NOBLE GAS RECORD IN A LARGE NUMBER OF SHERGOTTITES: POTENTIAL IMPLICATION FOR THE NUMBER OF EJECTION EVENTS ON MARS.

D. Weimer[1], H. Busemann[1], A. J. Irving[2], and C. Maden[1], [1]Inst. of Geochemistry and Petrology, ETH Zurich, Switzerland (daniela.weimer@erdw.ethz.ch), [2]Dept. of Earth and Space Sciences, Univ. of Washington, Seattle, WA.

Introduction: The number of Martian meteorites found increases rapidly. To date we count 115 unpaired specimens (i.e., independently found and with distinct terrestrial ages), of which ~85% represent shergottites [1]. All specimens are investigated for petrology and chemical composition for classification. Noble gas analyses contribute further to their characterization. Cosmic ray exposure (CRE) ages are commonly used to identify ejection events that induced the delivery to Earth. Combined investigations help to further constrain the variety in the crustal composition and, in general, formation and evolution of our neighbouring planet. Linking Martian meteorites to candidate source craters is also of importance for future sample return missions [e.g., 2]. It seems reasonable that nakhlites and chassignites (CRE age ~11 Ma [3]), ALH 84001 (~14 Ma [3]), and the only polymict breccia NWA 7034 and paired specimens (~5-10 Ma [4,5]) were launched by events separate from those yielding most shergottites, which mainly show CRE ages of 0.5-6 Ma [3,6], except for Dhofar 019 with a CRE age of ~20 Ma [7]. However, the number of impact events having launched the shergottites is still difficult to assess due to the small range and comparably large uncertainties [e.g., 3,8,9]. Using newly aquired noble gas data for several recently found shergottites and taking literature data into account, we revisit the question of the number of separate ejection events that formed the shergottites and examine if CRE age clusters potentially correlate with the petrological and/or chemical classification.

Samples and Methods: We analyzed >20 shergottites (bulk samples, ~80 mg) with variable chemical/petrologic type for their noble gas composition. Gases were extracted by heating in one step to ~1700°C. All He to Xe isotopes were measured [see, e.g., 10 for details]. We determined relative abundances of cosmogenic (cos), radiogenic (rad), and trapped (tr) components and calculated CRE ages based on $(^{3}He, ^{21}Ne, \text{and } ^{38}Ar)_{cos}$. Production rates are based on the chemical composition of each individual shergottite (where available), shielding parameter $(^{22}Ne/^{21}Ne)_{cos}$, and the model by [11]. In case the $(^{21}Ne/^{22}Ne)_{cos}$ ratio indicated a solar cosmic ray (SCR) component ($^{21}Ne/^{22}Ne < 0.80$), we followed the procedures described in [6] to calculate CRE ages. To allow comparison, we treated literature noble gas and bulk chemical composition data for other shergottites the same way as for our own samples.

Results and Discussion: All newly measured noble gas compositions are within the same range as found previously for shergottites. Neon is almost entirely cosmogenic and ~85% of the samples exhibit a low $(^{21}Ne/^{22}Ne)_{cos}$ likely induced by SCR, implying low preatmospheric shielding and ablation loss [6]. Elemental and isotopic noble gas ratios fall in the typical range for shergottites (e.g., [4]). We also observe characteristically elevated $^{129}Xe/^{132}Xe$ ratios with respect to Earth's atmosphere (EA) in most samples related to the contribution of the Martian atmosphere (MA). The trapped component in all samples represents a mixture of MA, EA, and Martian interior/fractionated air.

The preliminary mean (^{3}He, ^{21}Ne, ^{38}Ar) CRE ages determined in this study are all except for one between 1.0 and 5.3 Ma and, hence, within the typical range. For NWA 4480, we determined a CRE age of >12 Ma. When considering also CRE ages determined from literature data using our own method, we currently obtain a total number of 56 shergottites that all show exposure ages between 0.6-5.5 Ma (again except for Dhofar 019 and NWA 4480). Their errors are high and depend on the uncertainties of chemistry and cosmogenic concentrations as well as the variation in ^{3}He, ^{21}Ne, and ^{38}Ar ages. Not least, all ages determined for the ~85% of samples with low $(^{21}Ne/^{22}Ne)_{cos}$ represent upper limits, since we cannot correct for the SCR component. However, the results are reasonable in relative terms since we applied the same approach to all samples. The necessity to use the same model is, e.g., illustrated in the discrepancy between the CRE ages determined for NWA 7034 by [4] (~5 Ma) and [5] (~10 Ma).

Most samples scatter between 2.0-4.2 Ma. In addition, we can resolve two separate clusters at 0.6-1.5 Ma (9 samples) and 4.9-5.5 Ma (6 samples), respectively. Hence, we can distinguish at least five ejection events responsible for the shergottites, based on differences in their CRE ages alone (counting both Dhofar 019 and NWA 4480 separately). However, especially within 2.0-4.2 Ma, we have shergottites of highly variable petrologic and chemical types [1]. Hence, the variable characteristics of the shergottites argue for more launch sites [9], with CRE ages being similar. More work is required to unravel further distinct clusters based on these characteristics and to relate them to (possibly simultaneous) impact events and corresponding target areas on Mars.

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