DETERMINING A PRECISE HE, NE COSMIC-RAY EXPOSURE AGE FOR GRAINS FROM ITOKAWA.

M. M. M. Meier[1], C. Alwmark[1], S. Bajt[2], U. Böttger[3], H. Busemann[4], J. Gilmour[4], U. Heitmann[5], H.-W. Hübers[3], F. Marone[6], S. Pavlov[3], U. Schade[7], N. Spring[4], M. Stampanoni[6], F. Terfelt[1], I. Weber[5]. [1]Dept. of Geology, Lund Univ., Sweden (matthias.meier @geol.lu.se), [2]Photon Sci., DESY, Hamburg, Germany, [3]DLR, Planet. Res. Inst., Berlin, Germany, [4]SEAES, Univ. of Manchester, UK, [5]Inst. f. Planetologie, Univ. of Münster, Germany, [6]Swiss Light Source, PSI, Villigen, Switzerland, [7]Helmholtz-Zentr. Berlin, Germany.

Introduction: In this consortium study (c.f., [1]), we aim to measure the He, Ne and Xe concentrations and isotopic compositions of seven olivine-rich particles (RA-QD02-0035, -0049-1, -0049-4, -0051, -0158, -0187 and -0197) returned from the surface of asteroid Itokawa. One of our primary goals is the determination of a cosmic-ray exposure (CRE) age for individual olivine particles, using cosmic-ray produced ^{3}He and ^{21}Ne. This requires a noble gas instrument with a very high sensitivity, but also a precise determination of the grain masses. Otherwise, the uncertainty of the CRE age will be dominated by the mass error, which, for such small grains, can easily reach or exceed 100% (at microbalance errors of ~0.1-0.2 µg). We have therefore chosen to image all our grains with Synchrotron Radiation X-ray Tomographic Microscopy (SRXTM) to determine precise volumes, and Raman microspectroscopy (see also [2]) and FTIR to nondestructively determine the mineral composition (and thereby, density) [3].

Methods: SRXTM was done at the TOMCAT beamline of the Swiss Light Source at PSI in Villigen, Switzerland. We used beam energies of 10 and 20 keV. Tomographic reconstructions were carried out on a 30-node Linux PC cluster [4]. The cubic voxel size of the reconstructed images is 325 nm. The He, Ne analysis was done on the compressor-source noble gas mass spectrometer at ETH Zurich connected to an ultra-low-blank extraction line [5]. The noble gases were extracted from the grains in a single temperature step using melting with an IR-laser (λ=1064 nm).

Results: Volumes between 17800±900 µm^3 (RA-QD02-0187) and 442700±5900 µm^3 (RA-QD02-0049-1) have been determined for six of the seven grains, and will be presented at the symposium (together with shapes, surface areas and the abundance of additional mineral phases present). At a density of olivine with an LL-chondritic Fe/Mg ratio (3.63 g/cm^3), these volumes correspond to masses between 0.0646±0.0032 µg and 1.61±0.02 µg (i.e., relative errors are ~10-100 times smaller compared to weighing). We have also measured the He, Ne concentrations and isotopic composition in grain RA-QD02-0035, and will present the data for two additional grains at the symposium. We clearly observed a cosmogenic excess over solar wind for Ne in this grain, corresponding roughly to a CRE age of 1-3 Ma., lower but compatible with the upper limit of ~8 Ma given by [6], suggesting that the Itokawa regolith has been exposed to cosmic rays for a significantly shorter time than most LL chondrites (e.g., [7]).

References: [1] Busemann, H. et al., 2013. This meeting. [2] Böttger, U. et al., 2013. This meeting. [3] Meier M. M. M. et al., 2013. LPSC XLIV, #1937. [4] Marone F. & Stampanoni M., 2012. J. Synchrotron Rad. 19:1029-1037. [5] Baur H., 1999. EOS Trans. AGU 46, #F1118. [6] Nagao K. et al., 2011, Science 333:1128-1131. [7] Marti K. and Graf T., 1992. Ann. Rev. Earth. Planet. Sci. 20:221-243.