COMPARISON OF MID-IR SPECTRA OF VARIOUS SILICATES UNDER HIGH VACUUM

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Introduction: The analysis of spectral properties in the mid-IR range has become an important tool for the investigation of the surface mineralogy of Mercury [1]. The MERTIS-instrument (MErcury Radiometer and Thermal Infrared Spectrometer) collects emission spectra in the range of 7 µm to 14 µm (spectrometer channels) and 7 µm to 40 µm (radiometer channels) of surface-forming minerals [1]. The spectra can not only be used to investigate the surface evolution of Mercury, but provide also information about the evolutionary history of the early Solar System [1]. The minerals expected on Mercury include olivine and plagioclase, which is why we performed a detailed investigation of the spectral characteristics of these two minerals [2]. In particular, we used mixtures of the two minerals in different amounts, hence, producing relevant analog samples of Mercury in preparation of results of the MERTIS instrument. The samples were measured under conditions similar to the conditions on Mercury's surface under high vacuum and in uncompressed state to serve as regolith analog. The measurements on the powders are particularly important, since the surface on Mercury is covered by loose regolith resulting from strong space weathering on this planet without atmosphere [1].

In addition, pellets were investigated to compare the results to [3,4], whether the spectra of the pressed pellets change compared to the loose sample. Thus, the results obtained for the loose powders are closer to reality than those for the tightly pressed samples.

The aim of the study is to show whether the Christiansen feature (CF) in the mid-IR shows a linear dependence of the composition or not.

Samples: Two minerals were taken from our collection: (ID 249) olivine (Fo_{92}) and (ID 28) low labradorite (An_{51}). These were mixed in different ratios (Tab.1). Each mixture was measured as compressed pellets (grain size <125 µm) and as loose powders (grain size 63 µm to 125 µm).

Table 1: Overview of mixtures analyzed in this study.

ID 249 Olivine 100%
ID 556 Mix Ol 85% Plag 15%
ID 557 Mix Ol 70% Plag 30%
ID 558 Mix Ol 50% Plag 50%
ID 559 Mix Ol 30% Plag 70%
ID 560 Mix Ol 15% Plag 85%
ID 28 Labradorite 100%

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/).

Methods: Since it is interesting to compare the spectra of the samples not only in the loose state but also in the solid state, small quantities of the powder were pressed into pallets on the mechanical Po-Weber press. The pressing was carried out in three stages:
First 5 minutes with 5 kN, then 15 minutes with 25 kN and finally 5 minutes with 5 kN.
Afterwards, the samples were measured in the Bruker VERTEX 70v spectrometer equipped with a Praying Mantis reflection chamber in the IRIS laboratory. The detector used was a liquid nitrogen cooled MCT and the sample chamber was evacuated with a Pfeiffer High Cube turbo pump down to 10^{-3} Pa [5]. An Infragold™ standard was used for background calibration.

Results: The Christiansen feature is an important diagnostic spectral feature of an IR spectra and can, among other things, provide information about the sample's composition [6].
Fig. 1 top shows that the CF of pure olivine derived from the pressed pellets is located at about 8.75 µm**,** in the plagioclase spectra it occurs at 7.93 µm. In the mixtures the CFs shift between these values. The higher the abundance of olivine, the farther the CF shifts to longer wavelengths. For example, the CF of the mixed sample with around 50 % olivine is at 8.01 µm and, in contrast, the CF of the sample with 85 % olivine is already at around 8.90 µm. Therefore, the most remarkable change is between 70 % (8.05 µm) and 85 % (8.90 µm) olivine with a total change in CF position of 0,85 µm. In olivine/plagioclase mixtures it is possible to determine if the Ol-content is below or above 50 % by analyzing the CF.
In Fig. 1 bottom it can be seen, that the CF from the unpressed samples is located in the spectrum of pure olivine at about 8.88 µm and in the plagioclase spectra at 7.89 µm. The CFs of the samples with 0 % to 50 % olivine are still at around 7.97 µm to 7.99 µm. The total difference there is just 0.01 µm . In contrast to this, the CF of the sample with 70 % olivine is located at 8.07 µm. Furthermore, the CFs of the samples with 85 % and 100 % olivine shifted only slightly from 8.95 µm to 8.88 µm. Analog to the powder samples, the CFs of the pressed samples shift in a similar way. There is also a clear change in the position of the CFs from the unpressed samples with 70 % and 85 % olivine with a

total difference of 0.88 µm. In addition, the CF range of those un-pressed powder samples is a little smaller and only slightly shifted. A reason for that could be, that the pressed samples have a smoother surface than the powder samples, which causes changes in the refractive index and in the CF position [4].

