LITHIUM, BORON AND LIGHT NOBLE GAS ANALYSES ON THE SURFACE OF THE ITOKAWA ASTEROIDAL REGOLITH RETURNED BY THE HAYABUSA MISSION.

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Introduction: Asteroidal regolith from the surface of Itokawa was brought to the Earth by a Japanese spacecraft, Hayabusa. Because the sample was taken from the uppermost layer of the asteroid, it had been exposed to solar wind (SW) [1]. In this study, we investigated the SW Li, B and light noble gas isotopic compositions on the surface of Hayabusa samples.

Experimental: The allocated samples, RA-QD02-0167 and RA-QD02-0209 (hereafter 0167 and 0209), are ~50 μm sized olivine grains. We pressed them onto ultra-pure Au foils. First we analyzed them with a NanoSIMS 50 at MPI. We obtained depth profiles of secondary $^{6,7}Li^+$, $^{10,11}B^+$ and $^{30}Si^+$ ions produced by an O^- primary ion beam (100 pA) by acquiring a series of 200 ion images [2]. The total analyzed depth was ~120 nm. Subsequently, we measured He and Ne isotopic ratios at ETH Zurich.

Results and Discussion: No Li isotopic anomalies were detected throughout the depth profiles, as opposed to the results by [3] for grains from lunar soil. As for B, grain 0167 is clearly enriched in ^{10}B by ~16 %, with $^{10}B/^{11}B = 0.288 \pm 0.023$ (2σ; solar = 0.248) in the region deeper than ~30 nm. The B concentration of this grain is ~250 ppb. Grain 0209 shows solar B isotopic composition within error (0.240 ± 0.015). Because [1] found no detectable cosmogenic ^{21}Ne excesses for three Hayabusa grains, we invoke SW implantation rather than cosmogenic B to explain the observed high $^{10}B/^{11}B$ of grain 0167. There are several ways to increase the $^{10}B/^{11}B$ ratio in SW and/or the solar photosphere. 1) Spallation reactions in the Sun's atmosphere [3]. However, spallogenic B accounts for only <1 % of total B in the Sun's atmosphere, so its contribution is minimal. 2) Gravitational settling within the Sun, which also plays a minor role [4]. 3) Nuclear burning of B at the base of the Sun's convective zone [5]. Since ^{11}B is more easily destroyed than ^{10}B, this results in higher $^{10}B/^{11}B$. But if a substantial amount of ^{11}B is destroyed, ^{9}Be should be completely destroyed and depleted in the Sun, which is not observed. 4) Isotope fractionation between SW and the Sun's outer convective zone, which is expected to occur during SW acceleration (e.g., [6]). The inefficient Coulomb drag model, e.g., predicts enrichment in ^{10}B relative to ^{11}B by ~4 % (assuming B^{+5} in SW) to ~40 % (B^{+3}). In any case, if we assume the SW $^{10}B/^{11}B$ to be in the range of 0.265 to 0.347 (the latter corresponds to a 40 % enrichment in ^{10}B), then the observed $^{10}B/^{11}B$ of >0.265 can be explained by a SW B contribution of 46 to 250 ppb in the analyzed zone. For a SW B implantation rate at 1.3 AU of 0.14 $cm^{-2}s^{-1}$ (based on the SW He flux and the solar B/He ratio; [7,8]), the corresponding irradiation age is between 5.5 and 30×10^4 years. The data reduction of the noble gas analysis is in progress, and the results will be presented at the workshop.

References: [1] Nagao K. et al. 2011. *Science* 333:1128. [2] Fujiya W. et al. 2013. *MetSoc 2013*: abst. #5061. [3] Chaussidon M. and Robert F. 1999. *Nature* 402:270. [4] Turcotte S. and Wimmer-Schweingruber R. F. 2002. *JGR* 107:1442. [5] Bochsler P. and Geiss J. 1973 *Solar Phys.* 32:3. [6] Heber V. S. et al. 2012. *ApJ* 759:121. [7] Heber V. S. et al. 2009. *GCA* 73:7414. [8] Asplund M. et al. 2009. *Rev. Astron. Astrophys.* 47:481.