Lu-Hf dating of biogenic phosphates – Prospects and pitfalls

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Lutetium-Hf geochronology has been successfully applied to date high Lu/Hf phases such as garnet or apatite. The Lu-Hf system also appears to be a promising tool for direct radiometric dating of fossil biogenic apatite [1]. However, this chronometer will only yield meaningful ages, if the skeletal apatite behaved as a closed system with respect to Lu and Hf after a rapid early diagenetic REE-uptake. To closely assess the potential of the Lu-Hf chronometer in biogenic phosphates, we performed Lu-Hf measurements on well characterized fossil bones and teeth from many different taphonomic settings and fossil sites of Mesozoic to Cenozoic age. Measurements were perfomed using a mixed ^{176}Lu-^{180}Hf tracer and the Neptune MC-ICP-MS at Bonn.

An evaluation of different digestion strategies on a fossil bone standard [2] resulted in significantly different Hf contents and ^{176}Lu/^{177}Hf. Measured Hf contents where highest employing bomb digestion in 10:1:1 HCl:HF:$HClO_4$. The measured contents become successively lower for the same acid mixture employing tabletop digestion and for dissolution in conc. HNO_3 only.

Rare Earth Element profiles through fossil bones in combination with our Lu-Hf measurements indicate late diagenetic REE uptake and open system behaviour for many specimens. In these cases, Lu-Hf isochrons yield significantly younger ages than the known chronostratigraphic age. For Lu-Hf dating of phosphatic fossils it is thus crucial to ensure a closed system behaviour for each fossil site. Lutetium-Hf systematics of phosphatic vertebrate fossils from the world famous 47 Ma old Messel pit, Germany, were analyzed as a potential example for a closed system site, including bones and teeth of terrestrial mammals, fish scales, turtle carapaces and coprolites as well as diagenetic siderite and the sourrounding oil shale. The samples exhibit remarkably low ^{176}Lu/^{177}Hf (<0.035), hence only defining an isochron with a large error (48±28 Ma, MSWD = 1.4). However, the low ^{176}Lu/^{177}Hf appear to be a site specific feature of Messel fossils, controlled by bedrock properties.

[1] Barfod *et al.* (2003) *Chem. Geol.* **200**, 241-251. [2] Chavagnac *et al*. (2007) *Analytica Chimica Acta* **599**, 177-190.

MC^3: Mass conservation, metamorphic changes and modelling consequences

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Geodynamic models [*e.g.* 1] simulating subduction zone or mountain building processes have evolved rapidly with the increasing availability of phase equilibrium data. Typically these data are used to compute the physical properties, and in particular, to account for density effects in the conservation of momentum equation; but few, if any, attempts have been made to account for the volumetric effects of phase transformations in the continuity governing equation of geodynamic models. We explore the consequences of this simplification by developing an approach that allows us to obtain rigourously correct solutions for continuity. Density data are used to control volumetric changes due to phase transformations through the modification of the regional stress-field. The approach is implemented in the finite element modelling tool Cast3M [2] and has been tested using elastic and visco-elastic rheologies, in the presence of erosion.

Preliminary applications focusing on the deformation of an orogen show that the neglect of densification in the continuity equation has major consequences: the effects on the evolution of topography are of the same order of magnitude as effects resulting from the action of erosion. The two processes compete in shaping the orogen and in localizing deformation; the domination of either process over the others depends on defintion of the boundary conditions.

In models where metamorphic reactions are not correctly implemented, not only are the resultant errors with regard to mass conservation significant, but the importance of different physical processes governing crustal deformation and topographic evolution of the orogen are also misrepresented.

[1] Burov and Yamato (2008) *Lithos* **103**, 178–204. [2] Verpeaux *et al.* (ed.)(1988) Castem2000: une approche moderne du calcul des structures. *Calcul des Structures et Intelligence Artificielle*, Pluralis, 261–271.