

precise data pertinent to the existence of favorable structures.

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CALCIFIED ALGAL FILAMENTS IN REEFS: CRITERION OF EARLY DIAGENESIS

Calcified algal filaments are a prominent and probably diagnostic feature of the extensive syngenetic submarine cementation in recent Bermudan reefs. The filaments occur within millimeter- to decimeter-size cavities of the reef frame to depths of at least 12 m; they range from 20 to 300 μ in diameter and are up to 5 mm long. The filaments are worm-like threads with lateral branching and commonly form an irregular meshwork which lines or fills the cavities; the meshwork commonly incorporates fine sediment that is in turn cemented.

SEM photographs show that the original filaments are enveloped by crusts, 5–150 μ thick, of bladed to fibrous, outward-growing crystals that bear rhombs at their terminations. The internal casts of the filaments are inward-growing equant and bladed crystals. X-ray diffraction analyses indicate that the crystals are magnesium calcite with 16 mol % MgCO₃.

The filaments remaining after decalcification are *Ostreobium* sp., a widely distributed boring green algae characterized by variations in diameter of the filaments from 1–20 μ , by a lack of transverse partitions, and by local swellings of the filaments. Individual filaments show both the boring habit and incrustation with magnesium calcite.

Whether the outward-growing crust around the filaments is the result of vital activities of the alga, photosynthesis, or boring, and whether the filaments provide an active organic matrix or a passive substratum to localize calcification have not been determined yet. However, it is clear that this type of cementation is submarine and early diagenetic; hence, similar calcified filaments in ancient reefs provide a criterion for and measure of early diagenesis.

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CRETACEOUS LITHOCLASTS IN MODERN BEACH AND RIVER SANDS, VERACRUZ, MEXICO

Abundant Cretaceous carbonate lithoclasts have been found in modern volcanic beach and river sands between Tecolutla and Punta Delgada, Veracruz, Mexico.

The major rivers (Río Nautla and Río Misantla) drain a volcanic terrane which also has outcrops of Lower Cretaceous cherty micrite (Tamaulipas Formation). The stream sediments are composed primarily of volcanic rock fragments and quartz except just downstream from the carbonate outcrop where lithoclasts may make up 50% of the stream sediment. The lithoclast content then drops to 10% at the river mouth.

Micritic lithoclasts make up 35–60% of the beach sands, the rest being volcanic rock fragments and quartz. The lithoclast content increases irregularly from south to north, but drops to 20% or less at the river mouths. Volcanic rock fragment trends are opposite. Wind concentrates the lithoclasts in dunes and the upper beach backslope. The lithoclast percentage is directly proportional to grain size.

The lithoclasts probably were delivered to the coast at a time when the gradient was steeper and/or the climate drier. They are presently being mixed with volcanic debris brought in by the river system and a northward-flowing longshore current.

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GYP SUM—ENVIRONMENTAL INDICATOR IN EVAPORITES

Crystal habit and textural relations of early gypsum, or pseudomorphs after early gypsum, can provide useful indices of subenvironments of evaporite deposition. Attention is directed to the environmental significance of such features of the gypsum as crystal habit, primary versus replacement origin, free versus attached growth, mechanical force of crystal growth, and orientation.

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DELTAIC DEPOSITS OF UPPER PART OF DAKOTA FORMATION (UPPER CRETACEOUS), CENTRAL KANSAS

Sedimentary deposits within the upper 40–100 ft of the Dakota Formation exposed in Russell County, Kansas, record deposition in an environmentally diverse deltaic setting developed during the initial stages of the Greenhorn marine cyclothem. The lower two thirds or more of the Dakota (200–300 ft thick in central Kansas) consists predominantly of nonmarine kaolinitic mudstone and disconformously channel sandstone lenses; however, the upper part contains a complex of fluvial-deltaic, delta-plain and marginal-marine lithofacies, which grade upward into the shallow-water marine Graneros Shale. Such lithofacies have been mapped in detail and can be differentiated according to macroinvertebrate and trace-fossil assemblages, sedimentary body geometry and lateral depositional relations, sedimentary structures, and petrology.

The sedimentary complex in Russell County is dominated by an elongate fluvial-deltaic channel sandstone which changes within 30 mi from a highly meandering, trough-shaped fluvial sandstone body containing freshwater mollusks to a tabular-wedge shaped, delta-front sandstone body containing freshwater to brackish-water macroinvertebrates and a variety of trace fossil types. Kaolinitic floodplain deposits containing abundant plant fossils most commonly are laterally associated with channel sandstones; however, within the upper 20–30 ft of the formation, freshwater lignitic coal-swamp facies and freshwater to brackish-water sideritic clay-ironstone swamp facies are common. Locally, laminated to highly burrowed delta-marine and strandline marine sandstones are present. These contain a diverse association of marine macroinvertebrates and an abundance of trace fossil types. The deltaic facies grade upward into the fossiliferous, glauconite-rich marine sandstone and montmorillonitic shale of the Graneros.

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BUDGET OF CALCIUM CARBONATE SEDIMENTATION, SOUTHERN CALIFORNIA CONTINENTAL BORDERLAND

Although calcareous organisms are abundant in temperate waters of the southern California continental borderland, CaCO₃ is a relatively minor constituent of the sediments. Noncarbonate dilution provides only a partial explanation. Estimating rates of particulate CaCO₃ mass transfer to or from that

water volume in the borderland bounded above by the air-sea interface and below by the sediment-sea interface clarifies the situation.

