Diffusion kinetics of Hafnium in garnet: Experimental determination and geochronological implications

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When utilizing the Lu-Hf decay system for garnet-whole rock (WR) geochronolgy, the potentially slow diffusivity of Hf^{4+} relative to Lu^{3+} results in complexities in the interpretation of Lu-Hf ages that have not been fully explored. The two main problems that arise are (a) the possibility of partial or complete retention of prograde radiogenic ^{176}Hf (Hf*) within garnets and (b) diffusive gain/loss of Lu for a significant period of time after the closure of Hf diffusion in garnet during cooling; the latter would result in a nonlinear $Hf^{*}/^{177}Hf$ growth curve in an isochron diagram and has already been partially explored [1].

The problems described above can be addressed quantitatively once diffusion data for Lu and Hf in garnet are available. While Lu diffusivity can be estimated from the general expression developed for trivalent rare earth diffusion in garnet [2], there are currently no data available for Hf diffusion in garnet. Thus, we have begun a series of experiments in order to determine the diffusivity of Hf in garnet; our initial results show that D (Hf) is at least a factor of 15 smaller than D (Lu).

Because Lu develops a bell-shaped growth-zoning profile analagous to Mn in metapelitic garnets [1, 3], Hf* will develop a similar profile until it is homogenized by volume diffusion. The calculated extent of relaxation of Lu and Hf profiles in garnet as a function of metamorphic T-t cycles and grain size [4] show that significant proportions of prograde Hf* are likely retained in metapelitic garnets with peak temperature ≤ 800°C and radius ≥ 1mm. We are currently developing numerical models for the non-linear growth of $Hf^{*}/^{177}Hf$ vs. $^{176}Lu/^{177}Hf$ in garnet, incorporationg the effects of garnet growth, T-t cycles and differences between the closure temperatures of Lu and Hf, in order to demonstrate the implications of the complexities associated with garnet-WR Lu-Hf geochronology.

[1] Kohn (2009) *GCA* **73**, 170–182. [2] Tirone *et al.* (2005) *GCA* **69**, 2385–2398. [3] Cheng *et al.* (2008) *JMG* **26**, 741–758. [4] Chakraborty & Ganguly (1991) *Adv. In Phys. Geochem.* **8**, 119–175.

Slow cooling in the lowermost crust of a continent-continent collision: Evidence from accessory phase U-Pb thermochronology of deep crustal xenoliths from the Mozambique Belt, Tanzania

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The Mozambique Fold Belt in Tanzania marks the suture between East and West Gondwana during the Neoproterozoic East African Orogen. As this orogen is of the same scale as the modern Himalayas and granulite-facies rocks are now exposed at the surface of a 40 km crust, xenoliths entrained in modern-day rift magmas, sampling a range of depths within the crust, provide a rare opportunity to examine the thermal history of the lowermost portions of a continent-continent collision zone. U-Pb IDTIMS dates for a range of accessory phases (zircon, monazite, titanite, apatite, rutile) with different closure temperatures for Pb-diffusion were determined for both xenoliths and surface samples.

Zircons from all samples are Archean (≥ 2.6 Ga); apatite and rutile from most granulite-facies xenoliths contain U but essentially no radiogenic Pb, which we interpret to indicate that the present-day lower crust must be > 450-550 °C. These results, combined with radiogenic Pb retention and Neoproterozoic dates from coexisting titanites, support this interpretation and demonstrate that the xenoliths have not been significantly heated by the host basalt but rather were reheated above apatite Pb closure in the lower crust by the modern rift. Titanite and apatite from the lower, middle, and upper crust record a 200–300 Myr lag in lower crustal cooling compared to the upper crust. Lower crustal titanite data are consistent with an average cooling rate (0.4 – 1.0 °C/Myr) from peak conditions (ca. 800 °C and ~2 GPa) at the base of the crust in the Neoproterozoic. These rates are consistent with mineralogic and thermochronologic estimates of granulite facies metamorphism in the lower portion of a doubly thickened crust in comparable continental collision zones.