alteration or segregation. With respect to ancient deposits, however, approaches confined to these factors are inadequate where diagenesis of clay minerals has occurred, as it apparently has in the Atoka sandstone and sandy shale.

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Bermuda Carbonate Platform: Quantitative Analysis of Depositional Environments

The responses to attrition and redistribution of the skeletal elements of the major sediment-contributing taxa govern interpretation of the depositional environments of skeletal carbonate sediments. The sediments, biotas, and physical conditions of the Bermuda platform provide data for such an integrated interpretation.

Inward from the margin of the Bermuda carbonate platform there is a succession of environments: (1) a reef-front terrace; (2) a reef tract; and (3) a shallow central lagoon. The southwestern half of the lagoon is characterized by reef flats and clusters of patch reefs; these subdivide the lagoon into small basins. The northeastern half occupies a single large basin. The beaches of the Bermuda Islands, a series of Pleistocene dune ridges on the southern edge of the platform, constitute a fourth environment. Carbonate muds are found on deeper bottoms in the more protected basins, molluscan-algal sands in the less protected basins and at the shallower depths, and coralline-foraminiferal-algal sands in the reef tract and reef-front terrace.

Trend-surface analysis of sedimentary and biotic data (based on approximately 300 grab samples and supported by direct observations made by snorkeling and SCUBA diving), stratified according to depth, indicates a clear correlation with factors in the physical environment. The sediment textural parameters are related to those organisms contributing to the sediment and are related to the depositional environment by discriminant function and factor analysis. Artificial "sediment" obtained from the breakdown of hard parts of assemblages of Bermuda organisms in laboratory tumbling-barrel experiments compare closely with sediments on the platform.

The sedimentary record is a product of (1) the ecologically controlled distribution of organisms, (2) the size distributions resulting from the breakdown of the hard parts of the major sediment contributors, (3) the sorting and transport of the skeletal detritus, and (4) the degree of mixing of sediments derived from different environments.

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Geology and Exploration of Sicily and Adjacent Areas

Surface seeps first attracted attention to industrial exploration for hydrocarbons in 1901. The first major success occurred after passage of the Sicilian petroleum law of 1950; three major structural accumulations have been discovered—Ragusa (1954), Gela (1956), and Gagliano (1960). Recoverable reserves of Ragusa are estimated at 110 million bbl and Gela at 120 million bbl. Although in-place oil at Gela is calculated at 1.2 billion bbl only 10 percent is expected to be recovered. Gagliano reserves are not fully defined although a minimum of 700 Bcf of gas and 20 million bbl of condensate is estimated. Development drilling is still underway at Gagliano and Gela.

Commercial production is limited to the Central Tertiary basin and the Ibelo Mesozoic platform. The Central basin is characterized by a thick series of normally sedimented Pliocene and Miocene clastics interrupted with chaotic gravitational slides. Gagliano produces from multi-pay Miocene-Oligocene sandstones.

The Ibelo platform is represented primarily by carbonate sedimentation, and Ragusa and Gela produce from a thick dolomite of Triassic age.

Volcanic activity which began in the Jurassic continues to the present day and intrusive and extrusive rocks commonly are associated with the producing reservoirs.

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Pennsylvanian-Permian Horseshoe Atoll, West Texas

The Horseshoe atoll is composed of bedded bioclastic limestone and limestone detritus that accumulated in the interior part of a developing intracratonic basin during late Paleozoic time. The reef environment was established early in the basin history and retained because of the lack of significant terrigenous clastic filling in the basin interior. Mixed types of bioclastic debris accumulated cyclically and the upper level of the reef complex was maintained near sea level as basin subsidence continued. About 1,800 ft of limestone accumulated during the Pennsylvanian, and primary dips as great as 8° developed along the margins of the atoll. During early Permian time the reef was restricted to the southwest side of the atoll where more than 1,100 ft of additional limestone accumulated before death of the reef. Continued tilting of the reef complex after burial elevated Pennsylvanian pinnacles along the east side of the atoll 1,400 ft higher than Permian pinnacles along the west side. The updip migration of hydrocarbons was uninhibited, and reef pinnacles along the eastern half of the atoll are full to the spill point. The Scurry reef is the largest single area of closure on the Horseshoe above the oil-water contact. It includes approximately 69,000 productive acres and has a maximum oil column of 765 ft. The reef was discovered in 1948 with reflection-seismic methods. Production from the Scurry reef exceeded 500 million bbl by the end of 1967, and this represents approximately 60 percent of the oil produced from the Horseshoe atoll

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Golden Lane Fields, Veracruz, Mexico

History of oil in Mexico is related closely to the development of a series of aligned discoveries located in the central part of the Tampico embayment from San Diego de la Mar to San Isidro. This series of aligned discoveries is known as the "old Golden Lane," whose cumulative production to December 1967 is near 1.25 billion bbl of oil. In 1908 the first productive well of the Golden Lane, San Diego de la Mar No. 1, was brought in with an estimated daily production of 2,500 bbl of oil. During the following years, production was found in other places by drilling near seepages and following a trend of productive fields about 50 mi long and more than 0.5 mi wide. Within the old Golden Lane is located the famous Cerro Azul No. 4 well, probably the world's largest well, which had an estimated daily production of 260,000 bbl of oil.

