Fe and Mg isotope fractionation in olivine from the NWA 1068 shergottite

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The origin of olivine megacrysts in the Northwest Africa (NWA) 1068 enriched shergottite has long been debated. Megacryst cores crystallized at more reducing conditions (FMQ – 2.5) compared to the groundmass (~FMQ) [1], and the P content in olivine, which exhibits three regimes of zoning, attests for a multi-stage crystallization history [2].

Recent studies have shown that chemical diffusion produce significant anticorrelated fractionation of Fe and Mg isotopes in olivine [3] and that changing the oxygen fugacity conditions could affect the distribution of Fe isotopes [4]. These two processes might have occurred during the crystallization of NWA 1068, which thus represents a unique candidate to apply the emerging technique of *in situ* Fe and Mg isotopes analysis. We measured isotopic variations (δ^{56}Fe and δ^{26}Mg) by femtosecond-LA-MC-ICPMS to understand crystallization conditions and evolution of olivine megacrysts in NWA 1068. Analyses were performed with a laser spot size of ~40 μm and a precision of ± 0.10 ‰ (2σ).

Olivine cores are chemically ($Fo_{77\text{-}70}$) and isotopically homogeneous with unusually low δ^{56}Fe (≈ -0.8 ‰) and high δ^{26}Mg (≈ +0.1 ‰). The outer 100 μm rims are chemically (down to Fo_{50}) and isotopically zoned with increasing δ^{56}Fe (up to ~0 ‰). δ^{26}Mg shows complex bell-like zoning with an increase to +0.9 ‰ followed by a sharp decrease to -0.4 ‰. These findings cannot easily be explained by a one-stage Fe-Mg inter-diffusion history, although the extent of isotope variations strongly indicates kinetic isotope fractionation. Rather, several petrologic observations, such as the occurrence of crystals both zoned and merged together, strongly suggest that at least two growth stages occurred and are responsible for the observed zoning. A model taking both diffusion and growth into account is being developed to extract relevant timing constraints from isotopic profiles.

[1] Herd *et al* (2006), *GCA* **66**, 2025-2036 [2] Shearer *et al* (2013), *GCA* **120**, 17-38 [3] Sio *et al* (2013), *GCA* **120**, 302-321 [4] Dauphas *et al* (2009), *EPSL* **288**, 255-267