considered in hypotheses that explain the development of continental margins.

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ECONOMICS, DECISION MAKING, AND EXPLORATION POLICY

The objective of exploration is to find petroleum and increase the company's reserves. To accomplish this goal, the company must utilize its resources (*i.e.*, money and personnel) in the most effective way possible. This might seem to indicate that, to accomplish this goal, exploration should be restricted to those areas in which the potential big fields (*e.g.*, offshore) are being discovered. This is incorrect, however, because a company has limited resources and may not be able to obtain favorable leases in such areas. If this is the case, any effort spent on these areas will be a fruitless dissipation of resources. This does not mean that a company should not compete in these areas, but rather that it should learn how and where it can compete effectively.

Independents do not face this problem because their resources are so limited they cannot have illusions about how and where to compete. Very large companies can overcome this difficulty by overbidding on areas of interest, thus insuring that they can obtain their goals. It is the companies which fall between these extremes which face the problems of how and where to compete.

In attempting to compete, most companies use the trial-and-error method and in the process dissipate resources which they cannot afford to expend. Another alternative is to use the computer. Algorithms have been developed to simulate decision making in conditions of uncertainty; some have been done concerning exploration and lease bidding. By use of this type of approach and adapting the *OR* method to the problems of exploration, a company can find how and where best to invest its resources.

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RIPPLE-DRIFT CROSS-LAMINATION IN TURBIDITES

Ripple-drift cross-lamination is the name given to a series of ripples which "climb upon the backs" of each other as a result of the addition of sediment from suspension during ripple migration. The type found in turbidites is characterized by continuity of lamination across the ripple system, changing composition of laminae from lee side (mud) to stoss side (silt and sand), and gradual upward decrease of ripple amplitude.

Geometric analysis has shown that the angle at which the ripples climb is a function of lamina thicknesses on the lee and stoss sides, the angle of the lee and stoss slopes, and the symmetry of the ripples. Computation of many angles of climb and different ripple geometries has shown that all three factors (thickness, angle, and symmetry) are equally important in determining the angle of climb. Field measurements of ripple-drift morphology in Ordovician turbidites of the Gaspé Peninsula, Quebec, indicate angles of climb from about 3 to 40°, with cosets of ripple-drift cross-lamination ranging in thickness from 4 to 37 cm. There is a direct correlation between coset thickness and angle of climb, and lee-side lamina thicknesses tend to be two to four times greater than stoss-side thicknesses. The factor controlling the angle of climb is the ratio of volume of sediment deposited from suspension to the volume of sediment moved on or very close to the bed and deposited on the lee sides. The velocity at which the ripples move downstream is also a function of the same ratio, plus a function of the hydraulic parameters controlling the formation of the ripples. Because of the complex interactions of these variables, it is not yet possible to estimate accurately the time taken for formation of the ripple-drift cosets. Crude estimates suggest a period of less than 1 or 2 hours for a coset 40 cm thick.

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SEDIMENTARY STRUCTURE ZONATION ON TIDAL LEVEES, ANDROS ISLAND, BAHAMAS

The natural levees of tidal channels on northwestern Andros Island, Bahamas, show how primary sedimentary structures record small-scale variations in elevation and lateral position on a tidal flat. These levees, like stream levees, are highest adjacent to the channels, crest less than 50 cm above mean high water, and slope gradually for 25–300 m into shallow subtidal ponds.

The most pronounced variation in sedimentary structures is between the well-laminated sediments of the levees and the bioturbated sediments of the pond. In the intertidal and subtidal ponds, browsing and burrowing animals completely destroy primary lamination, but the long periods of desiccation on the levees keep burrowers out of the sediments.

Within the levees there are three distinct zones: (1) the levee crest, 30–50 cm above MHW, adjacent to the channel has smooth, parallel laminations 1–5 mm thick; mudcracks, where present, are discontinuous; (2) the central part of the levee, 10–30 cm above MHW, has thinner laminations, mostly less than 1 mm, that are disrupted by shallow mudcracks 2–6 cm apart. Cornflake-size chips and larger clasts are abundant; (3) on the pond side of the levees, 0–10 cm above MHW, thin, crinkled laminations less than 1 mm thick alternate with thicker laminations that have a prismatic structure inherited from surface mats of the blue-green alga *Scytonema* sp. Small mudcracks (2–8 mm) disrupt the lamination.

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SURFICIAL ALTERATION OF PLEISTOCENE(?) LIMESTONE ADJACENT TO SALINE LAKES, ISLA MUJERES, QUINTANA RÓO, MEXICO

Two interesting rock types result from calichification and alteration of the weathered surface of bedrock limestone adjacent to shallow saline lakes on Isla Mujeres, Quintana Róo, Mexico.

Jet-black micritic limestone is produced on the periphery of the saline lakes, apparently as the combined result of calichification, blue-green algal penetrations, and sulfate-reducing bacterial action. Micrite layers are added by calichification. The black color is attributed to finely disseminated organic material and iron sulfide(?) produced by bacteria. Bacterial action not only may be partly responsible for the black color of the limestone, but also may account for the small amount of calcium sulfate found in the lake deposits. Similar black, algal, filament-bearing micrite, found as rounded pebbles on Caribbean beaches of Isla Mujeres, most likely was produced in a similar environment at a lower stand of sea level and worked shoreward from eroded, submerged outcrops.

