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Triple Oxygen Isotope Paleoaltimetry – Evaluating an Emerging Tool in Tectonic Reconstructions

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Triple oxygen isotopes of hydrothermally altered minerals from crystalline rocks, sediments, and clays can be used to determine past elevations of mountain ranges. In this work, we summarize the utility of using all three stable isotopes of oxygen (^{16}O, ^{17}O, and ^{18}O) to create data trends in $^{17}O/^{16}O$ vs $^{18}O/^{16}O$ that are extrapolated back to the meteoric water line. We present the application of this method to the early uplift of southern Tibet.

The timing and magnitude of the early Cenozoic surface uplift of the Tibetan Plateau is controversial due to a scarcity of unaltered terrestrial sediments required for paleoaltimetry techniques. Such information is critical, however, for constraining the geodynamic and paleoclimatic evolution of the Indian and Eurasian continents, and for interpreting global climate, biodiversity, and biogeochemical cycles since the Cenozoic. Recently published work proposes that substantial uplift occurred by 63 to 61 million years ago, prior to the collision of the Indian and Eurasian continental plates, based on comparison of triple oxygen isotopes of modern meteoric waters with epithermal quartz veins from the Paleocene Gangdese Arc in southern Lhasa. This suggests that by 63 to 61 Ma, the Gangdese Arc reached an elevation of ~3.5 km, achieving >60% of its current elevation prior to continent-continent collision.

This early high paleoelevation estimate for the Himalaya-Tibetan system challenges previous assumptions that southern Tibet uplift required continent-continent collision to achieve substantial topography. We interrogate the assumptions of such reconstructions and outline tools for determining the robustness of such calculations for future and ongoing dataset generation and interpretation. We also provide preliminary comparisons between triple oxygen isotope measurements, fluid inclusion hydrogen and oxygen isotope datasets, fluvial paleosol clay isotope datasets, and lacustrine carbonate clumped isotope measurements. The application of triple oxygen isotopes as a tool for paleoaltimetry reconstructions is nascent, but it provides complementary information to be used in conjunction with more traditional isotope-based approaches.