thus our continental margin will become increasingly important as a source of supply for new oil and gas.

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APPLICATION OF INFORMATION THEORY TO PALEONTOLOGIC PROBLEMS: I. TAXONOMIC DIVERSITY

Information theory deals with the relative frequencies of nominal classes by treatment of average uncertainty,

$$H = \sum_{i=1}^{k} p_i \ln p_i,$$

where p_i is the relative frequency of the i^{th} class, connected with observation of the system. Applied directly to proportions of the taxa in a collection, the equation yields a diversity measure. One may then generate an equitability measure $E = s'/s$, where s' is the number of taxa necessary to yield the observed diversity if the proportions of taxa were random and s is the observed number of taxa. Applied to foraminifer data from Sabine Lake, La.-Tex., diversity/equitability parameters define salinity gradients more clearly than the presence of particular taxa. Similarly, where applied to invertebrate fossils from the Mississippian of Scotland, these parameters make it possible to subdivide a transgressive sequence in finer detail than an analysis of taxonomic composition. Interpretations in terms of community structure are not justified, but empirical treatment of contemporaneous and successional patterns appears to be a useful paleoecologic tool.

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GOLDEN LANE–POZA RICA TRENDS, MEXICO—AN ALTERNATE INTERPRETATION

Middle Cretaceous cores from the prolific oil fields of the Golden Lane and Poza Rica trends in eastern Mexico were studied to determine the environment of deposition of the reservoir and associated rocks and to compare these with similar middle Cretaceous carbonate rocks along the Gulf Coast.

The Golden Lane fields produce from the El Abra Limestone, which was deposited in a shallow shelf or lagoon with scattered rudistid patch reefs. The structurally lower Poza Rica trend fields are 5–8 mi west and southwest of the Golden Lane, and contain rocks of the Tamaulipas and Tamabra Formations. The Tamabra Formation is composed largely of shallow-water coral-rudistid reefs, debris derived from the reefs and deposited in shoal-water nearby, and forereef talus mixed with basinal carbonate mudstone of Tamaulipas facies. Production in the Poza Rica trend is mainly from the reef debris. No coral-rudistid reef was recognized in the small amount of core examined from the Golden Lane, and available data do not support the prevalent view that the materials comprising the Tamabra Formation were transported 5–8 mi from the Golden Lane.

The carbonate rocks of the Golden Lane and Poza Rica trends and of the "Deep Edwards" trend in south Texas are of approximately the same age and, broadly speaking, were deposited under similar environmental conditions on a shallow shelf and at the shelf edge, adjacent to a basin. The Golden Lane and Poza Rica trends are only 30–40 mi from the Sierra Madre Oriental, a major early Tertiary orogenic belt, whereas the "Deep Edwards" trend is hundreds of miles from the same belt. Thus, although depositional environments of the Lower Cretaceous in south Texas parallel those of eastern Mexico, the subsequent geologic histories of the two regions differ markedly.

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KUMMERFORM FORAMINIFERA AS CLUES TO OCEANIC ENVIRONMENTS

Most planktonic foraminiferal shells resemble strings of hollow spheres of increasing diameter. The strings are coiled in a plane or on the surface of a cone. Shells of this type are defined as "normalform." Of all the chambers making up such a string, generally the last one only may be smaller than or equal to the previous one. If a foraminifer builds such a chamber, it leaves the normalform stage and enters the "kummerform" stage (German *kümmerlich* = measly). Attainment of the kummerform stage probably indicates environmental stress, notably lack of food.

In many samples of calcareous deep-sea sediment, a large proportion of the planktonic Foraminifera are kummerforms. This contrasts with the living populations in the upper water column where kummerforms are rare. The enrichment of deep-sea sediment with kummerform Foraminifera may be caused by (1) a greater propensity for living kummerforms, than for normalforms, to deliver an empty shell and (2) selective destruction of normalforms on the ocean floor.

There is evidence that both mechanisms may be important, depending on the oceanic environment in the upper water and on the ocean floor. Vigorous oceanic circulation may increase the proportion of kummerforms. Changes in the stability of oceanic environments thus may be recorded in the amount of kummerform Foraminifera in older deep-sea deposits.

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CRITERIA FOR RECOGNIZING ANCIENT BARRIER COASTLINES[1]

Worldwide modern barrier coastlines constitute a minor part of the total coastlines of all the continents. The aggregate length of present barrier coastlines in the world is approximately 3,530 mi, distributed as follows: North America, 2,000 mi; Europe, 500 mi; South America, 350 mi; Africa, 300 mi; Australia, 200 mi; and Asia, 200 mi.

Barrier islands commonly border coastal plains adjacent to broad continental shelves. They form in areas of abundant sand accumulation where longshore currents are prominent. Sandstone lenses which represent ancient barrier islands would be expected in thick wedges of interfingering terrestrial and marine sandstone, siltstone, and mudstone. Barrier islands of Pleistocene age have been recognized inshore from present

[1] Publication authorized by the Director, U.S. Geol. Survey.