Reconstructing terrestrial environments using oxygen isotopes in biogenic apatite: a modern case study from Mpala and Tsavo, Kenya

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Stable isotopes of oxygen from biogenic apatite are often used to reconstruct past terrestrial environments because, in the case of mammals, attributes of the food they eat, air they breathe and water they drink are recorded in their tooth enamel. Oxygen bound in the phosphate group of apatite is less sensitive to alteration (as compared to the carbonate group) during weathering or burial, therefore it is also an excellent target for reconstructing terrestrial environments from both the recent past (e.g., Plio-Pleistocene) and deep time (e.g., the Late Cretaceous and Paleocene).

Here we review how aridity, dietary preference and changes in the local hydrological cycle are recorded in $\delta^{18}O_{phosphate}$ of modern mammalian tooth enamel. In addition, we discuss the significance of ^{17}O, an often overlooked stable isotope of oxygen, which can be used to reconstruct past atmospheric conditions (in particular, CO_2 concentrations). We demonstrate how modern herbivores record their local environment by coupling new measurements of $\delta^{18}O_{phosphate}$ to previously published $\delta^{18}O_{carbonate}$ [1] from Mpala and Tsavo, Kenya. We find that $\delta^{18}O_{phosphate}$ varies by up to 10 ‰, with hippos and giraffes representing the end-member species acquiring water from drinking and leaves, respectively. We also report the isotopic composition of surface water and plant waters collected at Mpala, Kenya and use these data, along with an isotope mass balance model of mammalian body water, to interpret our $\delta^{18}O_{phosphate}$ data. As expected, Mpala plant waters are enriched in $\delta^{18}O$ and δD as compared to local surface waters. Therefore, the balance between water derived from food versus water from drinking is essential for interpreting enamel $\delta^{18}O$. The model is also used to predict the $\Delta^{17}O$ of phosphate in modern east African environments, and demonstrate how variable atmospheric CO_2 concentrations are likely to be reflected in phosphate $\Delta^{17}O$.

[1] Levin, N.E., *et al* (2006), *PNAS*, v.**103**, p.11201-11205