Coupled hydrogen isotope paleoaltimetry and (U/Th)/He thermochronology of river deposits

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Stable isotope paleoaltimetry exploits changes in the isotopic composition of precipitation that occur during orographic ascent of cloud systems. Oxygen isotope compositions of intramontane lake deposits provide a long-term proxy for the isotopic composition of precipitation and lake deposit-based approaches recently provided provocative insights into the topographic history of continental plateaux. However, these approaches recover topographic history from the dry, leeward side of the range where effects such as evaporation potentially affect the isotope signal.

We determine paleoelevation of the Eocene Sierra Nevada, California by tracking the immediate effects of topography on (paleo-)precipitation, as recorded in hydrogen isotopes of kaolinite along the windward western slopes of the (paleo)range. The unusual preservation of this ancient fluvial system, from paleo-sea level to about 1600 m of modern elevation, provides an ideal target to evaluate our ability to recover orographic effects on the isotopic composition of precipitation from the geologic record and allows us to explicitly test different hypotheses for the topographic history of the Sierra Nevada. δD of kaolinite along the Eocene Yuba River decreases systematically from ca. -80 permil in fluvial deposits at the current base of the Sierra to -106 permil about 60 km into the ancient range.

(U/Th)/He aghes from detrital apatite range from 40 to 115 Ma, with a probability peak at ca. 80 Ma. High river discharge and rapid Early Cenozoic erosion rates (as evidenced by syndepositional cooling ages) indicate that mountainous topography characterized the (pre-)Eocene northern Sierra Nevada that may have formed the western edge of a high-elevation continental plateau. Our isotope paleoaltimetry and (U/Th)/He data suggests that modern and Eocene (~40 Ma) stream gradients were similar and headwaters extending to at least 2200 m characterized the northern Sierra Nevada. This result is consistent with cobble-sized clasts that dominate the upper part of the fluvial system where we observe Eocene river incison into bedrock. These data also indicate uplift of the mid- and high elevations of the western Sierran slope by about 300-500 m since the Eocene and place previously unavailable constraints on tectonic models that predict the post-Eocene topographic evolution of the northern Sierra Nevada.