

RARE EARTH ELEMENT DISTRIBUTION AND LU-HF AND SM-ND ISOTOPE SYSTEMATICS OF ANTARCTIC H CHONDRITES

R. Maeda^{1*}, S. Goderis¹, V. Debaille², G. Hublet², H. Pourkhorsandi² and P. Claeys¹,

¹Analytical, Environmental and Geo-Chemistry (AMGC), Vrije Universiteit Brussel, Pleinlaan 2, 1050 Brussels, Belgium (*Ryoga.Maeda@vub.ac.be),

²Laboratoire G-Time, Université Libre de Bruxelles, Avenue Franklin Roosevelt 50, 1050 Bruxelles, Belgium

Introduction: Long-lived radioactive isotopes such as ¹⁷⁶Lu and ¹⁴⁷Sm, which decay to ¹⁷⁶Hf (half-life ~37.1 Gyr) and ¹⁴³Nd (half-life ~10.6 Gyr), respectively, are known to be important chronometers and tracers for chemical differentiation processes. The redistribution of rare earth elements (REEs) and other large ion lithophile elements during planetary processes have strong effects on the Lu-Hf and Sm-Nd isotope systems, as observed in a wide range of chondritic and achondritic materials [e.g., 1]. However, the relative mobility of these elements during aqueous alteration or thermal metamorphism on their parent bodies, as well as during weathering in hot and cold desert remain poorly understood, even in the case of common chondrites [e.g., 2]. Although the Lu-Hf system has been applied to H chondrites due to their large abundance (~30% of all meteorites), previous studies have mostly focused on falls [e.g., 3]. Based on published isotopic data [3, 4], there is a small but significant difference in ¹⁷⁶Hf/¹⁷⁷Hf between unequilibrated and equilibrated L chondrites. However, we cannot conclude whether the isotopic shift reflects a primary characteristic or results from the applied experimental procedures as no systematic study has been done on H chondrites. In addition, almost no data has been collected for Antarctic meteorites. In this study, therefore, the results of Lu-Hf and Sm-Nd isotope systematics in Antarctic H chondrites are examined in a methodical manner.

Samples and Methods: Ten Antarctic H chondrites from H3.0 to H7 are studied for their REE distribution and subsequently analyzed in bulk, for a determination of the Sm, Nd, Lu and Hf isotopic compositions and major and selected trace elemental abundances, including REEs. Three H chondrites (H3-H5) obtained from hot deserts are also considered to quantitatively constrain any effects related to weathering. The corresponding powdered samples were digested using acids, and the solutions were divided into two aliquots for elemental abundance and isotope ratio analysis. The abundances of major and trace elements were determined using ICP-OES and Q-ICP-MS at the Université Libre de Bruxelles (ULB). Once isolated from the aliquots for isotope analysis using ion exchange chromatography, the isotopic compositions of Nd and Hf were determined using the Nu II MC-ICP-MS at ULB. At the same time, the corresponding polished thick sections were investigated for their major and trace element distribution. After elemental maps for each sample were produced using micro-XRF, constituent mineral phases in the samples were identified that were subsequently confirmed using an SEM-EDS. Major components in constituent minerals of each sample, which are used as an internal standard element for LA-ICP-MS, will be determined by using EPMA at the National Institute of Polar Science in Japan, and then the REE distribution between minerals will be investigated using LA-ICP-MS/TOF based on single point drilling and mapping at Ghent University.

Results and Discussion: According to the first micro-XRF results, the average modal abundance of Ca-phosphates in equilibrated H chondrites is 0.83±0.11 vol. % (equivalent to 0.71±0.10 wt. %, n=6), which is good agreement with literature values [5, 6]. Surprisingly, however, the average modal abundance in unequilibrated H chondrites is 0.47±0.13 vol. % (equivalent to 0.40±0.11 wt. %, n=7), which is a significantly lower abundance relative to equilibrated H chondrites. In addition, there is no resolvable difference in the bulk P and REE abundances between unequilibrated and equilibrated H chondrites based on our primary results for the determination of elemental abundances (n=2 for unequilibrated H chondrite and n=4 for equilibrated H chondrite), which is consistent with published bulk analyses [7, 8]. Therefore, the difference in the modal abundances of Ca-phosphates can only be explained by the generation of Ca-phosphates during thermal metamorphism in H chondrites. Because Ca-phosphates in H chondrites must have formed or grown larger during thermal metamorphism, REEs may have been re-distributed to Ca-phosphates during that time [9]. The isotopic shifts of the Lu-Hf and Sm-Nd systems between unequilibrated and equilibrated H chondrites may thus be linked to the Ca-phosphates that are known to be important host phases of REEs in equilibrated ordinary chondrites [e.g., 10]. Systematic bulk and phosphate analyses will indicate whether the observed isotopic differences result from different time scales or efficiencies for the re-distribution of REE during thermal metamorphism between unequilibrated and equilibrated H chondrites.

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