

LATE PLEISTOCENE SEQUENCE GEOMETRY BENEATH THE LONG ISLAND SHELF FROM CHIRP SONAR DATA

Attreyee Ghosh and **Nicholas Christie-Blick**, Department of Earth and Environmental Sciences, and Lamont-Doherty Earth Observatory of Columbia University, Palisades, New York 10964, USA

Gregory S. Mountain, Department of Geological Sciences, Rutgers University, Piscataway, NJ 08854, and Lamont-Doherty Earth Observatory of Columbia University, Palisades, New York 10964, USA

Cecilia M.G. McHugh, School of Earth and Environmental Sciences, Queens College, C.U.N.Y., 65-30, Kissena Blvd., Flushing, NY 11367 and Lamont-Doherty Earth Observatory of Columbia University, Palisades, New York 10964, USA

Stephen F. Pekar, Lamont-Doherty Earth Observatory of Columbia University, Palisades, New York 10964, USA

High-resolution swept-frequency (“chirp”) sonar data collected at the continental margin of New York and adjacent New Jersey during R/V Endeavor cruise 370 (May, 2002) shed light on late Pleistocene sedimentation beneath the inner shelf south of Long Island. Post-Paleogene sediments, some of which may be older than 150 ka, are thin (mostly < 25 m), discontinuous, preserved preferentially within incised valleys, and thought to have accumulated mainly during times of shoreline transgression and sea-level rise.

Four chirp profiles were acquired between 40°00' and 40°35' N., and between 72°58' and 73°32' W. A strike profile (En370-145), which parallels the shoreline approximately along the 20m isobath, connects the northern ends of two dip profiles off Jones Beach (En370-140) and the western end of Fire Island (En370-150), both of which extend seaward to a water depth of ~40 m. A fourth profile (En370-135) intersects the first of these obliquely at a water depth of about 30 m, and connects with the southern end of En370-150.

Three prominent erosional unconformities (sequence boundaries) are inferred on the basis of offlap of underlying strata and onlap of overlying strata, and they are tentatively related to surfaces mapped beneath the outer continental shelf and slope (Austin, Christie-Blick, Malone, et al., 1998; Metzger et al., 2000; Christie-Blick et al., 2002). The uppermost sequence boundary, informally termed pp0, in many places coincides with the seafloor. Locally, it is overlain by lenticular sediment bodies 2-3 m thick, similar to modern shoreface-attached ridges. Surface pp0 is characterized in places by erosional features that vary in apparent width from ~230-450 m and are ~3-7 m deep. Sequence boundary pp1(?) is approximately 3-15 m beneath pp0 in most places (although locally coincident with it or intersected by it), and is characterized by well developed offlap. Strata beneath pp1 are inclined at 1.7° to 3.6° (apparent dips) near the intersection of profiles En370-135 and 150 where they define concave-upward clinoforms that in places are observed to downlap against a subhorizontal surface. A third sequence boundary lies beneath the other two at a depth of 2-25 m below the sea floor. This surface, which is characterized by local erosional relief of ~5 m, rises towards the north and northwest, and merges with pp1(?). Offlap beneath the third unconformity is defined by more gently dipping reflections (~0.7°).

These observations are interpreted as follows. Surface pp0 is hypothesized to have developed during an interval encompassing the Last Glacial Maximum (LGM) at ~22 ka (Teller, 1987; Stanford, 1993; Duncan et al., 2000). Erosional features in pp0 are interpreted as subaerially incised valleys. The sequence boundary mapped as pp1 is thought to trace to a surface beneath

the continental slope that is as young as Oxygen Isotope Stage 6 at ~150 ka (McHugh and Olson, 2002; and Christie-Blick et al., 2002). Its age is not well constrained beneath the inner shelf where, given its proximity to the top of the Cretaceous and feather edge of the Paleogene, it could represent a composite of two or more unconformities. Offlapping concave-upward clinoforms beneath pp1(?) are interpreted to represent a late Pleistocene delta that prograded towards the southeast along a broad incised valley. Abrupt lateral variations in clinoform dip suggest changes in the direction of progradation (lobes), although these are superimposed on apparent changes in dip related to the turn between profiles En370-135 and 150. A Pleistocene rather than Paleogene or Miocene age for the delta is inferred on the basis of stratigraphic character. Dipping Paleogene strata are generally tabular or associated with subtle clinoforms. Early Miocene clinoforms are known from multichannel seismic data to be well outboard of the location at which the delta has been imaged. The presence of only minor channels in pp1(?) where this surface overlies the deltaic deposits is attributed to shoreface ravinement during subsequent transgression. The third unconformity imaged in our data marks the Cretaceous-Pleistocene boundary along the south shore of Long Island and the Paleogene-Pleistocene boundary farther seaward, and is a composite of numerous erosion surfaces. The location of this boundary is known from cores acquired off Jones Beach by Rampino and Sanders (1981), and is inferred at the southern end of profile En370-150 on the basis of broad tectonic folding evident in pre-Pleistocene strata.

