served in Eocene Simsboro deposits in Milam County. Texas.

Annual rainfall of approximately 60 in., channel pattern slightly to highly meandering, average stream gradient of about 5 ft/mi, and bank stabilization by dense vegetation are major parameters controlling Amite deposition of coarse sand and pebble-gravel sediment. Stratification types are related directly to specific depositional features, and include (from thalweg to overbank): thalweg (large-scale cross-stratification), lower point bar (trough cross-stratification, avalanche beds), chute bar (parallel laminae, avalanche beds, trough fill), chute fill (parallel inclined laminae, climbing ripples), and overbank (parallel inclined laminae, mud drape, avalanche beds).

Fundamental differences between point bars of streams transporting coarse-grained bed load and streams having fine-grained bed load are: muddy floodplain deposits are associated only with fine-grained bed-load streams; upper point-bar sediments with ripple cross-stratification and parallel inclined laminae occur only in fine-grained fluvial deposits; chute-front avalanche beds are common in coarse-grained fluvial deposits but are not found in fine-grained fluvial deposits. Coarse-grained fluvial deposits do not show the upward decrease in grain size that is reported to characterize fluvial sediment.

The Simsboro consists mainly of thalweg, lower point-bar, and chute-bar deposits; chute-fill and overbank deposits are preserved only in the last depositional sequence.

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INTRODUCTION TO SYMPOSIUM

(No abstract submitted)

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CONTINENTAL SHELF POSITIONS DURING GEOLOGIC TIME

Exploration of continental shelves and slopes requires a thorough understanding of the implications of the sea-floor-spreading hypothesis. If the Americas and Eurafrica once were joined, as sea-floor spreaders allege, no great intellect is required to see that the geology of the circum-Atlantic shelves and slopes would be different than if the Atlantic Ocean had always existed. Most sea-floor-spreading advocates believe that the Atlantic basin first opened during Jurassic or Early Cretaceous time. If true, drilling for pre-Jurassic objectives in certain areas is senseless. However, if sea-floor spreading has *not* taken place, pre-Jurassic objectives may underlie almost all shelf and slope areas. Similar conclusions can be made for the shelves and slopes surrounding the Indian Ocean.

Sea-floor spreading also would affect the circum-Pacific margins, which should contain strongly deformed post-Jurassic sediments. Drilling objectives in the circum-Pacific shelves should be mainly in young strata, principally of Tertiary age. This seems to be true around most of the Pacific rim, and sea-floor-spreading proponents cite the youthful geology of the circum-Pacific as evidence for their viewpoint.

Although the problem of sea-floor spreading is unusually complex, the problem can be summarized simply: can the hypothesis be proved or disproved? The correct answer to this question will affect world mineral economics for decades to come.

Numerous facts of geology and geophysics contradict the hypothesis of sea-floor spreading. A combination of Ushakov's, Talwani *et al.*'s, and Melson *et al.*'s models of the mid-ocean ridges explains the linear magnetic anomalies of the ridges, their topography, the distribution of rock types on the ridges, their gravity expresssions, and the Sykes' "transform-fault" solutions on the basis of *known* processes, as opposed to *inferred* processes. G. D. Afanas'yev's discovery that most metamorphic rocks of the Indian Ocean ridge system have Proterozoic (Riphean) and Paleozoic K-Ar dates severely damages the sea-floor-spreading concept as it has been applied in the Indian Ocean. Rezanov has proved that paleomagnetic methods cannot be used to determine ancient polar positions, or to demonstrate continental separations. Maxwell's, Glangeaud *et al.*'s, and Watson and Johnson's studies of the Mediterranean Sea region eliminate both spreading and closing of that sea since late Paleozoic or earlier time. A problem which is even more baffling is that of the *immaculati: i.e.,* the presence of flat-lying, undeformed sediments in parts of the deep ocean basins where strong deformation is predicted by sea-floor spreading. Such areas include (1) fracture zones which cross the mid-ocean ridges (undeformed sediments as old as Paleocene are exposed in these fracture zones), (2) abyssal plains, (3) continental slopes and rises (except for gravity-slide blocks), and (4) island-arc trenches. Why does a strongly deformed Early Jurassic to Eocene fold belt extend from the Cape Verde Islands to Tunisia? How does one account for the presence of bathyal to abyssal Jurassic sediments in the Cape Verde Islands, beneath the Hatteras Abyssal Plain, and elsewhere?

Almost conclusive evidence against sea-floor spreading comes from the fields of climatology, meteorology, and biology-paleontology. The field of meteorology is particularly critical, but few geologists, geophysicists, or oceanographers have studied this science. Salomon-Calvi, one of Wegener's staunchest advocates, concluded before his death that widespread continental glaciation would be impossible without an adequate supply of moisture and, therefore, that separation of the southern continents was essential from Mississippian through Permian times. Rukhin's recent analysis of late Paleozoic tillite distribution is even more conclusive because of the wealth of climatology data available to him.

To test Salomon-Calvi's and Rukhin's conclusions, the writer prepared detailed maps of coal, evaporite, and tillite distributions by age and epoch from late Proterozoic time to the present. The evaporite-coal-tillite distribution patterns shown on the maps differ appreciably from previously published compilations, and coincide very closely with the distribution pattern of modern deserts, evaporites, peat bogs, and till deposits. Meteorological and ocean-current analyses of these maps show that the distribution of these rock types *requires,* for the past 1 billion years, an ocean basin-continent distribution nearly the same as that of today. If the continent and ocean-basin distribution of the past was significantly different from that of today, the distribution patterns of pre-Holocene evaporites, coals, and tillites cannot be explained. The maps even show that the position of the horse latitudes has not changed appreciably for 1 billion years. The maps do *not* eliminate some polar tilting since Proterozoic time, but such tilting is not required to explain the patterns.

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