Asuka 12325: A new depleted shergottite

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Introduction: Besides their mineralogical classification, shergottites, a subgroup of martian meteorites, have also been divided in 3 categories according to their content in rare earth elements (REE) (e.g. Debaille et al., 2007). As such, shergottites that are depleted in the most incompatible REE, the light REE (LREE), are called the depleted shergottites, with a progressive enrichment in LREE, to obtain the intermediate shergottites and then the enriched shergottites. Interestingly, the mineralogical and chemical classifications do not match, as the geochemical range encompasses all mineralogical categories, as well as several ejection events (e.g. Lapen et al., 2017). The chemical variation between depleted and enriched shergottites has been attributed to contamination of the magma by the martian crust (e.g. Humayun et al., 2013) or contamination by enriched cumulates resulting from the solidification of the martian magma ocean (Debaille et al., 2007; Armytage et al., 2017). In any case, while the enriched shergottites clearly represent a contamination by an enriched endmember, the depleted shergottites are thought to be representative of the depleted martian mantle (Borg et al., 1997; Debaille et al., 2007; 2008), hence bringing important information about the geological evolution of Mars and the martian interior. As such, they are particularly important within the shergottite compositional continuum. During the Belgian-Japanese field expedition on the Nansen Blue Ice field in 2012-2013, a greenish stone was collected and later identified as a shergottite (NIPR-RBINS Meteorite Newsletter April 26 2018). The stone weights 28 g and is devoid of fusion crust (Fig. 1). Geochemical investigation has been performed at the Laboratoire G-Time (Université Libre de Bruxelles) in order to understand the geochemical affinities of Asuka 12325 and bring new light of the geological evolution of Mars.

Figure 1: Picture of Asuka 12325, scale is 1 cm. © NIPR

Method: Around 50 mg of samples has been dissolved by alkaline fusion for major and trace elements content. Major elements were measured on the iCAP ICP-AES at ULB using Y as internal standard. Overall, the total reproducibility estimated using USGS rock standards is better than 2%. Trace elements were measured on the Agilent 7700 ICP-MS at ULB, using In as internal standard. The total reproducibility estimated using USGS rock standards is better than 10%. For isotope analyzes, around 0.8 g of sample was gently crushed and sieved, and minerals separation was performed using heavy liquids and Frantz magnetic separator. After dissolution using 3:1 mixture of $HF:HNO_3$, and then HCl, a small aliquot was removed for Lu-Hf and Sm-Nd spiking. Hafnium and rare earth elements (REE) were purified first using a cationic resin and 2N HCl and 6N HCl respectively. Hafnium was subsequently purified first on anionic column to eliminate Fe and then on a HDEHP column, where Ti was removed and Hf eluted with 4N HF. On the other hand, REE were purified on HDEHP resin. The Nd cut of the whole rock was then further purified for removing the Ce because of the isobaric interference of the mass 142 with Nd, using again an HDEHP column (Armytage et al., 2017) and the Na introduced for that purification was finally removed using a small cationic column. All spiked and unspiked cuts for Lu-Hf and Sm-Nd have been measured on the Nu II HR-MC-ICP-MS at ULB using an Aridus 2. The bulk rock Nd fraction will be measured on the Thermoscientific Triton plus at ULB.

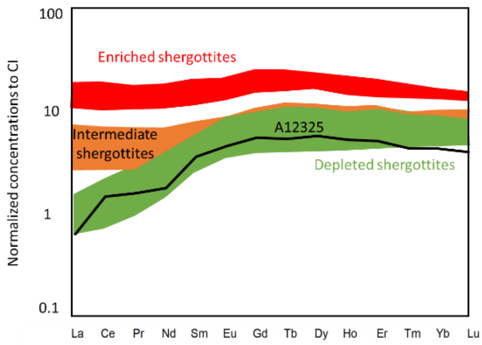

Figure 2: REE pattern normalized to CI chondrites, of Asuka 12325, compared to literature data for shergottites.

Results and discussion: According to the REE pattern (Fig. 2), Asuka 12325 is a depleted shergottite, showing a clear depletion in LREE. The Mg# is 0.42, similar to mafic shergottites, according to the classification introduced by Irving et al. (2010). However, the CaO content is unusually low for mafic shergottites, of 4.1 %wt, resembling the permafic or even the ultramafic shergottites. Because of its very low trace element contents, the Lu-Hf and Sm-Nd isochrons are inconclusive at the present time, giving an age of 394 ± 61 Ma for the Sm-Nd systematics and 272 ± 39 Ma for the Lu-Hf systematics. The two ages are not concordant within error. However, the Sm-Nd age is not definitive as the bulk fraction has currently not yet been measured. On the other hand, the Hf content of the different fractions were very low and not all fractions could actually be measured. As such, the Lu-Hf age is potentially erroneous and more investigations are needed. The initial ε-values obtained on the isochrons are $\varepsilon_i{}^{143}$Nd of +6.6 ± 3.1 and $\varepsilon_i{}^{176}$Hf of +29.6 ± 0.3. Those values do not correspond to the depleted shergottites range ($\varepsilon_i{}^{143}$Nd from ~+36 to +39; and $\varepsilon_i{}^{176}$Hf from ~+46 to +50). However, they are preliminary and will be tested with new data. In any case, from major elements concentration already, Asuka 12325 might be a new flavor in the shergottite continuum.

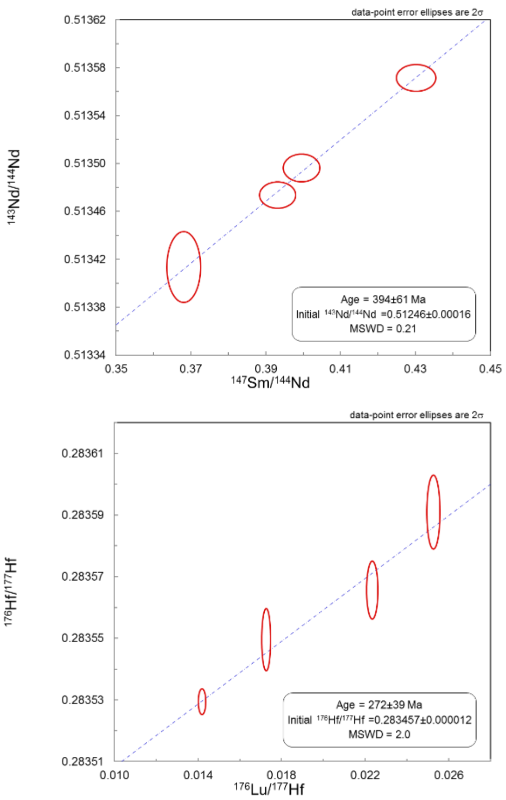

Figure 3: Sm-Nd and Lu-Hf isochrons for Asuka 12325.

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