PhD Course in Models and Methods for Material and Environmental Sciences – XLII Cycle

Tracing diagenetic alteration in bioapatite using stable strontium isotopes: implications for bioarchaeological research

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The reconstruction of past human and animal life histories through the analysis of odontoskeletal remains provides valuable information about mobility, diet and the interactions between mammals populations and their environments [1]. Among the bio-geochemical proxies used to investigate mobility, the radiogenic strontium isotope ratio $^{87}Sr/^{86}Sr$ is widely applied to assess provenance by comparing the isotopic composition of skeletal tissues with local bioavailable strontium. However, the interpretation of isotopic data requires a critical assessment of the geological, taphonomic, and diagenetic processes that influence both the incorporation and preservation of biogenic signals. This issue is particularly relevant in volcanic-insular environments, where strontium bioavailability is shaped by the complex interaction between volcanic substrates, marine inputs, weathering processes, and post-depositional factors.

Current approaches to assessing diagenetic alteration in bioapatite commonly rely on trace element concentrations, including uranium (U), manganese (Mn) and rare earth elements (REE), which can provide evidence of post-depositional alteration. When combined with other geochemical indicators, these elements help identify diagenetic overprinting and assess the preservation of biogenic signals. However, they do not necessarily provide a direct quantitative estimate of the extent to which the original strontium signal has been altered [2, 3]. This study aims to develop and test a new analytical approach based on stable strontium isotope composition $\delta^{88/86}Sr$ as a potential direct proxy for assessing strontium preservation in bioapatite. Stable Sr isotope compositions are influenced by mass-dependent fractionation during biological processes, including trophic transfer, but may also be modified by post-depositional diagenetic processes [4, 5, 6]. This provides the basis for investigating whether the isotopic composition of a sample can reveal the extent to which its original biogenic signature has been altered. Where the biogenic and diagenetic isotopic compositions can be sufficiently constrained, mixing models may allow the contribution of diagenetic Sr to be estimated. The study will therefore test the potential of stable Sr isotopes to provide quantitative information on strontium preservation and assess whether this information can help evaluate the reliability of radiogenic $^{87}Sr/^{86}Sr$ data used to reconstruct past human mobility. $^{87}Sr/^{86}Sr$ and $\delta^{88/86}Sr$ ratios will be measured via solution MC-ICPMS. Sr data will be accompanied by a comprehensive assessment of diagenetic alteration exploiting 'traditional' geochemical methods, namely trace element analysis *via* (LA-)ICPMS.

The proposed approach will be tested on fossil and archaeological bioapatite samples, spanning a broad range of geographical, chronological, and diagenetic contexts, from the Middle Pleistocene to the Holocene. The sample will include dental specimens of different ages (including modern) and from diverse depositional environments, providing a framework for evaluating the potential of stable strontium isotopes as indicators of diagenetic alteration. I hypothesize that samples with more extensive diagenetic alteration will show $\delta^{88/86}Sr$ values shifted towards heavier isotopic compositions, compared to well-preserved bioapatite (modern bioapatite average $\delta^{88/86}Sr \sim$ -0.20‰). Building on this framework, the approach will be applied to archaeological human dental remains, with a particular focus on Bronze Age communities from the Aeolian Islands [7]. The volcanic-insular setting makes this a key case study for investigating the preservation of biogenic strontium isotope signatures and their implications for reconstructing past human mobility. By integrating stable and radiogenic strontium isotope analyses with complementary geochemical investigations, the study will thus link methodological development to broader questions of mobility and settlement dynamics in the central Mediterranean during the second and first millennia BCE.

Bibliography: [1] Müller, W. *et al*. In Treatise Geochem. (3rd ed.), 281–328 (2024). [2] Rey, L. *et al.* Chem. Geol. 587, 120608 (2022). [3] Gatti, L. *et al.* Sci. Rep. 12, 1–13 (2022). [4] Armaroli, E. *et al*. Palaeogeogr. Palaeoclimatol. Palaeoecol. 678, 113226 (2025). [5] Guiserix, D. *et al.* Geochim. Cosmochim. Acta 367, 123–132 (2024). [6] Michailow, M. M. *et al.* Geochim. Cosmochim. Acta 400, 172–189 (2025). [7] Bernabò Brea, L. & Cavalier, M. Meligunìs Lipára I (1980).