**DECONVOLUTION OF LABORATORY IR SPECTRAL REFLECTANCE MEASUREMENTS OF OLIVINE AND PYROXENE MINERAL MIXTURES.** K.E. Bauch[1], I. Weber[1], M.P. Reitze[1], A. Morlok[1], H. Hiesinger[1], A.N. Stojic, and J. Helbert[2], [1]Institut für Planetologie (IfP), Westfälische Wilhelms-Universität Münster, Wilhelm-Klemm-Str. 10, 48149 Münster, Germany (karinbauch@uni-muenster.de), [2]DLR-Institute for Planetary Research, Rutherfordstrasse 2, 12489 Berlin, Germany.

**Introduction:** The imaging spectrometer MERTIS (Mercury Radiometer and Thermal Infrared Spectrometer, Figure 1) is part of the payload of ESA/JAXA's BepiColombo mission, launched in October 2018 [1,2]. The instrument consists of an IR-spectrometer and radiometer, which will observe the surface in the wavelength range of 7-14 µm and 7-40 µm, respectively. The scientific objectives [2,3] are to

a) study Mercury's surface composition,
b) identify rock-forming minerals,
c) globally map the surface mineralogy, and
d) study surface temperature and thermal inertia.

In preparation of the mission, we are investigating Mercury analog minerals at the IRIS (Infrared and Raman for Interplanetary Spectroscopy) laboratory of the Institut für Planetologie at the Westfälische Wilhelms-Universität Münster. We study typical rock-forming minerals, e.g., pyroxenes, olivines, and feldspars, as well as mineral mixtures. This ongoing analysis provides a spectral database, which will enable the correct interpretation of MERTIS spectral data.

Here we present results of a deconvolution model to quantify abundances of mineral mixtures [4,5]. As planetary surfaces are composed of a variety of different minerals, the obtained spectral data reflects a mixture of these minerals. In order to quantify the mineral abundances a non-linear unmixing model is necessary. Our model is based on the Hapke reflectance model [6-8]. This model has previously been used for spectral unmixing of NASA RELAB data [4], and lunar analog materials [5]. In the framework of MERTIS, it is applied to data obtained at the IRIS laboratory [9]. Results of olivine and pyroxene mixtures, as well as grain size mixtures, will be presented at the meeting.

**IR spectroscopy:** At the IRIS laboratory, samples are sieved in grain size fractions of <25 µm, 25-63 µm, 63-125 µm, and 125-250 µm. For the mineral mixing analysis presented here, we focus on the 63-125 µm fraction, which was also used by [10,11] for further investigations. For the study of grain size mixtures we investigated <25 µm and 125-250 µm mixtures. Samples are placed in aluminum cups and analyzed by a Bruker Vertex 70v spectrometer with an A513 variable mirror reflectance stage for 13° incidence (i)/13° emergence (e), 20°(i)/30°(e), and 30°(i)/30°(e) angles. After background calibration using a commercial diffuse gold standard (INFRAGOLD™) a total of 512 scans were accumulated to ensure high signal-to-noise ratios.

**Samples:** We used olivine ($Fo_{91}$) from Dreiser Weiher, Germany, and pyroxene ($En_{87}$) from Bamble, Norway and a range of mineral mixtures for IR measurements. The crystals were ground in a steel mortar. These samples were also investigated through a variety of analytical techniques, such as light microscopy, electron microscopy, and irradiation experiments [10,11].

**Results:** Here we present results of spectral unmixing FTIR analyses of both pyroxene and olivine mineral mixtures and pyroxene grain size mixtures, investigated with the Vertex 70v spectrometer at the IRIS laboratory. Spectral data of the endmembers and their mixtures are shown in Figure 1. The pure pyroxene and olivine spectra clearly show characteristic Christiansen feature and Reststrahlen bands for all applied geometries. However, regarding the phase angle it is apparent, that the intensities decrease with increasing angles (Figure 1). The intensity increases from pyroxene and pyroxene-rich mixtures to olivine and olivine-rich mixtures. Moreover, the olivine-rich mixtures exhibit more olivine reflectance features, compared to pyroxene-rich mixtures [11]. The results of the spectral unmixing procedure of these mixtures are summarized in Table 1.

**Table 1:** Spectral unmixing results of pyroxene-olivine mixtures under different geometries.

| | wt.% | Computed wt. % 13°(i)/13°(e) | 20°(i)/30°(e) | 30°(i)/30°(e) |
|---|---|---|---|---|
| | | *Mix 1* | | |
| Px | 85 | 86.12 | 86.89 | 85.08 |
| Ol | 15 | 13.87 | 13.11 | 13.92 |
| | | *Mix 2* | | |
| Px | 70 | 71.84 | 70.49 | 69.71 |
| Ol | 30 | 28.16 | 29.51 | 30.29 |
| | | *Mix 3* | | |
| Px | 50 | 45.05 | 45.73 | 45.93 |
| Ol | 50 | 54.95 | 54.27 | 54.07 |
| | | *Mix 4* | | |
| Px | 30 | 30.54 | 30.39 | 30.12 |
| Ol | 70 | 69.46 | 69.61 | 69.88 |
| | | *Mix 5* | | |
| Px | 15 | 18.43 | 18.69 | 19.41 |
| Ol | 85 | 81.57 | 81.31 | 80.59 |

Results of the pyroxene grain size analysis are shown in Figure 2. Here we focus on two pyroxene mixtures of 50% fine/50% coarse and 30% fine/70% coarse material (fine material refers to the grain size fraction <25 µm, while coarse denotes the 125-250 µm fraction). The spectral data were obtained under specular geometries of 20°(i)/30°(e) and 30°(i)/30°(e). Generally, the intensities increase with increasing grain sizes. The transparency feature is evident for small grain sizes and the 50% fine/50% coarse mixture. Results of our unmixing procedure are summarized in Table 2.