Fig. 2 shows the dependency of the CF on the Ol-abundance of the samples. Samples with an olivine abundance below 50 % show their lowest reflectance at approximately the CF position of the pure plagioclase, whereas samples with an Ol-abundance above 50 % show a CF that reflects that of pure olivine. At 50 % olivine in the mixture, the powder spectrum display a plagioclase-like CF whereas the pellet spectrum exhibits a CF position which corresponds to olivine.

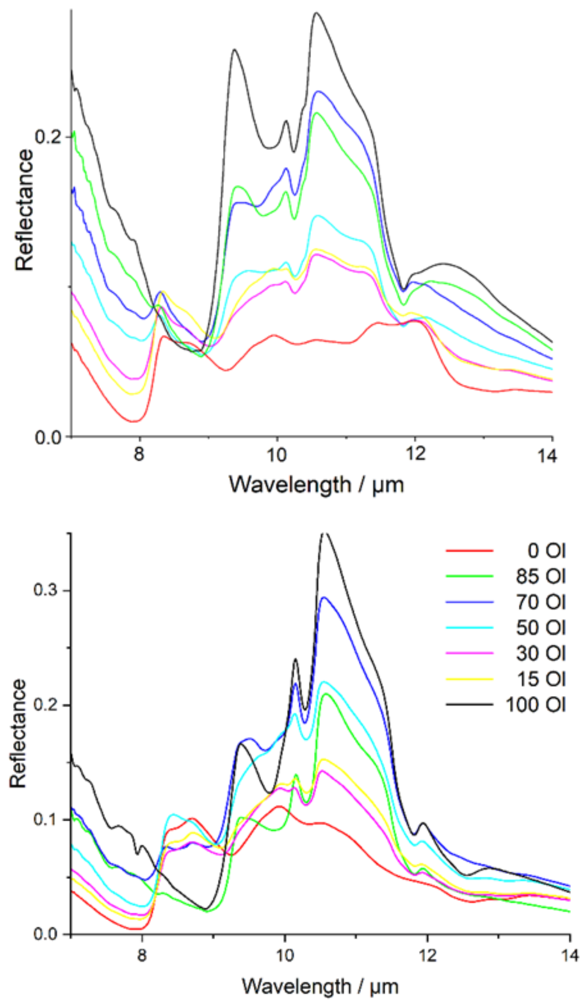

Fig. 1: Mid-IR spectra in the MERTIS range from 7 µm to 14 µm. Top: Spectra of the analyzed pressed samples (grain size <125 µm). Bottom: Spectra of the analyzed powder samples (grain size 63 µm to 125 µm).

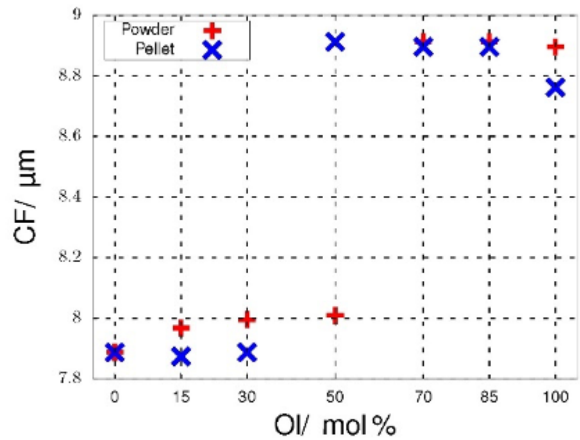

Fig. 2:Position of the CF (lowest reflectance value in the representative spectrum) depending on the Ol-abundance of the mixed samples.

Conclusion and Outlook: Both, the pressed and the un-pressed samples show shifts in the CF that are dependent on the olivine abundances in the mixtures. However, the shifts are not linearly dependent on the olivine abundances. Our results for mineral mixtures are relevant for the accurate interpretation of MERTIS spectra of Mercury. Because the CF is an important diagnostic feature for determining the mineralogy on Mercury's surface. Further investigations are necessary to extract the olivine/plagioclase abundances more accurately from remote sensing data. The results also show that there are clear spectral differences between pressed smooth and a loose powder surfaces. The results for the powder samples can be best compared with the MERTIS spectra as they were measured under similar conditions and most closely resemble the structure of regolith. The pressed samples can also make an important contribution, since they can be compared with samples from solid rock surfaces at steep outcrops on Mercury or with measured results from other experiments.

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