A 100 Million-Year Record of Sea-Level and Ice-volume Variations from Continental Margin and Deep Sea Isotopic Records

Kenneth G. Miller
Rutgers, The State University of New Jersey

Abstract

Reconstructions of secular variations in globally average sea level (eustasy), derived primarily from sequence stratigraphic records, are fundamental for understanding Earth's processes. On geological time scales, global sea-level changes are tied primarily to long-term (10^7-10^8 yr scale) tectonism and short-term (10^3-10^6 yr scale) changes in continental ice volume, though recent studies also illustrate the importance of tectonism on 10^6 year time scales. The history of 10^6 yr scale eustatic changes has been controversial; the most widely used sea-level curves (e.g., Haq et al., 1987) are generally correct in the ages of sea-level falls, but are incorrect in amplitudes.

Miller presents here a history of sea-level changes focusing on the last 100 Myr. Prior to the Oligocene (ca. 33.5 Ma), the Earth had been a warm, high CO_2 Greenhouse world that was largely ice-free back to 260 Ma, though recent evidence suggests that 15-25 m sea-level changes observed may have been caused by growth and decay of small, ephemeral ice sheets. The growth and decay of a continental scale ice sheet in Antarctica caused 50-60 m variations on the 106 yr scale beginning ~33.5 million years ago (Ma).

He provides new million year (Myr) scale eustatic estimates from ~40-11 Ma by scaling deep-sea benthic foraminiferal $\delta^{18}O$ records using Mg/Ca to constrain temperature effects and backstripping of core data from onshore New Jersey (NJ), accounting for the effects of compaction, loading, and thermal subsidence. Both show the same amplitudes and timings and testify to a primary glacioeustatic control on the stratigraphic record on the Myr scale. Regional differences document that mantle dynamic changes strongly imprint the stratigraphic and geomorphologic evolution of the passive U.S. Middle Atlantic continental margin. Pliocene peak global average sea levels of 20±10 m above present occurred in a world only 2°C warmer than today and with similar atmospheric CO_2 levels. From 33.5 to 0.8 Ma, sea-level was controlled primarily by astronomical tilt cycles (1.2 Myr and 40 kyr), though the 100 and 400 kyr eccentricity were important in some Miocene intervals and during 100+ m cycles of the past 800 kyr.