DECONVOLUTION OF LABORATORY IR SPECTRAL REFLECTANCE DATA FOR MERTIS ONBOARD THE ESA/JAXA BEPICOLOMBO MISSION.

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Introduction: The imaging spectrometer MERTIS (Mercury Radiometer and Thermal Infrared Spectrometer, Figure 1) is part of the payload of ESA/JAXA's recently launched BepiColombo mission [1,2]. The instrument consists of an IR-spectrometer and radiometer, which 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
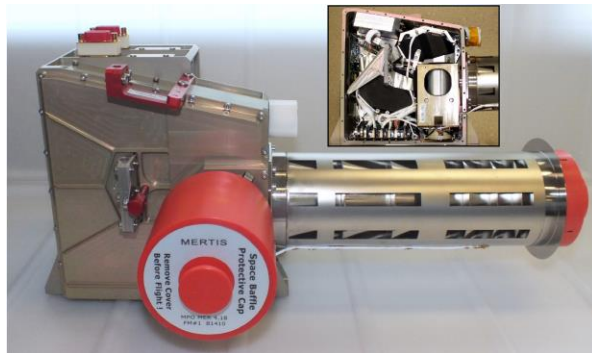d) study surface temperature and thermal inertia.

Figure 1: MERTIS flight model. Dimension of the housing are 180x180x130 mm.

In order to interpret the results obtained by MERTIS during 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 University of Münster. Ongoing analyses provide a spectral database, which will enable the interpretation of MERTIS spectral data.

Here we present results of a deconvolution model to quantify abundances of mineral mixtures [4,5]. This model has previously been validated for spectral unmixing of NASA RELAB data [4] and lunar analog materials [5]. In the framework of MERTIS it will be applied to data obtained at the IRIS laboratory. First results of olivine and pyroxene mixtures will be presented at the meeting.

Spectral mixing: Planetary surfaces are composed of a variety of different minerals. Therefore the obtained spectral data reflect a mixture of these minerals and deconvolution of the spectral data is necessary to quantify mineral abundances [6]. Two different kinds of mixtures, namely macroscopic and microscopic mixtures are applied to the solution of this problem [e.g., 7,8]. Assuming a macroscopic mixture, light rays interact only with members of one distinct group or mineral before reaching the detector (Figure 2.a). The spectral reflectance of a mixture in this case is simply a weighted sum of the endmember's reflectance spectra [4]. In microscopic mixtures particles are not separate and therefore the incident light rays can freely interact with different minerals (Figure 2.b) [5]. This results in a non-linear mixture of the reflectance.
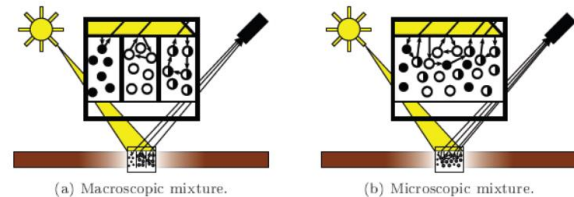
(a) Macroscopic mixture.   (b) Microscopic mixture.

Figure 2: Comparison of macroscopic (a) and microscopic (b) mixtures. (a) Endmembers are spatially separated, thus light rays incident on a macroscopic mixtures are reflected by only one endmember.
(b) On a microscopic mixture incident light rays are possibly reflected by multiple distinct endmembers [Fig. by 4,5].

Planetary surfaces, such as the hermean regolith exhibit microscopic mineral mixtures, therefore it requires a non-linear unmixing model [9].

The reflectance of the planetary surfaces is commonly modeled by the Hapke model [10-12]. The intrinsic reflectivity of an average single surface is described by the "single-scattering albedo" [10]. Multiple scattering within a surface is governed by the incidence and emission angle, but depends also non-linearly on the single-scattering albedo. Scattering behavior of an individual particle is described by a "single-particle scattering function". The full set of equations is given by [10].