Carbonate deposition (output) totals approximately 125×10^{10} g/yr. The major carbonate mineral is Mg-calcite, \langle_{41} , with some Mg-calcite, \langle_{41} , aragonite, and dolomite. Noncarbonate dilution totals about 800×10^{10} g/yr.

Other mechanical transfer is primarily river input (15×10^{10} g/yr) of Mg-calcite, \langle_{41} , and some dolomite. Neither aerial nor ocean current transfer affects the budget significantly.

Biologic transfer involves primarily input of CaCO_3 . Foraminifera produce about 250×10^{10} g/yr of Mg-calcite, \langle_{41} , and aragonite. Production of 400 (g/m²)/yr by macrobenthos in shallow, hard-bottom areas is comparable to tropical, nonreef production rates.

Chemical transfer involves solution (output) of about 200×10^{10} g/yr CaCO_3 on basin floors. Apparently all carbonate minerals except dolomite undergo solution.

These input and output estimates balance to within about 10%.

Rivers entering the borderland supply only enough dissolved calcium for 30% of the CaCO_3 deposited.

Of the CaCO_3 input to the borderland, over half dissolves, the remainder is deposited. The CaCO_3 deposition rate is sufficient to extract some dissolved calcium from seawater flowing through the borderland.

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SILICOFLAGELLATE BIOSTRATIGRAPHIC ZONATION OF DEEP-SEA SEDIMENTS

Silicoflagellates have been recognized in land outcrops and deep-sea sediments, but they have not been accepted widely as biostratigraphic indicators. In order to evaluate their occurrences and to establish a workable biostratigraphic framework, approximately 100 deep-sea sediments were studied. These were from a broad geographic area and were of Cretaceous (Cenomanian) and the middle Eocene to Holocene ages. The samples chosen were dated by other planktonic microfossils, thus making cross correlation possible.

The complete absence of silicoflagellates in the few JOIDES samples examined from the Upper Cretaceous and the lack of samples from the Paleocene through the early Eocene interval prevent a complete zonation. Three zones are recognized from the middle Eocene to the top of the Oligocene. There was a sharp decrease in the silicoflagellate population in the Oligocene. In the Miocene evolutionary diversification of taxa permits greater biostratigraphic resolution; 7 zones have been recognized. A massive extinction of silicoflagellates occurred toward the end of the Miocene, with only a few species continuing into the Holocene. The brief recurrence of *Mesocena* cf. *elliptica* at the Jaramillo event within the Matuyama Reversed Epoch both in low and middle latitudes of the Pacific marks a biostratigraphic datum within the Pleistocene. Determining the first appearance of many Holocene taxa will add further resolution within the Quaternary interval.

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MULTIPLE ORIGIN OF HEMIPELAGIC MUD FILL IN MEDITERRANEAN BASIN

Mud, predominantly silty clay, accounts for at least

95% of the Holocene fill of the western Alboran basin in the western Mediterranean Sea, 110 km east-south-east of the Strait of Gibraltar. This mud has a multiple origin; it is not deposited from a simple rain of pelagic material onto the basin floor. The mud distribution is closely related with topography, as determined from cores and high-resolution seismic records. Total thickness of the Holocene section is approximately 2 m on basin slopes, but increases to over 4 m (sedimentation rates up to 30 cm/1,000 years) in the near-horizontal basin plain at a depth of 1,500 m. Thickest mud deposits are localized in lows where thin sand layers most abundant, and major mud transport paths appear to be similar to sand dispersal patterns. Mud is hemipelagic in composition: lutite with planktonic and benthonic Foraminifera, deep- and shallow-water ostracods, and plant fibers. Components are, at least in part, near-shore in origin.

X-radiographs show that 10–20% of the mud in the cores is parallel- and cross-laminated, indicating the importance of bottom traction transport. Bottom currents also have truncated the top of sand layers and concentrated microfossils in thin laminae. A few graded mud units are probably *mud turbidites*. The predominant "trigger mechanism" of the fine-grained turbid flows is floods that seasonally inject material at fluvial point sources along the mountainous Moroccan and Spanish margins. Homogeneous mud layers with scattered microfossils, comprising more than half of the Holocene fill, reflect a more regular deposition from less dense suspension layers. The suspensate is also in part extrabasinal, derived from low-density Atlantic surface water entering at the Strait of Gibraltar and denser Mediterranean water circulating at depth.

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PALEOECOLOGIC AND BIOSTRATIGRAPHIC IMPLICATIONS OF EOCENE PLANKTONIC FORAMINIFERAL ASSEMBLAGES, CALIFORNIA

Correlations and age assignments based on the system of benthic-foraminiferal faunozones and provincial stages developed for the California region are contravened by those based on planktonic species, notably within the Eocene. For example, the Ulatisian and Narizian provincial stages are presently assigned to the middle and upper Eocene, respectively. Our data indicate that strata containing Ulatisian benthic-foraminiferal assemblages range in age from late early Eocene to early middle Eocene whereas Narizian sequences are of early to late middle Eocene age and further, that the "Ulatisian" Rose Canyon and the "Narizian" Cozy Dell formations are correlative. Significantly, none of the Narizian sequences for which planktonic foraminiferal data are available are of late Eocene age. Inasmuch as the presently available stages and faunozones are time-transgressive, it is urged that this system no longer be used for West Coast Paleogene correlations.

The development of a faunozonal succession based on planktonic foraminiferal species provides an adequate chronostratigraphic framework for paleogeographic interpretation, but the absence or rarity of thermophilic species important in standard faunozones necessitates use of regionally dominant forms.

Delineation of dominance and diversity trends reveals modification by shifting watermass boundaries of planktonic-foraminiferal assemblages occurring over