deposited in adjacent low areas. With deepening of water, sand ridges first stabilize then eventually become buried in shelf mud. Repeated cycles of development of highs and changing water depth can give rise to a series of locally sourced shelf-bar sandstones associated with shale. This sequence of events assumes erosion and deposition can occur on different parts of the shelf topographic high, which is of the same general size as northwestern Atlantic shelf highs upon which Holocene ridges sit.

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Early Cretaceous Drowning and Recovery of a Carbonate Continental Margin, Eastern Arabia

The eastern margin of the vast Mesozoic carbonate platform which underlies much of Arabia is exposed in the mountains of Oman and the United Arab Emirates. Outer platform and margin facies occur as autochthonous windows in the Oman Mountains and as allochthonous terrane in the Musandam Mountains to the north. These strata are in turn surrounded by westward-thrust nappes of contemporaneous deep-water strata and oceanic lithosphere.

Inundation or drowning of the platform occurred in earliest Cretaceous time and is reflected by Jurassic reef limestones overlain directly by Lower Cretaceous pelagic carbonates. In Oman the outer platform strata are buried by over 250 m (820 ft) of these radiolarian lime mudstones. The abrupt upward transition in middle Cretaceous time to ooid grainstones and then muddy fossiliferous limestones interbedded with rudist biostromes documents buildup to sea level and eastward progradation of first high-energy facies and then lower energy interior facies. In the Musandam Mountains to the north, however, where the Jurassic margin proper was drowned, deep submergence was accompanied by flexure and the Lower Cretaceous limestones are slope deposits as indicated by numerous turbidites, debris flows, and slope unconformities. These strata are also transitional upward into shallow water facies so that by Middle Cretaceous time the high-energy facies were once more at the shelf edge.

These events, which are reflected along the length of this extensive continental margin, occurred during a time of apparent eustatic sea level rise.

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Regional Variations in Development and Characteristics of Barrier Island Foredunes Along Texas Coast

Analyses of grain-size parameters, carbonate content, and heavy-mineral content of foreshore and dune sediment samples collected along the Texas coast indicate that five textural zones exist. The characteristics of these zones are controlled by sediment supply, nearshore hydrography, and shoreline stability. In general, Texas coast sediments are fine to very-fine grained, well-sorted sands. Dune and foreshore subfacies can be distinguished from one another by mean standard deviations, skewness values, and carbonate content.

Variations in dune geometry and size are controlled by climate, coastal orientation, and wind direction and velocity. Measurements of the foredune cross-stratifications show that polymodal distributions of the dip angles and azimuths are typical along the Texas coast. Pyramidal dune forms, which are produced by seasonal variations of wind direction, result in bimodal distributions of cross-bedding azimuths; the two direction modes are bisected by the prevailing winds from the southeast. Offshore-directed winds from the north and west produce a significant number of offshore-dipping beds at each sample station.

Analysis of the internal structure of the Texas coast dunes demonstrates the variability of cross-stratification dip angles and azimuth values that is possible in an eolian environment. The information from this study may be used to help define relict coastal orientations and eolian processes that acted within an ancient depositional setting. Depending upon diagenetic processes, the well-sorted character of the dune sediments may provide porosity values that are suitable for hydrocarbon accumulation. Therefore, it is important to recognize and understand these eolian deposits.

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Fourier Grain Shape Analysis as a Tool for Indicating Batch Recoveries of Bitumen from Athabasca Tar Sands

Effects of weight percent fines have been considered in the past as important factors in controlling the recoveries of bitumen from tar sands using batch extractors. However, in the marine sands of the Athabasca deposit, fines break down as a predictor of batch recovery; in some places even low fines tar sands do not yield acceptable batch bitumen recoveries. It was predicted that a sand unit high in rough-surfaced, diagenetically altered grains would yield low primary bitumen recovery. Scanning electron microscopy of the solids from batch extraction tests revealed that quartz grains with very rough, pitted, and overgrown surfaces retain bitumen. (These solids appear to be transported preferentially with the bitumen to froth and secondary tailings.) Grains with smooth surfaces were found to be dominant in primary tailings.

