topographic features that have profound influence on subsequent subaqueous sedimentation. Effective porosity in these Holocene dune limestones ranges from 26 to 36%.

The oolitic sand passes seaward into uncoated bioclastic and lithoclastic sand gravel. Periodic storm waves wash ooids landward into the muddy lagoon behind the Isla Blanca dune and beach-ridge barrier.

Preservation of the carbonate facies deposited on the inner shelf of northeastern Yucatan would create stratigraphic traps in the most updip carbonate grainstones. Carbonate mudstones of the coastal lagoons would be both permeability barriers and source rocks for hydrocarbons.

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ESTIMATED COSTS OF PRODUCING PETROLEUM IN GULF OF MEXICO

The objective of this study is to present costs of producing petroleum (oil, condensate, and associated gas) in the Gulf of Mexico. It includes a financial analysis of an offshore operation.

To prepare the financial analysis, a model was derived to show the costs necessary to explore, acquire, develop, produce, and abandon a 5,000-acre block and the estimated income from the sale of the hydrocarbons produced. To establish cost and income guidelines for the model, 7 oil fields in the Gulf of Mexico ranging from 7 to 75 mi from shore and in water 20–130 ft deep were selected for study. A net-profit or loss statement was prepared for each field, and a discounted cash-flow rate of return was calculated.