INVESTIGATING EARLY SOLAR SYSTEM VOLATILES THROUGH IN SITU ANALYSIS OF PHOSPHATES IN THE GRAVES NUNATAKS 06128 ACHONDRITE

R. Tartèse[1] and M. Anand[2].[1] School of Earth and Environmental Sciences, The University of Manchester, Manchester M13 9PL, UK – romain.tartese@manchester.ac.uk. [2] School of Physical Sciences, The Open University, Milton Keynes MK7 6AA, UK.

The paired achondrites Graves Nunataks (GRA) 06128 and 06129 are samples of an asteroid that underwent partial melting within a few million years after the start of Solar System formation [1-2]. In order to better constrain the origin and processing of volatiles on asteroidal parent bodies in the early Solar System, we have investigated the abundance of H, F and Cl and the isotopic composition of H and Cl in phosphates in GRA 06128 using secondary ion mass spectrometry. GRA 06128 contains two phosphates, merrillite and apatite. Merrillite crystallized at ~4.56 Ga while apatite formed from hydrothermal alteration of merrillite by Cl-rich fluids about 100 million years later at *ca*. 4.46 Ga [3-4]. GRA 06128 phosphates thus offer an opportunity to characterize both indigenous and late hydrothermal fluids that were involved in their formation.

Merrillite contains ~20-60 ppm H_2O characterized by an average δD of ~200 ± 200‰, which is roughly similar to H isotope composition of other differentiated asteroidal and planetary bodies such as Mars, the Moon and the angrite and eucrite meteorite parent bodies. Apatite contains 5.4-5.7 wt.% Cl, 0.6-0.8 wt.% F, and similar amounts of H_2O (~20-60 ppm) compared to merrillite from which it formed. In contrast, the apatite δD values range between *ca*. 300‰ and 1400‰ and are roughly anti-correlated with apatite H_2O abundance, suggesting that metasomatic alteration of merrillite was accompanied by the introduction of trace amounts of D-rich fluid (δD > 3000‰) into newly-formed apatite. GRA 06128 apatite yielded an average $\delta^{37}Cl$ of +3.2 ± 1.2‰, a fractionated signature compared to typical Solar System materials [5]. The striking similarity between phosphate assemblages in GRA 06128/9 and those observed in ordinary chondrites, in which Cl-rich apatite is also thought to have formed from metasomatic reactions between merrillite and Cl-rich fluids. Thus, fluid circulation on asteroidal bodies occurring during the first 10's of Myr after their accretion seem to be common in Solar System objects.

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