Fourier grain-shape analysis was employed to identify tar sand shape types since scanning electron microscopy inspections are time-consuming and expensive. Five grain shape families were so identified and verified by SEM.

Two types of grains unaltered by diagenesis are very fresh, rounded, sub-aerially abraided grains, and fresh, angular grains with concoidal fractures. Three other grain shape families represent particles whose surfaces were strongly modified by diagenesis. The diagenesis was found to be primarily overgrowth: (1) rough silica plastering with a sponge-like appearance, producing high surface areas; (2) silica plastering with multiple crystals; and (3) complete simple overgrowth.

Fourier grain-shape analysis yields the proportion of high surface area grains in 900 grain samples taken from marine sand intervals of 3 cores. That proportion, plotted versus weight percent primary recovery by batch extraction, indicates that when the proportion of high energy grains exceeds 40%, primary recoveries were less than 80 wt. %. (Primary recovery, in contrast, shows no relationship to weight percent fines for these marine sands and cannot be used as a batch recovery indicator.)

The results suggest the feasibility of predicting recovery in advance of mining, thus permitting adjustments to mining/extraction strategies. It must be kept in mind, however, that extrapolation of bitumen recovery results from bench-scale batch tests to large-scale continuous units is not straightforward.

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3-D Stratigraphic Modeling from High-Resolution Seismic Reflection Data: An Example from North Carolina Continental Shelf

Over 2,000 km (1,240 mi) of high-resolution seismic reflection data were "rapidly" reduced to stratigraphic line drawings with a predetermined vertical exaggeration of 100:1 using a graphics digitizing tablet and desk-top computer. These data form the basis of a three-dimensional stratigraphic model for the upper southeastern North Carolina continental margin.

Correlations between the seismic data and drill, core, quarry, and outcrop data from the adjacent emerged coastal plain, supplemented by lithostratigraphic and biostratigraphic analyses of over 200 (9 m [30 ft]) vibracores collected along the seismic lines depicts an internally-consistent chronostratigraphic framework ranging in age from middle Eocene to late Pliocene. Seismic sequence analysis delineates five mid-late Paleogene depositional sequences, each bound by basin-wide unconformities. The distribution of these sequences is regionally controlled by the mid-Carolina Platform high of the Cape Fear Arch and locally influenced by Gulf Stream erosional events.

The Neogene section is an extremely complex, highly variable lithic package consisting of at least ten depositional sequences bound by regional unconformities and associated channels. Preliminary biostratigraphic analyses (both nannoflora and planktonic foraminifera) of vibracores penetrating these sequences suggest they represent high-frequency (4th- and possibly 5th-order) sea-level cyclicity. The seismic data indicate that these short pulse sea-level episodes were primarily low amplitude (< 50 m [164 ft]) events. The general distribution for each Neogene sequence, as well as the temporal and spatial relationships of lithofacies changes, seems to be a consequence of a constant interplay between high-frequency sea-level cyclicity and concomitant Gulf Stream dynamics.

The evolving depositional model for the upper southeastern North Carolina margin consists of a few low-frequency (3rd-order) high-amplitude, mid-late Paleogene sea-level events. During their maximum transgression, the western boundary current bypassed the Charleston Bump to the south and impinged on the North Carolina shelf 35 to 40 km (22 to 25 mi) southeast of Cape Fear. These Gulf Stream erosion events deeply scoured the shelf, extending the Blake Plateau to the north. Conversely, the Neogene was dominated by high-frequency, low-amplitude sea level cyclicity. Maximum transgression was relatively lower, forcing the Gulf Stream to be deflected by the Charleston Bump to the south. Consequently, the Neogene sequences comprise a major depositional episode in which the shelf prograded east to the present location of the Florida-Hatteras slope.

