DUST FORMATION AROUND AGB STARS AND THE ORIGIN OF NUCLEOSYNTHETIC VARIATIONS IN THE SOLAR NEBULA.

M. Ek[1*], A. C. Hunt[1] and M. Schönbächler[1]. [1]Department of Earth Sciences, ETH Zurich, Clausiusstrasse 25, 8092 Zürich, Switzerland. *mattias.ek@erdw.ethz.ch

Introduction: Nucleosynthetic isotope variations in bulk meteorites are well known for a range of refractory elements and reflect the heterogeneous distribution of presolar grains in the solar nebula. It is often assumed that the solar nebula was initially well mixed. To introduce heterogeneities, several mechanisms for dust sorting in the solar nebula were proposed, e.g. grain size sorting [1] or thermal processing [2]. Correlated nucleosynthetic variations were identified in Zr, Mo and Ru isotopes [3-6]. They agree with an *s*-process deficit recorded by meteorites, relative to Earth, and fall along a mixing line between the terrestrial composition and an *s*-process endmember predicted by nucleosynthetic models of asymptotic giant branch (AGB) stars (e.g. [7]). Palladium is a powerful element to better constrain the origin of nucleosynthetic variations because it is more volatile (50 % T_c = 1324 K [8]) than the neighbouring Zr, Mo and Ru (50 % $T_c \geq$ 1551 K [8]) and less refractory than e.g. Cd and Te (50 % $T_c \leq$ 709 K [8]), which show no nucleosynthetic variations. A study on IVB iron meteorites reported nucleosynthetic Pd data with smaller offsets from the terrestrial composition than those predicted based on the Mo and Ru data [9]. The authors attributed this to the selective destruction of a Pd carrier phase in the solar nebula [9]. In this study, we determined the mass-independent Pd isotope compositions for a range of iron meteorite groups.

Methods and Results: We report Pd isotope data for 24 iron meteorites from the IAB, IIAB, IID, IIIAB, IVA and IVB groups. The external reproducibility (2 SD) of our study is 1.58 for ε^{102}Pd, 0.26 for ε^{104}Pd, 0.13 for ε^{106}Pd and 0.27 ε^{110}Pd. The data show Pd isotope variations both between different iron meteorite groups and within the same group. We corrected the Pd isotope data for galactic cosmic ray (GCR) irradiation effects using ε^{196}Pt data obtained on the same sample aliquot, allowing us to determine the nucleosynthetic Pd isotope composition. The IVB and the IID irons yield the largest nucleosynthetic offsets, while the IAB and IIAB groups display compositions within uncertainty of the terrestrial standard.

Discussion: The GCR-corrected Pd isotope data define a linear correlation with those reported for Mo and Ru. The Pd offsets, however, are only 1/4th of those predicted based on the slope of the Zr-Mo-Ru correlation and nucleosynthetic models (e.g. [7]). Several studies suggest that the majority of dust in the solar nebula formed in the interstellar medium (ISM), while only a small fraction of 'stardust' or 'presolar grains' [10, 11] formed around active stars and retained unique nucleosynthetic isotope compositions. Likewise, only a small fraction of the mass produced by AGB stars condensed around the star, the majority of the material was returned to the ISM in the gas phase [12]. We attribute the smaller Pd offsets seen in our data to incomplete condensation of Pd into stardust around AGB stars, relative to the more refractory Zr, Mo and Ru. Selective processing of dust in the early solar nebula that led to an enrichment of stardust, which was predominantly of *s*-process origin [10, 11], in regions closer to the Sun can explain the slope of the Zr-Mo-Ru-Pd correlation defined by different meteorite groups and the Earth. This model negates the need for a process that selectively destroys a Pd carrier phase in the solar nebula. Elements more volatile than Pd would not readily condense into dust around AGB stars, which can explain the lack of nucleosynthetic offsets in e.g. Cd [13] and Te [14]. Asymptotic giant branch stars with supersolar metallicities have recently been proposed as the source of mainstream SiC grains in meteorites [15]. These stars produce less of the heavy elements (> Ba) relative to Zr, Mo, Ru, and Pd, compared to the solar abundance of these elements [16]. If the majority of stardust originated from AGB stars with supersolar metallicities, this can, at least partially, explain the smaller, or lack of, nucleosynthetic offsets reported for the heavy refractory elements, e.g. W [17-19] and Pt (e.g. [17, 18]).

References: [1] Dauphas, N. et al. (2010) *The Astrophysical Journal* 720:1577-1591. [2] Trinquier, A. et al. (2009) *Science* 324:374-376. [3] Akram, W. et al. (2015) *Geochimica et Cosmochimica Acta* 165:484-500. [4] Dauphas, N. et al. (2004) *Earth and Planetary Science Letters* 226:465-475. [5] Fischer-Gödde, M. et al. (2015) *Geochimica et Cosmochimica Acta* 168:151-171. [6] Poole, G.M. (2017) *Earth and Planetary Science Letters* 473:215-226. [7] Bisterzo, S. et al. (2011) *Monthly Notices of the Royal Astronomical Society* 418:284-319. [8] Lodders, K. (2003) *The Astrophysical Journal* 591:1220-1247. [9] Mayer, B. et al. (2015) *The Astrophysical Journal* 809:180-187. [10] Zhukovska, S. et al. (2008) *Astronomy & Astrophysics* 479:453-480. [11] Hoppe, P. et al. (2017) *Nature Astronomy* 1:617–620. [12] Ferrarotti, A.S. & Gail, H. P. (2006) *Astronomy and Astrophysics* 447:553-576. [13] Wombacher, F. et al. (2008) *Geochimica et Cosmochimica Acta* 72:646-667. [14] Fehr, M.A. et al. (2005) *Geochimica et Cosmochimica Acta* 69:5099-5112. [15] Lugaro, M. et al. (2018) *Geochimica et Cosmochimica Acta* 221:6-20. [16] Cristallo, S. et al. (2011) *The Astrophysical Journal Supplement Series* 197:17. [17] Wittig, N. et al. (2013) *Earth and Planetary Science Letters* 361:152-161. [18] Kruijer, T.S. et al. (2013) *Earth and Planetary Science Letters* 361:162-172. [19] Qin, L. et al. (2008) *The Astrophysical Journal* 674:1234-1241.