STEM Analysis of Simulated Solar Wind Space Weathering

KIMBERLY R. KUHLMAN[1]*, KUMAR SRIDHARAN[2] AND ALEXANDER V. KVIT[3]

[1]Planetary Science Institute, 1700 E Fort Lowell Blvd., Suite 106 Tucson, AZ 85719, *correspondence: kim@psi.edu

[2]University of Wisconsin – Madison, Dept. of Engineering Physics, 1500 Engineering Dr. Madison, WI 53706, kumar@engr.wisc.edu

[3]University of Wisconsin – Madison, Materials Science Center & Dept. of Materials Science and Engineering, 1509 University Ave. Madison, WI 53706 kvit@wisc.edu

We have simulated solar wind-based space weathering on airless bodies in our Solar System by implanting hydrogen and helium into minerals at solar wind energies (~1keV/amu). We present the results of the first scanning transmission electron microscope (STEM) study using electron energy loss spectroscopy (EELS) spectroscopic imaging of these simulants. Inner solar-system bodies showing "space weathering" effects include the Moon, Mercury and the asteroids 4-Vesta and 1-Ceres. Our results are especially relevant in light of the recent paradigm shift caused by the remote sensing discoveries of hydrogen in the form of hydroxyl by the Lunar Crater Observation and Sensing Satellite (LCROSS) mission to the Moon and by the direct measurement of hydroxyl in Apollo samples.[1, 2] It has been demonstrated that the visible/near infrared (VNIR) reflectance spectra of airless bodies are dependent on the size and abundance of nanophase iron ($npFe^0$) particles in the outer rims of regolith grains.[3] However, the mechanism of formation of $npFe^0$ in the patina on lunar regolith grains and in lunar agglutinates remains debated.[4, 5] This work illustrates that $npFe^0$ can be nucleated in orthopyroxene under implantation of solar wind hydrogen and helium. Our data suggest that the solar wind, particularly the helium component, provides the primary solar wind mechanism by which iron is reduced in the matrix and $npFe^0$ is nucleated in the outer surfaces of regolith grains. This formation mechanism should operate on airless bodies in the Solar System.

[1] Colaprete, A., *et al* (2010) *Science* **330** (6003), 463-468 [2] Liu, Y., *et al* (2012) *Nature Geoscience* **5** (11), 779-782 [3] Noble, S.K., C.M. Pieters, and L.P. Keller, (2007) *Icarus* **192** (2), 629-642 [4] Feldman, W.C., *et al* (2001) *Journal of Geophysical Research-Planets* **106** (E10), 23231-23251 [5] Hiroi, T., C.M. Pieters, and H. Takeda (1994). *Meteoritics*, **29** (3), 394-396