NWA 7034 and the isotopic diversity of the martian mantle

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Shergottites form a compositional continuum with respect to incompatible trace elements and radiogenic lithophile isotope systematics that can be subdivided into enriched, intermediate, and depleted subgroups. This array does not correlate with indices of differentiation and is difficult to interpret in terms of simple crustal assimilation and fractional crystallization [e.g. 1]. Instead, the array could have been generated by the mixing between sources that were formed early in the planet's history, likely during magma ocean crystallization [2]. The martian meteorite NWA 7034, a polymict breccia, is sourced from an ancient crustal reservoir, previously unrepresented in our meteorite collection [3]. On the basis of REE systematics alone, NWA 7034 is consistent with being the enriched end-member of the shergottite array [4]. We interrogated this relationship further by collecting ^{147}Sm-^{143}Nd, ^{176}Lu-^{176}Hf and high precision ^{142}Nd data on NWA 7034.

The meteorite NWA 7034 falls on a least-squares hyperbolic regression through the shergottite source compositions in $^{147}Sm/^{144}Nd$-$^{176}Lu/^{177}Hf$ space. However, calculated mixing curves between NWA 7034 and either the depleted shergottites or the DMM (depleted martian mantle) composition of [1], do not accuarately model the shergottite array. In a coupled $\mu^{142}Nd$-$\varepsilon^{143}Nd$ plot of the shergottite sources evolved to $\varepsilon^{143}Nd_{150Ma}$, the Nd isotopic composition of NWA 7034 falls off the shergottite regression line (r^2 ~0.99), providing futher isotopic evidence that the "crust" represented by NWA 7034 cannot be the end-member of any mixing between shergottite sources. This points to a variety of differentiation processes such as including magma ocean crystallization and partial melting contributing to an isotopically diverse martian mantle.

[1] Borg and Draper (2003) *MAPS* **38**, 1713-1731. [2] Debaille et al. (2007) *Nature* **450,** 525-528. [3] Agee et al. (2013) *Science* **339**,780-785. [4] Humayun et al. (2013), *Nature* **503**, 513-516.