

# ULTRA TRACE ELEMENT CONCENTRATIONS OF OLIVINE IN OLIVINE-PHYRIC SHERGOTTITES AND CHASSIGNITE-NAHLITE METEORITES

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**Introduction:** Shergottites are the most abundant (~ 88 % of all known martian meteorites by both quantity and mass [1]. They are a chemically diverse group of martian meteorites and can be classified based on their (i) texture into basaltic, olivine-phyric, gabbroic, and poikilitic shergottites, and (ii) light rare earth element (LREE) abundances and isotopic compositions into depleted, enriched and intermediate [2-5]. Olivine-phyric shergottites are porphyritic textured rock comprised of olivine megacrysts (large single crystals that are considerably bigger than the typical grain size of the minerals found in that rock) and pyroxene phenocrysts set in a groundmass of Fe-rich olivine, clinopyroxene, maskelynite (shock modified plagioclase) and accessory oxides (including spinel, ulvospinel, chromite and ilmenite), phosphates (merrillite and apatite) and sulphides. Olivine megacrysts in these shergottites are the first phase to have crystallised and as such record the composition of the parent magma from which they crystallised. However, there is still some debate on the xenocrystic, antecrystic or phenocrystic nature of olivines in these shergottites. If the olivines are xenocrystic then they cannot be used to assess parent melt compositions, and if they are antecrystic can only be used if they are co-genetic with groundmass material. In this study, we use a recently developed laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS) technique [6] with enhanced sensitivity to determine ultra-trace element concentrations (down to ~0.1 ppb) of olivine megacrysts in olivine-phyric shergottites from representative samples of depleted, intermediate, and enriched groups as well as one chassignite and one nahlite. The improved limit of detection of this method facilitates the acquisition of complete REE patterns for martian olivine, which will allow us to constrain the xenocrystic, antecrystic or phenocrystic nature of olivines in these meteorites. The primary aim of the study is to test whether olivine REE concentrations are in equilibrium with bulk-rock REE concentrations.

**Methods:** The trace and ultra-trace element concentrations of olivine megacrysts from 11 olivine-phyric samples, including: Dar al Gani (DaG) 1037, Dhofar (Dho) 019, Northwest Africa (NWA) 1068, 2046, 4925, 6234, 10170, Larkman Nunatak (LAR) 12011, Sayh al Uhaymir (SaU) 005 and Tissint, one chassignite (Chassigny) and one nahlite (NWA 11013) were measured by LA-ICP-MS, using an Agilent 7700cs quadrupole ICP-MS coupled with a Photon Analyte G2 193nm ArF Excimer laser system equipped with a HelEx II Cell, housed at Macquarie GeoAnalytical (Department of Earth and Planetary Sciences, Macquarie University, Australia). Analyses were performed using the "hydrogen mode" where a few mL min<sup>-1</sup> of H<sub>2</sub> are added to the traditionally used Argon (Ar) carrier gas, which has been shown to increase the sensitivity of most elements measured by at least two-fold [6-7]. Operating parameters were set at a frequency of 10 Hz, an energy density of between 7.2 J cm<sup>-2</sup>, spot sizes of 100 µm, and counting times of 60 and 220 s on peaks and background respectively. Plasma torch conditions were optimised to keep the ThO/Th ratio (oxide levels) to a minimum (below 1%).

**Results and Discussion** Our preliminary results show that olivine megacrysts in depleted olivine-phyric shergottites crystallised from depleted melts consistent with bulk-rock data. Almost all of the olivine analysed in the intermediate and enriched shergottites are LREE depleted, with CI-chondrite normalized REE patterns (i.e., La/Yb<sub>CI</sub> > 0.24) similar to olivine in depleted shergottites. These LREE depleted olivine in the intermediate and enriched shergottites appear to have crystallised from depleted sources and are thus are not in equilibrium with their bulk-rock.

**References:** [1] Udry A. *et al.* (2020) *Journal of Geophysical Research: Planets*, 125(12). [2] Goodrich C.A. (2002) *Meteoritics & Planetary Science*, vol. 37:31–34. [3] Debaille V. *et al.* (2008) *Earth and Planetary Science Letters*, 269(1-2):186–199. [4] Walton E.L. *et al.* (1977) *Meteoritics & Planetary Science*, 47(9):1449–1474. [5] McSween Jr H.Y. (2015) *American Mineralogist* 100(11-12):2380–2395. [6] Veter M. *et al.* (2019) *Geochimica et Cosmochimica Acta*, 73:1755–1778. [7] Demouchy S. and Alard O. (2021) *Contributions to Mineralogy and Petrology*, 176(4):1–25.