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Quantifying surface elevations in deep time through stable isotope paleoaltimetry

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Reconstructing the elevation of mountain ranges in the geological past is crucial for understanding the drivers of mountain building, as well as interactions of topography with the hydrosphere and biosphere. Mountain building results in regional climatic changes, including cooling and changes in wind speed and direction. Simultaneously, mountain building affects regional biodiversity through climate change and landscape differentiation.
Stable isotope paleoaltimetry allows for the quantification of surface elevations in deep time. The method is based on the systematic inverse relationship between the stable isotopic composition (δD, $\delta^{18}O$) of meteoric waters and elevation. The method highly benefits from contrasting the isotopic composition of minerals that incorporated meteoric waters from low- and high-elevation sites. Such minerals may include e.g. lake or authigenic soil carbonates that formed in foreland and intra-montane basins or hydrous minerals from detachment and fault zones. However, incorporation of soil/lake water into pedogenic/lake carbonates and hence setting its $\delta^{18}O$ values depends both on temperature and water oxygen isotope composition. We therefore couple results of $\delta^{18}O$ measurements with clumped isotope paleothermometry (Δ_{47}) to determine both carbonate formation temperatures and the $\delta^{18}O$ values of soil and lake water. This approach refines the estimation of past elevations reconstructed from bulk isotope measurements exclusively.
Here, we show examples of paleoelevation reconstructions of the European Alps and the Anatolian plateau (Turkey) since the Miocene. Results from the Alps support the theory that surface uplift in the Central Alps predates that of the surface uplift in the (far) Eastern Alps. In Anatolia, surface uplift of the plateau occurred rapidly during the latest Miocene – possibly in response to removal of lithospheric mantle - and affected regional large mammal overturn on the plateau, as well as its margins.

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