EFFECTS OF SPACE WEATHERING ON DIAGNOSTIC SPECTRAL FEATURES: RESULTS FROM HE+ IRRADIATION EXPERIMENTS.
Xiaohui Fu[1, 2], Yongliao Zou[1], Yongchun Zheng[1], Feng, Zhang[1, 2] [1] National Astronomical Observatories, Chinese Academy of Sciences, Beijing 100012, China, fuxh@naoc.cas.cn, [2] Graduate University of Chinese Academy of Sciences, Beijing 100039, China.

Introduction: Space weathering is the physical and chemical alteration changes at the surface of airless bodies. It includes two main processes: cosmic and solar wind ions irradiation and micrometeorite bombardment. To interpret spectral modifications on airless bodies by ion irradiation, several simulations[1-7] have been performed via keV-MeV ion irradiation.

In these investigations, spectral slope (or color index) and albedo are often used as spectral parameters in previous space weathering study, including laboratory simulations. Actually, these are not considered diagnostic parameters[8]. And most of these simulations only focus on mafic minerals, such as olivine and pyroxene, which are the most abundant minerals in ordinary chondrites. But spectral modifications of other mineral during ion irradiation have not been well characterized. This may impede our understanding of diverse space weathering on different types of asteroids.

This study is aimed to determine ion irradiaton effects on diagnostic spectral parameters, such as band center, band depth. Modified Gaussian Model (MGM) is applied to extract absorption band parameters of minerals before and after ion irradiation

Experiments: Three different samples are chose in the experiments, Luobusha olivine (~Fo80), basatic glass, and Panzhihua ilmenite. The loose powder sample was packed in aluminum containers and pressed into a pellet under about 300 psi. The samples are irradiated by 50 keV He^+ with the dose 5×10^{16} ion/cm^2. The experimental technique was similar to that described in [9].

We measured the reflectance spectra of mineral samples before and after irradiation using Lambda 950 UV/VIS/NIR spectrophotometers. The reflectance spectra were acquired between 0.375 and 2.50 μm, using a deuterium lamp and a tungsten lamp as radiation sources. The resolution of the spectrophotometer was 1 nm for visable and near-infrared range. The measurements were performed in directional-hemispherical reflectance (normal incident) geometry at room temperature and normal atmospheric pressure.

Results and disccusion:

Reflectance Spectroscopy: Figure 1(top) shows the measured reflectance spectra of Luobusha olivine before and after He+ irradiation. Unirradiated Luobusha olivine spectra exhibit typical olivine absorption features, ~1 μm band due to Fe^{2+} ions located in distorted octahedral crystallographic sites. He^+ irradiation darken and redden Luobusha olivine spectrum. This agrees well with previous investigations [5,7]. Irradiated basaltic glass also displays lower reflectance and steeper spectral slope, compared with unirradiated sample.

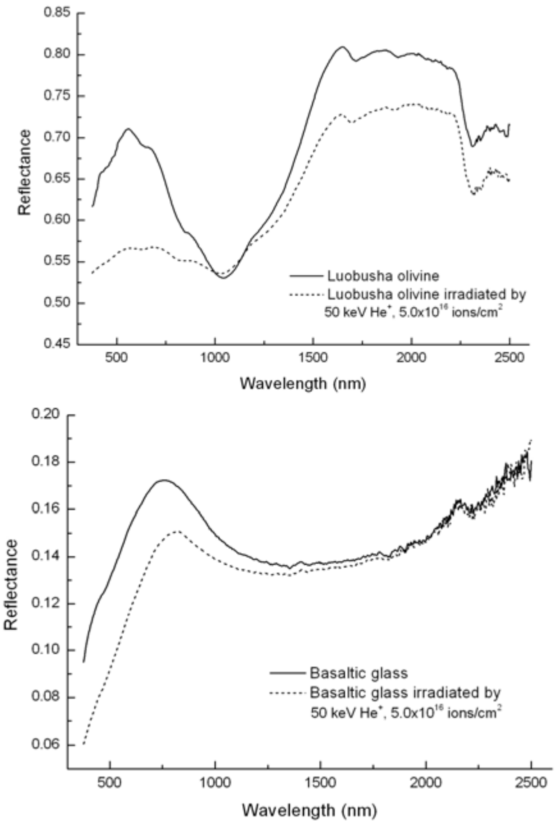

Figure 1. Reflectance spectra of Luobusha olivine and basatic glass before and after He+ irradiation

Ilmenite is the most common opaque mineral on the Moon, as well as possible darkening agent of Mercury's surface [10]. He^+ irradiation dramatically modified spectra of Panzhihua ilmenite, as shown in Figure 2. Irradiated ilmenite show stronger absorption features and higher reflectance, which are completely different with what happened to silicate in this study and previous investigations. Even new absorptions showed up at 0.87 μm, which corresponds to the characteristic absorption feature of hematite (α-Fe_2O_3).

