COMPARISON OF MID IR SPECTRA OF SILICATE AND GLASS UNDER HIGH VACUUM

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Introduction: On board the BebiColombo mission [1] is the MERTIS- (MErcury Radiometer and Thermal Infrared Spectrometer) instrument, which collects emission spectra in the range of 7 µm to 14 µm (spectrometer channels) and 7 µm to 40 µm (radiometer channels) of surface minerals [2,3]. For the investigation of the surface mineralogy of Mercury, understanding the spectral characteristics in the mid-IR range is crucial [2]. Two expected endmember-materials on the surface of Mercury are plagioclase and glass. Hence, our study focuses on the investigation of these two materials [4,5]. Knowing the surface composition of Mercury will lead to a deeper understanding of its evolution and history, and will further improve our understanding of the formation of the early Solar System [2]. In order to accurately interpret future spectra, we produced a series of mixtures of the above-mentioned materials with different mixing ratios. In an effort to reproduce the conditions on the Mercury surface for our measurements as realistically as possible, the samples were studied under a high vacuum and in the loose powder state to simulate regolith. In addition, pellets were investigated for comparison of presented results.

Aim of our study is to investigate the changes in spectral properties of plagioclase, glass, and their mixtures in the mid-IR region for the MERTIS instrument.

Samples: The samples were mixed as follows:

ID 157 Olivine 100%
ID 561 Mix Gl 85% Plag 15%
ID 562 Mix Gl 70% Plag 30%
ID 563 Mix Gl 50% Plag 50%
ID 564 Mix Gl 30% Plag 70%
ID 565 Mix Gl 15% Plag 85%
ID 28 Labradorite 100%

Table 1: Overview of mixtures in this study.

The two samples used were (ID 157) a low-Mg glass and (ID 28) a low plagioclase (Labradorite/_An_{51}) taken from our collection and mixed in various ratios, so that seven different compositions were analyzed. All mixtures have an identification number under which they can be found in the MERTIS IRIS (Infrared & Raman for Interplanetary Spectroscopy) spectral database (http://bc-mertis-pi.uni-muenster.de/) [3].

Each sample (Table 1) was measured as pressed pellets (grain size <125 µm) and as loose powders (grain size 63 µm to 125 µm). The powder samples are particularly important because they best simulate the regolith on Mercury, which covers most of the hermean surface [2]. Mercury contains no protecting atmosphere, which leads to strong space weathering, causing surface gardening and the formation of a regolith [2]. Consequently, powder samples are most likely closer to reality than tightly pressed samples. However, the pressed samples will be used for further investigation and comparison to [6] and [7].

Methods: Small amounts of the powder were pressed into pellets on a mechanical PO-Weber press. The pressing process consisted of three stages to ensure stable pellets, but also to avoid potential phase changes: For the first step the sample was pressed for 5 minutes at 5 kN. then for 15 minutes with 20 kN, and finally again for 5 minutes with 5 kN.

All the 14 samples (7 powder, 7 pellet) were analyzed by a Bruker VERTEX 70v spectrometer equipped with a Praying Mantis reflection chamber at the IRIS laboratory. The sample chamber was evacuated to a pressure of about 10^{-3} Pa, using a Pfeiffer High Cube turbo pump. The detector is a liquid nitrogen cooled MCT [8].

Results: An important characteristic of spectra in the investigated wavelength range are the Reststrahlen bands (RB), which are prominent reflectance peaks caused by the vibration of the Si-O-bondings. Thus, RBs can provide information about the sample's overall structure. This knowledge can help to identify glass components on Mercury and consequently facilitate remote sensing applications [9].

The Figure 1a shows that the RBs for pure plagioclase has a pronounced peak at 8.73 µm and 9.91 µm. Also, for the mixtures with 85% and 70% plagioclase (ID 565 and ID 564), two peaks at 8.71 µm 9.10 µm are visible. With increasing abundances of glass, the difference in the peaks becomes less pronounced and only one wide peak at 9.63 µm is recognizable.

This implies that samples with less than 70% plagioclase only show a wide maximum typical for glass.

Figure 1b shows that the RB from the pressed samples has a similar shape as the powdered samples. As in Figure 1a, the samples with high plagioclase abundances have two pronounced RB peaks. In comparison to the powder samples, the peaks of the pressed pellets shifted to a wavelength of 8.30 µm and 9.83 µm. In the samples with at least 50% glass, just one wide peak at 9.73 µm is visible, which is similar to the powder samples.

