INFRARED SPECTROSCOPY OF EXPERIMENTAL AND SYNTHETIC PLANETARY ANALOGS FOR THE BEPICOLOMBO MISSION TO MERCURY.

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Introduction The IRIS (Infrared and Raman for Interplanetary Spectroscopy) laboratory generates spectra for a database [1] for the ESA/JAXA BepiColombo mission to Mercury. Onboard is a mid-infrared spectrometer (MERTIS-Mercury Radiometer and Thermal Infrared Spectrometer). This unique instrument allows to map spectral features in the 7-14 µm range, with a spatial resolution of about 500 meters [2-5]. With these infrared characteristics the mineralogical compositions of the hermean surface can be determined via remote sensing

Heavy impact cratering played an important part in the formation of the surface regolith of Mercury [e.g.6]. Glass, which can form through such impacts, and in volcanic processes, lacks an ordered microstructure and represents the amorphous phase of a material, typical for events involving high shock pressures and temperatures [7]. Using synthetic materials allows us to produce infrared spectra of analogue materials based on the observed chemical composition of planetary bodies, for which no material (returned samples or meteorites) is available so far [8-10].

Furthermore, we use synthetic analogs to study the gas-solid reaction between S-rich gases produced in early volcanism and in impacts with silicate materials on early Mercury and its effect on the mineralogy [11].

Samples and Techniques:

Sample Production: Bulk glasses are synthesized based on the chemical composition for surface areas obtained by the MESSENGER X-ray spectrometer data [12].

For the study of bulk glasses we present an analogue sample based on the composition of the High Magnesium Region (HMR) modeled in [13]. The glass was synthesized following a procedure described in [14]. In addition, the oxidation state of the material was controlled by exposing the samples to a CO-CO_2 gas-mixture.

Further glassy and crystalline analogue material was produced in experiments simulating the petrologic evolution of early Mercurian magmas under controlled temperatures, pressures and oxidation states [8-10]. For this presentation, we selected spectra from the high-Mg NVP (Northern Volcanic Plains) region (Fig.1a), produced at 0.1 GPa and 1210 °C [8-10].

For studies of the interaction between S-rich gases and silicates, a high-Mg glass [11] as starting material was produced under in a graphite crucible under CO-CO_2-gas at 1500 °C, with an effective oxidation state four log-units below the iron-wüstite buffer (IW-4). The quenched glass sample was subsequently reacted with a reducing (IW-4) S-bearing gas at 800 °C.

Infrared Spectroscopy: For the bulk powder FTIR diffuse reflectance analyses, powder size fractions 0-25 µm, 25-63 µm, 63-125 µm, and 125-250 µm were measured. The sample for gas/silicate reactions was a highly polished block.

For mid-infrared analyses from 2-20 µm, we used a Bruker Vertex 70 infrared system with a MCT detector at the IRIS laboratories at the Institut für Planetologie in Münster analyses were conducted under low pressure to reduce atmospheric bands.

Additional FTIR microscope analyses of polished thick sections were conducted on the experimental runs using a Bruker Hyperion 1000/2000 System at the Hochschule Emden/Leer. We used a 250×250µm sized aperture.

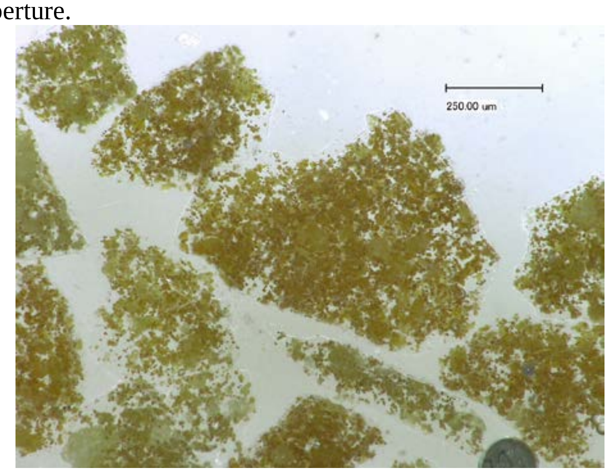

Fig.1a: Optical image of the HMR analog material shows a high abundance of crystalline material.

