Three-dimensional geometries of Miocene progradation, New Jersey margin: Understanding sea-level change during the "Icehouse"

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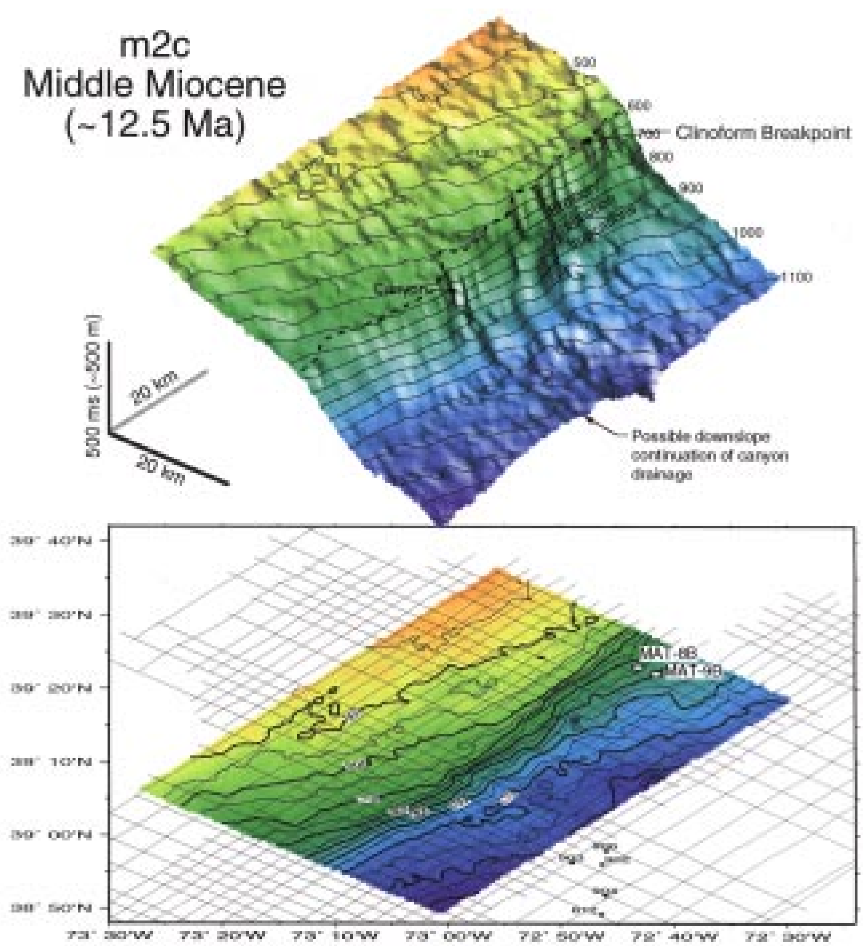
Sea-level changes have direct consequences for mankind; they profoundly affect shallow-water deposition and erosion, nearshore ecosystems, particle and nutrient transfer to the deep sea, and, at time scales of decades to centuries, the evolution of coastal civilization. Determining the timing, amplitudes, and causal mechanisms of sea-level variations, as well as their relation to the resulting stratigraphic record, continues to be a fundamental goal of ODP.

Cycles of global sea-level rise and fall generate unconformity-bounded packets of sediment, known as sequences, on continental margins. Such sequences have been used by Exxon researchers to develop a highly publicized global sea-level curve for the last 250 m.y. The curve remains controversial in part because local processes, notably rates of sediment supply and subsidence, can also influence relative sea level, hence sequence formation, and must be understood in order to decipher the global record of sea-level change. A large influx of sediment, eroded from eastern North America during the Miocene (~25-5 Ma), caused the New Jersey margin to prograde rapidly. As a result, sequences there have lenticular cross sections with "clinoform" bounding surfaces, i.e., featuring a break in slope analogous to the modern shelf/slope breakpoint, and are particularly well resolved on seismic profiles. ODP Leg 174A will drill Miocene clinoform sequence boundaries beneath the New Jersey shelf as the next stage of the Mid-Atlantic Sea Level Transect (see figure). This transect already comprises Leg 150 slope sites and Leg 150X onshore sites. The primary goal of Leg 174A is to determine the stratigraphic response of this margin to sea-level change during



Buried clinoform m2c (middle Miocene, ~12.5 Ma), offshore New Jersey, one of four Miocene clinoforms mapped in this study. Lower: structure map showing seismic grid, existing slope drill sites 902-904, 906 (ODP Leg 150), and 612 (DSDP Leg 95), and shelf drill sites MAT-8B and -9B (Leg 174A). Units are milliseconds two-way traveltime below present sea level. Upper panel: 3D perspective shaded image with traveltime contours (azimuth of artificial illumination = 220°). Both panels are viewed from an azimuth of 180° and an elevation of 30°. Sequence boundary m2c is assumed to be correlative with sequence boundary m2 drilled during Leg 150. The correlation must remain tentative, until it can be confirmed by Leg 174A drilling, owing to the difficulty of tying reflections between shelf and slope. The clinoform slope canyon is V-shaped; the mapping reveals an apparent downslope continuation of this drainage feature and a broad erosional region to the northeast (possible slope failure?).

the “Icehouse” interval, so called because sea level has been primarily controlled by the growth and melting of continental ice sheets during the past ~35 Ma.

Documentation of margin-parallel variations in the morphologies of continental-margin clinoforms is an essential complement to the drilling results, in order to understand the inherently three-dimensional (3-D) mechanisms of continental-margin progradation, and hence the fundamental relationships between depositional processes, preserved stratigraphy and sea-level variations. Maps (see figure) based on a grid of commercial multichannel seismic data, extending >70 km parallel and ~50 km perpendicular to the margin, reveal the 3-D morphology and evolution of four buried surfaces correlated with middle-upper Miocene (13.6 - 8 Ma) sequence boundaries calibrated by Leg 150 drilling on the adjacent continental slope.

Canyons are absent on three of four mapped clinoform slopes; the fourth (see figure) has one V-shaped canyon and a broad erosional area (possible slope failure?). Planar-floored canyons also occur, albeit rarely, seaward of clinoform toes. Apparently, V-shaped and planar-floored canyons, previously ascribed to downslope erosion vs. slope failure/headward erosion, respectively, can coexist. The actively prograding northern slope of modern Little Bahama Bank, characterized by shallow (<100 m) gullies and lacking large canyons, is a possible morphologic analog.

Since Miocene clinoform breakpoints formed during a period of rapid progradation, they are not depositional analogs of the modern shelf edge, which is generally static or eroding. Miocene breakpoints are linear to gently arcuate; their trends indicate a systematic southward displacement of deposition over ~5.6 m.y. Progradation apparently responded to point-source (fluvial) sediment input. However, efficient margin-parallel sediment dispersal by longshore currents muted riverine influence. By analogy with Pleistocene shelf/slope geometries, an absence of canyons breaching clinoform breakpoints suggests that Miocene rivers did not discharge at paleo-shelf edges. Postulated middle-upper Miocene sea-level lowstands must not have exposed breakpoints. Reconstruction of breakpoint paleo-elevations supports this conclusion for three of the four mapped horizons, and also suggests that elevations of parts of some Miocene cycles on the Exxon global sea-level curve are too high by up to 60 m.