FTIR REFLECTANCE AND RAMAN STUDIES OF SYNTHETIC GLASS WITH PLANETARY COMPOSITIONS.
A. Morlok[1], S.Klemme[2], I. Weber[1], A. Stojic[1], M. Sohn[3], H.Hiesinger[1], [1]Institut für Planetologie, Wilhelm-Klemm Strasse 10, 48149, Germany, [2]Institut für Mineralogie, Corrensstraße 24, 48149 Münster, Germany, [3]Hochschule Emden/Leer, Constantiaplatz 4, 26723 Emden, Germany

Introduction: The ESA/JAXA BepiColombo mission to Mercury has a mid-infrared spectrometer (MERTIS-Mercury Radiometer and Thermal Infrared Spectrometer) onboard, for the mapping of spectral features in the 7-14 µm range, with a spatial resolution of ~500 meter [1-4]. At the IRIS (Infrared and Raman for Interplanetary Spectroscopy) laboratory we produce mid-infrared spectra for a database that will help us to accurately understand the data, which are expected to be returned after MERTIS' arrival at Mercury's orbit in 2024. With these infrared spectra the mineralogical composition of the planetary surface of Mercury will be studied in unprecedented detail.

Material on the Hermean surface was exposed to heavy impact cratering in its history [4]. Glass lacks an ordered microstructure and represents the most amorphous phase of a mineral assemblage, a typical result generated by events involving high shock pressure and temperatures [5,6] such as impacts. 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. In addition to glass studies with the average composition of distinct surface regions on Mercury, we present further spectra based on synthetic glasses with bulk mantle composition or crustal regions of the terrestrial planets. Here we show the first results for such analog glasses for surface materials from Venus [7] and Moon [8,9].

Samples and Techniques: Glasses were synthesized equivalent to the chemical compositions of mantles and crustal units of Mercury, Venus, Earth, Moon and Mars based on remote sensing, meteorite and model data [7,8,9]. Mixtures of major element 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-1600°C for 2h and quenched immediately afterwards.The resulting glasses were characterized qualitatively and quantitatively using Raman Spectroscopy and EPMA .

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. We used a 1000×1000 µm sized aperture, for each spectrum; 128 scans were added. Additional FTIR microscope analyses of thin sections are planned for polished thick sections. For in-situ mid-infrared specular reflectance analyses we will use a Bruker Hyperion 1000/2000 System at the Hochschule Emden/Leer.

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 wavelength is 532 nm with a spot size of ~ 2 µm. Measurements were performed in a range from 200 cm^{-1} to 2000 cm^{-1}.

EPMA: Detailed quantitative analyses were done with a JEOL JXA-8530F Hyperprobe electron probe micro analyzer (EPMA). For the glass analyses we used an excitation voltage of 15 kV, a beam current of 5 nA, and a defocused beam diameter.

Results: The IR spectra for glasses based on the chemical model composition of the surface of Venus and Moon show simple spectra typical for amorphous materials. A single, strong RB occurs at 10.6 µm (CF 8.1 µm) for the Venusian surface glass (Fig.1), 10.5 µm for lunar highland glass (CF 8.0-8.2 µm) (Fig. 2a) and 10.6 µm (CF 8.2-8.3 µm) for the lunar mare glass (Fig. 2b). Interestingly, the glasses exhibit no recognizable Transparency Feature (TF), in contrast to natural glasses like tektites and impact melts [10].

The spectrum based on starting material with the chemical composition of the bulk silicate Moon, however, demonstrates clear crystalline RB features at 10.6 µm and 10.1 µm, and weaker features at 9.7 µm, 11.9 µm, and 16.2 µm. These bands are typical for forsterite [11,12]. A TF in the finest grain size fraction is found at 12.5 µm. The CF is between 8.2 and 8.5 µm.

Summary and Conclusions: The CF and RB features for the synthetic glasses of lunar and Venusian surface composition are typical for basaltic material [10, 13]. These glasses have comparatively low Mg contents (below 10 wt% MgO), which allows fast quenching without the formation of quench crystals. The bulk silicate Moon composition, on the other hand, has a MgO content of 35.1 wt%, which resulted in the formation of significant Fo-rich olivine crystals during quenching [11]. Groundbased spectra of Mercury [14] show no strong RB at the 10.5-10.6 µm region, which are characteristic for the glassy analogs. Glasses with Hermean surface composition [15] fall in the compositional range between the samples here and show similar spectral features.

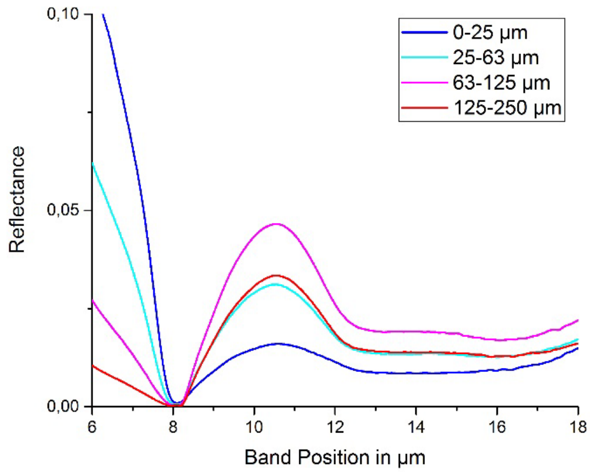

Fig.1: FTIR spectrum of glass based on chemical composition averaged from analyses of the surface of Venus determined by the Venera and Vega missions [7].

