EVOLUTION OF THE SPACE WEATHERING – LABORATORY SIMULATIONS. T. Kohout[1,2], J. Čuda[3], J. Filip[3], D. Britt[4], T. Bradley[4], J. Tuček[3], R. Skála[1], G. Kletetschka[1,5], J. Kašlík[3], O. Malina[3], K. Šišková[3], and R. Zbořil[3], [1] Institute of Geology, Academy of Sciences, Prague, Czech Republic (kohout@gli.cas.cz), [2] Department of Physics, University of Helsinki, Finland, [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] Faculty of Science, Charles University in Prague, Czech Republic.

Introduction: Airless planetary bodies are directly exposed to space weathering. The main spectral effects of space weathering are darkening, suppression of silicate mineral absorption bands, and spectral slope increase towards longer wavelengths (reddening). Production of nanophase metallic iron ($npFe^0$) during space weathering plays a major role in these spectral changes [1].

Space weathering simulations with olivine: A laboratory procedure for controlled production of $npFe^0$ in silicate mineral powders has been developed [2]. The method is based on two-step thermal treatment of low-iron olivine in ambient air followed by reduction in a hydrogen atmosphere. Through this process, a series of olivine powder samples was produced with increasing amount of $npFe^0$. The size of $npFe^0$ for all of the samples fall in the 7-20 nm size range. The amount of $npFe^0$ was estimated from saturation magnetization measurements and quantitative spectral changes were evaluated.

Results:

1. Linear trend is observed between the amount of $npFe^0$ and 1 µm band center position (Fig. 1)
2. Logarithmic trend is observed between the amount of $npFe^0$ and darkening, suppression of 1 µm olivine absorption band, and reddening (Fig. 2)
3. A logarithmic trend between reddening and the space weathering exposure duration has been observed by [3] on asteroids. In combination with our results we conclude that similar trend is valid for darkening and suppression of 1 µm olivine absorption band and the amount of $npFe^0$ increases linearly with the space weathering exposure duration.
4. The 1 µm band width at half depth generally decreases with increasing amount of $npFe^0$, but no reliable fit was found.
5. Olivine sample with the additional population of larger $npFe^0$ particles follows similar spectral trends as other samples, except for the reduced reddening trend (Figs. 2 and 3). This is interpreted that larger, ~40-50 nm sized, $npFe^0$ particles contribute to the slope change less efficiently than smaller $npFe^0$ fraction.

Conclusions: Compared to fresh olivine, our olivine samples with artificially introduced ~5-20 nm sized $npFe^0$ particles exhibit all spectral characteristics of lunar-type space weathering. Through comparison of our results with space weathering observations [2] we conclude that the $npFe^0$ amount in planetary regoliths exposed to space weathering increases linearly with time. Similar linear trend with space weathering duration is expected for 1 µm band center position, while a logarithmic trend with space weathering duration is expected for darkening, suppression of 1 µm olivine absorption band, and reddening. The 1 µm band width at half depth generally decreases with increasing amount of $npFe^0$ and time, but no reliable fit was found.

References:

[1] Hapke B. et al. (1975) *Moon, 13,* 339-353. [2] Kohout T. et al. (2014) *Icarus,* submitted. [3] Nesvorny D. et al. (2005) *Icarus, 173,* 132-152.

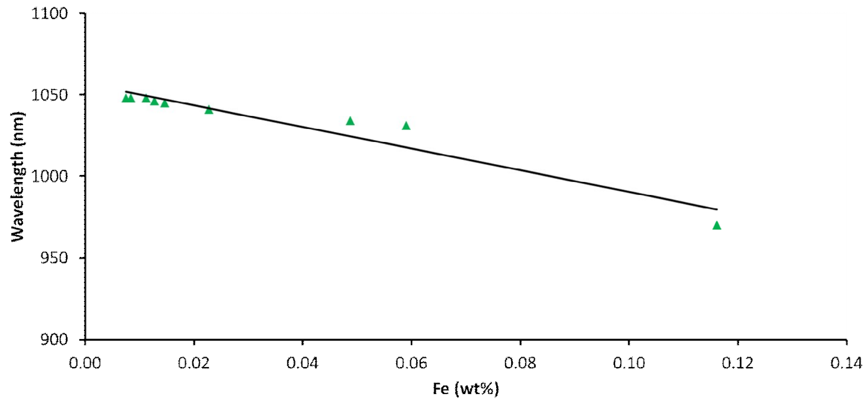

Fig. 1. Linear trend is observed between the amount of $npFe^0$ and 1 µm band center position.

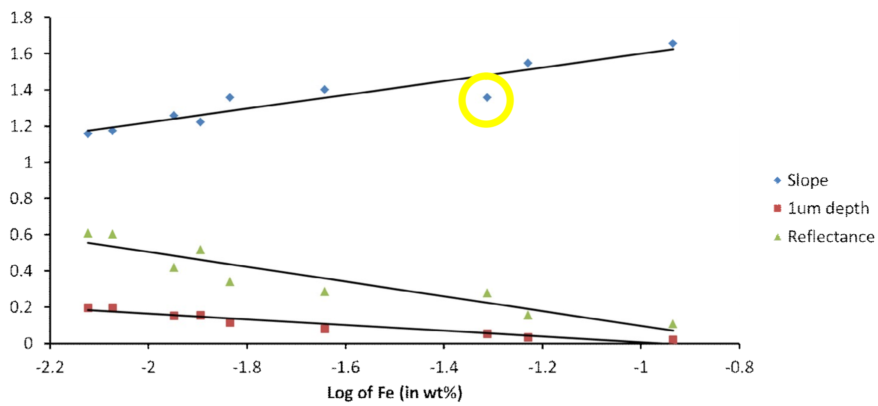

Fig. 2. Logarithmic trend is observed between amount of $npFe^0$ and darkening, suppression of 1 µm olivine absorption band, and reddening. The sample highlighted by yellow circle contains additional population of larger $npFe^0$ particles and does not fully follow the reddening trend.

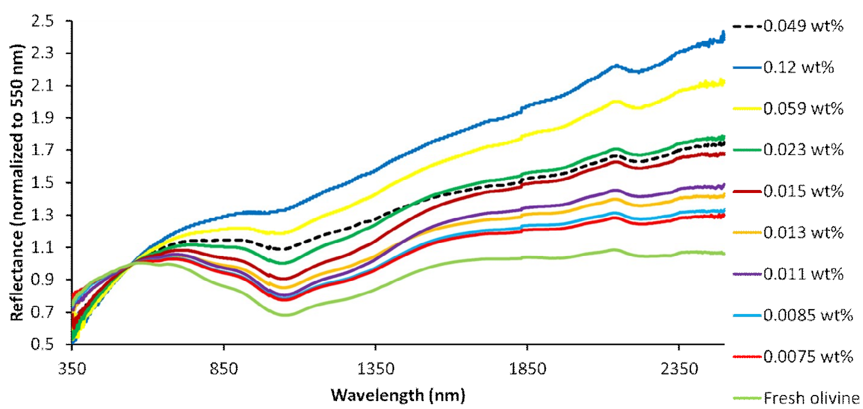

Fig. 3. Systematic change in olivine reflectance spectra as a function of the increasing $npFe^0$ amount. The sample marked by a dashed line contains additional population of larger $npFe^0$ particles and does not fully follow the reddening trend. The $npFe^0$ amount is indicated in wt%.