AN IMPACT-VAPOR CONDENSATE FROM ASTEROID ITOKAWA: EVIDENCE FROM O AND Si ISOTOPES.

R. C. Ogliore[1], K. Nagashima[2], A. Thomen[2], E. Dobrica[3]. [1]Washington University in St. Louis (rogliore@wustl.edu). [2]Univ. of Hawai`i at Manoa. [3]Unv. of New Mexico.

Introduction: Vaporization of lunar regolith during micrometeoroid impact results in isotopically heavy residue and correspondingly light vapor by Rayleigh distillation. Lunar soils have been measured to have heavy isotope enrichments of O, Si, S, and K [1], likely due to the contribution of impact residue. Impact vapor can recondense into, e.g., volatile-rich alumina-poor (VRAP) glass that is chemically complementary to high-alumina, silica-poor (HASP) evaporative residue found in mature Apollo 16 regolith [2]. Regolith from asteroid Itokawa, an S-type asteroid sampled by JAXA's Hayabusa mission, also contains evidence of micrometeoroid impacts [3, 4]. We have identified two adhering, μm-sized amorphous SiO_2 particles with multi-droplet porous textures on the surfaces of two ~30 μm regolith grains from Itokawa [4]. The interface between the host and adhering grain shows evidence of deformation where the adhering grain impacted at high velocity, implying the adhering grain is not contamination. We hypothesize that the porous particles are vapor condensates from an impacted silicate target. To test this hypothesis, we measured O and Si isotopes in a porous Itokawa adhering particle and the underlying host olivine.

Methods: A 5x5 μm FIB section containing the 1.5 μm porous adhering particle was extracted from Hayabusa grain RB-DQ04-0091. The section was milled to a thickness of ~1 μm and attached to a Cu TEM grid. A 10x10 μm FIB section of a quartz isotope standard was attached to the same grid. After TEM analysis, this grid was attached to a stainless steel bullet using C paint and coated with 15 nm of C for ion probe analysis. Using the UH Cameca ims 1280, we multicollected $^{16}O^-$, $^{17}O^-$, and $^{18}O^-$ for 30 s, jumped to $^{28}Si^-$, $^{29}Si^-$, and $^{30}Si^-$ for 30 s, then jumped to $^{56}Fe^{16}O^-$ for 4 s. We used a <3 pA Cs^+ primary beam focused to 250 nm and ~5500 mass-resolving power for the monocollector EM ($^{17}O^-$, $^{30}Si^-$) to minimize interference from $^{16}OH^-$. We collected 128x128 pixel maps over a 5x5 μm raster for 100 cycles (2.5 hrs per analysis) for standards and unknowns.

Results: The porous Itokawa adhering particle has O and Si isotopic composition: $\delta^{18}O = -101 \pm 31$, $\delta^{17}O = -57 \pm 71$ and $\delta^{30}Si = -43 \pm 38$, $\delta^{29}Si = 6 \pm 30$. All errors are 2σ.

Discussion: The porous Itokawa adhering particle has isotopically light O composition, consistent with a recondensed, Rayleigh-distilled vapor. The host Itokawa olivine, which the porous grain adheres to, was simultaneously measured to have normal O isotopic composition. The uncertainties in our silicon isotope measurements were slightly larger than the expected Rayleigh effect in the adhering Hayabusa grain based on the O measurements. We conclude, based on its morphology, mineralogy, and isotopic composition, that the porous Itokawa particle is an impact-vapor condensate. We identified a metallic Fe particle close to a fluffy amorphous silica grain on one of our Hayabusa particles. This was also likely created by micrometeoroid impact. Impact products like this can significantly affect the spectral features of asteroid Itokawa.

References: [1] Clayton, R. N. et al. 1974. *5th LPSC* 1801. [2] Keller, L. P. & McKay, D. S. 1992. *22nd LPSC* 137. [3] Nakamura, E. et al. 2012. *PNAS* 109, E624. [4] Ogliore, R. C. & Dobrica, E. 2015. *46th LPSC* #1631.