TRANSMISSION ELECTRON MICROSCOPY OF ITOKAWA REGOLITH GRAINS. 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: In a remarkable engineering achievement, the JAXA space agency successfully recovered the Hayabusa spacecraft in June 2010, following a non-optimal encounter and surface sampling mission to asteroid 25143 Itokawa. These are the first direct samples ever obtained and returned from the surface of an asteroid. The Hayabusa samples thus present a special opportunity to directly investigate the evolution of asteroidal surfaces, from the development of the regolith to the study of the effects of space weathering. Here we report on our preliminary TEM measurements on two Itokawa samples.

Methods: We were allocated particles RA-QD02-0125 and RA-QD02-0211. Both particles were embedded in low viscosity epoxy and thin sections were prepared using ultramicrotomy. High resolution images and electron diffraction data were obtained using a JEOL 2500SE 200 kV field-emission scanning-transmission electron microscope. Quantitative maps and analyses were obtained using a Thermo thin-window energy-dispersive x-ray (EDX) spectrometer.

Results: Both particles are olivine-rich (Fo_{70}) with μm-sized inclusions of FeS and have microstructurally complex rims. Particle RA-QD02-0125 is rounded and has numerous sub-μm grains attached to its surface including FeS, albite, olivine, and rare melt droplets. Solar flare tracks have not been observed, but the particle is surrounded by a continuous ~50 nm thick, stucturally disordered rim that is compositionally similar to the core of the grain. One of the surface adhering grains is pyrrhotite showing a S-depleted rim (~8-10 nm thick) with nanophase Fe metal grains (<5 nm) decorating the outermost surface. The pyrrhotite displays a complex superstructure in its core that is absent in the S-depleted rim.

Particle RA-QD02-0211 contains solar flare particle tracks (~$2x10^9$ cm^{-2}) and shows a structurally disordered rim ~100 nm thick. The track density corresponds to a surface exposure of ~10^3-10^4 years based on the track production rate of [1]. The disordered rim is nanocrystalline with minor amorphous material between crystalline domains. Quantitative element maps show the outermost ~10 nm of the disordered rim is Si-rich.

Discussion and Conclusions: Both particles record the effects of space weathering processes on Itokawa. Noguchi *et al*. [2] proposed that the disordered rims they observed on Itokawa particles largely result from solar wind radiation damage and we arrive at a similar conclusion for the two particles we analyzed. The microstructure of the S-depleted layer on the pyrrhotite grain in RA-QD02-0125 is similar to that observed in troilite irradiated with ~10^{18} 4 kV He^+ [3, 4]. Prolonged irradiation has also been shown to disorder pyrrhotite such that the superstructure reflections are lost [5].

References: [1] Sandford S. A. 1986. *Icarus* 68:377-386. [2] Noguchi T. *et al*. 2013. *MAPS* 48: in press. [3] Keller L. P. *et al*. 2010. Abstract #1172. 41st Lunar and Planetary Science Conference. [4] Loeffler M. J. *et al*. 2008. *Icarus* 195:622-629. [5] Christoffersen R. and Keller L. P. 2011. *MAPS* 46:950-969.