Variation in nanophase metallic iron particle occurrence in exsolved space-weathered lunar pyroxene

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Abstract. The mechanisms responsible for the development of nanophase metallic iron ($npFe^0$) particles in space-weathered lunar regolith remain a long-outstanding question. Several formation schemes have been proposed, most prominently involving H^+-mediated reduction of vaporized Fe, necessitating tandem influence of solar wind irradiation and micrometeorite bombardment[1]; however, this scheme has been challenged by laboratory experiments[2,3]. Simulations of space weathering as a function of mineral phase have also been conducted previously, most robustly in olivine and pyroxene standards[2,4,5]; however, the influence of mineral chemistry on the development of $npFe^0$ remains poorly constrained in natural samples. In order to address this knowledge gap, we analyzed space-weathered lunar pyroxene grains with scanning transmission electron microscopy (STEM), electron energy loss spectroscopy (EELS) and energy-dispersive spectroscopy (EDS). The pyroxene grains examined were exsolved, exhibiting lamellae of low Ca pyroxene (LCP) and high Ca pyroxene (HCP) and thus were well suited to compare the effects of space weathering on different mineral compositions. In a pyroxene grain from sample 71501, we determined that $npFe^0$ particles occur densely at the grain rim in LCP lamellae whereas they are sparser in the rim of HCP lamellae. The $npFe^0$ also occur 150-200 nm deep into the grain in LCP lamellae whereas $npFe^0$ occurrence in HCP is limited to the rim (Fig. 1). In additional to compositional variation in the lamellae observed with EDS suggesting preferential sputtering phenomena, variation in the oxidation state of Fe was observed with EELS in each of the domains.

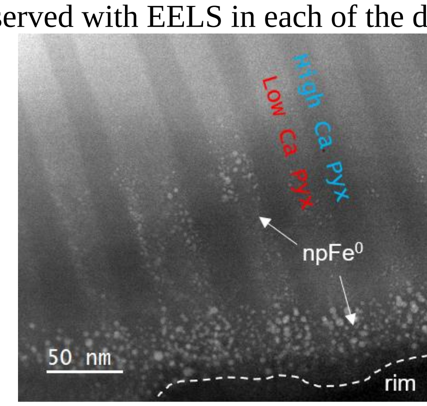

Figure 1. HAADF-STEM image of an exsolved pyroxene rim bearing $npFe^0$ particles.

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