Deciphering the volatile inventory of rocky planetary bodies using the NanoSIMS ion microprobe

Romain Tartèse [1,*]

[1] Department of Earth and Environmental Sciences, The University of Manchester, Manchester – United Kingdom

It is thought that inner Solar System rocky bodies mostly accreted dry, and that any water (and other volatiles) should have been lost from bodies that were once fully molten such as the Moon. And surely enough, studies of Apollo samples in the 70's failed to detect indigenous lunar water. However, this dry Moon paradigm has recently been overturned, thanks to continued analysis of lunar samples using modern analytical instrumentation, and notably NanoSIMS.

In 2008, Saal *et al.* [1] used NanoSIMS to show that the H_2O content (as well as F, Cl, and S) of a *ca.* 100 µm pyroclastic glass bead decreases from core to rim, indicating that these volatiles were indigenous, and were affected by degassing upon eruption. This breakthrough was permitted by the NanoSIMS high spatial resolution, typically 500 nm to 1 µm beam size rastered over *ca.* 5-10 µm^2 areas for volatile studies, and low H_2O backgrounds around 5-10 µg.g^{-1}. This has sparked numerous NanoSIMS-based measurements of volatile abundances (H_2O, C, F, Cl) and isotope compositions (H, Cl) in lunar volcanic glasses, apatite in varied lunar rock types, and melt inclusions they host [see 2]. Similar protocols have also been applied to meteorites from differentiated bodies such as Mars and the asteroid 4-Vesta [2].

Such *in situ* studies, which we will review, have proved vital to assess the volatile inventory of differentiated bodies, and have shown that they do contain indigenous volatiles, including hydrogen. Interestingly, H isotope data for these differentiated bodies are consistent with the bulk H isotope compositions of volatile-rich carbonaceous chondrites. While these studies have certainly measured indigenous hydrogen in samples from inner Solar System rocky bodies, they also highlight some challenges that need to be overcome to comprehensively characterise the origin and processing of volatiles in the inner Solar System.

References: [1] Saal *et al.* (2008) Nature 454, 192 [2] McCubbin & Barnes (2019) EPSL 526, 115771

Mots-Clés : NanoSIMS; Volatiles; Hydrogen Isotopes; Planetary Samples