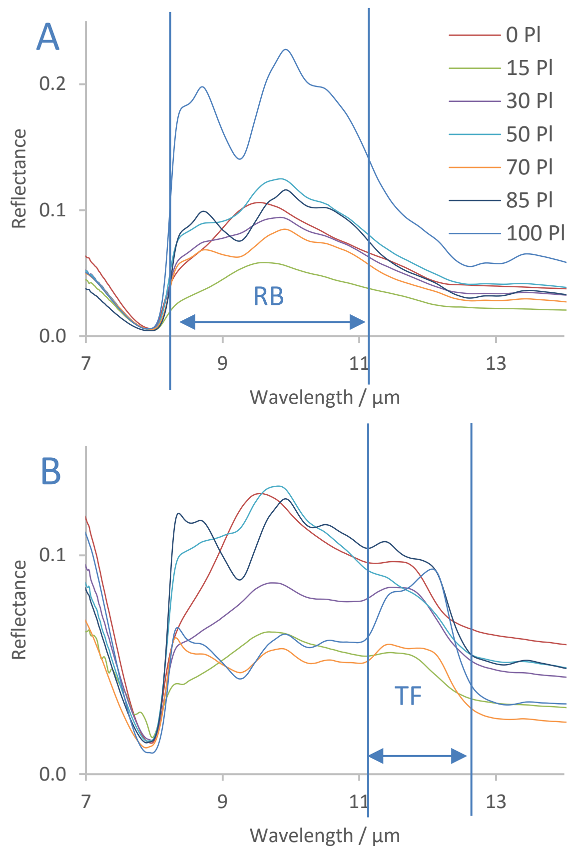

Fig. 1: Mid-IR spectra in the MERTIS range from 7 µm to 14 µm. A: Spectra of the analyzed powder samples (grain size 63 µm to 125 µm) B: Spectra of the analyzed pressed samples (grain size <125 µm).

In comparison to the powder samples, only the pressed samples show the Transparency Feature (TF) between approximately 11.00 µm and 12.50 µm, because the TF is only detectable for samples with very small grain sizes. In contrast to the very well-defined RB peaks, the TF shows a wide variety. This might be related to unavoidable shaking during transport of the pressed pellets and the resulting changes on pellets surface. Despite this complication, we find that the plagioclase-rich mixtures have two prominent peaks, whereas the glass-rich samples tend to have only one peak.

Figure 2 shows the dependency of the RB on the plagioclase abundance as well as the modification of the RB peak with increasing glass content.

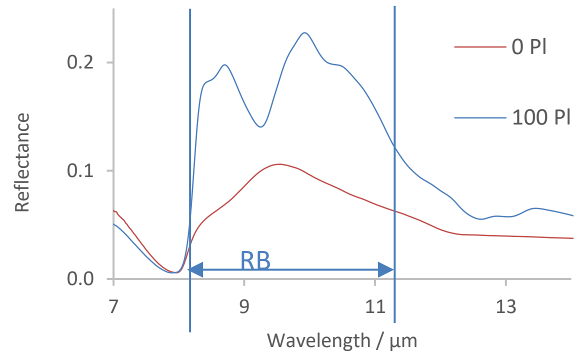

Fig. 2: Comparison of the RB in the samples with highest (blue) and lowest (red) abundance of plagioclase.

Conclusion and Outlook: Our investigation of the RBs of both the pressed and the unpressed powder samples indicates shifts in the RB positions that are dependent on the plagioclase abundance.

The observed differences (e.g., Figure 2) might be useful in identifying plagioclase or estimating the glass abundance. In particular, we observe that with increasing glass abundance, the RB only shows one peak (Figure 2). By comparing samples with different mixing ratios analyzed in this study with the data obtained remotely from Mercury, it seems possible to derive information about the composition and glass abundance of Mercury. However, more in-depth investigations need to be carried out to accurately determine the plagioclase/glass abundancies.

We also found differences in the spectral characteristics between the pressed smooth and loose powder samples. MERTIS spectra are expected to be more similar to our powder samples, as they most likely better represent the natural fine-grained porous regolith that forms on a planetary body without an atmosphere.

However, solid rock surface at steep outcrops on Mercury or rocks affected by impacts most likely are better represented by our pressed pellets. Hence, the results from these samples are also applicable for the interpretation of MERTIS spectra of Mercury.

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