equatorial currents are diverted poleward. The reverse situation is true along west-facing coastlines where cooler waters are brought into low latitudes by polar currents. Here, buildups are usually restricted to near the ancient equator. Another control on the distribution of carbonate buildups might be related to a decrease in light penetration poleward due to an increase in the angle of incidence of light striking the oceans. Work done by others suggests that significant seasonal reduction in light penetration occurs between 30° and 40° from the equator.

Maps showing the global distribution of carbonate buildups have been constructed for several intervals in the Mesozoic and Tertiary. These reconstructions illustrate the effects of ocean circulation, and continental placement and orientation on the distribution of carbonate buildups.

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Cretaceous Black-Shale Deposition Within an Oxidized Red Clay, Turbidite Environment, Southern Angola Basin, South Atlantic Ocean

Beds of black shale, intercalated with red and green claystone of Albian to Coniacian age, were recovered at DSDP site 530 in the southern Angola Basin. The 260 beds of black shale have an average thickness of 4.3 cm (range of 1 to 62 cm) and an average organic-carbon content of 5.7% (range of 1.4 to 16%). The green claystone beds resulted from reduction of iron in red claystone beds around black shale beds. A green-black-green reduced sequence may occur alone within predominant oxidized red claystone, or several, closely spaced reduced sequences may merge to form interbedding of black and green lithologies. The predominant red claystone beds were deposited as distal turbidites. Many of the black shale beds contain graded silt laminae, very low amplitude ripple cross-lamination, and fine, indistinct, discontinuous laminae, suggesting that the material in the black shale beds also may have been transported by turbidity currents. All lithologies are commonly bioturbated. The sequence, including the black shales, at Site 530 suggests that deposition of the distal turbidites, low in organic matter, in an oxidized bottom-water environment was interrupted periodically by the deposition of organic-carbon-rich clay. We conclude that the cyclic interbeds of more- and less-reduced strata, with frequencies and durations measured in thousands or even hundreds of years, resulted from variable supply of organic matter, most of which is of marine origin, and not from bottom-water stagnation. We favor periodic regional increases in organic productivity that resulted in increases in production of organic matter, and an expanded and intensified mid-water oxygen minimum that impinged on the continental margin, as a cause of periodic increases in accumulation of organic matter. These conditions would produce variations in the amount of organic matter in both time and space, and result in interbedding of organic-carbon-rich, reduced sediments and organic-carbon-poor, oxidized sediments, a characteristic of all so-called anoxic sequences in the Atlantic Ocean.

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Marmul Field, South Oman: Appraisal and Development of Structural and Stratigraphic Trap Oil Field with Reservoirs in Glacial/Periglacial Clastics

The Marmul field lies in the Dhofar province of the Sultanate of Oman. The heavy oil accumulation was discovered in 1956 by Dhofar Cities Services who drilled five wells, but the field was not considered commercial and operations were abandoned. Petroleum Development Oman acquired the concession in 1969. Producible oils occur in Paleozoic clastics overlain unconformably by a Cretaceous sealing shale. Initial appraisal showed the complex nature of the reservoir distribution to be due to its glacial/periglacial environment of deposition, and a simple geologic model was conceived. Seismic impedance contrast at the seal's unconformity surface was then used as a predictive tool to differentiate glacial waste zones (tillites) from periglacial reservoirs and as support to the continuing appraisal and development drilling. The glacial/periglacial geologic model was progressively refined by further development drilling. The appraisal effort based on geologic and seismic impedance models was then deliberately pursued toward possible additional younger stacked reservoirs stratigraphically trapped at the periphery of the field. These reservoirs were proved by drilling to be separate from the main field and oil bearing. The unraveling of the field's complex trapping mechanisms, and the buildup of the geologic models needed for primary development and secondary recovery schemes, could only be achieved through an integrated and dedicated approach by geologists and geophysicists.

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What is Horizontal Resolution?

Horizontal resolution is the smallest interval measurable in the horizontal direction by the seismic method. Because both migrated and unmigrated sections are used for interpretation, the resolution of both must be evaluated. On unmigrated sections, the horizontal resolution is generally limited by Fresnel zone size for dominant frequency of the reflection being mapped. Features smaller than this seen on the section are probably noise or processing artifacts.

The horizontal resolution of a migrated section is much better than that of an unmigrated section and, theoretically, is directly related to the vertical resolution and angle of migration. In practice, the horizontal resolution is limited by uncertainties in velocity, inadequate spatial sampling, and presence of coherent noise, as well as shortcomings of, and approximations used in, the stacking and migration algorithms.

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Effect of Non-Hydrostatic Stress on Chemical Processes During Diagenesis

Non-hydrostatic stress facilitates porosity reduction in sandstones at elevated temperatures. Experimental results indicate that chemical equilibrium between fluids and solids in fluid-saturated, porous rocks will not be attained under conditions of directed stress. In rocks in which pore fluid pressures are less than lithostatic ($P_f < P_L$), downward directed stress at grain contacts can produce an inhomogeneous distribution of mineral solubilities. High strain at grain contacts causes higher solubilities of the solids and leads to dissolution (pressure solution), whereas growth may occur at solid/water interfaces with low surface strain. The driving free energy for coupled dissolution and growth reactions under non-hydrostatic loading is proportional to $P_L - P_f$. Consequently, the magnitude of the departure from solid/fluid equilibrium during diagenesis will increase with depth of burial if the pore fluid pressure is hydrostatic.

