massive burrow-mottled silts, moderate species diversity, moderate abundance of individuals, mainly microscopic, with a wide size range among individuals.

4. Flooding > 90% of the time (*subtidal*)—massive pelletal silts and clays, highly burrow-mottled, high species diversity, high abundance and wide size range of individuals within species, many macroscopic invertebrates. Areas of high intertidal and supratidal sediments where ponding of waters occurs for extended periods are characterized by single or multiple algal and sediment laminae much thicker than in areas where waters drain rapidly.

Sedimentation in zone 1 forms thin beds, derived from sediment-laden waters driven over the area during storms. In Zone 2, sediments are deposited in thin laminae; sedimentation is controlled by the trapping of particles carried by tidal currents and binding them onto mats of blue-green algae. Sedimentation in zone 3 occurs mainly in the form of thin beds deposited during storms and subsequently reworked by organisms. In zone 4, deposition occurs by settling of (1) *in situ* sediments; (2) particles carried into the area by tidal currents; and (3) particles from sediment-laden storm waters.

Measurement of production of calcareous sediment within the Cape Sable area, measurements of the net transport of sediment into the area by tidal currents, and measurement of the volume of sediment deposited in the area since its opening to the sea in the 1920s allow the following calculations to be made. Since 1920, 4% (0.01 cm/yr) of the total deposit has been derived from *in situ* production, 34% (0.28 cm/yr) by net transport into the area on tides, and 62% (0.50 cm/yr) by storms.

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### Effect of Three Different Depositional Environments on Dipmeter Results

Many dips that appear on a high-resolution dipmeter plot reflect environmental energy conditions existing at the time of deposition rather than structural dip. Beds deposited in a high-energy marine environment tend to exhibit a great scatter of dip magnitudes. Conversely, low energy environments cause "layer-cake" deposition and uniform dip magnitudes. Recent studies have identified 3 distinct environments from dip plots.

The first environment lies between the bench and the seaward edge of the continental shelf. This shoreward energy band shows dip magnitude scatter which can be divided into high, medium, or low dips corresponding to deposition in high-, medium-, or low-energy environments. Most of the energy is supplied by wave and current action.

The second environment lies between the seaward edge of the continental shelf and the abyssal zone. This seaward energy band shows dip magnitude scatter similar to the shoreward energy band. Its high-energy zone is found on the upper slope and the medium-energy zone on the lower slope. Most of the energy is supplied by gravity. Dip patterns are more cyclic in this environment.

The third environment is near an active delta. The rules for water depth identification in the other energy bands do not apply. Beds deposited in such an environment show mainly "current patterns" on the dip plot. The direction of dip of these "current patterns" defines the direction of transport and the dip pattern magnitude indicates the most probable shape of the distributary-front sand body.

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### Landward Movement of Carbonate Mud: New Model for Regressive Cycles in Carbonates

Repeated regressive cycles are characteristic of the Paleozoic shallow-water carbonates of North America; similar cycles are present, although less abundant, in Mesozoic and Cenozoic strata worldwide. Several of these cyclic carbonates contain major hydrocarbon reservoirs: Permian, Central Basin platform; Mississippian, Saskatchewan; Ordovician and Silurian, Montana. Studies of comparable recent deposits in Florida, the Bahamas, and the Persian Gulf suggest an alternative to the accepted tectonic explanation of these cycles.

The Florida Bay lagoon and the tidal flats of the Bahamas and Persian Gulf are traps for fine sediment produced on the large adjacent open platforms or shelves. The extensive source areas produce carbonate mud by precipitation and by the disintegration of organic skeletons. The carbonate mud moves shoreward by wind-driven, tidal or estuarinelike circulation, and deposition is accelerated and stabilized by marine plants and animals.

Because the open marine source areas are many times larger than the nearshore traps, seaward progradation of the wedge of sediments is inevitable. This seaward progradation gives a regressive cycle from open marine shelf or platform to supratidal flat. As the shoreline progrades seaward the size of the open marine source area decreases; eventually reduced production of mud no longer exceeds slow continuous subsidence and a new transgression begins. When the source area expands so that production again exceeds subsidence a new regressive cycle starts.

The seaward progradation suggested by this model should be observable in ancient deposits.

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### Slide-Block Geology, Coyanosa and Adjacent Areas, Pecos and Reeves Counties, Texas

A large-scale submarine slide occurred in early Wolfcampian (Permian) time in the Coyanosa and adjacent areas of the southeastern Delaware basin of West Texas. The slide, which bisects the Coyanosa field, comprises all rocks above the Upper Devonian Woodford Shale, the surface of detachment. Maximum dimensions were 16 mi from east to west, 9 mi north to south, and 2,000 ft thick. Lateral displacement from east to west was about 7 mi.

Wildcat and development drilling in the area has revealed many paradoxical structural and stratigraphic conditions in the Mississippian through Wolfcamp interval. These sequences include repeated sections, exotic blocks, displaced facies, and abrupt stratigraphic hiatuses.

The sole of the allochthonous plate was a thick, competent Mississippian limestone. Thick Permo-Pennsylvanian conglomerates shed from the rising Central Basin platform on the eastern side of Coyanosa, coupled with steepening of the flexure on the western and southwestern flank of Coyanosa, triggered the slide.

