COSMIC-RAY EXPOSURE AGES OF PALLASITES DERIVED FROM METAL AND OLIVINE SEPARATES. L. Huber[1], M. Cosarinsky[1], D. Cook[2,3], I. Leya[1], and G. Herzog[2]. [1]Space Research and Planetology, Physics Institute, University of Bern, CH3012 Bern, Switzerland; [2]Rutgers University, Piscataway, NJ, USA; [3]University of Oxford, Oxford, UK. (mariana.cosarinsky@space.unibe.ch).

Introduction: Pallasites are intriguing rocks composed of olivine and metallic Fe-Ni, suggesting they derive by mixing material from matle and core in a differentiated body [e.g., 1,2]. A link between main group pallasites and iron meteorites (IIIABs) was made based on chemical and isotopic signatures [2,3]. If both meteorite groups derived from the same parent body, the exposure histories should then correlate. We present a study of 15 pallasites based on measurements of light noble gases in iron and olivine separates in combination with radionuclides measurements in the iron fraction. From these data, reliable cosmic ray exposure (CRE) ages can be derived for 12 pallasites.

Samples: We measured the activities of the cosmogenic radionuclides ^{10}Be, ^{26}Al, and ^{36}Cl as well as the concentrations and isotopic compositions of He, Ne, and Ar in metal separates of the pallasites Admire*, Ahumada, Albin*, Brenham, Eagle Station, Esquel, Finmarken*, Glorieta Mountain, Huckitta*, Imilac*, Krasnojarsk, Molong*, South Bend, and Springwater*. The mark (*) indicates those samples from which we also measured the olivine fraction for light noble gases, in addition to olivine from Seymchan. The olivine and metal samples were obtained independently.

Results: The noble gas blanks are low for the metal and olivine samples (i.e., less than a few percent for ^{3,4}He, ^{21,22}Ne, and ^{36,38}Ar). However, Ar concentrations in the olivines are very small and the blanks represent ~10% of the measured gas. The Ne and Ar data are almost purely cosmogenic, with ^{36}Ar/^{38}Ar ratios as low as 0.60. Only very minor corrections (4% at most, normally less than 1%) are necessary for trapped gases and/or impurities. There was no indication of trapped solar gases in the iron phase or the measured olivines, with the exception of solar or planetary-like Ar in one Imilac olivine aliquote, which is the only sample with a high Ar concentration (^{36}Ar ~26×10^{-8} cm^{3}STP). In addition, the amount of cosmogenic ^{21}Ne is ~30% higher than in the other aliquot. Preliminary results on the metal samples, including the radionuclides activities, were already reported in [4,5]. Eagle Station and Brehnam are excluded from further discussions because the results are inconclusive or the amount of gas too low.

Olivine contamination: To properly calculate exposure ages one has to guarantee that the samples were as pure as possible, without olvine in the metal samples and vice versa. To assess the presence of samples and vice versa. To assess the presence of olivine in the metal, we used the average ^{21}Ne/^{38}Ar values modeled for pure metal (0.155 ± 0.042, [6]) and the modeled production rate ratio of ^{21}Ne in olivine vs. metal ($^{21}Ne_{ol}/^{21}Ne_{met}$ ~100±70, I. Leya pers. comm.). For most samples the olivine contamination is below 1 %, contributing thus 20-60% of ^{21}Ne and 1-5% of ^{3}He and ^{4}He.

We also constrained the contribution of ^{21}Ne from olivine inclusions in metal using the ^{21}Ne measured directly in olivine, even if the samples are unrelated. These results give similar fractions of olivine contamination. The only discrepancies are found in smaller meteorites, for which lower production rate ratios (i.e., $^{21}Ne_{ol}/^{21}Ne_{met}$ ~20 to 40) would be more appropriate.

Exposure Ages: The Ne and Ar noble gas and the radionuclide data allow us to calculate exposure ages in the metal samples by various methods, once the samples are corrected for the terrestrial residence time. Terrestrial ages were determined vie the decay of ^{41}Ca. The advantage of the ^{36}Ar-^{36}Cl method is that it provides information independent of the shielding conditions of the sample in the meteoroid. The ages thus calculated are within 2 and 120 My (Fig. 1a). The results calculated via the ^{21}Ne-^{10}Be pair are the most consistent with the Ar-Cl ages, whereas the ^{21}Ne-^{26}Al and ^{38}Ar-^{10}Be ages are ~30% lower and higher, respectively (Fig. 1b). The disagreement is worse in the cases of Krasnojarsk, Glorieta Mountains and Ahumada. The ^{36}Cl activity measured in those pallasites is too high compared to the ^{10}Be decay which indicates that they may have experienced recent complex exposure histories. Other possible sources of disagreement among the ages calculated via different nuclide pairs for the other meteorites might arise from the correction for terrestrial ages or the olivine contamination correction.

