SIMULATION OF SPACE WEATHERING ON ASTEROID SPECTRA THROUGH HYDROGEN ION IRRADIATION OF METEORITES. Lakshika Palamakumbure[1], Kateřina Chrbolková[1,2,3], David Korda[1], Tomáš Kohout[1,2], Kenichiro Mizohata[4]

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Introduction: Space weathering can be defined as the combination of physical and chemical changes that occur in material exposed to interplanetary environment on the surface of airless bodies. This process produces amorphous surface layers often containing small opaque particles such as $npFe^0$. This darkens the topmost layer resulting alterations in their spectroscopic features which can lead to misinterpretation of remotely sensed data in visible- near-infrared (VIS-NIR) spectrum. The goal of this research is to simulate solar wind effects on asteroid spectra through low-energy 1 keV hydrogen ion irradiation of meteorite powder samples and measure the changes in their reflectance spectra and to understand how space weathering depends on the mineralogy of the meteorite. Compared to previous studies where higher H^+ energies were used [1],[2]. 1 keV H^+ ions represent more realistic irradiation energy representative of solar wind. To achieve this, two meteorites were selected: Bjurböle (L/LL4), and Luotolax (Howardite).

Methods: H^+ ion irradiation was carried out on powdered samples compressed in to pellets. The pellets were placed in to a vacuum chamber with pressure between $1.2x10^{-7}$-$2.4x10^{-7}$ mbar for the whole experiment. To simulate solar wind irradiation, H^+ ions were used with 1 keV under three fluences; 1 x 10^{17}, 2 x 10^{17} and 5x 10^{17} ions/cm^2.

After ion irradiation, the hemispherical VIS-NIR reflectance spectra were measured immediately after the irradiations using an OL-750 automated Spectro-radiometric measurement system by Gooch & Housego located at the Department of Physics, University of Helsinki. The OL-750 instrument is equipped with a polytetrafluoroethylene (PTFE) and golden integrating spheres and with a specular reflection trap. The spectra were measured relative to a PTFE (VIS) and golden (NIR) standards. To obtain spectral parameters from the measured VIS-NIR spectra, Modified Gaussian model (MGM) by [3] was used to identify the best fit of the spectrum.

Results: The spectra resulting from irradiation are displayed in Fig. 1. Spectral parameters as a function of exposure time are plotted in Fig. 2.

For Bjurböle composed predominantly of both olivine and orthopyroxene, four absorption bands were identified approximately at 0.8 µm, 0.9 µm, 1µm (combined olivine and orthopyroxene bands) and 1.9 µm (orthopyroxene). With increasing fluences, there is minimum variation in band positions. The band width and the band strength of the all four bands tend to decrease with increasing fluence (Fig.2). Also, from Fig. 1 we observe that the spectral slope in VIS region tends to relatively increase (reddening).

For Luotolax composed predominantly of orthopyroxene, clinopyroxene, and plagioclase three absorption bands were identified approximately at 0.9 µm (most likely orthopyroxene), minor at 1µm (most likely clinopyroxene), and major at 1.9 µm (combined pyroxenes). In contrast to Bjurböle, the Luotolax bands do not show a clear correlation with increasing fluence (Fig. 2). From Fig. 1, significant slope change in VIS region is observed.

Discussion: Bjurböle composition is dominated by olivine with lower fraction of orthopyroxene. With increasing H^+ ion irradiation, strength of the absorption bands of reflectance spectra decreases. This indicates that even for low-energy solar wind conditions the chondritic materials with high olivine content are more susceptible reduction of diagnostic silicate absorption bands and spectral reddening. Similar observations were made by [4] when simulating solar wind irradiation on olivine pellets.

Luotolax meteorite being Howardite rich in orthopyroxene and clinopyroxene shows VIS reddening but not observable band depth change with increasing exposure to H^+ ion irradiation. As explained by [4], the smaller change in Luotolax may be due to higher pyroxene resistance to low-energy ion irradiation.

References:

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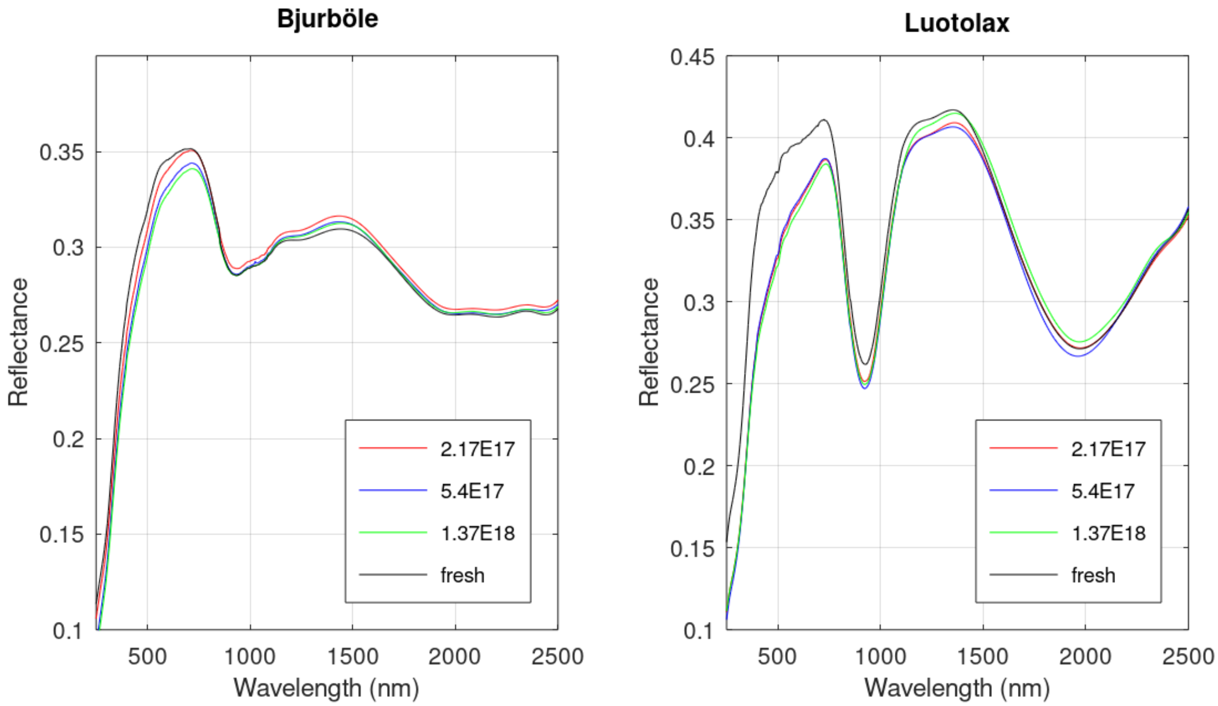

Fig 1. Spectral results of irradiation of Bjurböle and Luotolax

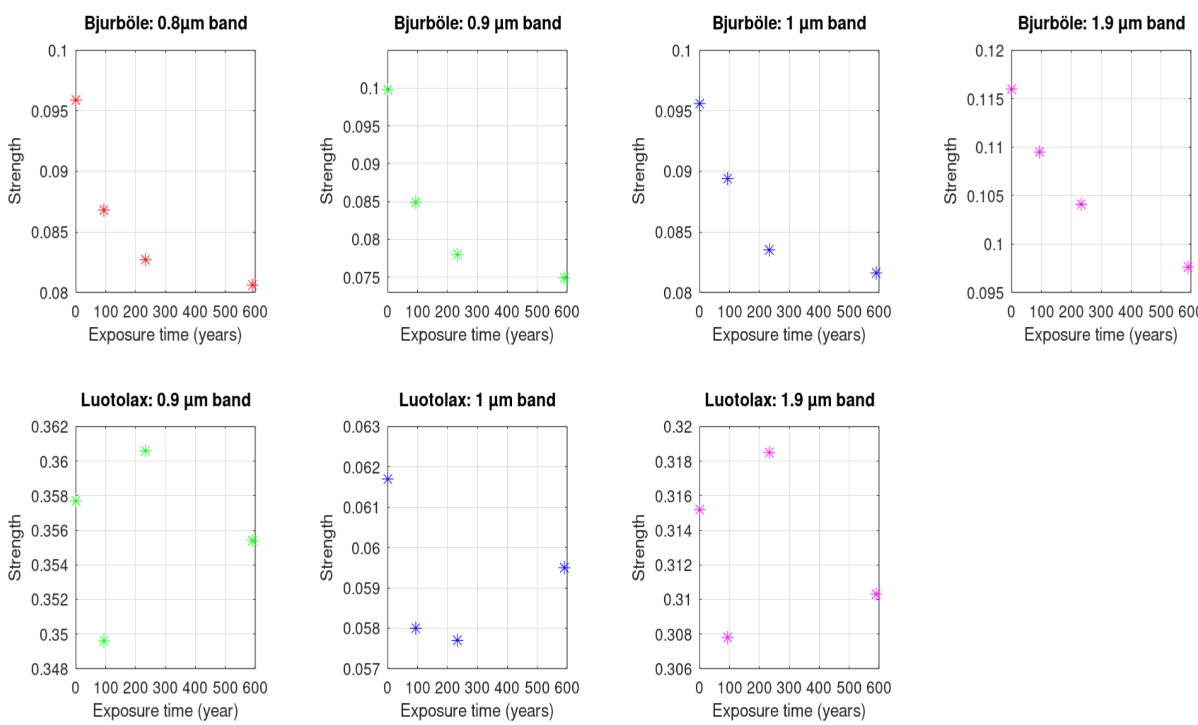

Fig 2. Spectral parameters as a function of exposure time