ATOM PROBE TOMOGRAPHY AND VISIBLE/NEAR-INFRARED SPECTRAL ANALYSIS OF SIMULATED SOLAR WIND HYDROGEN IMPLANTED OLIVINE.

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Introduction: In an extensive review of the literature on "space weathering", Hapke defines the term as an "aggregate of the physical and chemical changes that occur to material exposed on the surface of an airless body" [1]. The processes that can affect these changes include the solar wind, ultraviolet radiation, meteorite and micrometeorite impacts, and solar and galactic cosmic rays. It has been demonstrated that small particles (<50 nm) of $npFe^0$ darken and redden spectral properties while large particles (>50 nm) of $npFe^0$ only darken spectra [2,3]. Recently it has also been discovered using scanning transmission electron microscopy (STEM) that hydrogen implanted into silicates generates H_20 and -OH [4]. The mechanism(s) of $npFe^0$ formation within low-iron materials and their kinetics are not well understood and remain contentious [5,6]. In fact, some investigators have found that hydrogen implantation causes depletion in the water content of irradiated samples [7].

Methodology: Here we present the results of the first atom probe tomography (APT) and visible/near-infrared (VNIR) spectral study of a sample of San Carlos olivine (Fo90.1 [8]) exposed to simulated solar wind-based space weathering due to hydrogen at solar wind energy (~1keV/amu). This work was accomplished using plasma source ion implantation (PSII) similar to work performed previously on orthopyroxene [9], except that here we used a fluence of 10^{17} H ions/cm^2 instead of 10^{18} H ions/cm^2. Pressed pellets consisting of ground olivine seived to less than 75 micrometers were implanted alongside samples of polished olivine for VNIR analysis. The polished sample was removed from the PSII chamber and returned to the U.S. where it was coated with 100 nm nickel and prepared for APT analysis using a standard focused ion beam (FIB) liftout method [10]. The pressed pellet was returned to RELAB at Brown University for VNIR analysis.

Results: The VNIR analysis of the pressed pellet demonstrated no change in darkening or reddening of the sample, contrary to previous results from polished specimens implanted with 10^{18} H ions/cm^2. The APT analysis of the polished olivine revealed a very complex structure within the outer 10 nm of the specimen's surface. This structure includes nanophase iron particles in the region roughly 5 nm below the surface. Regions of higher concentrations of magnesium appear to reside closer to the surface than the nanophase iron.

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