PROBING THE IRON OXIDATION STATE OF SPACE-WEATHERED RIMS ON LUNAR SOIL GRAINS AT THE NM-SCALE

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Introduction: The nanophase Fe metal (npFe^0) particles resulted from space weathering effects in lunar soils occur within the glassy matrix of agglutinates and in the ~100 nm thick amorphous rims of lunar soil grains. The size and abundance of these npFe^0 dramatically affect the optical properties of the soil and are strongly correlated with sample maturity indices [1]. Electron energy loss spectroscopy (EELS) analyses allow the quantitative determination of the Fe^0/Fe^{2+} ratio on the rims of individual soil grains as well as in the agglutinate glass. These data provide information regarding the origin of the npFe^0 particles, the efficiency of their formation, and the soil maturity as a function of surface exposure time.

Results and Discussion: We analyzed amorphous rims on <20 μm silicate grains from 10084. Several of the analyzed rims on anorthite grains in sample 10084 are characterized by an irradiated amorphous rim (~80 nm) overlain by a thin layer (~30 nm) with only tiny (<5nm) npFe^0 inclusions. The EELS analysis shows no detectable Fe^{2+} in the outer rims, which is consistent with the vapor deposition mechanism [2]. In contrast, we detect significant Fe^{2+} with EELS in the thicker rims (outer layer >100 nm) that contain both fine- and coarse-grained npFe^0. Some of these rims may in fact represent accreted melts on the particle surface. The solar flare track density of (~10^{11} /cm^2) recorded in the host anorthite grains are consistent with a ~10^5 yr surface exposure. In the solar wind irradiated rims of Fe-bearing minerals (e.g. olivine and ilmenite), a 50-nm-thick rim with minute inclusions of npFe^0 is observed. In olivine, subequal amounts of Fe^0 and Fe^{2+} are present in the rim [3]. Even more Fe^{2+} was reduced to Fe metal in the ilmenite rims [4], partly due to the further reduction on the H-implanted surface by impact-generated heat.

The Fe^0/Fe^{2+} ratio obtained through EELS analysis from regions in the agglutinate glass normalized to the total Fe content could be used as a maturity index. Compared to the I_s/FeO parameter, which is widely used for bulk measurement of lunar soil maturity, the fraction of Fe^0 and the total Fe content are measured from exactly the same region using EELS and quantitative x-ray mapping analysis, respectively. These combined techniques will allow us to estimate the maturity of grain rims on a grain-by-grain basis. Our preliminary EELS data indicate the conversion from ferrous iron to npFe^0 in the agglutinate glass is far from complete even in the mature sample 10084. Statistical comparison of the Fe^0/Fe^{2+} ratio among the rims and agglutinate glass in the immature, submature and mature samples are underway.

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