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Infrared Spectroscopy of Synthetic Planetary Analogs for Mercury for the BepiColombo Mission

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Abstract

We present mid-infrared spectra of silicate powder material and in-situ studies of surface analogs for Mercury synthesized based on chemical remote sensing data from the NASA Messenger for the interpretation of future data from the ESA/JAXA BepiColombo mission.

1. Introduction

The purpose of the IRIS (Infrared and Raman for Interplanetary Spectroscopy) laboratory is to produce spectra for the ESA/JAXA BepiColombo mission to Mercury [1]. The mid-infrared spectrometer MERTIS (Mercury Radiometer and Thermal Infrared Spectrometer) will map spectral features in the 7-14 µm range, with a spatial resolution of ~ 500 meters [2-5]. Silicate and several oxide minerals have characteristic spectral signatures. These infrared features will permit the determination of Mercury's surface mineralogy..

Glasses formed by impact cratering, lava extrusion and explosive volcanic eruptions are likely part of the surface mineralogy, since these processes played a central part in the formation of the surface of Mercury [e.g. 6]. Glasses lack ordered microstructures and are amorphous, rapidly quenched from high temperature melts [7]. We produce synthetic analog materials to analyze infrared spectra of materials with compositions determined by remote sensing,

We produce synthetic analog materials to analyze infrared spectra of materials with compositions determined by remote sensing, for which no material is available so far in our collections [8-10]. Furthermore, we use synthetic analog material to investigate the gas-solid reaction between S-rich gases produced in early volcanism and in impacts with silicate minerals on early Mercury and its effect on the mineralogy [11].

2. Samples and Techniques

Sample Production: The bulk glass composition is based on MESSENGER X-ray spectrometer compositional data for the High Magnesium Region (HMR) [12, 13]. The glass was synthesized following a procedure described in [14] with the oxidation state controlled by exposing the sample to a CO-CO2 gas-mixture equivalent to four orders of magnitude below the iron-wüstite buffer (IW-4).We synthesized an additional analog material simulating the petrologic evolution of magmas on early Mercury under controlled temperature, pressure and oxidation state [8-10]. We selected spectra from the high-Mg NVP (Northern Volcanic Plains) region (Fig.1a) for this presentation, synthesized at 1210 °C, 0.1 GPa and IW-4 [8-10].

Furthermore, we synthesized a high-Mg glass [11], as starting material for studies of the interaction between S-rich gases and silicates, in a graphite crucible under CO-CO2 gas at 1500 °C and IW-4. The quenched glass sample was subsequently reacted with a reducing (IW-4) SO2-CO-CO2 gas at 800 °C.

Infrared Spectroscopy: We measured FTIR diffuse reflectance spectra of powder size fractions 0-25 µm, 25-63 µm, 63-125 µm, and 125-250 µm. The sample for gas/silicate reactions was a highly polished glass chip.

We used a Bruker Vertex 70 infrared system with a MCT detector at the IRIS laboratories at the Institut für Planetologie in Münster. We conducted the analyses at low pressure (10-3bar) to reduce atmospheric bands from 2-20 µm.

For additional FTIR microscope analyses of polished thick sections, we used a Bruker Hyperion 1000/2000 System at the Hochschule Emden/Leer. We used a 250×250 µm sized aperture, and a spectral range of 2-15 µm.

3. Results and Summary

The high Mg samples presented here (Figs.1-3) show a high amorphous component with glass features. A strong glass Reststrahlenband (RB) is dominating the spectra between 9.7 µm and 9.9 µm.

Crystalline components (Figs.1,2) indicate pyroxene and olivine contents [15,16]. This shows the consistency of the analogs produced with different methods under varying conditions.

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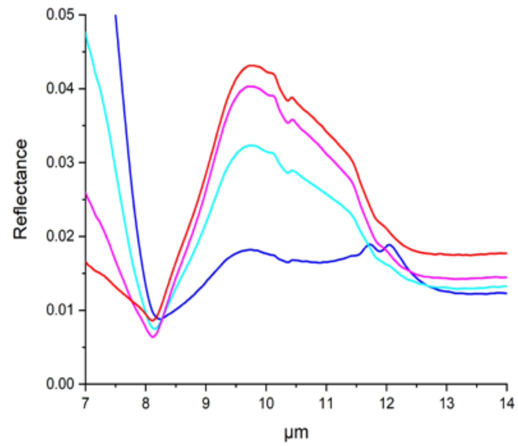

Fig.1. Infrared spectra of a powdered analogue sample for the HMR region on Mercury, produced under reducing conditions.

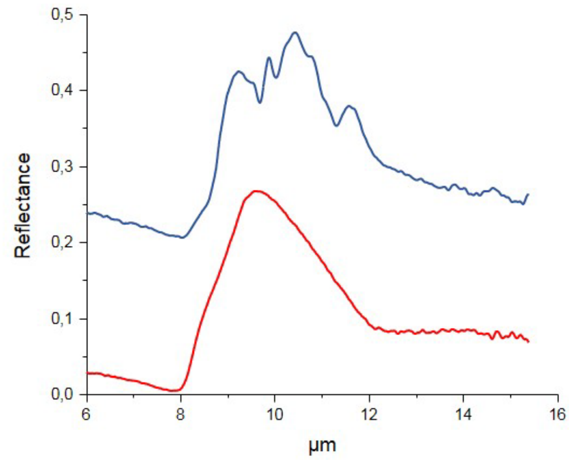

Fig.2: Micro-FTIR analyses of High-Mg Northern Volcanic Plains region (Fig.1a). Blue: crystalline phases, red: glass.

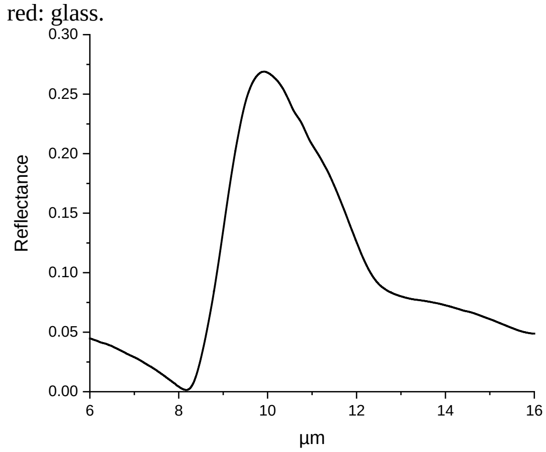

Fig.3: FTIR spectrum of polished High-Mg sample for gas/silicate reaction experiments.