A new model for prograde timescales based on Lu-Hf garnet ages

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Garnet-whole rock (Grt-WR) ages of metapelites determined by the Lu-Hf decay system are almost always older than Sm-Nd ages obtained from the same aliquots. Unambiguous interpretation of the observed age differences has been hindered by a lack of adequate information about grain size, diffusion data for Hf in garnet, and in many cases about peak metamorphic conditions and cooling rates, all of which affect the significance of the ages obtained from these decay systems.

As part of this work, the diffusion kinetic properties of Hf^{4+} and Lu^{3+} in garnet were determined as functions of temperature, pressure and oxygen fugacity; these data were then input into a numerical model in order to address the complexities which arise from the dissimilar diffusion kinetic properties of these two elements in garnet. The results of this model explain the commonly observed age discrepancies between Lu-Hf and Sm-Nd Grt ages, and also show that Grt-WR Lu-Hf isochrons do not generally yield ages which correspond to an unambiguous temporal event in the history of the host rocks.

The numerical model developed in this study was used to explain the Lu-Hf and Sm-Nd Grt-WR ages of basement rocks from the Andean Putumayo foreland basin in south-central Colombia. By dissolving handpicked garnets of uniform radius, we obtained a Lu-Hf Grt-WR age that is 63 Myr older than the Sm-Nd age obtained from the same aliquots. By modeling retrograde Fe-Mg zoning in garnet adjacent to biotite, the initial cooling rate of these rocks was constrained independently of the geochronological data. Because SIMS transects of garnet within these samples reveal complete diffusive relaxation of REE growth-zoning profiles at peak P-T conditions, a peak metamorphic age that is younger than the Lu-Hf Grt-WR age is inferred from the Sm-Nd Grt-WR age and cooling rate discussed above. By imposing a parabolic prograde T-t path and a garnet growth model that assumes garnet radius is proportional to the square root of the elapsed time since garnet nucleation, the numerical model accurately reproduces the observed Lu-Hf and Sm-Nd Grt-WR ages, and predicts a garnet nucleation age that is 12 Myr younger than the Lu-Hf age. Thus, although Lu-Hf Grt-WR ages are commonly spurious, they can still be used to constrain the duration of prograde garnet growth.