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Location, location: deciphering the significance of in-situ hydrogen analyses of Martian meteorite phases

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Understanding how inner planets acquired their volatiles such as hydrogen (H) is fundamental to constrain models of solar system formation [e.g. 1]. One avenue of estimating the H content and isotopic characteristics of differentiated planets is to analyze the samples we have from them as meteorites. Ideally, the H content and isotopic characteristic of the mantle sources of these igneous rocks should give insight into the volatile origin of each planetary body. However, we will illustrate the processes that can modify the H content and D/H ratios of pyroxene, olivine and feldspar in selected Martian meteorites relative to those of their mantle sources, with two key protocols for SIMS analysis.

The first key is to put each analysis in textural context ("location, location"). In particular, of prime importance is whether an analysis is done at the center or the edge of a mineral grain, close or far from a shock disturbed area, and in a mineral crystallized at the beginning or late in the differentiation sequence. For example, volcanic degassing can be evidenced by decreasing water contents and increasing D/H ratios from core to edge of nakhlite pyroxenes [2]. Traverses towards shock melted zones of H analyses in pyroxene and maskelynite in shergottite LAR 06319 provide examples of decreasing H contents and increasing D/H ratios resulting from degassing following shock [3]. The second key is to assess if the area analyzed by SIMS has shock generated damage of the mineral structure, as will be shown in pyroxene and olivine from shergottite RBT 04262. Olivine in shergottites have too high water contents to be explained with an igneous origin and their D/H ratios are more consistent with terrestrial alteration, as observed before [4]. A review of all these processes shows how careful one has to be prior to using H measurements in meteorites to infer the origin and amount of water in differentiated planetary interiors.

[1] Peslier *et al.* (2017) *SSR* 212, 743. [2] Peslier *et al.* (2019) *GCA* 266, 382. [3] Dudley *et al.* (2022) *GCA* 317, 201. [4] Stephant *et al.* (2018) *Nature Sci. Rep.* 8, 12385.