

The paleoclimatic and paleometeorologic conclusions which can be made from the maps are confirmed independently by Stehli's species-diversity gradients and by Axelrod's tree-ring distribution studies. Additional support includes: (1) A single Jurassic climatic and floral province extends from the Ust-Urt Plateau, on the eastern side of the Caspian Sea, onto the Indian shield. (2) The late Paleozoic sequence of the northern Indian shield is remarkably like that of the Tarim basin of China; the faunas and floras are nearly identical; and both can be mapped across the Himalayas; therefore, India has been part of the Asian continent since mid-Paleozoic time; the presence in India and much of the central Himalayas of Late Pennsylvanian tillites can be understood in terms of the effects of a cold world climate on the monsoons of the Indian Ocean. (3) Many of the Late Pennsylvanian and/or Early Permian glacial deposits of the Andes, of Brazil, of Suid-West Afrika, and of India, are mountain glaciers, as Martin, Grabert, and others have shown. (4) Pennsylvanian and Permian reefs flourished in southern Chile. (5) The "Nubian" desert sandstone—from Spanish Sahara to Iran—remained in the same position relative to the equator from Cambrian through Holocene time. (6) Smiley's floral zones from Holocene through Triassic time parallel the present equator.

These and many additional facts from field geology and from paleozoological-paleobotanical studies refute the spreading-sea-floor hypothesis. The writer concludes that continents and ocean basins have maintained the same relative positions for at least 1 billion years. Exploration of the shelves and slopes, therefore, should proceed on this premise.

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ENVIRONMENTAL ANALYSIS OF ANCIENT SANDSTONE BODIES BY DISCRIMINANT ANALYSIS

Several sedimentologists have demonstrated that certain combinations of textural parameters (e.g., mean diameter vs. skewness; mean diameter vs. standard deviation) are environmentally sensitive and effective in differentiating between modern beach, river, and dune sands. However, the reliability of textural parameters as criteria for identifying analogous ancient sandstone bodies has never been documented clearly.

Recently, data which the writers presented show that linear discriminant analysis, a mathematical technique which uses a classifying function to assign an individual sample to one of two or more populations, can be used successfully to differentiate between various modern sand bodies. Results of applying discriminant analysis to whole ϕ grain-size analyses have demonstrated that the technique is more effective in differentiating between modern beach, coastal dune, inland dune, and river sands than textural parameters calculated from quarter ϕ data.

This study shows that discriminant analysis is also a reliable and effective technique for determining the depositional environment of ancient sandstone bodies.

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ROLE OF OFFSHORE OPERATIONS IN LONG-RANGE FREE WORLD SUPPLY AND DEMAND OUTLOOK

Stronger interest in and knowledge of future energy trends and petroleum's part therein are needed for the appraisal of rate and timing of development of

offshore resources, because of the significant role that offshore operations will have to play in satisfying the future demand for petroleum.

Total energy requirements are expected to more than double in the next 20 years and oil's share of the total is expected to remain at about the 50% level. A minimum of about 400 billion bbl of new reserves must be added in the next 20 years to satisfy cumulative production requirements and provide an adequate base for estimated production in the terminal year of outlook period. The writer speculates that the contribution required from offshore areas might represent as much as 25% of the free world requirements and amount to at least 100 billion bbl.

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EVAPORATIVE REFLUX HYDROLOGY OF SOUTH BONAIRE, NETHERLANDS ANTILLES

Flow of fresh seawater onto the tidal flats and salinas of the south end of the island of Bonaire takes place through permeability conduits in the underlying Pleistocene terrace limestone and emerges as numerous springs. Reflux of some heavy brine probably is taking place continuously because of gravitational instability. In addition, evidence suggests the existence of a major annual reflux event in early summer that causes a significant loss of heavy brine. This annual event is controlled as follows: the total pressure of the brine exerted at the level of an impermeable clay layer within the Holocene sediments is greater than the pressure exerted by the seawater at equivalent level. This annual return flow of brine moves through some of the same permeability conduits that supply fresh seawater through most of the year. Dolomite formed by such a hydrological system should be confined to permeability paths such as faults or dissolution channels under an evaporitic sediment in older rock. This pattern of rock-selective or permeability-controlled dolomitization by downward flow of brine through older rocks may be common in the geologic record.

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TEXTURE OF MODERN DELTAIC SEDIMENTS OF GODAVARI RIVER (INDIA)

Textures of modern sediments collected from distributary and tidal channels, lagoon, mangrove swamps, coastal beach and dunes, offshore barrier, and deep-marine facies of the Godavari delta differ significantly from place to place. Distributary-channel sediments are characterized by textures ranging from well-sorted sand to poorly sorted mud, and from positively skewed to negatively skewed sediments. The lagoonal sediments generally are poorly sorted and positively skewed. Their texture is believed to have resulted from mixing small amounts of present-day poorly sorted silt and clay with a well-sorted primary sand mode which is inferred to have been deposited earlier in a littoral environment. Coastal beach sands are moderately sorted and slightly negatively skewed. The dune sands are well sorted and slightly positively skewed. In contrast, the barrier sands are very well sorted and the skewness curve is nearly symmetrical. Beach sands differ from dune sands by having relatively larger amounts of silt plus clay-size particles. Mangrove swamps have silty clay to clay sediments, whereas all sediments from the deep-marine facies of the Godavari delta are clay. The difference between the paludal and deep-marine clays

is the relatively high content of particles of less than 1 μ size in the latter.