To calculate the ^{21}Ne ages for the olivine samples, we modeled the production rate of this nuclide in olivine assuming a metal matrix, as a function of meteoroid size. For olivine of average chemical composition in pallasites, the range of modeled cosmogenic ^{22}Ne/^{21}Ne ratios are slightly higher than the measured ratios (0.966-1.019). Nevertheless, the model appears to be accurate within a few percent. Based on these production rates, the calculated CRE ages range from 33 My (Finmarken) to 110 My (Albin) (Fig. 1c). The two aliquots of Imilac have different amounts of cosmogenic ^{21}Ne and yield different ages.

There is a very good agreement between the ^{36}Ar-^{36}Cl ages in metal and the ^{21}Ne ages in olivine. The only exception is Finmarken, which yields an age ~60% lower (i.e., ^{21}Ne age of 33 My). The Imilac olivine sample which does not contain the trapped Ar is in good agreement with the age for the metal.

The overall picture shows a cluster of ages around 75 to 120 My. At least 6 pallasites overlap in terms of exposure ages (106 to 122 My), suggesting that they may have been ejected from the same parent body in a single event. Two samples (Krasnojarsk and Esquel) have very low exposure ages. *Can a connection to iron meteorites be established?* Despite the poor statistics, it looks like pallasites have much younger overall CRE ages than the IIIAB's group of iron meteorites (Fig. 2). Even though the pallasites overlap with a few iron meteorites, no clear grouping can be established.

References:

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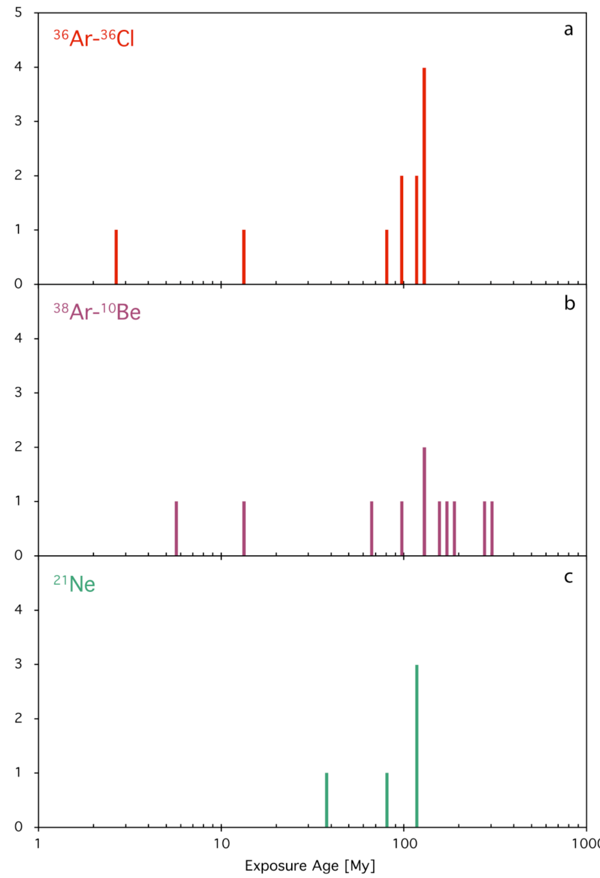

Fig 1 CRE ages distribution of pallasite metal (a, b) and olivine (c). Uncertainties are in the order of 10% and are represented by the thickness of each bar.

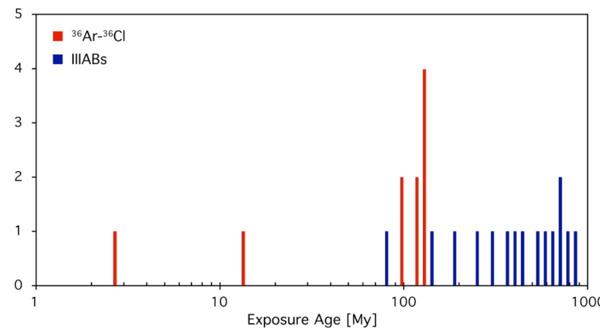

Fig. 2 Ar-Cl CRE ages of pallasites compared to the age distribution of the IIIAB iron meteorites [7].