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INVESTIGATING REFLECTANCE PROPERTIES OF SPACE WEATHERED SILICATES: EFFECT OF SWIFT HEAVY ION IRRADIATION

Cristian Carli (1), Rosario Brunetto (2), Giovanni Strazzulla (3), Giovanna Serventi (4), Francois Poulet (2), Fabrizio Capaccioni (1), Yves Langevin (2), Emmanuel Gardes (5), Rafael Martinez R. (5), Philippe Boduch (5), Alicja Domaracka (5), and Hermann Rothard (5)
(1) IAPS-INAF (Roma, Italy; cristian.carli@iaps.inaf.it), (2) IAS-CNRS (Orsay, France), (3) OACT-INAF (Catania, Italy) , (4) University of Parma (Parma, Italy), (5) CIMAP-Ganil, Normandie Univ, ENSICAEN, UNICAEN, CEA, CNRS (Caen, France)

Abstract

Space weathering strongly interests the surface of Mercury, affecting the characteristics of minerals and rocks. Here, we investigate the spectral variability from visible to mid infrared on three different silicates, partially covered by a thin film of carbon, irradiated with swift heavy ion at three increasing fluences. Ions and carbon affect spectral properties in different way from visible to near infrared (VNIR); whereas in mid infrared (MIR) only irradiation seems to contribute, describing an increasing process of silicate's amorphization.

1. Introduction

Mercury's surface can be strongly affected by weathering processes, due to the proximity of the Sun and the absence of atmosphere. Space weathering interests in different way the material present on the surface, inducing deformation and vacancy on the crystal lattice. Thus, spectral properties, from the VNIR to the MIR, can be affected by the environment (e.g. [1]).

MESSENGER mission results highlighted that Mercury's surface is mainly volcanic in origin, spectrally variegate, with evidences indicating low FeO in silicates (e.g. <1% [2]). The surface elementary composition has been analyzed by XRS and GRS [3], results suggest the presence of different geochemical terrains with composition that varies from high Mg/Si, in older plains with high Ca/Si, locally high S/Si, and low Al/Si ratios. Northern young plains have higher Al/Si, Na, K, and lower Mg/Si, Ca/Si [e.g. 4]. C was suggested as rest of a primary crust due to floating of graphite [5,6]. Thus, olivine (ol), pyroxene, plagioclase (pl), quartz, and in minor abundance, corundum, nepheline (neph), and Mg-Ca sulfides are proposed as principal minerals in the crust [e.g. 7,8].

Here, we present a spectral study of swift heavy ion irradiation of three silicates, ol, neph, and pl as a simulation of heavy ion irradiation of Mercury.

2. Samples

Four cm-sized chips were prepared for each mineral, Ol (Fo90), neph and pl (anorthitic). Half of the surface of each was covered with a thin film of carbon (C). Three chips of each mineral were irradiated at GANIL-IRRSUD (France) with 88 MeV $^{129}Xe^{23+}$ ion with fluences of 10^{11}, 10^{12} and 10^{13} ions/cm^2. The sputtering of nepheline was investigated in [9].

3. Analytical Methods

Spectra were acquired from the VNIR to the MIR (0.4-15 μm) on the unirradiated and irradiated targets. Two setups were used: a) The VNIR spectra were acquired at IAS-Orsay in a diffuse bidirectional configuration, i 30° and e 0°, using a grating spectrometer Maya2000 Pro (Ocean Optics), coupled to an optical microscope; b) The NIR-MIR confocal reflectance was investigated with FTIR micro-spectrometers (Agilent Cary 670/620, Thermo Scientific Continum XL and iN10) available at SMIS beamline of synchrotron SOLEIL.

4. Results

Preliminary analyses show that: 1) in the VNIR the film of C reduces the reflectance; 2) reflectance for samples without C increases in the NIR and it decreases in the VIS, with a consequent reddening, with increasing the ion fluence; 3) in the MIR, C has no effect, the Christiansen Feature has no evident shift, whereas the Reststrahlen band peaks are shifted with increasing fluence. This continues until the highest fluence, where the samples show signs of amorphisation (Fig.1), and a strong reduction of the absorption area up to 40% (Fig.2). Similar trends were observed in ion irradiated meteorites [10,11].

