Diffusion kinetics of Lu in clinopyroxene and applications to Lu-Hf ages of eucrites

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Many ancient meteorites are enigmatic in that they produce Lu-Hf ages that pre-date the accepted age of solar system formation by ~100-400 Myr. Although these anomalous ages have largely been attributed to accelerated decay of ^{176}Lu in the early solar system following at least one irradiation event, a number of studies have challenged this hypothesis and the origin of excess ^{176}Hf in these ancient meteorites has remained a controversial topic.

We have experimentally determined the diffusion kinetics of Lu in clinopyroxene, and find that Lu diffuses significantly more slowly than Hf [1]. An important consequence of this finding is that Lu will undergo a greater extent of diffusive re-equilibration between clinopyroxene and its surrounding phase(s) than Hf during thermal events. In some cases this could lead to spurious Lu-Hf ages, akin to the general effects of Lu and Hf diffusion on garnet Lu-Hf ages [2,3]. The extent to which the Lu-Hf age is effected, and whether the apparent age is younger or older than the true age, is predominantly dictated by the temperature and duration of the reheating event, the nature of Lu partitioning between the relevant phases and the size of the clinopyroxene grains.

We have constructed a numerical model to quantify the effects of thermal metamorphism on the Lu-Hf ages of the eucrites Millbillillie (MB) and Piplia Kalan (PK), and find that the previously estimated T-t paths of thermal metamorphism undergone by these samples are fully capable of producing the anomalously old Lu-Hf ages reported by [4]. The thermal histories and Lu-Hf systematics of the various meteorites that contain excess ^{176}Hf are not identical, and in many cases are more complex than those of MB and PK. For many eucrite and angrite samples, preferential diffusive re-equilibration of Lu with respect to Hf alone does not appear capable of explaining the observed excess ^{176}Hf; however, our results indicate that this phenomenon is a potential contributing factor that should be evaluated on a case-by-case basis with regards to ancient meteorites.

[1] Bloch and Ganguly (2014) *EPSL* **395**, 173-183. [2] Bloch *et al*. (2015) *CMP* **169**, 12. [3] Bloch and Ganguly (2015) *CMP* **169**, 14. Bast *et al*. (2012) *LPSC* **43**, abstr. #2542.