Investigation of martian surface history: NanoSIMS analyses of D/H ratios and U-Pb chronology of martian meteorites

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Mars is believed to have once possessed plentiful liquid water on its surface and still keeps a non-negligible amount of volatiles including H_2O and CH_4 in its near-surface system [1] [2]. Hydrogen isotopic (D/H) records in martian meteorites are important for understanding its environmental history, as they potentially reflect both the past atmospheric water that had isotopically evolved and the mantle primitive water (e.g. [3-5]). Meteoritic phosphates (i.e. apatite and merrillite) may provide both surface D/H records and U-Pb chronology, whereas melt-inclusions in nominally anhydrous hosts would preserve magmatic D/H ratios. Here, we report combined measurements of the D/H ratios and U-Pb system of phosphates, as well as D/H in melt-inclusions, in two distinctive martian meteorites, ALH 84001 (ALH) and LAR 06319 (LAR) using a NanoSIMS [6].

The D/H ratios of ALH merrillite showed large variations with the maximum δD of 1970‰, similar to those of secondary carbonates[3], while lower than previous apatite data[4]. Since the U-Pb of the same grains had 3990Ma shock age, it is likely that the D/H ratios reflect 3990Ma surface water, incorporated during the impact and/or at post-impact events. On the other hand, the δD values of LAR apatite, merrillite, and melt-inclusions were up to 4380‰, 5260‰ and 6830‰, respectively. They may have mineral trends: melt-inclusions ≥ merrillite ≥ apatite. A similar trend was reported previously [7]. The observed D/H differences suggest isotopically distinct multiple water sources at the present martian near-surface systems.

[1] Mahaffy et al. (2015) *Science* **347**, 412-415. [2] Webster et al. (2015) *Science* **347**, 415-417. [3] Sugiura and Hoshino (2000) *Meteorit. Planet. Sci.* **35**, 373-380. [4] Greenwood et al. (2008) *Geophys. Res. Lett.* L05203, 1-5. [5] Usui et al. (2012) *Earth Planet. Sci. Lett.* **357**, 119-129. [6] Koike et al. (2014) *Geochme. J.* **48**, 423-431. [7] Hu et al. (2014) *Geochim. Cosmochim. Acta* **140**, 321-333.