CHARGED PARTICLE WEATHERING RATES AT THE MOON AS DETERMINED FROM ARTEMIS OBSERVATIONS. A. R. Poppe[1], W. M. Farrell[2] and J. S. Halekas[3], [1]Space Sciences Laboratory, Univ. of California at Berkeley, Berkeley, CA, USA, [2]NASA Goddard Space Flight Center, Greenbelt, MD, USA, [3]Dept of Physics and Astronomy, Univ. of Iowa, Iowa City, IA, USA

Introduction: The weathering of airless bodies exposed to space is a fundamental process in the formation and evolution of planetary surfaces. At the Moon, space weathering induces a variety of physical, chemical, and optical changes including the formation of nanometer sized amorphous rims on individual lunar grains. These rims are formed by vapor redeposition from micrometeoroid impacts and ion irradiation-induced amorphization of the crystalline matrix [e.g., 1, 2]. For ion irradiation-induced rims, however, laboratory experiments of the depth and formation timescales of these rims stand in stark disagreement with observations of lunar soil grains. In particular, 1 keV proton and 4 keV alpha (He^{++}) irradiation from the solar wind, presumably the dominant flux to lunar grains, should penetrate lunar soil grains on the order of 10-20 nm. While most observations of amorphous rims on lunar grains are consistent with this, observations have also shown rims with thicknesses up to and over 200 nm [3]. Furthermore, [4] have shown a positively-correlated relationship between rim thickness and surface exposure age that is not fully understood and conflicts with laboratory measurements of surface weathering rates for 10-20 nm rims [5].

Methodology: In order to quantify the rate of space weathering of lunar grains, we have analyzed over five years of observations by the ARTEMIS spacecraft [6] in orbit around the Moon to compute the mean ion flux to the lunar surface and have convolved this flux with ion irradiation-induced vacancy production rates calculated using the Stopping Range of Ions in Matter (SRIM) model [7]. From this, we have calculated the formation timescales for amorphous rim production as a function of depth and compared to laboratory experiments and observations of lunar soil.

The mean ARTEMIS flux shows that while the solar wind proton flux near 1 keV is indeed the largest source of charged particle flux to the lunar surface, there is an extended range of ion energies up to 5 MeV (and potentially greater) with appreciable flux to the Moon. These higher energy ion fluxes originate from several sources, including the terrestrial ion foreshock region, the terrestrial magnetosheath and magnetotail current sheet, and occasional solar energetic particle events. In turn, SRIM simulations show that these higher energy charged particles penetrate and induce silicate amorphization in lunar grains at greater depths than the 1 keV solar wind particles.

Thus, we will show that this analysis resolves two outstanding issues: (1) the provenance of >100 nm amorphous rims on lunar grains and (2) the nature of the depth-age relationship for amorphous rims on lunar grains. We also present the hypothesis that ion beam-induced epitaxial crystallization [e.g., 8] is responsible for the discrepancy between observational and experimental results of the formation time of <100 nm amorphous rims. Future laboratory experiments with both a 1 keV charged particle beam and a secondary, higher energy beam should be able to test this hypothesis.

References:

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