The slide was along the bedding plane in the eastern two thirds of the area. In the western third of the area the arcuate leading edge cut up section along the western and southwestern flank of Coyanosa and continued along the sea floor to just beyond Rojo Caballos. Rapid emplacement is implicit from the westerly thinning wedge of detritus which was churned up by the toe of the slide as it traversed the sea floor.

Alternate interpretations to submarine sliding require almost inexplicable faulting and erosion to account for the observed phenomena.

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RATIONALE FOR DELIBERATE PURSUIT OF STRATIGRAPHIC AND PALEOGEOMORPHIC TRAPS

It is obvious that the results of exploratory onshore efforts in the last decade—which have been directed toward structural anomalies—have not been generally successful. Yet, the industry continues to neglect the purposeful search for stratigraphic and paleogeomorphic traps even though some of the largest oil and gas fields in the world are in such reservoirs. As explorationists it is our responsibility to originate new ideas, new methods, and arrive at a decisive "breakthrough" of some kind to discover these so-called subtle traps. Because these traps occur in a great variety of possible geologic environments—such as relic shorelines, channels, deltas, lagoons, river and stream beds, buried overlaps and onlaps, and in other ancient topography—ranging in size from inconsequential to supergiant—the industry is shirking its duty to the nation if it does not embark immediately on an extensive and concentrated effort to focus all of its exploration know-how toward searching for and finding the large petroleum reserves which surely exist in these subtle traps.

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GEOLOGY AND ENVIRONMENTAL FACTORS AFFECTING GIANT FIELDS

At least 187 giant oil fields and 79 giant gas fields are known in the world today. Giant fields are those that contain 500 million bbl or more of recoverable oil, or 3.5 Tcf or more of recoverable gas, or an equivalent combination of gas and liquids which has a calorific value equivalent to 500 million bbl of oil. Altogether these fields contain an estimated, minimum ultimate recoverable reserve of 638.77 billion bbl of oil and 1,180 Tcf of gas or *approximately* 30–40% of the total known world recoverable gas. Most giant fields (190 = 71%) are in the Eastern Hemisphere; only 76 (29%) are in the Western Hemisphere; 81% of those in the Eastern Hemisphere (58% of the world's total) are in a U-shaped belt 10,000 km long and 750–1,300 km wide that extends from Algeria to the Arctic Ocean at the longitude of the Polar Urals.

Giant accumulations show a distinct preference for certain geologic environments. Platform, semiplatform (parageosyncline), and platform-margin areas contain 83% (221 fields) of all giants; only 17% (45 fields) are in other geologic environments (*e.g.*, fold belts, actively subsiding grabens, *etc.*). The numerous giant fields in platform-related areas suggests that giant fields are more likely to be preserved in tectonically stable environments.

Of the reserves in giant oil fields, 58% are in sandstone and 42% are in carbonate reservoirs (an unusually large percentage of carbonate reservoirs are in the Middle East); of the reserves in giant gas fields 75% are in sandstone and only 25% in carbonate reservoirs. A total of 29% of the oil and 10% of the gas are in Tertiary strata; 63% of the oil and 65% of the gas are in Mesozoic beds; and 8% of the oil and 25% of the gas are in Paleozoic reservoirs. The abrupt increase in the number of giant fields in Mississippian and younger beds very possibly reflects the sudden proliferation during Late Devonian and Mississippian times of plant life in the terrestrial and, particularly, in marine environments. However, giant accumulations are not restricted to marine sediments. Of the 266 giant fields 6% (5 oil fields, 10 gas fields) are in rocks of nonmarine origin and 15% contain major oil and/or gas reserves of probable nonmarine origin.

Giant hydrocarbon accumulations require (1) abundant organic source materials; (2) depositional and postdepositional environments suitable for accumulating, preserving, and converting the organic materials into mobile hydrocarbons; (3) efficient carrier beds; (4) voluminous and/or high-quality reservoir rocks; and (5) a giant trap, ideally syndepositional. Unconformities, though important in some fields, are not important in most. Geothermal gradient can be of importance in controlling the types of hydrocarbons present and their degree of mobility during migration.

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GEOLOGIC HISTORY OF OCEANS: INTRODUCTION

Only a few years have passed since the concepts of the permanence of continents and ocean basins and the stability of the oceans were widely accepted, and the notion of continental drift was regarded as heresy. Since inception of the programs of deep ocean coring, however, a major new body of data has appeared. Many of the new observations are in conflict with traditional ideas. It has become evident that the oceans have a fascinating and complex history, and the history of ocean chemistry appears to be inextricably interwoven with the development of oceanic organisms. It had been tacitly assumed by many geologists that the oceans constituted a massive buffer system, stabilizing climate and affecting geochemical processes on the surface of the earth and in its atmosphere. Now deep-sea sediments are known to bear a record of dramatic changes, some local, some of worldwide significance. It is the purpose of this symposium to explore new ideas which are being generated, and to provide a synthesis of the present state of knowledge concerning the history of the oceans.

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HISTORY OF BIOGENIC SILICA IN DEEP SEA

The primary components of biogenic silica in deep-sea sediments are the tests of diatoms and radiolarians. Their distribution and concentration in open ocean deep-sea sediments are strongly influenced by the productivity of the overlying water masses. In general, in deep-sea sediments far from land where masking by continental detritus is not an important factor, sediments rich in opaline silica underlie regions of strong