SPACE WEATHERING OF ADJACENT PHASES IN SINGLE GRAINS FROM ITOKAWA.

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Introduction: Analysis of space weathering features in returned samples from asteroid 25143 Itokawa generally show them to be immature compared to lunar samples, with thin amorphous or partially crystalline rims [1] and relatively low density of solar flare tracks in some grains [2]. Vesicular rims and "blisters" seen in SEM have been noted in a number of these grains [3,4], and these features are consistent with solar wind irradiation being the dominant driver of space weathering on Itokawa. Vesicles are most commonly seen in pyroxene rims while other phases show varying degrees of amorphization or changes in chemistry due to differential sputtering. Using scanning electron microscopy (SEM) and scanning transmission electron microscopy (STEM), we can relate surficial features on grains directly to those seen in cross-sections of space weathered rims.

Methods: Samples were prepared using focused ion beam (FIB) microscopy. The grains were coated with 30-60 nm of carbon followed by e-beam deposited C or Pt and a thicker protective strap of ion-beam deposited C or Pt before milling to prevent damage to the grain surface by the ion beam. The thinned sections were heated to 140°C for six hours to drive off adsorbed water before insertion in the UHV system.

Equipment. Electron energy loss spectroscopy (EELS) and energy dispersive x-ray spectroscopy (EDS) data were collected with PRISM, the NION UltraSTEM200-X at the U.S. Naval Research Laboratory, equipped with a Gatan Enfinium ER EEL spectrometer with and a Bruker SSD-EDS detector. The STEM was operated with at 200 kV, with a 0.1 nm probe. Spectra were collected as spectrum images (SI), with a spectrum collected for each pixel, allowing for mapping of variations in thickness, oxidation state, and composition.

Results: The samples are highly immature in terms of space weathering features, with thin to non-existent rims on some phases and very low density of solar flare tracks.

RB-QD04-0045. Phases present in FIB sections from this grain include plagioclase, pyrrhotite and olivine, with a merrillite grain that was not exposed to space weathering. The rim of the pyrrhotite grain is deficient in S compared to Fe to a depth of ~12 nm, indicating differential sputtering. The plagioclase has a slight depletion in O at the surface and a low density of <3 nm nanophase Fe^0 particles on the surface. Two pyrrhotite and chromite inclusions (200-300 nm) are present in the olivine, which shows very little evidence of alteration due to space weathering.

RA-QD02-0114. Phases in FIB sections include plagioclase, high-Ca pyroxene, olivine, and merrillite. Vesicles in the pyroxene were apparent in SEM images as blisters on the surface. Preliminary analysis of EELS data of these vesicles shows a broad feature from ~12-18 eV that is lacking in the material directly surrounding the vesicle (Figure), which is suggestive of volatiles being trapped in the vesicles [5]. As in the other grain, the plagioclase and olivine show very little evidence of alteration due to space weathering. Small nanophase Fe metal inclusions may be present along portions of the olivine rim, but the features are not well-developed.

Discussion: The Itokawa grains presented here are consistent with previous work showing immature space weathering features due primarily to solar wind irradiation. There are distinct differences in how different phases are altered, however, with plagioclase and olivine showing little alteration, pyrrhotite losing S to sputtering, and pyroxene forming a vesicular rim. The presence of volatiles in vesicles in the pyroxene, if confirmed, is also consistent with solar wind irradiation being the dominant driver of space weathering on Itokawa. However, a micron-scale impact crater is observed on one of the grains as well, indicating micrometeoroid bombardment is not completely absent.

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