What is known as "the new Golden Lane" or as "the southern extension of the Golden Lane" was discovered in 1952 when the Ezequiel Ordoñez No. 1 well came in as a producer; afterward, new-field discoveries were made between 1952 and 1962. This trend includes several fields, including the giant Poza Rica field. This southern continuation of the Golden Lane had been inferred geologically but it was not until both gravity and seismic surveys were carried out and interpretative techniques were improved that "the southern extension of the Golden Lane" was identified.

At the same time, an offshore extension of the Golden Lane was suspected, and the offshore seismic surveys carried on led to the discovery of the "marine Golden Lane;" in 1963 offshore well Isla de Lobos No. 1 was completed as a producer. The "Golden Lane," as it now is interpreted, consists of a closed oval-shaped huge "atoll"-type reef about 85 mi long and 40 mi wide, the eastern part extending in the subsurface under the Gulf of Mexico.

In the course of exploitation and the discovery of new fields along its perimeter, the geologic genesis of the "atoll" of the Golden Lane is still the object of controversy; nevertheless, the most accepted theory is that it consists of a biohermal reef that started its growth in Early Cretaceous (late Neocomian) time on a late Kimmeridgian (Late Jurassic) positive element referred to as the "Isla de Tuxpan." At some localities within its inner part, evaporite, calcarenite, and dolomite occur; at others however, rudistid and miliolid limestones occur. Its periphery consists of a prominent belt of structural culminations which are made up indistinctively of rudistid and/or miliolid limestones. The Jardin No. 35 well, drilled in 1930, is the only well that ever penetrated the reef core. Its information, however, is questionable and very scarce. Notwithstanding the depositional environment attributed to rudistids (the principal component of this great reef), its morphology—regarding whether it consists of a bioherm, a biostrome, or a combination of the two—will persist as a subject of conjecture.

Golden Lane fields have produced to December 1967 more than 1.420 billion bbl of oil.

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BIOGENIC SEDIMENTARY STRUCTURES IN FACIES OF MIDDLE ORDOVICIAN BLACK RIVER GROUP OF NEW YORK STATE

This study is based on analysis of 450 large vertical slabs from eight stratigraphic sections in the Black River Group type area, the Black River valley, northwest New York State. The group is underlain by an irregular Precambrian surface, is 90–140 ft thick, and consists of three formations: the basal Pamelia, the Lowville, and the Chaumont. These represent a sequence of six nearshore sedimentologic facies. Superimposed on these are four biogenic sedimentary structure facies, each characterized by particular biogenic structures.

The Pamelia Formation consists of buff, algally laminated, fine-scale-mudcracked, supratidal dolomite characterized by rare vertical burrows like those of the succeeding Lowville Formation, and a sparse euryhaline fauna.

The lower Lowville consists of lithologic types representing two environments: (1) gray, mudcracked, ripple-marked, thin-bedded, intertidal limestone with a euryhaline fauna, and (2) dark gray, thick-bedded, laminated, subtidal limestone containing algally coated grains and a sparse stenohaline fauna. The intertidal Lowville is characterized by permanent, vertical, and U-shaped burrows which today are most common in intertidal environments. Filter feeders usually construct these burrows for protection in environments characterized by stress at the interface. The subtidal part of the lower Lowville Formation is characterized by complex, irregularly oriented, feeding burrows, and large, concentrically laminated burrows. Today these types of burrows are common in quiet subtidal environments where deposit feeders dominate.

The upper Lowville Formation represents a wave baffle formed by compound colonies of the spindle-shaped coral *Tetradium* associated with marginal zones of fallen *Tetradium*. These rocks are characterized by absence of biogenic structures, probably caused by the mechanical difficulty of burrowing into sediment with such a felted texture.

The Chaumont Formation consists of silt-size debris of a diverse stenohaline biota, and is unbedded because of thorough burrowing. It is characterized by small, horizontal, sediment-filled burrows, which today dominate in level-bottom marine environments where a thin oxidized zone favors deposit feeders which cover broad horizontal areas near the sediment surface. Thus, integration of faunal, sedimentologic, and stratigraphic data with information on recent biogenic structures allows ecologic interpretation of Ordovician structures.

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FACIES CHANGES DEVELOPED DURING FILLING OF A DEEP BASIN

A sequence of lithofacies developed during basin filling has been studied in a 150-m regression cyclothem in the Pennsylvanian of north Devon, England. The cyclothem can be divided from bottom upward into eight units.

Unit 1 (35 m) contains only black mudstone.

Unit 2 (12 m) contains 140 sharp-based, graded siltstone-turbidites, each about 2 cm thick. Sole marks indicate a wide spread of current directions, with a mean toward the south.

Unit 3 (9 m) contains regularly interbedded structureless muddy siltstone, and cross-laminated siltstone beds which usually have gradational bases. Six beds are sharp-based and bear sole marks.

Unit 4 (12 m) contains interbedded siltstone-turbidite and cross-laminated siltstone similar to those in units 2 and 3. There are also two channels at least 2 m deep and filled with thicker turbidite.

Unit 5 (18 m) is composed dominantly of muddy siltstone with irregular cross-lamination. Sharp-based siltstone-turbidite is rare, and dies out upward. Grada-