SPACE WEATHERING INDUCED SLOPE CHANGES IN PYROXENE AND HOWARDITE REFLECTANCE SPECTRA. T. Kohout[1, 2], O. Malina[3], A. Penttilä[1], A. Kröger[1], D. Britt[4], J. Filip[3], K. Muinonen[1,5], R. Zbořil[3], [1]Department of Physics, University of Helsinki, Finland (tomas.kohout@helsinki.fi), [2]Institute of Geology, The Czech Academy of Sciences, Prague, Czech Republic, [3]Regional Centre of Advanced Technologies and Materials, Departments of Physical Chemistry and Experimental Physics, Palacky University Olomouc, Czech Republic, [4]Department of Physics, University of Central Florida, USA, [5]Finnish Geospatial Research Institute, Masala, Finland.

Introduction: The major reason for spectral changes in lunar-type space weathering is production of nanophase iron ($npFe^0$) in the lunar regolith. The spectral changes include attenuation of silicate absorption bands, darkening, and slope change (reddening). Observations of the asteroid Vesta recently visited by DAWN mission revealed a different pattern of spectral changes (e.g. [1]). The darkening and the absorption band attenuation occur in similar way as on the Moon. The reddening, however, is not apparent. Thus, is space weathering on Vesta distinct from that we see on the Moon? Or is another mechanism, such as the addition of carbonaceous darkening material responsible for spectral darkening of Vesta?

Space weathering experiments with pyroxene and howardite: In order to study effects of $npFe^0$ on reflectance spectra a pyroxene (En 90) and howardite (NWA 1929) powder samples were subjected to the space weathering experiments using the double-heating method described in [2]. The aim of the experiments is to produce the $npFe^0$ on the silicate mineral grains with control of their concentration and size and to quantify related spectral changes.

Reflectance spectra: Both enstatite and howardite show progressive changes in their spectra as a function of the increasing $npFe^0$ amount (Fig. 1). In general, pyroxene is more resistant to space weathering than olivine (e.g. [3]) what is also seen in our simulations. Higher heating temperatures are needed to produce the same amount of $npFe^0$ than in the olivine [2] case.

This quantitative comparison confirmed a trend observed earlier in olivine where spectral parameters change with logarithm of the [2]. An interesting feature was observed in the comparison of the slope over the 1 and 2 µm bands in both pyroxene and howardite. While the slope over 2 µm band show progressive reddening with increasing $npFe^0$ amount (similarly to olivine), the situation is reversed in 1 µm band region (Fig. 1). The relative reduction in red slope is observed in this region.

This is due to the fact that the decrease in reflectance when adding $npFe^0$ is a nonlinear process where higher reflectance values will decrease more than lower values. If the original slope is positive, as the slope over the 1 µm band in pyroxene and howardite, the slope will decrease with increasing $npFe^0$, and vice versa. In addition, the $npFe^0$ has a small positive slope itself in the VIS-NIR range, and that will turn originally zero slopes in the host mineral into positive slopes when adding $npFe^0$.

This finding can potentially explain some of the space weathering observations for Vesta. The majority of DAWN observations were done in the 1 µm region where lack of reddening is observed, similar to our pyroxene and howardite results.

Conclusions: Based on our space weathering laboratory results the lack of reddening over 1 µm region as observed on Vesta does not contradict the space weathering mechanism driven by the presence of $npFe^0$. In order to confirm this more NIR data from Vesta are needed over the 2 µm region where our experiments predict progressive reddening.

References:

[1] Reddy V. et al. (2012) *Science* 336, 700-704 [2] Kohout T. et al. (2014) *Icarus, 237,* 75-83. [3] Quadery A. et al (2015) *JGR-Planets* 120, 1-19.

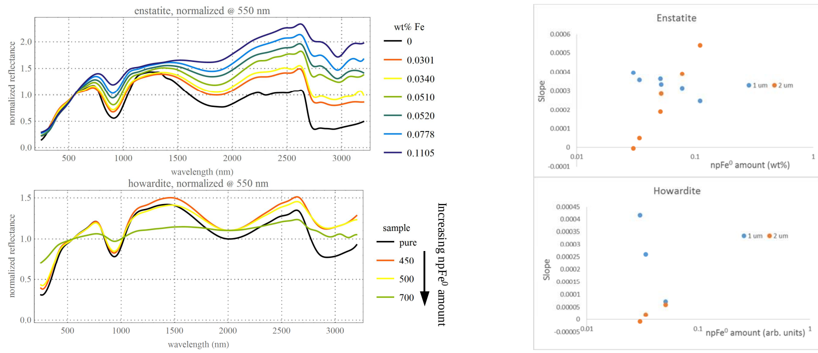

Fig. 1. Normalized reflectance spectra and slope change of pyroxene and howardite as a funnction of $npFe^0$.