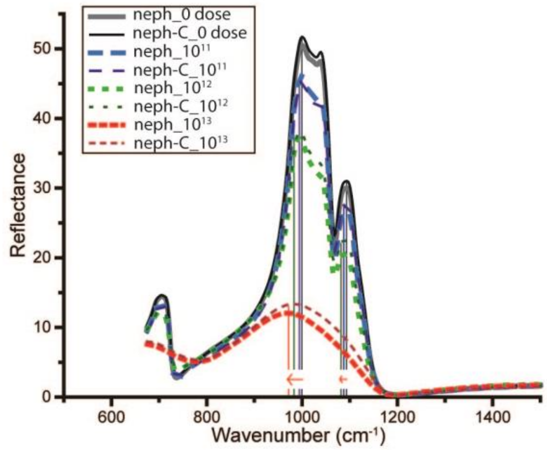

Figure 1: TIR nepheline spectra with different fluences; we highlighted the major shifts (red arrows).

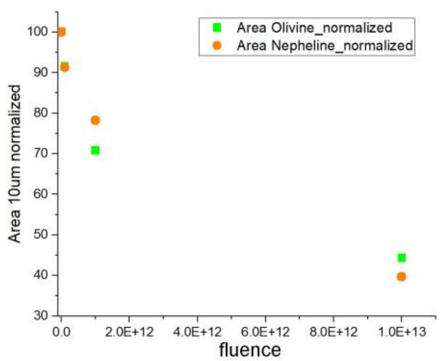

Figure 2: Normalized Reststrahlen absorption area at different fluences shows a similar intensity reduction for all silicates.

5. Future works

In preparation of BepiColombo mission, where VNIR and MIR will be investigated by SIMBIO-SYS and MERTIS [12], we plan to investigate several samples, natural and Mercury-like synthetic samples, as suggested by [6,7], and other irradiation conditions than those presented here (e.g. lighter ions and lower energies).

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References

[1] Domingue D.L. et al., 2014.: Mercury's Weather-Beaten Surface: Understanding Mercury in the Context of Lunar and Asteroidal Space Weathering Studies, Sp.Sci.Rev. 181, 121–214.

[2] Klima R.. et al., Visible to near-infrared hyperspectral measurements of Mercury: challenges for deciphering surface mineralogy, Whispers, July 2014.

[3] Solomon S.C. et al., 2007.: MESSENGER Mission Overview, Sp.Sci.Rev., 131, 3-39.

[4] Weider S.Z. et al., 2015.: Evidence for geochemical terranes on Mercury: Global mapping of major elements with MESSENGER's X-Ray Spectrometer, EPSL, 416, 109–120.

[5] Peplowski P.N. et al., 2016.: Remote sensing evidence for an ancient carbon-bearing crust on Mercury, Nature Geoscience, 9, 273-276.

[6] Vander Kaaden K.E. and McCubbin F. 2015.: Exotic crust formation on Mercury: Consequences of a shallow, FeO-poor mantle, JGR 120, 195-209.

[7] Namur O. et al. 2016.: Melting processes and mantle sources of lavas on Mercury, EPSL 439, 117-128.

[8] Vander Kaaden K.E. et al. 2017.: Geochemistry, mineralogy, and petrology of boninitic and komatiitic rocks on the mercurian surface: Insights into the mercurian mantle Icarus 285, 155–168.

[9] Martinez et al. 2017.: Sputtering of sodium and potassium from nepheline: Secondary ion yields and velocity spectra, NIMPB, 406, 523-528.

[10] Brunetto R. et al. 2014.: Ion irradiation of Allende meteorite probed by visible, IR, and Raman spectroscopies, Icarus, 237, 278-292.

[11] Lantz C. et al. 2017.: Ion irradiation of carbonaceous chondrites: A new view of space weathering on primitive asteroids, Icarus, 285, 43-57

[12] Benkhoff J. et al. 2010.: BepiColombo—Comprehensive exploration of Mercury: Mission overview and science goals, PSS 58, 2-20.