Isotopic effects from diffusive transport in zoned metal and olivine

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Laboratory experiments have shown that kinetic processes such as chemical diffusion and Soret effect can create large isotopic fractionation even at high temperature [1-4]. We have recently documented several occurrences of diffusion-driven isotopic fractionation in zoned minerals. Zoned minerals are very useful for reconstructing the thermal and crystallization histories of magmas but diffusive processes involved in the formation of those minerals are not always easy to recognize [5].

Significant Ni isotopic fractionation was found between taenite and kamacite in the Toluca iron meteorite [6], which was explained by isotopic fractionation associated with diffusive exchange of Ni and Fe during growth of kamacite out of taenite during cooling [7]. As discussed by Teng *et al.* [8], olivine affected by diffusive exchange of Mg and Fe could show similar isotopic fractionation. Mineral zoning can arise from crystallization and attendant magmatic evolution, in which case the zoning profile does not provide any constraint on cooling rates. Such zoning should be associated with little isotopic fractionation. Mineral zoning can also be produced by diffusive spread of sharp chemical interfaces, which should be associated with large kinetic isotope fractionation for Mg and Fe with a correlation between δ^{56}Fe and δ^{26}Mg of slope ~-5:1. Thus, isotopes allow us to unambiguously identify diffusive transport in zoned minerals and to constrain magmatic timescales.

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Is fossil tooth enamel exempt of diagenetic alterations?

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Numerous studies deal with the geochemical and/or isotopic composition of bones and teeth, but the main part does not take into account the structural preservation of the fossil tissues. Most studies consider that fossil bone and dentine are not reliable recorders of palaeoclimate or palaeodiet, because of the high content in organic matrices. Conversely, enamel is usually considered as a stable tissue, exempt from diagenesis, despite its stability has been questioned [1, 2].

The microstructures and nanostructures of the dentine and enamel from modern and fossil Suidae have been studied [2]. From a microstructural point of view, the dentine is more altered than enamel in these fossil teeth. Many dentinal tubules are filled with secondary deposits. Interdentinal tissue seems well-preserved. The prismatic structure of the fossil enamel, the plywood pattern and the crystallites are preserved, as shown by SEM images of fresh fractures of *Kubanochoerus massai* teeth (Miocene, Lybia). Nevertheless, AFM nanostructural images show that the fossil enamel is not exempt of alterations. Crystallite shape is modified, and the arrangement of the crystallites within a prism is not preserved. SEM and AFM techniques show that fossil dentine is modified by taphonomic and diagenetic processes, but only AFM is able to reveal that enamel is also altered. So there is a discrepancy between the preservation of micro- and nanostructures. Similar results have been observed in fossil mammal teeth from Malawi (unpublished data). Such data explain why some ‘well-preserved’ enamel and dentine are chemically and isotopically damaged.

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