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Evolution of a Fluvial Clastic Wedge, Abo Formation (Wolfcampian), Sacramento Mountains, New Mexico

Outcrops of the Abo Formation (Wolfcampian) in the northern and central Sacramento Mountains of south-central New Mexico record the evolution of fluvial systems within a major clastic wedge. This wedge was derived from the Pedernal uplift and prograded westward into the Orogrande basin. Regionally, the Abo Formation thickens from 60 m (197 ft) in the central Sacramentos, to over 545 m (1,788 ft) in the northern portion of the range, a distance of approximately 29 km (18 mi). Superposed on the regional pattern are local thickness variations of up to 91 m (300 ft). These occur within distances as small as 0.4 km (0.25 mi), and represent local tectonic and paleotopographic controls on sedimentation.

Clast-supported cobble conglomerates, associated with laminated mudstones and discontinuous coarse arkosic sandstones, are present near the base of the Abo Formation. The conglomerate lenses range from 0.5 to 20 m (1.5 to 66 ft) thick, and from 15 m (49 ft) to several kilometers wide. They exhibit poor stratification, occasional clast imbrication, and near horizontal to concave-upward erosional bounding surfaces. Locally, nodular $CaCO_3$ occurs in beds or scattered throughout the associated mudstones.

The central portion of the sequence is characterized by abundant conglomeratic medium to very coarse-grained arkosic sandstone lenses interbedded with laminated mudstones. These lenses range from 0.25 to 10 m (0.8 to 33 ft) in thickness, and 10 to 110 m (33 to 361 ft) in width. Commonly, several lenses will coalesce, forming laterally extensive belts. Both erosional and depositional (lateral accretion) bounding surfaces are well developed within individual lenses. Low-angle, large-scale trough cross-bedding is the dominant stratification type within these units, however, small to large-scale tabular foresets occur, as do planar, ripple, and small-scale trough stratification. Occasionally, individual units fine upward in grain size and/or scale of structures. This sandstone-rich horizon varies laterally in thickness, and grades upward into a mudstone-rich horizon at the top of the Abo Formation.

The upper interval of the Abo sequence contains infrequent fine to coarse-grained arkose lenses enclosed in laterally extensive red mudstones. Paleosols and caliche horizons are present, but not common, in the mudstones.

The basal conglomeratic horizon of the clastic wedge represents braided stream deposition at the distal end of arid alluvial fans associated with the tectonically active Pedernal uplift. Caliche and paleosols developed in the overbank mud drapes and levees of these deposits. The conglomerates grade into arkosic sandstones, reflecting the intense weathering and erosion of the granitic core of the uplift. The multilateral sandstone lenses characteristic of the mid portion of the Abo Formation were deposited in low-sinuousity, coarse-grained (bed-load) meander belts; however, higher sinuousity, mixed-load channel and crevasse splay deposits also occur locally. Finally, as the Pedernal source area was buried by its own debris, thick, broad flood-plain deposition predominated. Sandstones associated with the red mudstones were deposited in shallow ephemeral channels and crevasse splays.

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Effects of Lower Cambrian Archaeocyathid Patch Reefs on Distribution of Interreef Faunas

In general, reefs create a physical obstruction to existing circulation patterns as they develop and grow vertically; thus the growth of a reef can promote changes in the local physical-sedimentological conditions. As a reef grows, it develops a distinctive biological zonation that appears to be correlated with changes in the associated sedimentological regime of the reef. Thus some change should also be produced in the interreef organism-sediment associations. These changes should be more pronounced near the reef, where the perturbation in the circulation pattern is higher, and diminish gradually away from the reef. Such physical changes may be small and yet have a significant effect on the local biological habitat.

Archaeocyathid patch reefs of the lower Forteau Formation, southern Labrador, developed in the relatively quiet water environment of the Lower Cambrian epeiric sea. Even though the