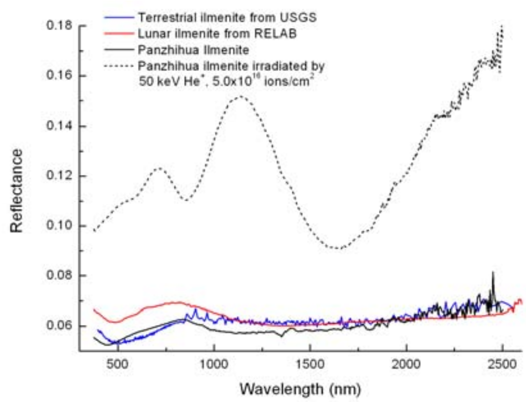

Figure 2. Reflectance spectra of Panzhihua ilmenite before and after He^+ irradiation

MGM fit results of olivine: In order to quantify spectral modification due to ion irradiation, we utilized MGM to deconvolve the spectra of Luobusha olivine and San Carlos olivine [5,7].

For this study, the increasing slope could introduce an apparent band center shifts to shorter wavelength if we directly use original reflectance spectra in MGM fits. Therefore, the continuum-removed spectra are adopted in the following MGM fits instead of original reflectance spectra [11]. We estimate error bar of band centers corresponds to ±8 nm for the VNIR range, using the same method of [12].

In the present study, we only focus on 1.0 μm absorption of olivine. Note that band centers all shifted towards longer wavelength, 11.2 nm, 9.1 nm, and 22.8 nm, individually for M1-1, M2, and M1-2. Compared with wavelength error (±8 nm), these bands shift seem to be negligible. After irradiation, these individual bands all turned narrower and shallower (Figure 3). Bands strength decreased about 43% on the average. In other words, absorption features of irradiated olivine exhibited decreasing strength and width. The data indicate ion irradiation can alter band strength decrease of olivine but negligible band center shifts. This conclusion agrees with lunar soil, and also provides one possible explanation for no systematic shift in band positions in lunar soil with different Is/FeO [13-14].

References: [1] Hapke, B. (1973) *Earth. Moon. Planets.*, 7, 342-355. [2] Dukes, C.A et al. (1999) *J. Geophys. Res.*, 104, 1865-1872. [3] Yamada, M. et al. (1999) *Earth. Planets. Space.*, 51, 1255-1265. [4] Strazzulla, G. et al. (2005) *Icarus*, 174, 31-35. [5]Marchi, S., G. et al. (2005) *A&A.*, 443, 769-775. [6]Brunetto, R. G. et al. (2005) *Icarus*, 179, 265-273. [7] Loeffler, M.J. et al. (1999) *J. Geophys. Res.*, 114. [8] Gaffey, M.J. (2010) *Icarus*, 209, 564-574. [9] Fu et al. (2011) *J.Earth Sci.*, 22, 566-577. [10] Riner, M.A. et al. (2009) *LPSC 40th*, #2062. [11] Isaacson, P.J. et al. (2011) *J. Geophys. Res.*, 116, E00G11. [12] Kanner, L.C. et al. (2011) *Icarus*, 187, 442-456. [13] Taylor, L.A. et a. (2001) *Meteorit. Planet. Sci.*, 36, 285-299. [14] Noble, S.K.et al. (2007) *Icarus*, 192, 629-642.

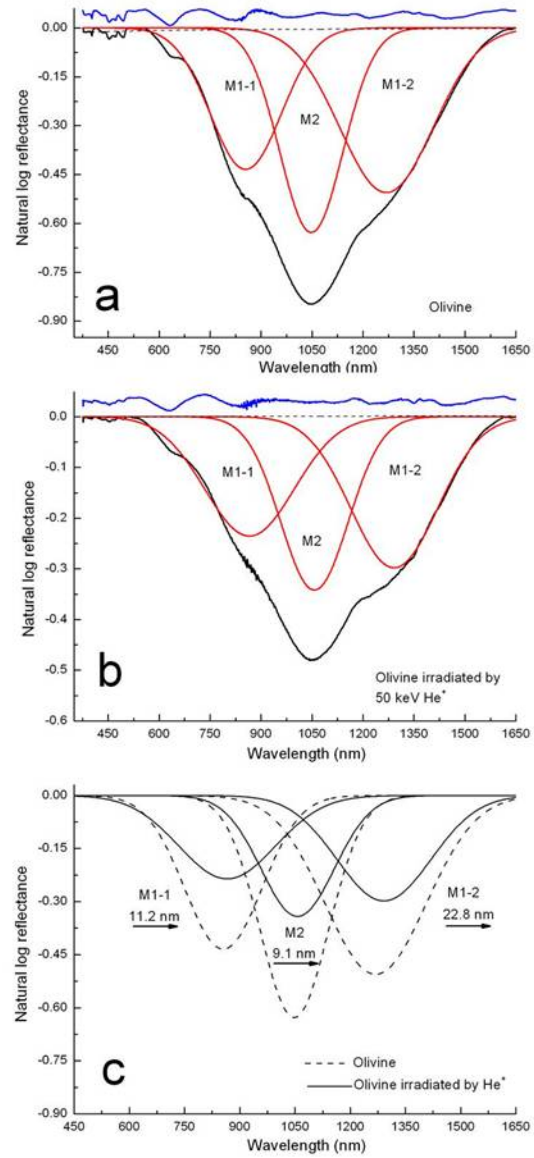

Figure 3. MGM fits of origin and irradiated Luobusha olivine. Natural logarithm reflectance spectrum and modified Gaussians are respectively shown in black and red solid line, and slash line represent the continuum spectrum. Residual error spectrum (blue solid line) is shown in the top of each plot. In the C panel, the numbers and arrows show band center variation and shift direction after irradiation.