FTIR REFLECTANCE AND RAMAN STUDY OF SYNTHETIC GLASSES: APPLICATIONS TO REMOTE SENSING OBSERVATIOSN OF THE SURFACE OF MERCURY

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Introduction: The ESA/JAXA BepiColombo mission to Mercury has a mid-infrared spectrometer (MERTIS-Mercury Radiometer and Thermal Infrared Spectrometer) onboard, which allows us to map spectral features in the 7-14 µm range, with a spatial resolution of ~500 meter [1-4]. At the IRIS (Infrared and Raman for Inter-planetary Spectroscopy) laboratory we produces mid-infrared spectra for a database for the interpretation of the data which are expected after arriving at Mercury in 2024. With these infrared spectra the mineralogical compositions of the planetary surface of Mercury will be determined.

Material on the surface of Mercury was exposed to heavy impact cratering in its history [4]. Glass lacks an ordered microstructure and represents the most amorphous phase of a material, typical for events generated by events involving high shock pressure and temperatures [5,6]. Using synthetic analog materials based on the observed chemical composition of planetary bodies allows us to produce infrared spectra of materials from which no samples in form of meteorites are available so far.

Samples and Techniques: Glasses were synthesized equivalent to the chemical composition of surface areas on Mercury, based on MESSENGER X-ray spectrometer data [e.g.7-11]. Mixtures of major oxides (SiO_2, TiO_2, Al_2O_3, Fe_2O_3, MgO) and carbonates ($CaCO_3$) were prepared. The finely ground powder was slowly heated to 1000°C to decarbonate and subsequently vitrified in a vertical furnace at ~1400°C for 2h and quenched immediately afterwards.

Infrared Spectroscopy: For the FTIR diffuse reflectance analyses, powder size fractions 0-25 µm, 25-63 µm, 63-125 µm and 125-250 µm were measured. For mid-infrared analyses from 2-20 µm we used a Bruker Vertex 70 infrared system with a MCT detector. Analyses were conducted under low pressure (3 mbar) to avoid atmospheric bands. Additional FTIR microscope analyses of thin sections are also planned for polished thick sections. For in-situ mid-infrared specular reflectance analyses we used a Bruker Hyperion 1000/2000 System at the Hochschule Emden/Leer. We used a 1000×1000 µm sized aperture, for each spectrum; 128 scans were added.

Raman Spectroscopy: In order to characterize the glasses and inclusions, Raman analyses were conducted using an Ocean Optics IDR-Micro Raman system. The laser excitation is 532 nm in a range from 200 cm^{-1} to 2000 cm^{-1}. The used 40 x objective results in a spotsize of ~ 2 µm. All measureuments were carried out at a laser power of 1.8 mW. Every spectrum is a result of 3 single spectra of 10 seconds length.

Results: Of 15 samples, 9 show FTIR spectra typical for glasses. A single Reststrahlenband (RB) dominates between 9.5 and 10 µm. Further characteristic features are the Christiansen Feature (CF), a reflectance miniumum observed here between from 7.9 to 8.3 µm. The finest grain size fractions (0-25 µm) also show the Transparency Feature (TF) from 11.8 to 12.1µm. The amorphous character of the glass was also confirmed with Raman-Analyses.

With increasing MgO content, signs of crystallinity are already regognizable optically. In the FTIR spectra, typical forsterite RB [12] appear with increasing intensity correlated with the MgO content at 10-10.1µm and 10.4-10.7µm, the CF are between 8.2 and 8.4 µm, and the TF appears from 12.1-12.3 µm.

Raman studies allowed to identify the small inclusion phases as mainly forsterite, with minor spinel and magnetite (?). Chemical composition such as SiO_2 contents correlate very well with the band positions of the RB and CF, which show systemtic shifts related to increasing SiO_2 contents.

Summary and Conclusions: First FTIR and Raman studies of synthetic glasses with the surface composition of areas on Mercury provided ‘pure’ glasses and simple spectra for mixtures with low MgO contents. Increasing MgO contents correlate with increasing abundances of crystalline phases over ~20 wt% MgO, mainly forsterite.

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