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Strontium isotope turnover event mapped onto an elephant molar: implications for movement reconstructions

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Strontium isotope ratios ($^{87}Sr/^{86}Sr$) of incrementally grown tissues have been used to study movement and migration of animals. Despite advances in characterizing $^{87}Sr/^{86}Sr$ turnover [1], the 2-D geometry of turnover in the tooth enamel is still poorly understood. The relocation of a zoo elephant (*Loxodonta africana*) named Misha provided an exceptional case study for understanding this pattern [1]. We documented the $^{87}Sr/^{86}Sr$ turnover in Misha's molar using high-resolution *in situ* measurements with laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS).

We prepared a longitudinally-cut thick section from Misha's molar plate for LA-ICP-MS analysis. Within the tooth enamel, we measured 10 LA-ICP-MS transects parallel to the enamel dentine junction (EDJ), to map the 2-D pattern of $^{87}Sr/^{86}Sr$ turnover. Within the dentine, we measured a transect adjacent to the EDJ to document the unattenuated $^{87}Sr/^{86}Sr$ turnover sequence. We also analyzed conventionally drilled enamel samples from the same molar plate using the solution method for $^{87}Sr/^{86}Sr$ to document any turnover signal attenuation.

Molar dentine data are consistent with the published Sr turnover pattern in Misha's tusk dentine. The inner half of the molar enamel preserves the turnover features in high fidelity, with a 2-D turnover geometry closely following that of enamel apposition. By contrast, the middle to outer surface of the enamel shows progressively more elevated $^{87}Sr/^{86}Sr$ values than those of the dentine. Data from drilled enamel samples show an attenuated turnover pattern due to averaging during drilling, as well as more elevated $^{87}Sr/^{86}Sr$. We attribute these elevated Sr ratios to post-relocation Sr overprinting primarily on the outer enamel surface during enamel maturation.

Our results suggest that *in situ* LA-ICP-MS analysis of the inner half of enamel best recovers the time scale and magnitude of the $^{87}Sr/^{86}Sr$ turnover in an elephant molar. By contrast, the attenuated and overprinted turnover sequence from conventionally drilled enamel samples may lead to biased interpretations of the timing and geospatial scale of the animal's movement history. To properly interpret conventionally drilled enamel sequences, future work would benefit from a

modeling framework that can account for attenuation, overprint, and turnover of Sr, to quantitatively reconstruct movement or life history of extant and extinct animals.

References:

[1] Yang, D., Bowen, G. J., Uno, K. T., Podkovyroff, K., Carpenter, N. A., Fernandez, D. P., & Cerling, T. E. (2023). BITS: A Bayesian Isotope Turnover and Sampling model for strontium isotopes in proboscideans and its potential utility in movement ecology. *Methods in Ecology and Evolution*, 14, 2800–2813. https://doi.org/10.1111/2041-210X.14218