bution by several causes, volcanic maxima can be correlated between cores separated by up to 2,000 n. mi. Paleomagnetic, micropaleontologic, and sedimentologic methods have been used.

The glass shards are mostly transparent, bubble-walled or platy in shape, and are silt size or smaller. The grain-size distribution of glass strongly parallels that of other sedimentary constituents wherever submarine transport or prolonged bioturbation has occurred, as determined by X-ray radiography. Concentration of glass also varies systematically with minor sedimentation-rate fluctuations, as independently shown by variations in microscopic manganese nodules and ice-rafted debris concentrations. Utilization of fine volcanic glass by siliceous plankton has resulted in productivity and diversity changes, and, perhaps, a corresponding modification of the glass distribution. High-power transmission and scanning electron microscope methods show that the relative amounts of glass finer than 10 microns decreased rapidly during volcanic episodes.

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SEDIMENTATION ON CRETACEOUS OCEAN RIDGE, TROODOS MASSIF, CYPRUS

The igneous rocks of the Troodos massif have been interpreted as an uplifted segment of Cretaceous ocean crust, formed at a spreading ridge. If so, the sediments overlying them should be similar to those forming at ocean ridges and to Tertiary basal sediments found by JOIDES drilling. Directly above the Troodos pillow lavas are iron- and manganese-rich mudstones ("umbers") that are closely comparable to the iron-rich sediments associated with the latest stages of volcanism on present ridges. They are enriched in trace elements, including copper, molybdenum, lead, zinc, and vanadium. These mudstones pass upward into Campanian radiolarites and radiolarian mudstones with a diverse and well-preserved siliceous microfauna. Silica diagenesis can be compared with that of deep-sea cherts. In the simpler sequences, the radiolarian rocks are overlain by Maestrichtian chalks.

In some areas, illite-montmorillonite clays above the radiolarian mudstones include major developments of mélange, with transported blocks of diverse Mesozoic sedimentary and igneous rocks. These include quartz sandstones of continental derivation. Chalks also overlie the mélange. The umbers, radiolarites, and chalks are interpreted readily as oceanic sediments, and the presence of the mélange implies proximity of a continental margin.

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COAL GASIFICATION DEVELOPMENTS

The production of pipeline quality gas from coal will become an important source of supplementary gas by 1990 when more than 3 Tcf/year are expected to be available. By the year 2000 the total may reach 8 Tcf/year; that is, 40% of present gas consumption. Elements such as coal quality and cost, plant location, water environment protection, and others contribute to the cost of gas.

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STRATIGRAPHY AND DIAGENESIS OF NIAGARAN PINNACLE REEFS (SILURIAN) IN NORTHERN MICHIGAN BASIN

In the Michigan basin, the Middle Silurian Niagaran reef facies directly underlies the Upper Silurian Salina evaporite facies. The basal Salina Formation includes the A_1-evaporite, subjacent to the A_1-carbonate and the A_2-evaporite in successive order. Subsurface study of 40 drill cores disclosed that most of the Niagaran pinnacle reefs in the inner-basin slope environment ceased growth by A_1-evaporite time and were regenerated during deposition of the A_1-carbonate.

The uppermost section of the algal stromatolite and algal boundstone facies at the top of the pinnacle reefs was deposited contemporaneously with the A_1-carbonate of the off-reef section. The algal-stromatolite facies of the A_1-carbonate overlies the A_1-evaporite on the reef flanks and extends laterally to the off-reef facies in the vicinity of the pinnacle reefs. The general lithology of the A_1-carbonate in the off-reef sections differs greatly from the lithology of the A_1-carbonate reef facies.

Some of the pinnacle reefs apparently continued to grow during the early formation of the A_2-evaporite. There is no significant erosional contact between the A_2-evaporite and the algal stromatolite at the top of the reef. Furthermore, LLH- and SH-type algal stromatolites show repeated stages of growth *in situ*, within the lowermost few feet of the A_2-evaporite section.

