Coupling of marine and continental isotope records during the Eocene/Oligocene transition

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During the Cenozoic, conditions existed that allowed for the formation of permanent continental-scale ice caps on Antarctica (Miller et al., 1991; Zachos et al., 2001). Long-term cooling commenced after the Early Eocene Climatic Optimum (52 to 50 Ma), culminating in the Oi-1 glacial maximum (~33.65 Ma) (Miller et al., 1991; Zachos et al., 2001; Bohaty and Zachos, 2003). This event reflects a transition from a greenhouse to an icehouse world and is recorded in the marine realm as a stepped positive δ¹⁸O shift in benthic and planktonic foraminifera (Coxall et al., 2005; Katz et al., 2008; Pearson et al., 2008; Lear et al., 2008).

Reported here is a δ¹⁸O record across the continental Eocene/Oligocene transition (EOT). The record derived from V. lentus displays 3 cycles followed by a positive δ¹⁸O shift across Oi-1 with subsequent recovery to pre-Oi-1 values. Within these cycles, plus across the isotope shift and recovery, δ¹⁸O values change in magnitude between 1.4 – 1.8‰. If entirely due to temperature this would equate to a 6 – 13°C (depending on calibration) temperature variation, which according to its high magnitude, implies a contribution from another factor, such as changes in the isotopic composition of the host water in which V. lentus grew. The ultimate control on this is likely to be related to changes in global ice volume. The V. lentus δ¹⁸O Oi-1 shift and recovery are comparable to that seen in the marine record. Furthermore, in cycle 1 the most positive δ¹⁸O value corresponds with the Late Eocene Event as observed in the marine record. Cycles 2 and 3 together occupy the same time interval, recording successive positive δ¹⁸O shifts in the marine realm. Moreover, the negative δ¹⁸O peak between cycles 1 and 2, associated with biotic and isotopic evidence for warming, matches a marine calcite compensation depth shoaling event. Although the cycle 2 positive δ¹⁸O peak has no equivalent in the marine realm, fluctuations within cycle 3 appear synchronous with the named events EOT1/Step 1 and EOT2 (Coxall et al., 2005; Katz et al., 2008; Pearson et al., 2008; Lear et al., 2008). Therefore, the δ¹⁸O record from V. lentus in a coastal floodplain environment shows substantial similarities with those from benthic foraminifera in the marine realm across the EOT and Oi-1 in timing and trajectory. Combined with multiproxy isotope derived summer temperatures, sea-level change and biotic data, some patterns of climate change with respect to the relative roles of temperature and ice-volume in this continental record are also comparable with those documented in the marine record. This suggests that when sampling resolution allows, a coupling of the marine and continental isotope records through the EOT can be observed.

References: