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.

Discounted cash-flow rates of return for the 7 fields ranged from 1.1 to 19.5%. Under the 2 specified conditions set up for the model (a 20-year and a 30-year oil depletion model), the rates of return are 17.2 and 13.7%, respectively.

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ORIGIN OF CRISTOBALITE-RICH TERTIARY SEDIMENTS IN ATLANTIC AND GULF COASTAL PLAIN

Chemically precipitated alpha-cristobalite is a common matrix constituent of many fine-grained siliceous Tertiary rocks of the Atlantic and Gulf coastal plains. It forms as a low-temperature authigenic mineral having a free growth morphology of fine blades arranged in spherulitic clusters 3–12 microns in diameter called "lepispheres." Cristobalite lepispheres have been observed via scanning electron microscopy of fracture surfaces through a wide variety of lower to middle Tertiary flint clays, claystones, "opal claystones," "buhrstones," and "pseudobuhrstones." Microspherulites of identical morphology also compose moderate to large percentages of offshore Caribbean-North Atlantic sediments of equivalent age including cherts, silicified limestones, and chalks. The source of silica for these deep-water sediments is thought to be fossil diatom and radiolarian tests.

The immediate source of silica precipated as low-temperature cristobalite in coastal plain sediments generally has been ascribed to supposed volcanic sources in the Gulf Coast or Caribbean areas. Volcanic ash accumulations or direct precipitation from silica-rich bottom waters circulating above such ashes have been postulated. In major ocean basins explored by the Deep Sea Drilling Project, however, cristobalitic cherts are seldom associated directly with ash sequences although some diatom and radiolarian remains usually are preserved in these cherts. Scanning electron micrographs and petrographic studies of opaline claystones from South Carolina (Black Mingo Formation) have revealed many molds or tests of siliceous fossils preserved in a cristobalitic matrix of lepispheres similar, if not identical to, the matrix of deep-sea cristobalitic cherts thought to be derived from the *in situ* dissolution and reprecipitation of siliceous microfossils. These findings suggest a biogenous source of silica for most of the cristobalitic matrix of these Atlantic coastal plain sediments, an observation supported by the paucity of zeolites in the units. Siliceous tests also are observed in the Tallahatta Formation of Alabama, an indication that a biogenous source was important in the silicification of some Gulf coastal plain sediments as well.

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ESTIMATE OF ANNUAL INPUT OF PETROLEUM TO MARINE ENVIRONMENT FROM NATURAL MARINE SEEPAGE

Part of the oil now present in the world's oceans results from the direct discharge of submarine seeps into the water. Proper assessment of the present "hydrocarbon load" carried by the oceans, as well as the evaluation of the proportion contributed by other sources (both natural and by man), requires a reliable estimate of the yearly worldwide seepage rate from marine seeps. Although only a few marine oil seeps presently are known and located, all evidence suggests that with further investigation, many more will be found. In view of the limited observations, only a few cursory estimates of total worldwide annual-marine seepage have been made; there appears to be no substantiation for any of these estimates. This paper, which represents a first documented approach based on geologic considerations, presents an estimate of yearly oil input into the oceans from naturally occurring marine seepage.

A geologic model based on structural styles, recent earthquake activity, and sediment thicknesses was used to classify the continental margins into areas of high-, moderate-, and low-seepage potential. Flow-rate data for each of the 3 type potential areas were fitted to a log-normal probability distribution and seepage volumes were determined.

The probable range of seepage into the marine environment is 0.2 to 6.0 million metric tons per year. Within this range the best estimate for present marine seepage worldwide is *0.6 million metric tons per year.* Based on this estimate, areas of high-seepage potential contribute about 45% of the worldwide seepage. In the Pacific Ocean, high-seep potential areas are by far the major contributors. In the Atlantic and Indian oceans, moderate-seep potential areas are most significant. The circum-Pacific area is the area of greatest seepage; it is estimated to contribute about 40% of the world's total.

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CALCAREOUS NANNOFOSSIL DATUM LEVELS ASSOCIATED WITH PLIOCENE-PLEISTOCENE BOUNDARY

The extinction horizon of *Discoaster brouweri,* or datum, commonly is applied by calcareous nannofossil workers as a criterion for placement of the base of the Pleistocene in deep-sea cores. Investigators also have said that at Le Castella, Italy, gephyrocapsids having a distinct central-bar area (*Gephyrocapsa caribbeanica*) appear first at a horizon several meters below the extinction horizon of *D. brouweri.* Deep-sea cores taken on the Nicaragua Rise in the Caribbean also support this relation. Analyses of piston cores from the southern ocean, however, show that the life ranges of *D. brouweri* and *G. caribbeanica* are not concurrent at high latitudes, and here the *Coccolithus doroncoides* zone was erected to span the interval between the datum levels of these species. This interval zone subsequently has been observed in southern California, the equatorial Pacific (defined there as the *Emeliania annula* subzone), and in deep-sea cores from the northern Atlantic and northeast Pacific Oceans, and in the Tyrrhenian basin west of Naples, Italy.

The magnitude of this interval at high latitudes seemingly is greater because of an earlier last occurrence of *D. brouweri* in boreal regions about 2.5 m. y. ago (Deep Sea Drilling Project core 173 offshore northern California, where the interval is 75 m). Therefore, it is suggested, that the first appearance of *G. caribbeanica* provides a better approximation of the base of the Pleistocene than does the last occurrence of *D. brouweri.*

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PRE-JURASSIC GEOLOGIC FRAMEWORK, NORTHERN GULF BASIN

The early history of the Gulf basin is conjectural. It once was believed the basin formed by late Paleozoic foundering of Llanoria, a postulated large offshore landmass occupying much of the present basin area.