Using the New Jersey Continental Shelf to Understand Sea Level Change

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Sea-level changes impact society in many ways: they profoundly affect erosion of barrier islands, beaches, and coastal bluffs; nearshore ecosystems; sediment and nutrient transfer to the deep sea; and, eventually, the evolution of coastal civilizations. Determining the timing, amplitudes, and causal mechanisms of sea-level variations is a fundamental goal of scientific ocean drilling.

Global sea-level rise and fall generate unconformity-bounded packets of sediment, known as sequences, that are widespread along continental margins. Exxon researchers have used these sequences to develop a global sea-level curve (i.e., a diagram showing interpreted past global sea-level changes) for the last 250 million years. This curve remains controversial because local processes, notably rates of sediment supply and subsidence, can influence relative sea level. Therefore, local conditions influencing sequence formation must also be understood in order to decipher a truly global record of sea-level change.

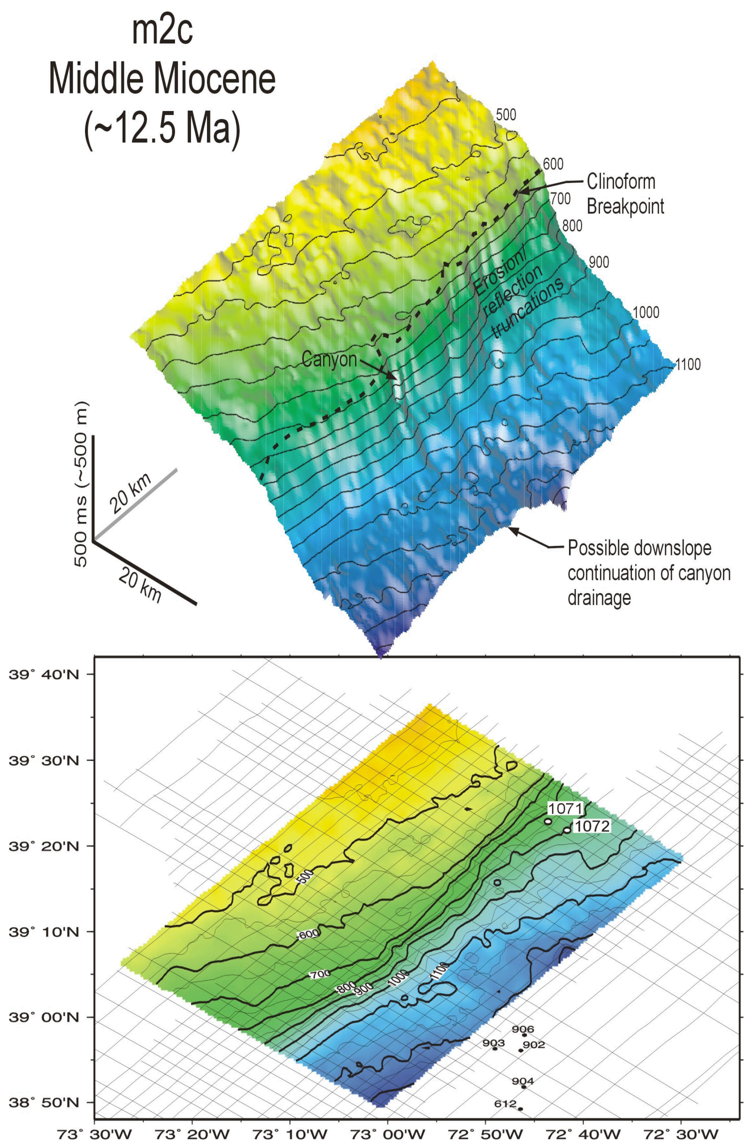
The continental shelf off New Jersey is an excellent site for ocean drilling to investigate controls on sequence formation because a large influx of sediment, eroded from eastern North America, caused the New Jersey continental shelf to grow rapidly seaward during the Miocene (~25-5 Million years ago (Ma)). As a result, sequences now preserved there feature a break in slope (breakpoint) analogous to the edge of the modern shelf/slope ("clinoform" bounding surfaces). Clinoforms are the most favorable geometries for defining sequence boundaries and those off New Jersey are well-imaged seismically. ODP has drilled these sequences beneath the slope (Leg 150), shelf (Leg 174A) and onshore (Legs 150X, 174AX), which together comprise the Mid-Atlantic Transect (see figure).

The cores recovered during these drilling operations, coupled with seismic observations, reveal that Miocene shelf/slope systems differ from those of today. Because ancient river channels incise some middle-to-late Miocene clinoform boundaries landward of paleo-shelf edges, at least some middle to late Miocene sea-level falls must have been large enough to expose the entire continental shelf. This finding is supported by recovery of probable estuarine/lagoonal sediments only 3 km landward of a ~8.6-5.9 Ma sequence boundary breakpoint at Site 1071 (Leg 174A). River systems reaching the outermost shelf were small and closely spaced, which may explain the observed linearity of Miocene shelf edges (see figure).

The distribution of slope canyons also provides insight into controls on sedimentation. Scientists have linked canyons to sea-level falls; however, their non-uniform distribution in time and space indicate that a sea-level fall is a necessary, but not sufficient, condition for canyon formation. The presence or absence of canyon incision off New Jersey must be dictated instead by more subtle fluctuations in local conditions or "regime variables." These include the efficiency of downslope sediment transport, rate of sediment supply, grain size, and possible slope collapse related to fluid escape/spring sapping.

Seismic data therefore complement ocean drilling to define the stratigraphic response to sea-level change and more local controls. Only by mapping seismic morphologies in detail can sedimentary geometries be linked properly to forcing functions.

Figure : Buried (middle Miocene, ~12.5 Ma) sequence boundary offshore New Jersey, showing paleo-shelf edge and clinoform front. Maps like this one require extensive geophysical coverage



Upper panel: 3D perspective shaded image with travel-time contours. The slope canyon is V-shaped; a broad erosional failure occurs to the northeast.

Lower: structure map showing seismic coverage, existing ODP/DSDP slope sites 902-904, 906 (Leg 150), and 612 (Leg 95), and shelf sites 1071 and 1072 (Leg 174A). Units are millisecond two-way travel-time below present sea level..