GASES TRAPPED DURING CATASTROPHIC EVENT ON L-CHONDRITE PARENT BODY REVEALED BY STEPWISE CRUSHING

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Introduction: Trapped argon with isotopic composition different from primordial/solar/terrestrial in samples of asteroidal origin was for the first time identified in L-chondrites [1] and later in meteorites from other small planets [e.g., 2,3]. The results of [1] gave a strong evidence that this component had been trapped following a large-scale impact event at ~470 Ma ago on the L-chondrite parent body. Its genesis was related to mixing and homogenization of implanted solar argon and accumulated radiogenic ^{40}Ar mobilized and redistributed during thermal processes accompanying the shock episode. In attempt to specify the location of the trapped Ar and to check its relation to other light noble gases and to nitrogen isotope composition we carried out stepwise crushing analyses for the Ghubara meteorite (L5, S4, W1), where $^{36}Ar_{trapped}$ accounts for >82% of the total ^{36}Ar release with the rest being of cosmogenic origin [1]. These are the first stepwise crushing data for L-chondrites.

Results and discussion: The dark chondritic material of Ghubara (62.87 mg) was stepwise crushed with cumulative number of strokes of 3500. The released amounts of ^{4}He, ^{20}Ne and ^{36}Ar are 5118, 188 and 1.8 ($\times 10^{-7}$, cm^3 STP/g), respectively. In the first crushing steps ^{20}Ne/^{22}Ne ratios are close to SW value (^{20}Ne/^{22}Ne = 13.78 ± 0.03 [4]), up to 13.72±0.08. The neon 3-isotope diagram shows a trend reflecting a mixture between solar-like and cosmogenic Ne with higher contribution of the latter at the end of crushing. Similar correlation has been observed during crushing of the Pesyanoe aubrite samples [5,6]. The total amount of ^{36}Ar extracted by crushing from gas inclusions/defects is identical to the amounts of $^{36}Ar_{trapped}$ reported in [1]. ^{40}Ar/^{36}Ar ratio gradually changes from 234 to 179 with crushing steps. This range of the ratios completely coincides with the compositions of the trapped argon precisely determined using isochron method for Ghubara samples [1]. Hence, Ar released during crushing seems to be dominated by trapped component of an asteroidal origin**.** The variations of ^{40}Ar/^{36}Ar ratio in crushing steps are possibly related to poor homogenization of trapped Ar component or to the presence of more than one trapped Ar components. In the first steps atmospheric Ar incorporated during terrestrial residence of the meteorite in the Oman desert is likely to be released. Ne in the third crushing step has the highest (close to solar) ^{20}Ne/^{22}Ne ratio and is associated with Ar having (^{36}Ar/^{38}Ar) ratio of 5.48 equal to solar [4]. Its ^{40}Ar/^{36}Ar of 222 could be considered as an upper limit of ^{40}Ar/^{36}Ar ratio value for trapped component in this Ghubara sample. ^{36}Ar/^{38}Ar ratios slightly decrease with progressive crushing indicating a higher contribution of the cosmogenic component in advanced crushing steps that is supported by the mentioned above Ne isotopic composition trend. The ^{4}He/^{36}Ar (~2000) and ^{4}He/^{20}Ne (~20) ratios are strongly fractionated relative to SW and they increase by a factor of 3.5-5.0 in the late extractions. N_2 content is 678 ppb. δ^{15}N is in the range between +6‰ and +39‰ that is usual for ordinary chondrites [7].

Summary: Based on the results of [1] and this study we conclude that trapped component degassing at high temperatures during stepwise heating is most probably located in gas inclusions/voids. Abundance and isotopic compositions of the light noble gases released by crushing can be explained by a mixture of gases trapped during L-chondrite parent body breakup event ~470 Ma ago and of cosmogenic gases accumulated during subsequent GCR irradiation. Gradual opening of the inclusions/voids different in mechanical strength indicates that the relative contribution of cosmogenic nuclides increases with progressive crushing. While trapped gases are mostly released from relatively large voids, cosmogenic nuclides are likely extracted from GCR tracks. The composition of trapped gases derived from mobilization and redistribution of different noble gas components (radiogenic, solar, cosmogenic) accumulated before catastrophic event in regolith material is dominated by the SW component, which was fractionated upon capture in voids, and by radiogenic ^{40}Ar.

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