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.