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A palaeoenvironmental proxy with more bite: assessing the applicability of O-isotopes in micromammal teeth

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The mineralised tissues of animals are formed from elements obtained from a combination of inherited parental material, ingested food and water as well as respired gases. In mature animals, locally ingested food and water are known to leave traceable O-isotopic signatures in the biogenic apatite of teeth and bones, allowing stable oxygen isotopes to be used as proxies for palaeoenvironmental conditions such as aridity and temperature. Since the development of precise analytical techniques to handle smaller biogenic apatite samples, the use of micro-mammal tooth geochemistry has been proposed for continental palaeoclimatic reconstructions. However, micro-mammal remains typically accumulate due to predation, and the preserved tissue will likely have undergone at least partial digestion. This raises questions regarding the integrity of isotopic signatures preserved in micro-mammalian remains from Cenozoic sequences.

In this study, the effects of digestion on rodent teeth were investigated to determine the predatory taphonomic disruption of geochemical signals in biogenic apatite. Incisors and molars from laboratory raised food mice were analysed by secondary ion mass spectrometry (SIMS) and gas isotope ratio mass spectrometry (GIRMS) to assess $\delta^{18}O$ signatures following ingestion and subsequent excretion or regurgitation by owls (barn owl and southern boobook), mammals (ghost bat and Tasmanian devil) and a reptile (perentie). Elemental abundances within teeth were also analysed via laser ablation inductively coupled mass spectrometry (LA-ICPMS). Disruption of primary geochemistry was compared against physical alteration using electron microscopy. The effect of digestion on elemental distributions and abundance varied significantly across and within tissue types. All analysed elements were affected by digestion (with the exception of Na and Si), but the amount of change was predator species dependant. Generally, the digestion of the teeth resulted in the enrichment of B, Mg, Cl, S, Cr, Ni, Zn, Mn and Cu, and the depletion of Ba and Sr, relative to undigested controls. Despite obvious physical and chemical alteration of ingested teeth across all predator species, O-isotope values appear relatively robust in co-occurring ingested teeth and were within the natural variation of undigested controls for all predator species except the barn owl (~0.7 ‰ depleted), and the perentie (~0.4 ‰ depleted). This was contrary to the physical examination, which showed greater damage in the samples digested by mammals. SIMS analysis showed particular depletion in $\delta^{18}O$ in the basal enamel of digested incisors, suggesting that less mature enamel is more susceptible to digestion-alteration. Dentine was also significantly depleted in ^{18}O relative to enamel in incisors analysed by SIMS, which can be attributed to its less mineralised histology. Variations in $\delta^{18}O$ and trace elements are attributed to numerous factors including tooth histology, the species of the predator resulting in different gastric environments and digestion times, and the amount

of exposure of the tooth to the gastric environment. Going forward, O-isotopes of micromammal teeth offer a potentially high-resolution palaeoenvironmental proxy and imply that a significant archive already exists in museum collections. However, precautions with respect to the predatory origin of the teeth and targeting of specific tissues are required for meaningful data interpretation.