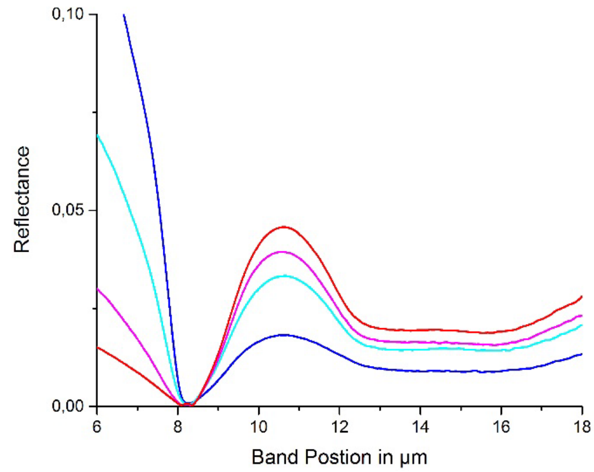

Fig.2b:FTIR spectrum of glass with the average chemical composition of the lunar maria [8]. It is dominated by a single RB band typical for glass.

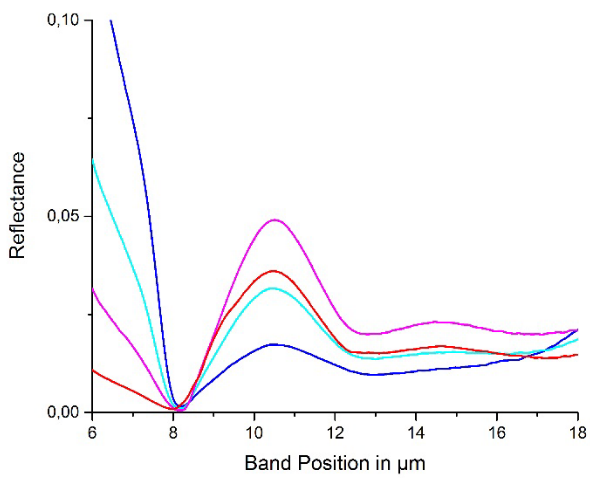

Fig.2a: FTIR spectrum of glass with the average composition of the lunar highlands [8].

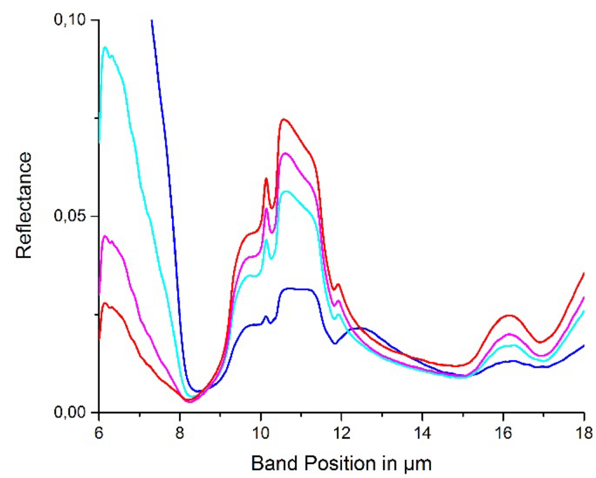

Fig.2c: FTIR spectrum of recrystallized glass with the chemical composition of the bulk silicate Moon [9], dominated by crystalline olivine features [10].

References: [1] Maturilli A. (2006) *PSS* 54, 1057–1064 [2] Helbert J. et al. (2009) *Earth Planet. Sci. Let.* 285, 347-354 [3] Benkhoff, J. et al. (2010) *Planetary and Space Science* 58, 2-20 [4] Hiesinger H. et al. (2010) *PSS* 58, 144–165 [5] Johnson (2012) *Icarus* 221, 359–364 [6] Lee et al. (2010) *J. Geophysical Res.* 115, 1-9 [7] Fegley et al. (2006) *Treatise Geochem.*I, 487-507. [8] Warren (2006) *Treatise Geochem.* I, 559–599 [9] O'Neill (1991) *Geochim. Cosmochimica Acta* 55, 1135-1157 [10] Morlok et al. (2016) *Icarus* 218, 162-179 [11] Hamilton (2000) *J.Geophys.* Res. 105, 9701-9176

[12] Salisbury (1993) In: Topics in Remote Sensing 4, Cambridge University Press [13] Lee et al. (2010) J. Geophys. Res. 115, B06202 [14] Sprague et al. (2000) Icarus 147, 421-432 [15] Morlok et al. (2016) LPSC 79th #1921

Acknowledgements: This work is supported by the DLR funding 50 QW 1302 in the framework of the BepiColombo mission.