It is concluded that the observed variations in the texture of the sediments from various environments of the Godavari delta may serve as criteria in the recognition of environments of deposition of a paleodelta.

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AMBIGUITY FUNCTIONS AND CONCEPT OF GEOLOGICAL CORRELATION

A profitable approach to quantitative geology is by identification of the methods currently employed. It is clear, for example, that the intuitive notion of correlation is vastly more general than the mathematical operation of the same name. Most obvious among the differences is the lack of provision for stretching or shrinking of scales during comparison.

The ambiguity function, an elementary extension of cross correlation, includes a scale variable, has a name taken from the parlance of radar engineers, and was devised originally for measuring target velocities or detecting fast-moving targets. Yet these same principles offer an effective means for identifying thinning or thickening stratigraphic sections with the use of well-log characteristics for matching magnetic profiles and following trends, or for estimating dispersion from seismic results.

Other applications will become apparent as the theory is exposed and simple examples studied. The principal accomplishment, however, is to bring the mathematical model of the correlation concept one step closer to the definition implied by actual practice.

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COMPOSITION, STRUCTURE, AND ERODIBILITY OF SUBTIDAL MATS, ABACO, BAHAMAS

In the Rock Harbour Cays, near Little Bahama Bank, the composition and microstructure of widespread, subtidal, sediment-binding, mat communities were examined and described. Mat-bound and unbound sediment surfaces were then subjected *in situ* to flume-created direct currents to test both resistance to erosion and breakdown behavior. The mat was removed by bleach treatment and the flume tests were repeated. The mats consist of algae, diatoms, and arenaceous tubes. Algae and/or tubes provide the resistant framework within which grains accumulate and are bound by mucilaginous secretions plus fine algal filaments. Three mat types were distinguished: a fibrous *Cladophoropsis* mat, a gelatinous *Lyngbya* mat, and an aggregated *Schizothrix* mat. Each mat type eroded in a characteristic manner and sequence dependent on mat composition and microstructure. Areas of intact mat withstood erosion better than irregular or broken surfaces. Mat-bound sediment surfaces withstood current velocities of more than 100 cm/sec, more than five times those required to erode mat-free surfaces. These studies indicate that particle size, sorting, packing, structure, and bedding-plane morphology are influenced by the presence of mats. Thus, consideration of mat communities is important when examining depositional and erosional processes at the sediment-water interface, or when making interpretation from ancient rocks which are the products of these processes.

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PLANKTONIC FORAMINIFERA FROM BASE OF TERTIARY, MILLERS FERRY, ALABAMA

The lower few centimeters of the Tertiary (Pine Barren) above the Cretaceous (Prairie Bluff) at Millers Ferry, Alabama, contains an assemblage of very small planktonic Foraminifera with largest dimensions of less than 100 μ . These foraminifers occur in the basal part of the *Globigerina edita* Zone (= *Globorotalia pseudobulloides* Zone) which corresponds in part to the lowest nannofossil zone of the Tertiary, the *Markalius astroporus* Zone. This assemblage occurs at a level similar to that of the central Apennines where Lüterbacher and Premoli Silva described a thin zone, named the *Globigerina eugubina* Zone, of very small planktonic Foraminifera.

A scanning electron-microscope study of the Alabama fossils suggests an evolutionary relation to species of the *Globigerina edita* Zone and to certain Cretaceous species. The Tertiary genera *Chiloguembelina* and *Globoconusa* appear morphologically close to *Guembelitra cretacea* Cushman of the Cretaceous, whose distribution in Cretaceous strata suggests that it was benthonic or had only a partly planktonic life stage. The Cretaceous planktonic species *Hedbergella monmouthensis* (Olsson) has morphologic characteristics similar to those of *Globigerina edita* Subbotina and also seems to be linked phylogenetically to *Globorotalia pseudobulloides* Plummer).

Perhaps the most significant evolutionary change that occurred in Cenozoic Globigerinacea is the modification of the outer bilamellid layers and the appearance of crustlike deposits of calcite in adult forms. These changes are viewed as adaptations to more efficient use of the water column including, perhaps for the first time, use of mesopelagic zone.

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SIGNIFICANCE OF PALYNOFORMS AS SEDIMENTATION INDICATORS IN CRETACEOUS STRAIGHT CLIFFS SANDSTONE, UTAH

Palynomorphs, which are abundant in maceration residues of many fine-grained clastic rocks, commonly include spore and pollen exines, waxy cuticles, resinous bodies, and vitrified and fusinized material which is incorporated with mineral grains in sediments. Differences in occurrence and relative abundance of the palynomorphs may be attributed to differential response of the particles to transport and sedimentation because of these parameters: (1) size: range from silt to fine sand; (2) shape: spheroidal, ovoidal, irregular, tabular, platy, or bladdered; (3) specific gravity: range from about 1.2 to 1.6.

Interpretation of the sedimentary environment of the Upper Cretaceous Straight Cliffs Sandstone is based on application of results of studies of the palylogy of several modern sedimentary areas, specifically by comparison of fossil and modern palynomorph residues. The following patterns are indicated for the paralic Straight Cliffs Sandstone:

1. In nearshore neritic beds, species of displaced terrigenous plants are numerous, marine microplankton abundant, resinous bodies and cuticles less abundant, and sorting poor. Apparently, once carried into the site of deposition, organic particles were winnowed little by offshore currents.