Our expectation, prior to acquiring these data, was that Pleistocene stratigraphy beneath the inner Long Island shelf might record the flexural moat associated with the Laurentide ice sheet, the margin of which lay only a few kilometers to the north at the LGM (Lewis and Stone, 1991). The regional northward pinchout of late Pleistocene stratigraphy indicates that whatever sediments accumulated in that moat during the latest and perhaps earlier glacial advances was largely removed as a result of glacio-isostatic rebound and erosion during marine transgression. South of the modern shoreline, the flexural moat may have been expressed by a reduction in the gradient of the shelf (or coastal plain when sea level was substantially lower) rather than by a reversal in the gradient towards the north. Such a reduction in slope would nevertheless have favored the accumulation of outwash sediment preferentially in the vicinity of the ice margin. The delta imaged beneath pp1(?) is preserved because it accumulated in an erosional low. Assuming that the delta top, now ~50 m below sea level, was at or slightly below sea level at the time of deposition (owing to minor subsequent erosion), and allowing for an unknown amount of flexure adjacent to the ice sheet, we infer that the delta developed during late glacial transgression when sea level stood at least 50 m lower than it does today. Each of the three Pleistocene-Holocene sequences is inferred to be dominated by transgressive deposits beneath the modern inner shelf because subaerial exposure during times of sea-level fall would have resulted in bypassing and erosion. In contrast, the same sequences are dominated by progradational deposits beneath the outer shelf.

References Cited

- Austin, J.A., Jr., Christie-Blick, N., Malone, M.J., et al., 1998, Proceedings of the Ocean Drilling Program, Initial Reports, v. 174A, Continuing the New Jersey Mid-Atlantic Sea-Level Transect: College Station, Texas, Ocean Drilling Program, 324 p.
- Christie-Blick, N., Austin, J.A., Jr., and Malone, M.J., eds., 2002, Proceedings of the Ocean Drilling Program, Scientific Results, v. 174A. (http://www-odp.tamu.edu/publications/174A_SR/174asr.htm)
- Duncan, C. S., Goff, J. A., Austin, J.A., and Fulthorpe, C.S., 2000, Tracking the last sea level cycle: Seafloor

morphology and shallow stratigraphy of the latest Quaternary New Jersey middle continental shelf: *Marine Geology*, v. 170, p. 395-421.

Lewis, R.S., and Stone, J.R., 1991, Late Quaternary stratigraphy and depositional history of the Long Island Sound basin: Connecticut and New York: *Journal of Coastal Research (Special Issue)*, v. 11, p. 1-23.

McHugh, C.M.G., and Olson, H.C., 2002, Pleistocene chronology of continental margin sedimentation: New Insights into traditional models, New Jersey: *Marine Geology*, v. 186, p. 389-411.

Metzger, J.M., Flemings, P.B., Christie-Blick, N., Mountain, G.S., Austin, J.A., Jr., and Hesselbo, S.P., 2000, Late Miocene to Pleistocene sequences at the New Jersey outer continental shelf (ODP Leg 174A, Sites 1071 and 1072): *Sedimentary Geology*, v. 134, p. 149-180.

Rampino, M.R., and Sanders, J.E., 1981, Evolution of the barrier islands of southern Long Island, New York: *Sedimentology*, v. 28, p. 37-47.

Stanford, S., 1993, Late Cenozoic surficial deposits and valley evolution of unglaciated northern New Jersey: *Geomorphology*, v. 7, p. 267-288.

Teller, J.T., 1987, Proglacial lakes and the southern margin of the Laurentide Ice Sheet, in Ruddiman, W.F., Wright, H.E., Jr., eds., *North America and Adjacent Oceans during the Last Glaciation*: Boulder, Colorado, Geological Society of America, *The Geology of North America*, Volume K-3, p. 39-69.