

COMPLETE CHARACTERIZATION OF THE NOBLE GAS INVENTORY IN CR CHONDRITE MILLER RANGE 090657 BY DIRECT ETCH RELEASE.

D. Krietsch¹, H. Busemann¹, M. E. I. Riebe¹, A. J. King², and C. Maden¹, ¹Institute of Geochemistry and Petrology, ETH Zurich, Switzerland (daniela.weimer@erdw.ethz.ch), ²Dept. of Earth Science, The Natural History Museum, London, U.K.

Introduction: Most carriers of primordial noble gas components in primitive carbonaceous chondrites (CCs) identified to date are acid-resistant. Their study, thus, mainly occurred on meteoritic “acid-resistant residues” [1]. Nevertheless, there is also evidence for primordial noble gases residing in acid-soluble phases (e.g., [2]). In this work, we investigate a very primitive CC using the “closed system step etching” (CSSE) technique, which allows a direct step-wise measurement of noble gases in these “solubles” in vacuum. For the first time, we used a series of five different etching agents targeting various mineral groups, in order to selectively release and detect all primordial components contained in a primitive meteorite. We aim to further constrain the initial composition of the primordial noble gases within the parent body before any secondary processing, and look for the Ar-rich component susceptible to aqueous alteration [3,4], as well as the respective (maybe unknown) carriers. Furthermore, we aim to detect potential nucleosynthetic isotope anomalies and test if they correlate with those discovered in other elements, e.g., by inductively coupled plasma mass spectrometry in leaching experiments using the same acids (e.g., [5]).

Experimental procedure: The very pristine CR chondrite Miller Range (MIL) 090657 [6] is an ideal sample for this experiment: it contains large amounts of primordial noble gases, shows no obvious evidence for solar wind, and has a short cosmic ray exposure age [4]. [7] classified this CR as a petrologic type 2.7. XRD analysis (at NHM London) confirmed a relatively low phyllosilicate fraction and, hence, a high petrologic type. CSSE was performed using our unique, all Au and Pt extraction line in five separate etch runs (for method details, see [2,8,9]). Water (cf. [3,4]) and acetic acid (HAc) were used for the first time as “etching” agents for noble gas extraction. Subsequent etching was done with HNO₃, HF, and finally HCl.

Results and discussion: The treatment of MIL 090657 with H₂O released surprisingly large amounts of light noble gases: ~35% of ²⁰Ne (percentages always refer to the expected bulk concentration in MIL 090657 measured by [4]), ~25% of ²²Ne, and ~25% of the ⁴He content. In a Ne-three-isotope plot, the data of the H₂O etch run plot close to the trapped components and are clearly different from air composition, showing that large amounts of primordially trapped noble gases are indeed released by H₂O treatment alone. An extrapolation of the error weighted linear regression through the data results in a (²⁰Ne/²²Ne)_{tr} ratio of ~10.3 (assuming (²¹Ne/²²Ne)_{tr} = 0.0294). This implies a release of a component with a composition in the range of Ne released from phase Q. However, almost no release of (^{36,38}Ar) was induced by H₂O treatment (< 2%). Hence, intense parent body aqueous alteration processes were not reproduced in this experiment on this already mildly aqueously altered CR2 chondrite. In contrast, most of the (^{36,38}Ar) was released by etching with HAc: ~60% of the total expected amount (for comparison: all other four etch runs together delivered only ~10% of the total (^{36,38}Ar)). Thus, with HAc, we likely dissolved the sought after Ar-rich carrier, which is lost upon moderate parent body aqueous alteration (cf. [3,4]). Smaller, but still high fractions of the expected totals of heavy noble gases were also released by HAc etching (~45% of ⁸⁴Kr and ~35% of ¹³²Xe). The Ne isotope ratios as well as the elemental ratios differ from the composition of known noble gas components [1]. Hence, we likely found a new noble gas component in a yet unknown, HAc-soluble carrier. As expected, etching with HNO₃ mainly resulted in the detection of heavy noble gases: ~30% ¹³²Xe and ~20% ⁸⁴Kr of Q composition, but also significant amounts of, mainly cosmogenic, ³He and ²¹Ne (both ~20%). The release of cosmogenic noble gases continues in the HF and HCl etch runs. Etching with HF further reveals lower cosmogenic endmember ²¹Ne/²²Ne ratios compared to all other etch runs. This points to a different chemical composition and possibly the dissolution of a Na-rich or Mg-poor carrier by HF. The last etch steps from HCl treatment under harsh etching conditions plot close to Ne-HL composition indicating the release of HL-gases, which are usually carried by predominantly acid-resistant presolar nanodiamonds [1].

Offline etching of MIL 090657 aliquots, using the same acids under similar conditions, and subsequent analysis for their mineralogy by XRD is currently performed in order to better constrain potential noble gas carrier phase(s).

Acknowledgements: This research is supported by the Swiss National Science Foundation (SNSF). Support from EU's Horizon Europlanet 2020 RI programme is greatly acknowledged. We thank the NASA meteorite working group for providing a specimen of MIL 090657.

References: [1] Ott U. 2014. *Chemie der Erde* 74:519-544. [2] Riebe M. E. I. et al. 2017. *Geochimica et Cosmochimica Acta* 205:65-83. [3] Weimer D. et al. (2017) *80th Meteoritical Society Meeting*, Abstract #6300. [4] Busemann H. et al. (2019) *82nd Meteoritical Society Meeting*, this volume. [5] Schönbachler M. et al. 2005. *Geochimica et Cosmochimica Acta* 69:5113-5122. [6] Davidson J. et al. (2015) *LPS XLVI*, Abstract #1603. [7] Alexander C. M. O'D. et al. 2013. *Geochimica et Cosmochimica Acta* 123:244-260. [8] Wieler R. et al. 1986. *Geochimica et Cosmochimica Acta* 50:1997-2017. [9] Busemann H. et al. 2000. *Meteoritics & Planetary Science* 35:949-973.