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Toward a better $\delta D_{alkanes}$ paleoclimate proxy; Partitioning of seasonal water sources and xylem-leaf deuterium enrichment according to plant growth form and phenology

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The DeepCHALLA consortium is preparing an ICDP (International Continental Drilling Program) deep-drilling project on Lake Challa, a crater lake near Mt. Kilimanjaro in equatorial East Africa, where the climate is tropical semi-arid climate and characterized by two distinct rainy seasons. The main objective of this project is to acquire high-resolution and accurately dated proxy data of continental climate and ecosystem change near the Equator over 250,000 years. One of the paleoclimate proxies to be used is the hydrogen-isotopic composition of sedimentary n-alkanes ($\delta D_{alkanes}$) derived from fossil plant leaf wax. However, this requires a better understanding of seasonal variability in the isotopic composition of precipitation, and of the fractionation of its hydrogen during incorporation in the plant waxes. In addition, recent studies have described the existence of "two water worlds", resulting in an additional deviation of the isotopic composition of the water taken up by plants.
In this study, we measured the δD and δ^{18}O of local precipitation, lake water, and xylem and leaf water from different plant species, seasons and sites with varying distances to Lake Challa. We use these data to set up a local meteoric water line (LMWL), and to assess spatial and temporal patterns of water utilization by local plants. Our data show a seasonal change in water-isotope partitioning with plants tapping water from isotopically lighter water sources during the dry seasons, as indicated by more negative xylem δD values and higher offsets from precipitation (i.e. greater distances from the LMWL), therefore supporting the "two water worlds" hypothesis. Surprisingly, trees appear to preferentially exploit isotopically more enriched sources of soil water, suggesting shallower water sources, than shrubs. Plants located at the lake shore use a mixture of precipitation and lake water, reflected in enriched xylem δD values and in the intersection of 2H and ^{18}O with the LMWL. Leaf-water deuterium enrichment, averaged over all plant species, sites and seasons equals 23 $\pm$ 27‰. Several factors influence the isotopic enrichment between xylem and leaf water, but according to our results, the growth form and phenology of plant species are the primary factors, while the location (proximity to the lake) and season exert relatively minor effects.