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Results:

The bulk powder analyses of the HMR region analog (Fig.1a,b) show a mix of crystalline and amorphous features. The spectrum is dominated by a strong, broad feature at 9.8 µm, typical for glassy materials. Clear signs of additional crystalline phases is a band at 10.4 µm and a shoulder at ~10.0 µm. These are typical forsterite or enstatite features [15,16]. The Christiansen Feature (CF), a reflectance low, is at 8.1 – 8.2 µm. The Transparency Feature characteristic of fine grained material is a double-feature in the 0-25 µm fraction at 11.7 µm and 12 µm, also indicating a mix of at least two phases.

The analog samples of the high-Mg NVP experimental runs already show abundant large crystallites in a glassy groundmass (Fig.2). The micro-FTIR analyses (Fig.2) confirm this, they show strong crystalline features at 9.3 µm, 9.9 µm, 10.4 µm and 11.6 µm, with minor features at 13.8 µm and 14.7 µm. The CF is at 8.1 µm, sign of enstatite features mixed with diopside bands [16]. The spectra of the spots with pure glassy material is similar to the glass with the regolith composition, with a single strong band at 9.7 µm and a CF at 7.9 µm. The high-Mg sample for gas/solid reaction experiments (Fig.3) has the CF at 8.2 µm and the main RB at 9.9 µm.

Summary:

The high Mg samples presented here show a high amorphous component with glass features. A strong glass RB is dominating the spectra between 9.7 µm and 9.9 µm. Crystalline components indicate pyroxene and olivine contents [15,16]. This shows the consistency of the analogs produced with different methods under varying conditions.

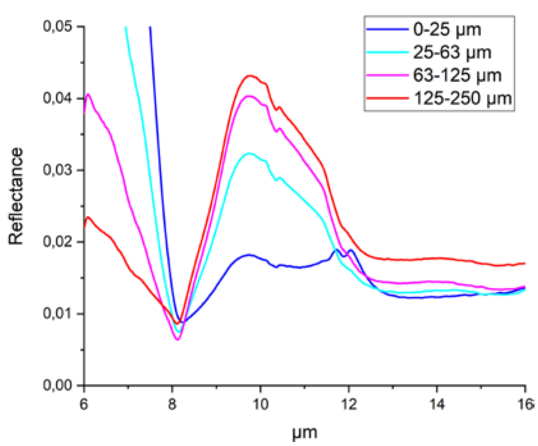

Fig.1b. Infrared spectra of a powdered analogue sample for the HMR region on Mercury, produced under reducing conditions.

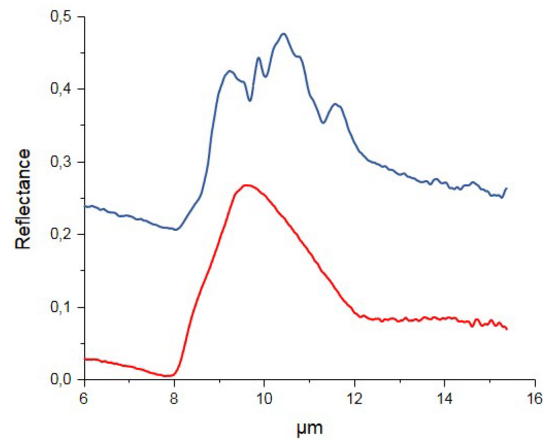

Fig.2: Micro-FTIR analyses of High-Mg Northern Volcanic Plains region (Fig.1a). Blue: crystalline phases, red: glass.

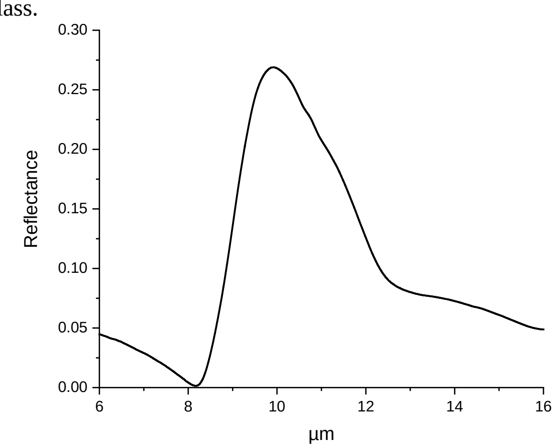

Fig.3: FTIR spectrum of polished High-Mg sample for gas/silicate reaction experiments.

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