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The surface of Mercury: space weathering effects

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Abstract

We present some results of an ongoing experimental research aimed at simulating the effects of ion bombardment (space weathering) in solid objects of the Solar System. In particular we have investigated the color changes induced by the ion bombardment in the UV-Vis-IR In this contribution we focus on materials (silicates) and spectral range (200-300 nanometers) particularly relevant to the study of the Mercury's surface.

1. Introduction

Cosmic and solar energetic ions continuously bombard, and alter, the surfaces of airless bodies in the Solar System. As a consequence of such "space weathering" the spectral reflectance of surface materials changes. Very often it relatively increases with wavelength (reddening) while degrading the absorption features and decreasing the overall reflectivity (darkening) [1]. Several materials have been investigated in our laboratory including carbon based species such as frozen hydrocarbons [2], spectrally red bitumens [3], polymers [4] and different kinds of silicates [5]. To our knowledge there is a lack of data relative to the spectral changes induced by space weathering of materials and spectral range (below 400 nanometers) relevant to the Mercury's surface although this region is suggested to be the most sensitive indicator of weathering [6].
Reflectance spectra of Mercury's surface indicate a low, if any, FeO content and the presence of highly weathered silicates [7]. In particular sodium, potassium, and calcium rich pyroxenes and tectosilicates are believed to be important constituents.
Here we present some of the results obtained so far by UV reflectance and Raman spectroscopies of some minerals: Forsterite, Jadeite, Sodalite and Nepheline whose compositional formulas are given in the table.

2. Experimental apparatus

Hemispherical reflectance spectra are obtained by an UV-Vis-NIR spectrophotometer (Perkin-Elmer Lambda 19). Irradiation experiments are carried out at room temperature inside a stainless steel vacuum chamber ($P<10^{-7}$ mbar). Bulk samples of the investigated minerals are placed inside the vacuum chamber and irradiated with different ions obtained from a Danfysik (1080 – 200) ion implanter. Ions with energy from 30 up to 200 keV (400 keV for double ionization) can be used; the beam produces a circular (1.5 cm in diameter) uniform spot on the target. After irradiation reflectance spectra can be repeated for comparison with pre-irradiation ones. Before and after irradiation Raman spectra (not shown here) of the chosen samples can be also obtained by a spectrometer (SPEX Triplemate) having a resolution of 4 cm^{-1} and a wavenumber accuracy of 1 cm^{-1}.

MINERAL	FORMULA
Jadeite (pyroxene)	$NaAlSi_2O_6$
Sodalite (tectosilicate)	$Na_8Al_6Si_6O_{24}Cl_2$
Nepheline (tectosilicate)	$(Na, K)AlSiO_4$
Forsterite (olivine)	Mg_2SiO_4

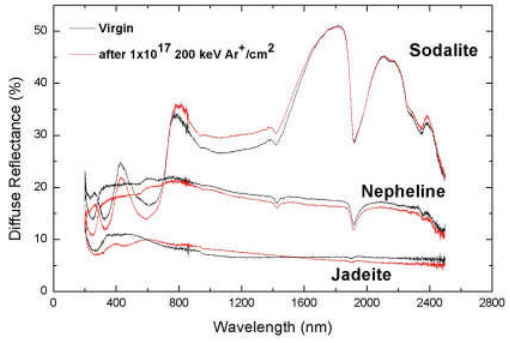

Figure 1. Diffuse reflectance spectra of three samples before and after irradiation with $1x10^{17}$ 200 keV Ar+ ions.

3. Results

In figure 1 we show the diffuse reflectance spectra of three samples before and after irradiation with $1x10^{17}$ 200 keV Ar+ ions. Fast ions penetrating a solid loose energy by elastic collision with target nuclei and by anelastic ionizations and excitation. The efficiency that 200 keV Ar ions have in producing reddening can be scaled to the solar wind 1 keV/amu particles population by supposing that, in first approximation, equivalent reddening are produced by different ions with different energy, if the elastic dose is the same (see [4] for details).The fluence used in laboratory corresponds to an to an exposure of the surface of Mercury to the solar wind of 10^4-10^5 yrs.

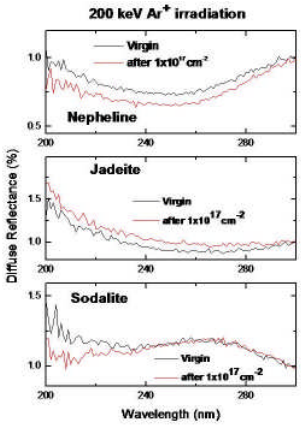

Figure 2. Diffuse reflectance spectra (normalized at 300 nm) of three samples before and after irradiation with $1x10^{17}$ 200 keV Ar+ ions.

In Fig. 2 the diffuse reflectance spectra (normalized at 300 nm) of the three samples before and after irradiation with $1x10^{17}$ 200 keV Ar+ ions are shown. This is a spectral range particularly relevant to Mercury (and the Moon by the way) being a range in which the spectrum we observe is mainly due to the reflection of the solar radiation and the contribution of the emission from the "hot" Mercury is negligible.

Acknowledgements

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