

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

INMAN, DOUGLAS L., and CHARLES E. NORDSTROM, Scripps Inst. Oceanography, Univ. California, La Jolla, Calif. 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 stillstand 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 calcimicritic 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-

tions, etc.), these data are providing useful information relative to the mapping of regional structure, joint patterns, drainage patterns, fault traces, and rock types.

Remote sensing should never be considered as a panacea for studying geoscience problems, but should be treated as a developing tool which will provide additional information for a multifaceted scientific approach to studying the earth and other planets. Remotely sensed data, especially that acquired from space, provides synoptic coverage of large areas and of environmental factors, not perceived by the unaided eye or during field observation. These environmental phenomena include surface distribution of heat, moisture, snow, open water, viable vegetation, and cultural features. Synoptic images and temporal change illustrated by sequential coverage are useful for teaching, research, and exploration in geoscience. Specific examples of remote sensing applications are described, including the recognition of several previously unrecognized faults on the Appalachian Plateau.

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#### NATURE AND SIGNIFICANCE OF BORINGS AND OTHER STRUCTURES ON AND WITHIN OOLITE ALLOCHEMS

A combination of scanning electron microscopy, light microscopy, decalcification, staining with malachite green, and a Lakeside-70 impregnation-decalcification technique shows that biogenic and inferred biogenic structures are present on and within all types of allochems in samples from 12 oolites ranging in age from Holocene to Silurian. The types of structures include borings, mucilaginous filaments, pits, irregular depressions, and globules. The most abundant and best preserved of the structures are in Holocene samples.

Borings are the commonest structure in all types of allochems, regardless of the age of the sample, and appear to be due to blue-green algae and to a lesser extent to fungi. Borings may consist of a single straight or anastomosing structure, or may have a ramiform structure. More commonly, borings form complex reticular, clotted, spongy, or polygonal structures.

In the samples studied, no systematic relation exists between the nature, abundance, and distribution of borings and the development of micrite envelopes in ooids. Most ooids which contain abundant borings do not display any sign of a micrite envelope. Also, borings may be as abundant in ooids as they are in peloids. These new findings support ideas presented previously by Bathurst and by Purdy that either decomposition of organic matter by bacterial activity, or the metabolic activity of the original borer, or both, play a more important role than the borings themselves in the development of micrite envelopes and of recrystallization in ooids.

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#### STRUCTURE AND STRATIGRAPHY OF RHARB BASIN AND RELATION TO PLATE-MARGIN TECTONICS

The Rharb basin is an east-west-trending trough in northwest Morocco. It separates Cenozoic Rif sedimentary sequences from older, pre-Cenozoic platform rocks. These platform deposits are relatively undisturbed; the Rif sequence is greatly deformed.

Timing of the filling of the Rharb basin suggests 3 separate and distinct events. These are: (1) pre-Rif sedimentary sequences related to the early Tertiary uplifting, folding, and faulting on the north; (2) emplacement of the Miocene "prerifaine nappe," with consequent deformation; and (3) deposition

of younger, relatively undisturbed, late Miocene to Holocene sediments.

Seismic, subsurface, and surface data suggest, in addition, that nappe emplacement was severely affected by preexisting topographic highs on the rapidly subsiding pre-Cenozoic platform. One consequence of this tectonic style of deformation was the formation of a series of large faults and fault-controlled mountains (Jebel Kafs, Jebel Zerhoun, etc.). Displacement along faults locally may exceed 1,000 m; possible lateral movement could be more than several kilometers.

A strong positive arch in the eastern Rharb basin has had great effect on the structural patterns of the Rharb basin, the Sais basin on the east, and the Dfarrar basin and contiguous mountains. This arch acted as a resistant buttress to laterally moving thrust sheets and the Miocene nappe. It also acted as a source for much of the Miocene sediment in the contiguous basin areas. Once stripped of sediment, the high began foundering and the tectonic patterns that already were established continued or were accentuated.

The relation of the African plate to the plate margins suggests only mild downwarping with no active zone of igneous activity. No well-developed fractures were observed. Several small oil fields are associated with the nappe; these produce from relatively weakly defined structures or structural traps.

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#### INTERACTION OF AQUEOUS $Mg^{2+}$ WITH GROWING CALCITE CRYSTALS AND ITS EFFECT ON THE ARAGONITE → CALCITE TRANSFORMATION BETWEEN 25 AND 90 DEGREES CELSIUS

The interaction of aqueous  $Mg^{2+}$  ions with growing calcite crystals was studied by closed system recrystallization of aragonite to calcite in the presence of aqueous  $CaCl_2$ - $MgCl_2$  solutions at 25-90°C. The measured heterogeneous distribution coefficients for  $Mg^{2+}$  between calcite and solution ( $\lambda_{Mg}^{C_2}$ ) are independent of the solution's composition and rate of recrystallization. They are strongly dependent on temperature, being  $0.0573 \pm 0.0017$  at 25°C,  $0.0681 \pm 0.0019$  at 35°C,  $0.0778 \pm 0.0022$  at 50°C,  $0.0973 \pm 0.0021$  at 70°C, and  $0.1163 \pm 0.0034$  at 90°C. If, as reported in literature, calcite containing 12-16 mole % magnesium has the same solubility as that of aragonite, the new  $\lambda_{Mg}^{C_2}$  values exclude its formation directly from sea water. However, in closed systems isolated from seawater, the transformation of aragonite to calcite should start spontaneously once the magnesium-calcium ratio of the interstitial fluids drops from 5 to 2 or less, no freshwater intervention in this process being necessary.

The kinetics of recrystallization in the absence of  $Mg^{2+}$  at 25 and 35°C are strictly diffusion controlled and are, thus, markedly affected by the mass of aragonite per unit-volume of solution taking part in the process. The kinetic effect of  $Mg^{2+}$  is still under study.

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#### GEOHERMAL EXPLORATION AT SUMMIT OF KILAUEA VOLCANO

An area of anomalously low resistivity, associated with high microearthquake activity at depths of 1-3 km, has been mapped near the summit of Kilauea Volcano, Hawaii. In view of the volcanic activity in the area, one possible explanation of this feature would be that a convection cell of warm water is present above the magma chamber feeding the volcano. To test this possibility, a hole has been drilled and cored in the center of the anomaly. Physical properties and temperatures have been determined in the well bore using standard geophysical logging techniques.