computer, thus regulating the model. By advancing the model through increments of geologic time, the response of the organism communities can be observed. This approach provides an experimental means of dealing with problems in which experimentation has, heretofore, been largely or wholly closed.

The model may be used by initially populating the sea floor with organism communities whose behavior is to be studied. Each community is assigned certain properties which affect its response to different water depths, presence of mud and sand, and other environmental factors. These properties can be finely adjusted so that the communities "behave" more or less like their actual ancient counterparts, competing with each other and adapting to changing conditions. The adjustments can be made on a trial-and-error basis until satisfactory results, as determined by comparison with observed distribution of fossils, are obtained.

Recent work with the model has dealt with environmental responses of leaf-like calcareous algae of the late Paleozoic. These algae were widespread in shallow Pennsylvanian and Early Permian seas, locally creating thickened banks or reefs. Today, some of these algal deposits serve as large oil reservoirs in southeastern Utah, northern Oklahoma, and West Texas. Exploration for these reservoirs will be enhanced if the environmental response of the organisms that created them can be determined experimentally and this knowledge used effectively in an exploration program.

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Date of Silicification and Relative Strengths of Biogenic Calcite in Plastically Deformed Permian Limestone, Ubehebe Peak Area, California

A thick sequence of alternating bioclastic limestone and other clastic beds of Early Permian age has been steeply tilted, but the rocks appear to have retained their sedimentary structure, even in detail. Microscopic examination shows, however, that at many places the limestone beds have undergone intense plastic flow. Most of the calcite shells, except crinoid ossicles, have been attenuated beyond recognition. Each crinoid ossicle was secreted by the animal as an anhedral crystal of calcite and each contained a biologically imposed, cribriform lattice structure and such pores or external canals or processes as the biologic or skeletal function required. It is widely accepted that calcite crystals in marble are weak, but the anhedral calcite crystals in these ossicles show astonishingly little deformation even where surrounded by flow lines of calcite shell material and the usual "shadow structures" in the low-pressure areas. The cribriform lattice and general form of many ossicles show some degree of warping and lamellar twinning in the crystal structure, but in all samples the crinoid plates were far more durable than any of the associated biogenic calcite.

Shells of *Triticites* and *Pseudofusulina* are present. Their well-known keriothecal wall structures serve not only as a measure of the extreme extent of attenuation locally, but also show that the plastic flow represents adjustments between particles of a fineness to and beyond the limits of visual resolution. Relatively little fracturing accompanied the deformation. Parts of a few fusulinid shells were agatized. The silicified parts of shells are undeformed, but the unsilicified parts are attenuated, showing that silicification preceded the plastic flow and that it can not have been a product of Recent exhumation and weathering. The adjacent igneous intrusions and associated deformation of these Permian beds have not yet been dated more accurately than Triassic to Miocene. Numerous examples of the greater durability of echinoderm ossicles than that of other calcite shells, even in environments of low-grade metamorphism, have been observed or reported, but the samples discussed here exceed by far any known differences in display of strength.

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Petroleum Migration and Accumulation: Paleohydrogeologic Concept

The intimate associations of petroleum and water can be treated geologically as pertaining to primary and recurrent migration and accumulation by recognizing the paleohydrogeologic cycles and cyclic stages, beginning with origin and diagenesis of fluids, and continuing to an end point of orogenesis and metamorphism.

The so-called stratigraphic, anticlinal, and fault traps are local fluid anomalies when measured with (1) reservoir-pressure gradients, (2) isobars (superposed on subsurface structure contours), and (3) permeability gradients inside and outside of reservoir rock bodies.

The concept is presented in an attempt (1) to widen professional horizons and make it possible for geologists to concur with mineral economists, who state that the future reserves of oil and gas are limited only by contemporary economics, and (2) to make geologists aware that future discoveries of oil and gas are limited only by their imperfect understanding of migration and accumulation.

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Coral Pinnacle Sedimentation, Alacrán Reef Lagoon, Mexico

Coral pinnacles growing in Alacrán Reef lagoon can be characterized by three different depositional environments. These are: (1) pinnacle crest—a rigid framework of living colonial corals and unconsolidated sediment which is poorly sorted, consisting of 2.5φ coral sand, with relatively high permeability, 20% calcite (90% aragonite), and 1-1.7% magnesium; (2) pinnacle slope—a transitional environment which accumulates very poorly sorted mixtures of gravelly coral, *Halimeda* sand and silt, having relatively low permeability, 10% calcite (90% aragonite), and 1% magnesium; and (3) lagoon floor—a topographic basin in which is accumulated poorly sorted 4.5φ *Halimeda* and *Halimeda*-fecal pellet silt, having relatively low permeability, 10% calcite (90% aragonite), and 0.75% magnesium.

Observed diagenetic processes are: (1) pelleting of lagoon-floor mud, (2) formation of galleries in the rigid framework by lithophagid pelecypods and in coral and mollusk sediment grains by boring algae, (3) growth of euhedral aragonite crystals in grain cavities, and (4) recrystallization of coral grains. Expected diagenetic processes in the future are cementation and dolomitization of pinnacle-crest sand, compaction of lagoon-floor mud, and mold-porosity formation in the rigid framework and in sediments of all three environments.