NOBLE GASES IN THE TWO LUNAR METEORITES AAU 012 AND SHIŞR 166.

M. Mészáros[1,2], I. Leya[1] and B. A. Hofmann[2,3], [1]Space Research and Planetary Sciences, University of Bern, Sidlerstrasse 5, Bern 3012, Switzerland, [2]Natural History Museum Bern, Bernastrasse 15, Bern 3005, Switzerland, [3]Institute of Geological Sciences, University of Bern, Baltzerstrasse 1+3, Bern 3012, Switzerland, (marianna.meszaros@space.unibe.ch; ingo.leya@space.unibe.ch; beda.hofmann@geo.unibe.ch)

Introduction: AaU 012, the first lunar meteorite from Saudi Arabia, was discovered in 2012 ~700 km away from Shişr 166, which was found in 2008 in Oman. Both are feldspathic lunar impact-melt breccias and possess a very similar bulk composition, implying a possible launch pairing. Although their textures are somewhat different (AaU 012 has a microcrystalline matrix, while Shişr 166 has a matrix composed of submicroscopic crystallites and contains melt veins), it is not a strong argument against launch pairing and could just indicate different positions in the source crater. The aim of our study was to obtain information on the exposure histories to further proof or reject launch pairing of these two lunar meteorites.

Experimental: We measured the isotopic concentrations of He, Ne, Ar, Kr, and Xe in two samples from each of the two meteorites (AaU1 ~56.3 mg, AaU2 ~50.8 mg, Shişr1 ~48.0 mg, Shişr2 ~47.8 mg). Subsample AaU2 was treated with 6N HCl for 5 min. before noble gas measurements to remove any terrestrial contamination. Gas extraction was performed at 1740 °C. Subsample AaU1 was re-heated to 1780 °C to ensure complete degassing.

Results: *AaU 012*. All the measured noble gas ratios show that AaU 012 contains both cosmogenic and trapped noble gases. Considering the isotope ratios the trapped component could be a mixture of fractionated solar wind (FSW) [1] and air. However, since AaU 012 does not contain significant amounts of terrestrial alteration products, we assume that the trapped component is dominated by FSW. Cosmogenic ^{21}Ne of (8.26 ± 1.46) $\times 10^{-8}$ cm^{3}STP/g was calculated assuming a cosmogenic ^{20}Ne/^{22}Ne = 0.8, a terrestrial atmospheric ^{20}Ne/^{22}Ne = 9.8 and ^{21}Ne/^{22}Ne = 0.029, and ^{20}Ne/^{22}Ne = 12.48 and ^{21}Ne/^{22}Ne = 0.03 for FSW. Cosmogenic ^{38}Ar of (15.1 ± 3.2) $\times 10^{-8}$ cm^3 STP/g was calculated assuming ^{36}Ar/^{38}Ar of 0.62, 5.305 [2], and 5.501 [3] for cosmogenic, air, and solar wind (SW), respectively. The isotopic ratios for Kr and Xe also plot on a mixing line between the respective cosmogenic and trapped endmembers.

Shişr 166. All isotopic ratios of Shişr 166 show that trapped noble gases, which are most likely air, are dominant in the meteorite. The presence of FSW can be excluded due to the low gas amounts, i.e., typically implanted FSW produces much higher gas concentrations. Another possible trapped component can be phase Q because the measured ^{20}Ne/^{22}Ne ratio of 10.4 ± 0.2 is inbetween the values reported for Q1 and Q2 (10.67 and 10.11, [4]). Chondritic meteorites are the main carriers of phase Q and also of the siderophile element Ir. Since we know that this type of meteorites have delivered significant material to the lunar surface, we should take phase Q into account as a possible trapped component, especially for lunar breccias with high Ir concentrations. This assumption is supported by the Kr and Xe data, which also suggest the presence of phase Q or a mixture of Q and air. Shişr 166 contains only trace amounts of cosmogenic gases. Calculated ^{21}Ne$_c$ is only (0.0020 ± 0.0001) $\times 10^{-8}$ cm^3 STP/g.

Discussion: Lunar meteorites usually have long residence times (2π-irradiation >>100 Ma) and relatively short transfer times (4π-irradiation <<11 Ma) [1]. We calculated production rates for the 2π-irradiation for shielding depths between 0-500 g/cm^2 according to [5] and production rates for the 4π-irradiation according to [6].

AaU 012 had a shielding depth on the Moon <20 g/cm^2 and a residence time between 80 – 100 Ma as calculated from ^{21}Ne$_c$. Since the residence time is already short compared to most other lunar meteorites, we propose that all cosmogenic gases were produced on the Moon.

Shişr 166. Based on cosmogenic ^{21,22}Ne data we calculated a very short residence time of 279 ± 11 ka at a shielding depth of 500 g/cm^2. Due to the large shielding depth we assume that essentially all of the measured ^{21}Ne$_c$ was produced during the transfer from Moon to Earth. We calculated the transfer time assuming a pre-atmospheric radius of ≤65 cm for a min. of 10% and a max. of 90% ablation loss. The thus calculated transfer times are in the range of 7 – 10 ka. Interestingly, another feldspathic lunar breccia, Dho 026 has similarly low ^{21}Ne$_c$ concentration (0.002$\times 10^{-8}$ cm^3 STP/g; [7]), a short transfer time (<10 ka; [7]), and a large shielding depth (~1400 g/cm^2; [8]).

Conclusion: All our data suggest that the two feldspathic lunar impact-melt breccias AaU 012 and Shişr 166 are most likely not launch pairs.

References: [1] Lorenzetti S. et al. 2005. *Meteoritics & Planetary Science* 40:315-327. [2] Lee J. Y. et al. 2006. *Geochimica et Cosmochimica Acta* 70:4507-4512. [3] Meshik A. et al. 2014. *Meteoritics & Planetary Science* 44:1061-1086. [4] Busemann H. et al. 2000. *Meteoritics & Planetary Science* 35:949-973. [5] Hohenberg C. M. et al. 1978. 9th Lunar and Planetary Science Conference. pp. 2311-2344. [6] Leya I. and Masarik J. 2009. *Meteoritics & Planetary Science* 44:1061-1086. [7] Shukolyukov Yu. A. et al. 2001. Abstract #1502. 32th Lunar and Planetary Science Conference. [8] Nishiizumi K. et al. 2001. Abstract #5411. 64th Annual Meteoritical Society Meeting.