INSIGHTS INTO REGOLITH DYNAMICS FROM THE IRRADIATION RECORD PRESERVED IN HAYABUSA SAMPLES. L. P. Keller[1] and E. L. Berger[2,1]. [1]Robert M. Walker Laboratory for Space Science, Code KR, ARES, NASA/JSC, Houston, TX 77058. E-mail: Lindsay.P.Keller@nasa.gov. [2]GeoControl Systems, Inc./JETS, Houston, TX 77058.

Introduction: The rates of space weathering processes are poorly constrained for asteroid surfaces, with recent estimates ranging over 5 orders of magnitude [e.g. 1,2]. The return of the first surface samples from a space-weathered asteroid by the Hayabusa mission and their laboratory analysis provides “ground truth” to anchor the timescales for space weathering. We determine the rates of space weathering on Itokawa by measuring solar flare track densities and the widths of solar wind damaged rims on grains. These measurements are made possible through novel focused ion beam (FIB) sample preparation methods [3].

Methods: Particles RA-QD02-0192 and RA-QD02-0211 were embedded in low viscosity epoxy and thin sections were prepared using ultramicrotomy. Imaging, diffraction, and compositional data were obtained using a JEOL 2500SE 200 kV field-emission scanning-transmission electron microscope. We determine accurate solar flare track densities and rim widths from the FIB sections of the particles.

Results: Both particles are olivine-rich (Fo_{70}), contain solar flare tracks, and are surrounded by space weathered rims [4]. The rims are continuous, show varying widths, and are nanocrystalline, not amorphous [4]. Interestingly, RA-QD02-0211 exhibits a solar flare particle track gradient across the particle, ranging from $3.4x10^9$ cm^{-2} down to $9.2x10^8$ cm^{-2}. The solar wind damaged rim is widest (80 nm) on the side of the grain with the highest track density and is thinner (40 nm) on the opposite side of the grain. The track density corresponds to a surface exposure of 10^5 years based on the track production rate we determined for olivine at 1 AU (3.5 $x10^4$ cm^{-2}) [5]. Particle RA-QD02-0192 also shows a solar flare track density gradient 2.9- to 1.1 $x10^9$ cm^{-2} and similar rim widths as in -0211. The track density in -0192 corresponds to an exposure of ~$8x10^4$ years.

Discussion and Conclusions: The solar flare track density gives a direct measure of the exposure time that the grain resided within a few mm of the parent body surface, whereas the solar wind effects are limited to the outer ~100 nm of grains that had a direct exposure to the solar wind. The heterogeneous distribution of the space weathering effects on -0192 and -0211 is consistent with both particles maintaining a relatively fixed orientation in the Itokawa regolith while they were irradiated by incoming solar wind and solar flare ions. Provided these results are confirmed by measurements on many more grains, they imply that the regolith at the Muses-C region on Itokawa was stable to mm-depths for the last ~10^5 years. We are modeling the direct space exposure time for such grains based on the width of their solar wind damaged rims [6].

References: [1] Willman, M. et al. 2010. *Icarus* 208:758-772. [2] Vernazza, P. *et al*. 2009. *Nature* 458:993-995. [3] Berger, E. L. & Keller L. P. 2014. *LPS XLV*, #1485. [4] Keller, L. P. & Berger, E. L. 2014. *EPS* 66:71. [5] Berger, E. L. & Keller L. P. 2014. *Goldschmidt mtg*. [6] Christoffersen R. and Keller L. P. 2014. *this volume.*