

THE EFFECTS OF THERMAL PROCESSING ON THE BUDGET OF LITHOPHILE ELEMENTS IN H CHONDRITESR. Maeda^{1,2,*}, S. Goderis¹, T. Van Acker³, F. Vanhaecke³, A. Yamaguchi⁴, V. Debaille² and P. Claeys¹¹Analytical-, Environmental-, and Geo-Chemistry, Vrije Universiteit Brussel, Pleinlaan 2, BE-1050 Brussels, Belgium (*ryoga.maeda@vub.be)²Laboratoire G-Time, Université libre de Bruxelles, CP 160/02, 50, Av. F.D. Roosevelt, BE-1050 Brussels, Belgium³Atomic & Mass Spectrometry Research Unit, Department of Chemistry, Ghent University, Krijgslaan, 281 – S12, 9000 Ghent, Belgium⁴National Institute of Polar Research, 10-3 Midori-cho, Tachikawa-shi, Tokyo 190-8518, Japan

Introduction: Elements are fractionated between the constituent minerals in meteorites, mainly depending on their ionic radii and partition coefficients. Previous studies have described these elemental distributions among the constituent minerals using physical mineral separation, chemical leaching techniques, or *in-situ* analyses [e.g., 1, 2], significantly improving our understanding of the conditions of equilibration induced by thermal metamorphism on their parent bodies, variations of isotopic compositions, etc. [e.g., 3]. In addition, it has been demonstrated that some elements are re-distributed into (a) specific mineral(s) during thermal metamorphism on their parent bodies. For example, rare earth elements (REEs) except for Eu are mostly present in Ca-phosphates in the case of equilibrated ordinary chondrites while these elements are partitioned in glass mesostasis in chondrules for unequilibrated ordinary chondrites [4]. Nevertheless, the budgets of other lithophile elements and the thermal effects on their distribution remain poorly understood. Here, we address the lithophile element budgets of both unequilibrated and equilibrated H chondrites (HCs).

Samples and Methods: Polished thick sections (PTSs) were prepared for ten Antarctic HCs, two HCs collected from hot deserts, and four fall HCs, with the petrologic types varying from 3.3 to 7. All samples were provided by the Royal Belgian Institute of Natural Sciences (RBINS), Belgium, and the National Institute of Polar Research (NIPR), Japan. Firstly, these PTSs were analyzed using micro-X-ray fluorescence spectrometry (μ XRF) at the Vrije Universiteit Brussel (VUB), Belgium, to obtain maps showing the distribution of the major elements. Secondly, back-scattered electron (BSE) images of all samples were acquired using a field emission-scanning electron microscope (FE-SEM) equipped with an energy-dispersive spectrometer (EDS) at NIPR. Once the constituent minerals in the samples were identified based on the elemental maps and BSE images obtained, an electron probe micro analyzer (EPMA) at NIPR was used for the determination of the major element abundances in each constituent mineral. After EPMA analysis, semi-quantitative trace element mapping was conducted for selected samples using laser ablation-inductively coupled plasma-time of flight-mass spectrometry (LA-ICP-TOF-MS) at Ghent University, Belgium. Finally, the abundances of lithophile elements were determined for Ca-phosphates and silicates using a LA system coupled to a sector field ICP-MS in single-point drilling mode at NIPR. Combined with their bulk elemental abundances previously determined at the Université libre de Bruxelles (ULB), Belgium, or relying on literature data [5, 6], mass balances were calculated for all samples.

Results and Discussion: For the most unequilibrated sample in this study, A-880941 (H3.3), only ~50-70% of the bulk REE abundance except for Eu is hosted in the main mineral phases analyzed, despite the fairly good agreement with the bulk major element composition. In addition, the Ca-phosphate phase in A-880941 accommodates ~25-40% of the REE content. On the other hand, the estimated whole-rock REE abundances in equilibrated samples are in excellent agreement with their bulk abundances, and ~60-90% of the REE content is allocated in Ca-phosphates. These observations are entirely consistent with the redistribution scenario of REEs during thermal metamorphism, as described by Shinotsuka and Ebihara [4]. In a similar manner, some high field strength elements such as Hf appear to originally have been distributed in chondrule glasses and then in feldspar (e.g., ~40-60% of Hf in plagioclase for unequilibrated HCs) based on both this study and Alexander [7]. As ~60-80% and less than 15% of Hf are allocated in Ca-rich pyroxene and plagioclase for equilibrated HCs, respectively, it appears that Hf is re-distributed from plagioclase into Ca-rich pyroxene with the growth of Ca-rich pyroxene and plagioclase during thermal metamorphism. We observe that a considerable amount of specific trace elements (e.g., REEs, Th, and U) reside in cracks formed during terrestrial alteration [8], hence their deposition in cracks may need to be taken into account during mass balance considerations to explain the discrepancies observed between the estimated whole-rock abundances and the bulk abundances.

References: [1] Mason B. and Graham A. L. (1970) *Smithson. Contrib. Earth Sci.* **3**, 1–17. [2] Curtis D. B. and Schmitt R. A. (1979) *Geochim. Cosmochim. Acta* **43**, 1091–1103. [3] Martin C. *et al.* (2013) *Geochim. Cosmochim. Acta* **120**, 496–513. [4] Shinotsuka K. and Ebihara M. (1997) *Meteorit. Planet. Sci.* **32**, A119–A120. [5] Maeda R. *et al.* (2021) *Geochim. Cosmochim. Acta* **305**, 106–129. [6] Kallemeyn G. W. *et al.* (1989) *Geochim. Cosmochim. Acta* **53**, 2747–2767. [7] Alexander C. M. O'D (1994) *Geochim. Cosmochim. Acta* **58**, 3451–3467. [8] Al-Kathiri A. *et al.* (2005) *Meteorit. Planet. Sci.* **40**, 1215–1239.