Influence of global mean sea level and mantle dynamic topography variations on passive-aggressive continental margins

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Tectonism and global mean sea level (GMSL) changes leave distinct imprints on the stratigraphic record of passive continental margins. During icehouse intervals (e.g., the last 50 Ma), the waxing and waning of ice sheets dominated sea-level changes on distinct Milankovitch periods (e.g., 19/23, 41, quasi-100, and 405 ka and 1.2 Ma tilt cycles). Tectonic subsidence and uplift is superimposed on passive margin records not only on long time scales (10–100 Ma) due to thermal cooling, loading, and flexure, but also on shorter time scales due to changes in mantle dynamic topography (>1–2 Ma scale) and Glacial Isostatic Adjustment (5–30 ka scale).

Drilling on the "passive" continental margin of the mid-Atlantic U.S. has provided unprecedented recovery of Upper Cretaceous to Holocene sequences. Ocean drilling has also provided a global array of ocean core holes allowing application of the $\delta^{18}O$-Mg/Ca proxy for ice volume. We spliced together astronomically calibrated Pacific deep sea benthic foraminiferal $\delta^{18}O$ records from the past 45 Ma and extended this compilation to 66 Ma using lower resolution records. The splice was scaled to sea level using a smoothed record (>2 Ma) of Cenozoic Mg/Ca variations to account for long-term bottom-water temperature changes. Our record provides an estimate of ice-volume and attendant Global Mean Sea Level changes due to ice (GMSL-I) with errors of approximately ±10 m, but is not a complete estimate of GMSL because it does not account for changes in the volume of the ocean basin, other tectonic effects, or other causes. We compare our GMSL-I records with independent estimates of million year-scale sea-level changes derived from passive margins by backstripping, progressively accounting for the effects of compaction, loading, and thermal subsidence.

Both GMSL-I and back-stripped records show synchronous 20–60 m variations on the million year scale during the late Middle Eocene to Miocene, suggesting that we have constrained changes in ice volume on this scale. However, there are differences between the onshore and offshore on the mid-Atlantic margin on the 1–5 Ma scale that we attribute to changes in mantle dynamic topography due to the influence of the subducting Farallon slab. The amplitude of the offsets is consistent with models of mantle dynamic topography that predict these differences. Such changes in continental elevation explain the patchwork preservation of sequences and regional differences on this "passive-aggressive" margin.

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