**Ongoing work:** At the IRIS laboratory, we will further investigate Mercury analog material and their mineral mixtures applying various analytical techniques. With these data we are establishing a database that will enable to correctly interpret the MERTIS results, once we obtain data from fly-by maneuvers and finally in orbit around Mercury.

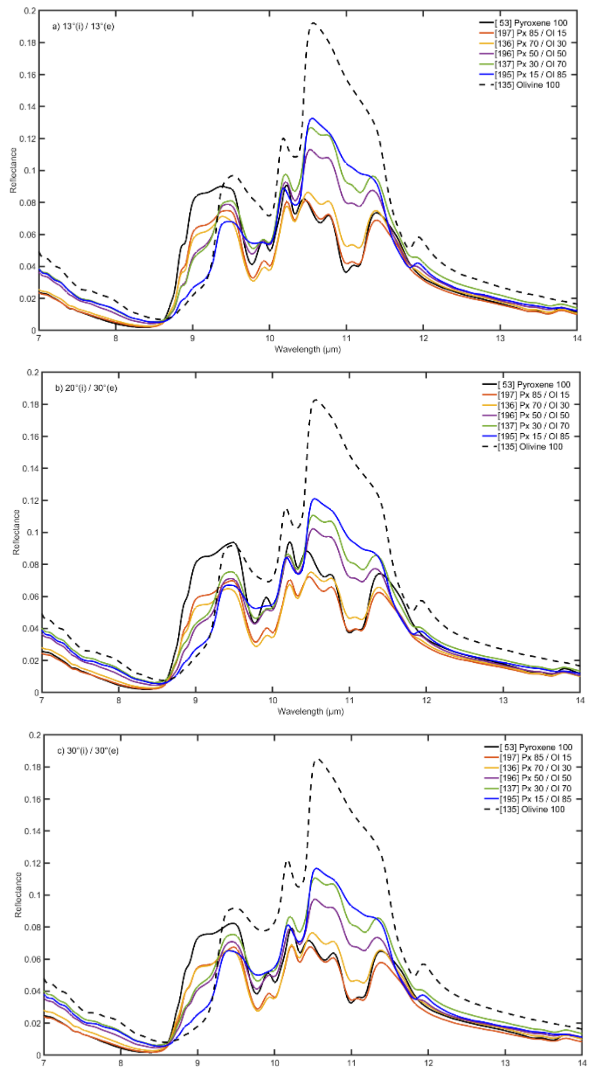


**Figure 1:** IR reflectance spectra in the MERTIS-relevant wavelength range between 7-14 µm. Black curves indicate the pure samples pyroxene 100 (solid line) and olivine 100 (dashed line) and their mineral mixtures Px85/Ol15 (red), Px70/Ol30 (orange), Px50/Ol50 (purple), Px30/Ol70 (green), and Px15/Ol85 (blue).
a) 13°(i)/13°(e), b) 20°(i)/30°(e), c) 30°(i)/30°(e).

**Table 2:** Spectral unmixing results of pyroxene-olivine mixtures under different geometries.

| Grain size fraction | wt. % | Computed wt .% 20°(i)/ 30°(e) | 30°(i)/ 30°(e) |
|---|---|---|---|
| | | *Mix 1* | |
| <25µm | 30 | 23.83 | 24.07 |
| 125-250µm | 70 | 76.17 | 75.93 |
| | | *Mix 2* | |
| <25µm | 50 | 57.61 | 56.90 |
| 125-250µm | 50 | 42.34 | 43.10 |

**Acknowledgements:** This work has been funded by DLR grant 50 QW 1701 in the framework of the BepiColombo mission.

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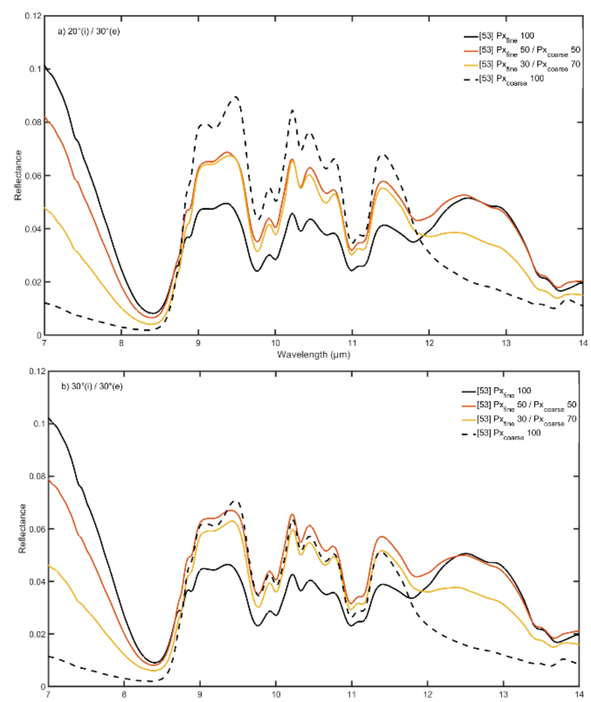


**Figure 2:** IR reflectance spectra of pyroxene grain size mixtures in the MERTIS-relevant wavelength range between 7-14 µm. Black solid line indicates the fine material fraction 0-25µm, dashed line corresponds to the coarse fraction 125-250 µm. The mixtures fine50/coarse50 and fine30/coarse70 are shown as red and orange lines, respectively
a) 20°(i)/30°(e), b) 30°(i)/30°(e).