When mineral/fluid equilibrium is not reached, the mineral assemblage developed may be controlled by kinetic rather than thermodynamic factors. Solid phases not stable at the prevailing temperature and fluid pressure may form if high local solubilities create supersaturation in the bulk fluid with respect to many solids. The growth of minerals which decreases the total supersaturation rapidly is favored. Hence, fast-growing less-stable phases (for example, clays, zeolites, and aragonite) may form or persist at the expense of more stable but more slowly forming phases (i.e., illite, feldspars, and calcite). Consequently, the influence of both kinetic factors and bulk phase equilibrium should be considered in evaluating the genesis of mineral assemblages formed during diagenesis and burial metamorphism.

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Calcite Cement Recognition—Fact or Fantasy

The features characteristic of competitive growth such as plane intercrystalline boundaries, and increasing crystal size away from the substrate, together with the high frequency of enfacial junctions are regarded by others as intrinsic to cements and form the mainstay of its identification. The features of competitive growth are based on published crystal growth diagrams which are unrealistic because of gross oversimplification. The high frequency of enfacial junctions, claimed as the least unequivocal criterion for cement recognition, still requires explanation. The jerky growth required by cessation of one crystal's face while others grow against it seems unnatural.

Three new diagrams for specific calcite crystallographic forms ($(10\bar{1}1)$, $(40\bar{4}1)$, and $(01\bar{1}2)$ rhombohedra) are introduced. These show competitive or impingement aggregates developed through 3 or 4 maturation stages, and occuring in two basic types, one in which the crystals develop positive elongation, and the other in which negative elongation develops. These graphic models find their closest natural analog in parallel-side veins, but their properties can be applied to pore-fill cements which grew by seeding (without epitaxy) onto the pore walls.

The apparent enigma between the absence of enfacial junctions in the new diagrams and the high recorded frequency in natural aggregates is explained by reference to selected examples.

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Role of Multiple-Headed Submarine Canyons, River Mouth Migration, and Episodic Activity in Generation of Basin-Filling Turbidity Currents

The initiation mechanism and source of turbidite sediments to fill both recent and ancient offshore basins can be explained by examining nearshore submarine canyons like those off the Magdelline River, Columbia, and Rio Balsas, Mexico. To generate turbidity currents, large amounts of sediments of mixed grain size must first be stored as a stable deposit in the upper reaches of a canyon, then some mechanisms must create instability and set the entire deposit into motion. Canyons which head at deltas respond to the pulsating sources of sediment and the migration of the river mouth from one area to another. There is a flip-flop in the processes active in the canyon heads from one of erosion when the head is proximal and a large amount of coarse sediment enters directly into the canyon, to one of deposition of fine-grained sediment when the canyon head is distal and processes quiescent. During the distal stage, fine-grained cohesive sediments build up forming V-shaped profiles. The walls literally grow together. The migration of the river mouth back to the vicinity of a formerly quiescent distal canyon head will introduce coarse-grained sediments and reinitiate submarine erosion of the poorly consolidated canyon fill. Erosion forms steep unstable slopes and progressive slumping, creating the mechanism for generating a turbidity current with a large volume of poorly sorted driving sediment.

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Blake Escarpment Carbonate Platform Edge: Conclusions Based on Observations and Sampling from Research Submersible

Three continuous transects of the Blake Escarpment, east of Florida, were made during 10 dives in the submersible Alvin at depths from 1,400 to 4,000 m. We observed and sampled outcrops of horizontal strata known, from multichannel profiles across the dive sites, to extend westward beneath the Blake Plateau carbonate platform. The northern end of the Blake Escarpment, at the salient of the Blake Spur, is a nearly vertical limestone cliff, which is pitted and commonly fluted by vertical borings, coated by ferromanganese oxide, and heavily encrusted by organisms. Presumably, the cliff face is maintained by bioerosion and corrosion, and debris is removed by the strong turbulent currents (2 kn). Average slopes were less steep at transects 130 and 200 km south of the Blake Spur, but vertical cliffs as much as 450 m high exist. Talus slopes are common, and the large blocks and landward dips of beds suggest collapse of fragments at least several hundred meters across. On the southern transect are broad slopes of rippled pteropod sand between near-vertical outcrops; a vertical 160-m cliff of massive limestone at the top of the escarpment and rudists in talus blocks suggest the presence of a Mesozoic reef. Preliminary analysis of calcarenous nannofossils shows rocks as old as Early Cretaceous; identification of older rocks is anticipated. Sedimentary structures and components indicate deposition in shallow water. Thousands of meters of subsidence and extensive erosional retreat were required to create the escarpment's present configuration.

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Field Study of Subaqueous Avalanching

Many submarine canyon walls consist of unconsolidated sand sitting at the angle of repose ($\sim 31°$). The sand walls commonly maintain this slope for many tens of meters before leveling out at the canyon bottom. Where such angle-of-repose sand slopes occur within scuba diving depth, they present an opportunity to study subaqueous grain flows in situ. Such a study has been conducted in the head of Carmel submarine canyon, Carmel Bay, California.