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FTIR Reflectance Studies of Synthetic Glasses with Planetary Compositions: Mid-Infrared Data for the ESA/JAXA BepiColombo Mission

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Abstract

We present mid-infrared diffuse reflectance spectra of analog materials with planetary compositions (Mercury, Mars, Venus, Moon, Earth) as part of a database for the MERTIS (Mercury Radiometer and Thermal Infrared Spectrometer) instrument on board of the ESA/JAXA BepiColombo mission. First results of glasses showing varying degrees of crystallisation are presented. Best results for glassy planetary materials are achieved with low Mg contents, which allows fast quenching. Materials with MgO well over 30 wt% result in mostly crystalline analogues.

1. Introduction

The ESA/JAXA BepiColombo mission to Mercury includes a mid-infrared spectrometer (MERTIS-Mercury Radiometer and Thermal Infrared Spectrometer). This unique instrument allows us to map spectral features in the 7-14 µm range, with a spatial resolution of ~500 meter [1-4]. For the interpretation of the data which are expected after arriving at Mercury in 2024, we produce mid-infrared spectra for a database at the IRIS (Infrared and Raman for Interplanetary Spectroscopy) laboratory*(http://www.uni-muenster.de/Planetology/en/ifp/ ausstattung/iris_spectra_database.html).*

Material on the surface of Mercury was exposed to heavy impact cratering throughout 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.

In addition to studies of glass with the average composition of distinct surface regions on Mercury, we present additional spectra based on synthetic glasses with bulk composition of mantle or crustal regions of the other terrestrial planets. In this presentation, we show the first results for such analog glasses for surface materials from Venus [7] and the Moon [8,9].

2. Samples and Techniques

Glasses were synthesized equivalent to the chemical composition of mantle and crustal units of Mercury, Venus, Earth, Moon and Mars based on remote sensing, meteorite and model data [7,8,9]. 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-1600°C for 2h and quenched immediately afterwards. The resulting glasses will be characterized using EMPA and SEM before the spectral studies.

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 will use 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 will be 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}.

3. Results

The first series of spectra for glasses based on the chemical composition of the surface of Venus and Moon show simple spectra typical for amorphous materials. A single, strong RB is 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) and 10.6 µm (CF 8.2-8.3 µm) for the lunar mare glass. Interestingly, the glasses show 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 (Fig.2), however, shows 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.

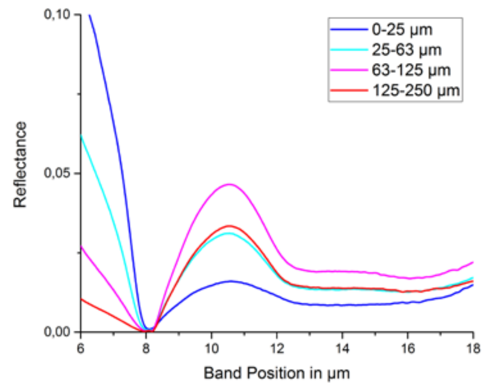

Figure 1: Example for spectra of glassy materials: FTIR spectrum of glass based on chemical composition averaged from analyses of the surface of Venus of Venera and Vega missions [7].

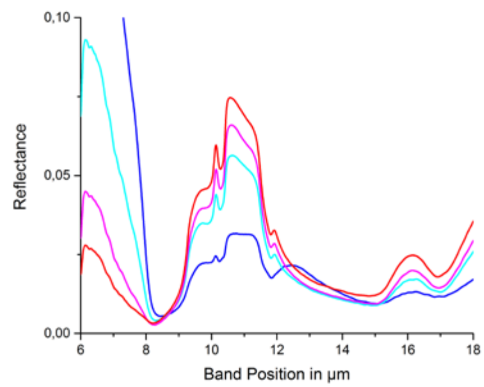

Figure 2: Example for results of materials dominated by crystalline material: FTIR spectrum of recrystallized glass with the chemical composition of the bulk silicate moon [9], dominated by crystalline olivine features [10].

4. 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]. The synthetic glasses have comparatively low Mg contents (below 10 wt% MgO), which allows fast quenching of the materials. The bulk silicate Moon glass, on the other hand, has a MgO content of 35.1 wt%, which resulted in mainly crystalline material with forsterite olivine content [11].

Future analyses in this part of our project will include similar glasses with compositions of terrestrial and martian surface and mantle.

Acknowledgements

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