Hard caliche breccias crop out in several places adjacent to the salt flats. These rocks contain both angular fragments of bedrock and caliche and rounded, pisolitelike structures. Similar breccias are found on low rocky sea cliffs just above the surf zone of Isla Mujeres as well as on other islands in that vicinity.

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LIVE AND DEAD MOLLUSKS IN A COASTAL LAGOON[1]

Living animals and empty shells have been collected in 55 samples from Mugu Lagoon, coastal southern California. The abundances and distributions of 73 molluscan species from the samples were studied in order to evaluate postmortem movement of shells. Although transportation is common across short distances within the lagoon, several lines of evidence indicate that most empty shells were buried about where they lived. Taxa collected alive are adequately reflected by the empty shells accumulating in the lagoon; whether live and dead, the specimens are compared on the basis of individual taxa, of whole communities (defined by numerical analysis), or of relative abundances within communities. Postmortem transportation within this environment is insignificant for most paleoecological purposes.

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CATASTROPHIC DESTRUCTION OF CORAL REEFS BY VENOMOUS SEA STAR *Acanthaster planci*

The sea star, *Acanthaster planci,* widely but sparsely distributed throughout the tropical Indo-Pacific region, has experienced sudden local population explosions causing unprecedented damage to certain coral reefs of the Pacific. By devouring and killing hard corals *en masse,* this animal has created massive environmental upheavals as hordes advance systematically over reef surfaces reducing coral communities to dead rubble. In order to preserve Green Island (Australia), divers have been collecting for destruction as many as 375 individuals per day for more than 15 months. Nevertheless, the entire width of more than 1 mi of reef has been devastated. As new outbreaks occur, there is fear in Australia that this sea star, if unchecked, ultimately could destroy the entire Great Barrier Reef and along with it the valuable marine community that it harbors. In 1966–1968 the writer discovered localized *Acanthaster* populations of very high density at Guam, Saipan, Koror, Fiji, and New Guinea. The problem is not only of considerable importance to the economy, health, and welfare of inhabitants of Pacific Islands, but elucidation of the factors permitting the phenomenal increase in numbers may help the understanding of apparent catastrophic events concerning coral reefs as indicated by the geologic record. The writer's ecologic studies of *Acanthaster* are guided by two hypotheses: (1) an unknown predator of the sea star has been removed from these reefs, possibly by man, and (2) a mutant, more venomous strain of *A. planci* evolved in the 1950s or 1960s. At present, there is some evidence supporting both hypotheses.

[1] In press. Journal of Paleontology.

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LATE PENNSYLVANIAN SHELF IN NORTH-CENTRAL TEXAS

Upper Pennsylvanian rocks were mapped on the surface and into the subsurface across 30,000 sq mi of north-central Texas. The study area includes most of the late Paleozoic eastern shelf of the West Texas basin. Strata in 2,500 wells were correlated using sample and mechanical logs. For surface mapping, formal stratigraphic nomenclature was used; in subsurface correlation, the strata were subdivided into 22 nearly isochronous stratigraphic intervals. Structural and isopach maps, and percentage isolith, ratio, three-component, and trend-surface lithofacies maps were constructed of various stratigraphic intervals.

Upper Pennsylvanian rocks dip less than 1° west. The average strike rotates from N45°E to N20°E to nearly north-south at the tops of the Desmoinesian, Missourian, and Virgilian rocks.

Three major facies are present: marine mudstone, marine limestone banks, and a paralic facies of sandstone and mudstone intercalated within beds of limestone. The average composition for Upper Pennsylvanian sediments in 2,500 wells is 68% mudstone, 15% limestone, and 17% sandstone. In Missourian rocks the marine mudstone (67%) and limestone banks (21%) dominate, whereas in Virgilian rocks, mudstone (69%) and paralic sandstone (18%) are the major lithofacies.

Little is known of the marine mudstone facies other than its distribution. The limestone banks are skeletal deposits that were wave and current resistant. Composited, the banks are elongate biostromal trends as thick as 200 ft, up to 180 mi long, and 40 mi wide. Biohermal deposits are as thick as 1,200 ft, 40 mi wide at the base, and 5 mi wide at the top. The primary bank builders, which behaved as sediment baffles, were phylloid algae and bryozoans mostly on calcareous muds (micrites).

Related facies include osagiid algae and crinoidal grainstones (sparites). On the eastern shelf three elongate banks persisted throughout Missourian time; two parallel northeast-striking biostromes and one east-striking biostrome along the Red River uplift. Following an epeirogenic warp of the Ouachita source a north-trending Virgilian bank persisted along the eastern edge of the West Texas basin. The most extensive bank growth occurred during two Missourian and one Virgilian transgressions.

The distribution of the sandstone, and the interpretations of the textures and structures in the sandstones, indicate that braided and anastomosing streams, deltas, and nearshore bars were major types of depositions in Missourian and Virgilian paralic facies. Principal source areas were both east and north. Paralic facies are most significant in Virgilian outcrops, because the shorelines had migrated far west and south of Missourian strandline positions.

A logical model for Late Pennsylvanian eastern shelf position is an ameboidlike front of terrigenous sandstone-mudstone facies advancing locally and episodically into a marine mudstone-limestone bank facies. Modern counterparts of these facies are known.