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Oxygen Isotopes as Indicators of Climate Change or Tectonics in Eurasia

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Spatial compilations of stable isotopes may be used to disentangle the competing effects of mountain uplift and paleoclimate change. Because both changes in paleoelevation and changes in paleoclimate result in fluctuations in the $\delta^{18}O$ recorded in authigenic materials, large-scale spatial compilations of oxygen isotope data are required to discern the main driver of isotopic change in the past. Spatially limited studies may lack sufficient geographic range to robustly attribute isotopic shifts to either climate or tectonics. To elucidate potential hydroclimate changes or orographic changes across Eurasia in the Cenozoic, we compile previously published analyses of oxygen isotopes, recorded in authigenic materials such as paleosol, lacustrine, and speleothem carbonates, and mammal tooth enamel, to generate a dataset of over 14,500 $\delta^{18}O$ datapoints spanning Cenozoic Eurasia. Compiled Quaternary $\delta^{18}O$ data across Europe indicate that different proxy materials reliably record the same or similar local meteoric water signatures, signifying the validity of a multi-proxy approach. Across the continent, these Quaternary data capture the decrease in $\delta^{18}O$ with increasing longitude that is observed in modern waters, indicating that the same proxies can be applied to reconstruct meteoric $\delta^{18}O$ during the Cenozoic. Preliminary results from pre-Quaternary Cenozoic proxy data show that the longitudinal $\delta^{18}O$ gradient is not markedly reduced or steepened relative to the modern, even during globally warmer periods such as the Miocene. This result suggests that westerly moisture transport across Eurasia during the Cenozoic resembled modern-day moisture transport processes, despite large changes in atmospheric CO_2 and paleogeography. Although this first-order isotopic trend appears throughout the Cenozoic record, many sites—particularly those nearer to the Paratethys—have elevated estimated paleo-precipitation $\delta^{18}O$ relative to modern. Disparities between the Cenozoic record and modern data may reflect elevation changes due to multiple small orogens that developed during the Cenozoic along the Tethyan margin, changes in moisture sources as the Paratethys shrank, differences in the seasonality of authigenic mineral formation, and changes in atmospheric CO_2 that affect moisture transport. Nevertheless, given the constancy of the overall decrease in $\delta^{18}O$ with increasing longitude, we find that tectonics and paleogeographic changes appear to be a secondary control on continental-scale moisture transport, as there are large changes in paleogeography and orography in the Cenozoic that are not substantially reflected in large-scale spatial patterns of $\delta^{18}O$. These paleogeographic changes appear to have local impacts, but do not drive continental-scale changes in $\delta^{18}O$. Consequently, we attribute first-order changes in $\delta^{18}O$ gradients to climatic effects rather than changes in paleogeography or topography.