A vadose zone representing subaerial exposure is present in the pinnacle reefs at the top of the organic reef facies, which overlies the basal biohermal facies. This zone is characterized by a more complex sequence of diagenesis than either the basal biohermal facies or the uppermost algal stromatolite facies.

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UNSOLVED PROBLEMS CONCERNING ORIGIN AND MIGRATION OF PETROLEUM

Current research suggests that most of the hydrocarbons in petroleum are formed from the organic matrix of sedimentary rock at depths greater than 5,000 ft. The increased generation of light hydrocarbons with depth is offset by decreases in the permeability of source beds and in the volume of migrating fluids. Empirical field studies may outline source-reservoir relations, but the mechanisms by which the hydrocarbons originate, migrate, and accumulate still are poorly defined.

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CALICHE SOIL HORIZONS ON OOLITIC SHOALS AND CARBONATE MUD MOUNDS IN CARBONIFEROUS (NEWMAN LIMESTONE) OF EASTERN KENTUCKY

A sequence of oolitic calcareous grainstone shoals and calcareous wackestone and packstone-bank and interbank deposits is exposed near Olive Hill, Kentucky. The shoals and banks underwent periods of exposure, as they are capped by beds that represent stages of deposition or caliche weathering in the supratidal zone. The caliche weathering zones are similar to those found on Caribbean Islands and in the southwestern United States.

The first type of caliche zone is analogous to the subaerial crusts of the Caribbean area. These crusts are brecciated, often silicified, laminated calcareous mudstones which formed on and within the shoals and mud mounds. They are present as beds or coat fractures which transect bedding planes. Petrographic characteristics include microbrecciation, grains coated with laminated or dense micrite, extensive micritization, pelletoid fabrics, root tubules, and micrite and yellowish-brown spar cements.

The second caliche type, similar to those of the southwestern United States, is a nodular, brecciated calcareous mudstone that developed from supratidal and intertidal calcareous muds. The basal part of this caliche unit is a fossiliferous, but intensely brecciated, parent rock; this zone grades upward into a nodular sequence which may be capped by a thin-brecciated, laminated crust. Original depositional fabrics have been obliterated in the nodular section; the nodules are composed of microspar containing breccia clasts and root tubules, and are disrupted by subhorizontal fractures. Both caliche types display

desiccation-expansion "teepee" structures. Caliche clasts are reworked into overlying intertidal-supratidal deposits, indicating that weathering occurred near sea level and contemporaneous with offshore deposition.

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SEDIMENTATION IN NHA TRANG BAY, SOUTH VIETNAM

Nha Trang Bay is an embayment at the mouth of the Cai River on the central coast of South Vietnam. The river is the principal source of sediment to the coastline, but intertidal reefs provide minor amounts of calcareous sand, and the continental shelf supplies some coarse quartz sand. The sediment supply to the coast and its distribution in Nha Trang Bay are closely related to the monsoon climate of the region. Northeast monsoons cause intense rainfall and runoff, combined with a unidirectional wind field causing strong southerly coastal currents. Most of the river sediment enters Nha Trang Bay during monsoons, and the sediment distribution reflects the monsoonal wave and current regime. Approximately one-fourth of the river-supplied sand enters the Nha Trang beach littoral cell, where it is transported south along the coast. Thus, the present configuration and orientation of Nha Trang beach are related also to monsoonal wave conditions. This pattern of sediment dispersion appears to have persisted during the Holocene still-stand of sea level, causing the accretion of an extensive beach-ridge coastal plain south of the river mouth. Similar orientation of the ancient beach ridges suggests that monsoonal waves have been the predominant factor in the development of the coastal plain.

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DIFFERENTIAL CEMENTATION OF PLEISTOCENE CARBONATE FANGLOMERATE, GUADALUPE MOUNTAINS

Pleistocene fanglomerates, extending southeastward from the Guadalupe Mountains, consist of predominantly micritic carbonate particles (limestone and dolostone) eroded from the Permian reef complex. Accessory particles consist of detrital monocrystalline grains of calcispar, quartz, and chert. The fanglomerate is firmly cemented by low-magnesium calcite. The fanglomerate was cemented in the vadose zone. Predominantly micritic particles are coated by bilaminar films, consisting of inner calcimicrite laminae and outer rims of drusy, dogtooth spar. Bilaminar films do not completely occlude porosity in large neighboring interstices. Monocrystalline carbonate grains are concentrated in the sand-size fraction and are enveloped by thin, discontinuous micrite films and thick overgrowth aureoles which expand outward to occlude porosity in adjacent interstices.

