

tion has destroyed most primary bedding features except the southwest-dipping master bedding. Dielectric anisotropy data indicate long-grain axis orientations toward the southwest, perpendicular to the length of the sandstone body and regional depositional strike. The 2 parallel limestone bodies consist almost entirely of coarse, well-sorted bryozoan-crinoidal biosparites. These limestones contain a minor percentage of terrigenous quartz; silicification of skeletal fossil debris is common. Directional properties in the 2 limestone bodies indicate a southwesterly transport direction.

The coarsening-upward sequence of highly bioturbated sandstone with an increase in carbonate down-dip indicates a littoral to infralittoral barrier separating a gently shallowing sea on the southwest from its shoreline on the northeast.

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LATE PLEISTOCENE BIOSTRATIGRAPHY AND PALEOCLIMATE OF GULF OF MEXICO DEEP-SEA CORES

Studies carried out on 25 of 55 piston cores collected during *Kane* surveys in the Gulf of Mexico show that detailed paleoclimatic curves can be determined for the late Pleistocene based on change in frequency of planktonic Foraminifera. Three carbonate-rich cores from the southwestern Gulf of Mexico have been examined in detail and show that most of the 28 species or forms distinguished in these cores show quantitative trends in response to paleoclimatic change. During warm intervals the *Globorotalia menardii* complex, *Pulleniatina obliquiloculata*, and *Globorotaloides hexagona* (interglacial) are characteristic whereas *Globorotalia inflata* and *Globigerina falconensis* indicate cool intervals.

A total of 3 major warmings and 2 major coolings are recorded; these probably correlate with zones Z to V of Ericson and Wollin. In addition faunal changes of less magnitude reflect secondary temperature oscillations superimposed on the more marked (glacial-interglacial) climatic oscillations. The climatic oscillations are remarkably uniform in some cores if fairly constant sedimentation rates are assumed.

Volcanic ash zones in 2 cores approximately correspond to the lowermost and uppermost boundaries of the last interglacial period. In one core a large increase in *Orbulina universa* coinciding with these ash zones may be due to temporary environmental changes associated with extensive ash deposition.

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DEPOSITIONAL ENVIRONMENT OF WIDESPREAD PENNSYLVANIAN BLACK SHALE (EXCELLO)

The Excello Shale covers an area of almost 200,000 sq mi in the Mid-Continent and the Illinois basin, and is the most widespread lithologic unit of the Summum cyclothem. It overlies both marine carbonates and coals, and is overlain by marine carbonates and deltaic clastics. The typically carbonaceous Excello grades laterally into more oxidized greenish-gray facies as it onlaps and crosses structural highs.

It is difficult to explain the great lateral extent of the thinly-laminated, fine-grained, organic-rich Excello Shale by a nearshore or lagoonal origin. The strati-

graphic relations and lithologic characteristics of the Excello Shale are indicative of deeper water sedimentation in a stratified anoxic water system.

The accumulation of organic-rich bottom sediments resulted from the growth of a widespread density gradient (thermocline) which inhibited circulation of bottom waters of the epicontinental Excello sea to such an extent that anoxic water conditions arose as a result of the subsequent processes of deoxygenation, denitrification, and sulphate reduction. The distribution of the sulfide-bearing bottom waters, and hence the distribution of the organic-rich bottom sediments, was controlled by submarine topographic highs and basinal depressions. Sedimentation was restricted to the slow influx of clay minerals (probably clad with organic films) and detrital plant and animal remains. Return to the normal marine environment and clastic deposition was brought about as the Excello sea became shallow, thus breaking up the thermocline and destroying the anoxic bottom waters.

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HOLOCENE AND PLEISTOCENE SUBAERIAL CRUSTS AND PISOLITES, NORTHERN BARBADOS, WEST INDIES

Laminated calcareous crusts are present on most surface outcrops of Pleistocene limestone on northern Barbados and are similar to the caliche so common in areas with semiarid climate and a source of CaCO_3 . Crust development is most intense at the surface of relatively young, poorly lithified, commonly little diagenetically altered carbonates. The complete zone of alteration (irregular, hard calcareous bands alternating with soft, chalky carbonate) may extend to depths of 6 ft or more. Large amounts of salt spray, either wind blown or direct splash, also contribute CaCO_3 to the system, resulting in the formation of thick crusts.

When developed on poorly indurated carbonates, crusts are usually interbedded with pisolites. These pisolites are either laminated microcrystalline grains, formed in the process of limestone alteration or, where salt spray is heavy, coated skeletal grains.

The Pleistocene section on northern Barbados includes a succession of transgressive reef complexes, unlike the generally regressive sequence on the rest of the island. Each episode of reef building is considered to represent a separate high stand of sea level during the late Pleistocene. Occurrence of fossil calcareous crusts and pisolites (similar to those forming on the surface today) between overlapping reef complexes in the transgressive sequence suggests a period of subaerial exposure and diagenesis between the formation of each successive reef complex.

The presence of comparable calcareous crusts and pisolites, both Holocene and fossil, in other Pleistocene and some Paleozoic limestone successions indicates they are useful criteria for subaerial exposure.

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NEW ASPECTS OF QUANTITATIVE INTERPRETATION OF VELOCITY DATA AND THEIR IMPACT ON GEOLOGIC EVALUATION OF EXPLORATION PROSPECTS

Studies on elastic wave velocities in rocks have proved increasingly useful in the geologic investigation of sedimentary basins. Velocities of sediments are