IR spectroscopy: At the IRIS laboratory, samples are sieved in grain size fractions of 0-25 µm, 25-63 µm, 63-125 µm, and 125-250 µm. For the analysis presented here we focus on the 63-125 µm fraction, as this was also used by [13] for further investigations. Samples are placed in aluminum cups and analyzed by

a Bruker Vertex 70v spectrometer with an A513 variable mirror reflectance stage for 20° incidence (i) / 30° emergence (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: Olivine (Fo91) from Dreiser Weiher, Germany, and pyroxene (En87) from Bamble, Norway were used for IR measurements. The crystals were ground in a steel mortar. These samples were further investigated through a variety of analytical techniques [13], such as
- Light microscopy
- Electron microscopy
- Irradiation experiments
- TEM.

First results: Here we present results of spectral unmixing FTIR analyses of olivine and pyroxene mixtures, investigated with the Vertex 70v spectrometer at the IRIS laboratory. The spectral data were obtained under specular geometries of 20°(i)/30°(e) and 30°(i)/30°(e) angles using an A513 variable mirror reflectance stage. Spectral data of the endmembers and mixtures are shown in Figure 3 for 20°(i)/30°(e), and Figure 4 for 30°(i)/30°(e).

The spectral unmixing of these mixtures show very good consistency with the sample mixtures:

	Actual %	Computed %	
		20°(i)/30°(e)	30°(i)/30°(e)
Mix 1			
Olivine	30	29.37	28.72
Pyroxene	70	70.63	71.28
Mix 2			
Olivine	70	71.03	72.27
Pyroxene	30	28.97	27.73

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

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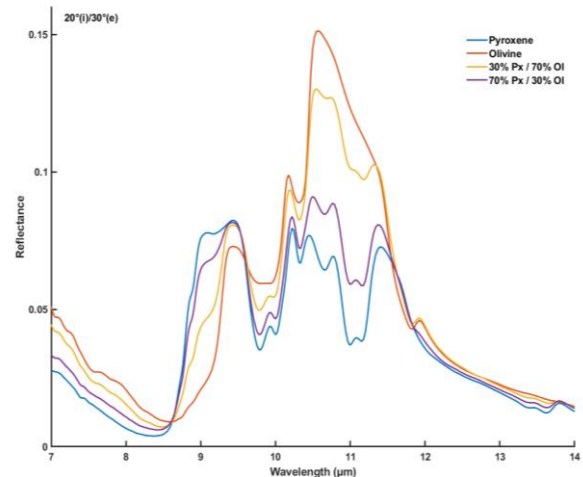[13] Weber I. et al. (2019) *LPSC L,* Abstract 2326.

Figure 3: IR reflectance spectra of olivine, pyroxene and their mixtures under 20°(i)/30°(e) angles in the MERTIS relevant wavelength range of 7-14 µm..
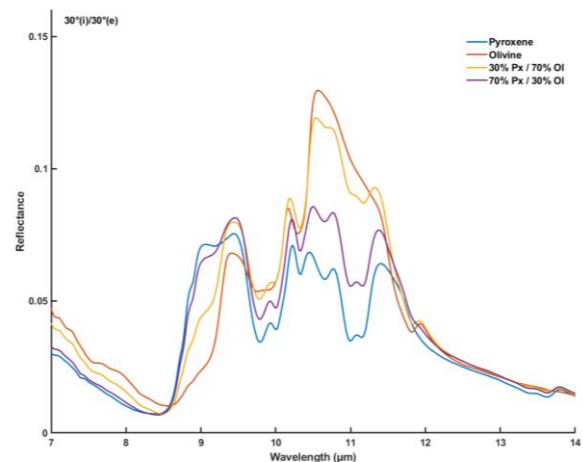

Figure 4: IR reflectance spectra of olivine, pyroxene and their mixtures under 30°(i)/30°(e) angles in the MERTIS relevant wavelength range of 7-14 µm.