The following lines of evidence suggest that overgrowth aureoles on monocrystalline grains were precipitated at much greater rates than outer drusy rims of bilaminar film-coated grains: (1) both monocrystalline grains and bilaminar film-coated grains are enveloped by thin inner micrite films, suggesting that outer drusy rims are homologous with overgrowth halos; (2) overgrowth rims on monocrystalline grains are 3-10 times thicker than outer rims of dogtooth spar on similar-sized, bilaminar film-coated particles; (3) where overgrowth halos expand outward and engulf neighboring grains, outer drusy rims are missing or poorly developed.

Bilaminar films, especially outer drusy rims, thicken downward from lower grain boundaries into interstices in response to a gravitational effect (downward thickening of water films).

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THERMAL ENVIRONMENTS AS MODELS OF PRECAMBRIAN ENVIRONMENTS

Thermal ecosystems are biologically simple. These systems contain a few species of unicellular organisms and may resemble ecosystems that existed on the ancient earth during the early stages of biological evolution. The analysis of fatty acids from some bacteria-algal mats in streams draining hot springs in Yellowstone National Park show distributions resembling those of fatty acids isolated from ancient cherts. A layered silica deposit, "stromatolite," taken from the perimeter of an alkaline hot spring was used as a modern analog of bedded chert deposits. The distributions of fatty acids from the surface, crust, and interior regions of the stromatolite indicate that the acids are syngenetic with the silica deposition, and that acid distributions have not changed significantly during the time of formation of the "stromatolite" (10^2–10^3 years).

Comparisons were made of fatty acids and hydrocarbons from natural ecosystems and laboratory cultures of thermophiles. Marked differences were observed between the distributions of the fatty acids and alkanes in the specific samples and of the fatty acids from different ecosystems.

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SUBSEA CEMENTATION OF SHALLOW BRITISH HONDURAS REEFS

Contemporary subsea cementation is restricted to specific zones in shallow British Honduras barrier and atoll reefs. On the southern half of the barrier reef and on Glovers Atoll, cementation occurs only on the seaward margins of the reefs, the reef flat, and spur and groove structure.

On the reef flat, coral rubble and skeletal sand are cemented to a hard pavement 10-100 m wide. Coral fronds from the pavement have a radiocarbon age of about 450 years B.P. The cores of projecting spurs, a growth frame of coral and *Millepora*, locally are bound with a mortar of cemented skeletal sand, forming marble-hard limestone. Coral fronds lying loose on groove floors between spurs contain well-cemented geopetals, indicating lithification of internal sediment in place.

Carbonate cement is present (1) in intraskeletal voids of reef-building organisms, (2) between skeletal sand grains that form the rubble mortar and that partly fill the growth frame, and (3) within fine skeletal sand and carbonate mud geopetals of mollusk and sponge borings.

The localization of subsea cementation on the reef flat and seaward faces of the British Honduras marginal reefs significantly enhances their wave resistance. A similar localization of early cementation by magnesium-calcite in ancient reef complexes would have reduced porosity and permeability and increased the amount of magnesium locally available for dolomitization. This facies-specific diagenesis would have directed subsequent subaerial and late diagenesis, which in turn determines the quality of reef reservoirs.

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ERTS AND REMOTE SENSING'S NICHE IN GEOSCIENCE

Remote sensing, defined here as "all methods of recording and measuring energy which is reflected or emitted from selected segments of the electromagnetic spectrum," has been used in natural sciences and earth resources fields for several decades. Data collection systems are highly developed, as are instruments designed to automate the analysis, enhancement, information extraction, and/or change-detection of the acquired data. When used with ancillary data (ground observa-