Atom Probe Tomography of Lunar Space Weathering Products returned by Apollo 16

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Nanophase iron (npFe0) is the most abundant product of space weathering, however its formation mechanisms are still poorly understood. On the Moon, npFe0 ranges in size from a few nm to 1 µm and are widely believed to have formed by a variety of mechanisms. These include the in-situ reduction of FeO during cosmic ray bombardment, by localized heating by micrometeorites and the subsequent reduction of FeO, as well as the addition of Fe^0 from iron-nickel meteorites during micrometeorite bombardment [1], [2]. The exact nature of formation has wide ranging implications for remote spectral analysis of airless planetary bodies, as well as the cosmic ray and micrometeorite flux to the Moon.

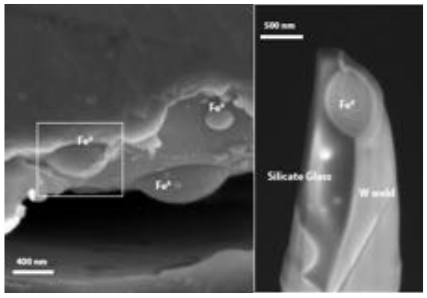

Figure 1: (left) edge of anorthite grain showing $npFe^0$, white box = $npFe^0$ on right (right) $npFe^0$ in APT needle prior to final milling

Here we present an Atom Probe Tomography (APT) study to characterize the chemistry of $npFe^0$ from Apollo 16 Regolith. APT provides the unique opportunity to conduct site specific analysis of these nanoscale space weathering products, and to generate spatially resolved trace element and isotopic chemical data on the near atomic scale, required to constrain their formation mechanisms. We looked at the iron:nickel ratios, trace elements, and iron isotopic signatures of the $npFe^0$ to determine diagnostic features of input from either meteorites (proving the micrometeorite bombardment) or lunar material (proving the in-situ reduction by cosmic ray bombardment). References:

[1] Hapke (2001) *J. Geophys. Res.*, **106**, 39–7.

[2]Gopon et al. (2017) *Meteorit. Planet. Sci.*, **22**, 1–22