

# Carbonate clumped isotope paleothermometry of the interior Kalahari Plateau

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Climate reconstructions of southern Africa are relatively poorly constrained. In particular, there is limited paleotemperature data from the interior, high elevation Kalahari Plateau that today stands at ~1100 masl. A thin sequence (<100m) of Upper Cretaceous to Recent soils, sediments and calcretes is preserved across the Plateau, but unravelling this condensed record is often complicated by chemical weathering and bioturbation. We investigate outcrops and new drillcores of NW Botswana, from Tsodilo Hills and the Okavango Delta System, and test carbonate clumped isotope thermometry on: 1) kimberlites, 2) subsurface calcretes, 3) soil concretions, 4) pan-lacustrine sediments with fossils, and 5) modern snails for comparison. Kimberlitic samples have  $\delta^{13}\text{C}$  values between -9.8 and -6.9‰ VPDB and  $\delta^{18}\text{O}$  values between -11.6 and -7.8‰ VPDB; measured  $\Delta_{47}$  temperatures are ~650°C, consistent with melt composition studies. Calcretes at 5 to 50 m depth are reprecipitated and of polygenetic origin, with carbonates of different phases present. They have  $\delta^{13}\text{C}$  and  $\delta^{18}\text{O}$  values between -7.9 and -5.2‰ VPDB, and between -9.7 and -4.9‰ VPDB, respectively. Measured  $\Delta_{47}$  temperatures from 9 of these calcrete samples range between 27.7 and 40.1°C (average:34.3°C). Those containing basement clasts have the highest values. In comparison, soil samples have enriched  $\delta^{13}\text{C}$  values between -5.0 and 4.3‰ VPDB and  $\delta^{18}\text{O}$  values between -8.9 and -3.3‰ VPDB. Their results reflect organic decomposition and influence of meteoric water. In addition, measured  $\Delta_{47}$  temperatures are generally higher in A horizons (average:50.2°C) compared to the Bk horizons (average:31.0°C). Pan-lacustrine marlstones have  $\delta^{13}\text{C}$  values between -3.2 and 5.0‰ VPDB, similar to the results of the soil samples. The  $\delta^{18}\text{O}$  values in these marlstone samples range between -9.6 to 9.4‰ VPDB. This large variation is attributed to the occurrence of different calcite fabrics as determined by petrography. Measured  $\Delta_{47}$  temperatures from 11 of these samples range between 3.0 to 55.0°C (average:30.4°C); including a fossil gastropod that gives one of the highest values (41.3°C). An initial screening of these results based on  $\delta^{18}\text{O}$  and  $\Delta_{47}$  yields an average temperatures of  $18.8 \pm 0.5^\circ\text{C}$ , which suggests cooler conditions during the Late Pleistocene (129–11ka). This study provides novel constraints on the paleo-environmental evolution of the Kalahari Plateau.

