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Bi-directional reflectance and NanoFTIR spectroscopy of synthetic analogues of Mercury: Supporting MERTIS payload of ESA/JAXA BepiColombo mission

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1. Introduction

The mid infrared (MIR) spectral region is especially sensitive to the abundance of Si-O abundance, unlike the visible-near infrared spectral region. Though the geochemical suite on the NASA MESSENGER spacecraft to Mercury revealed compositionally diverse crustal materials [eg., 1], the spectrometer suite (MASCS; VIS-IR) could not reveal the silicate mineralogy of crustal materials due to the Fe2+-poor nature of the silicate minerals on the surface of Mercury. The Mercury Radiometer and Thermal Imaging Spectrometer (MERTIS) as part of the payload of the ESA/JAXA BepiColombo mission will map the surface mineralogy globally in the thermal IR wavelength range (7-14 μm) at spatial resolution of 500 m/pixel [2].

In this study, we investigated the experimental products by [3] which represent major terranes namely the low-Mg Northern Volcanic Plains (NP-LMg), high-Mg Northern Volcanic Plains (NP-HMg), Intercrater Terrane (ICT), High-Mg Province (HMR), and Smooth Plains (SP) of Mercury. These experimental products are 5 x 5 mm^2 in area containing major minerals including forsterite, diopside, enstatite, plagioclase, and locally FeSi. Therefore, studying the spectra of bulk sample and the spectra of each mineral phases in these samples will cast a new light on understanding the spectral behaviour of the silicate mineralogy of Mercury.

2. Facilities and Methods

The study consists of three parts in which we obtain; 1. Bulk spectra of the samples (DLR-PSL), 2. High resolution elemental mapping of the samples for all terrains (MfN-SEM), 3. Nano-FTIR spectra of each mineral units (PTB-NanoFTIR).

2.1 Bulk spectra of the samples

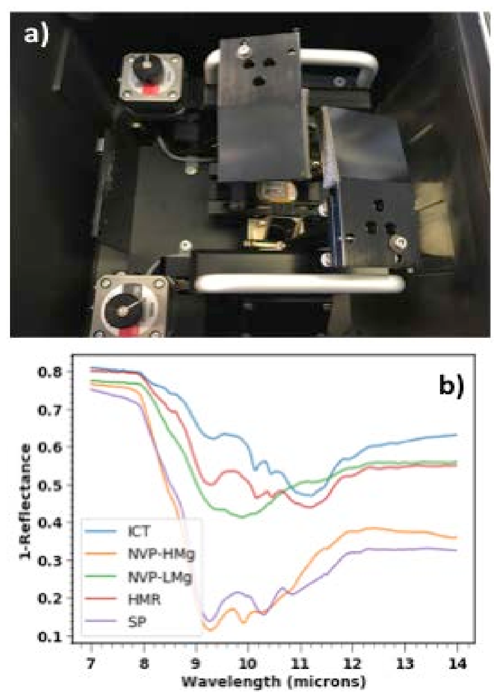

Figure 1: a) the bi-directional reflectance set-up at PSL, b) the bulk reflectance of the experimental products representing the geochemical terranes of Mercury – showing distinct spectral behavior.

Bulk bi-directional reflectance spectra of these experimental products representing Mercury terrains are measured in IR range (1-25 µm) using a Bruker Vertex 80V at the spectral resolution of 4 cm^{-1} with the smallest aperture of 0.25 mm diameter [4-5] at PSL. The bi-directional reflectance setup is shown in Fig. 1a and the results are shown in Fig. 1b.

2.2 High-resolution elemental mapping

In order to navigate the very high resolution (nano-FTIR) spectroscopy, we first obtained the high resolution elemental composition map (Fig. 3a) of all the samples using the Secondary Electron Microscope (SEM) facility at the Museum für Naturkunde in Berlin.

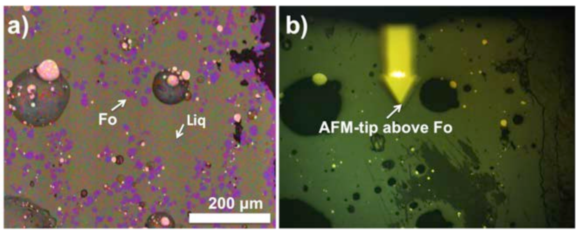

Figure 3: Sample Y0128-HMg containing 32% Forsterite (Fo). a) SEM image where pink units are Fo; b) nano-FTIR setup where cantilever tip pointing to Fo.

2.3 NanoFTIR spectra of mineral units within the sample

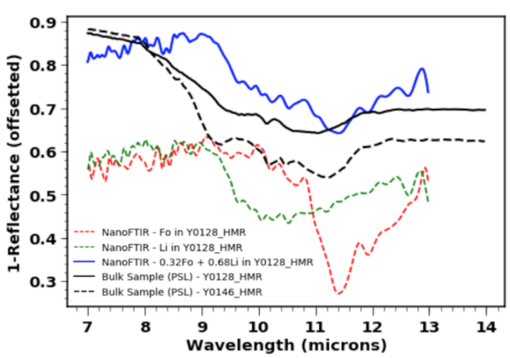

Figure 4: showing the NanoFTIR spectra of Forsterite (dashed red) and liquid/melt (dashed green); solid black is the bulk spectra of sample (shown in Fig. 3) containing 32% Fo and 68 % liquid - the linearly mixed NanoFTIR spectra using the corresponding endmembers (Fo, Li) is shown as solid blue spectra.

The use of broadband synchrotron radiation from IR-beamline of the electron storage ring (Metrology Light Source; MLS) at PTB-Berlin allows us to perform nano-FTIR (nanoscale) spectroscopy on these experimental products using a Neaspec scattering-type scanning near-field optical microscope (s-SNOM) [5-6] (Fig. 3b). This metallic probe acts as an antenna which confines the incident electric field around the tip-apex thus providing a nanoscale light source for very high-resolution imaging. Using this facility, we obtained the spectra of each mineral units guided by SEM images of the samples at the spatial resolution of <40nm for the spectral range of 5-12µm with the spectral resolution of 6.25cm^{-1}(Fig. 4).

3. Ongoing Work

Nano-FTIR spectra obtained for all terrain samples are currently being analyzed for its silicates. The spectral deconvolution algorithm will be tested on bulk spectra obtained at PSL using the endmember nano-FTIR silicate spectra. All the results will be presented at the conference.

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