MERTIS@MERCURY: FIRST ATTEMPT IN MAPPING THE HERMEAN SURFACE MINERALOGY.
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Introduction: The MERTIS (MErcury Radiometer and Thermal Infrared Spectrometer) is a mid-infrared imaging instrument, onboard the BepiColombo ESA/JAXA mission to Mercury, launched in October 2018. After arrival in 2026, among other objectives, it will map the mineralogy of the surface of Mercury [1,2].

Part of MERTIS is the Thermal Infrared spectrometer (TIS) covering the wavelength range from 7 to 14 µm.

The MERTIS instrument is one of the few detectors used during the 5th flyby at Mercury, resulting in the first thermal infrared data of the hermean surface from a spacecraft after radiometer studies by Mariner 10 [3]. While the footprint is still large (26-30 km) due to the distance of nearly 40000 km during the flyby, the first results already allow distinguishing surface details.

One challenge is to derive quantitative mineralogical information from the vast amount of spectra. One way is to model modal mineral data using complex unmixing routines, which provide detailed mineralogy, but require much time and input [e.g., 4]. A simple and fast method to obtain maps of the mineral distribution is the use of simple band ratios instead.

Techniques: While most minerals exhibit characteristic features in their 'pure' spectra (**Fig.1**), most of these idiosyncratic bands are difficult to identify in mixtures owing to overlapping features and physical effects like temperature. Therefore the first step is identifying bands that are easy to find even in complex mixtures expected from the surface regolith.

In a first attempt to identify such band ratios, we used spectra of 28 synthetic mixtures with exactly defined modal mineralogy [5,6]. We limited ourselves to the spectra of the finest size fraction (0-25µm), which is expected to be the dominant grain size on the surface of Mercury [2]. Since our surface data from Mercury are emissivities, we calculated our laboratory reflectance spectra into emissivity using Kirchhoffs' law [7]. This is a simplified approach, for detailed future studies the directional hemispherical laboratory setup will be taken into account.

In order to minimize the influence of absolute spectral intensities, we apply band ratios in our modelling. Here the integrated area of two bands are divided. MERTIS obtains spectra using 80 channels, which are binned by a factor of 2. The first and last channel are usually omitted due to instrument noise.

We set up a Python code that first calculates all possible bands – starting with bands consisting of one channel, to bands with a width of 38 channels, at all positions possible in the range of a given mixture spectrum. Afterwards each of these bands was divided by all other bands. As a result, we obtained 28 arrays containing all possible band ratio intensities for each spectrum of the synthetic mixtures. Thus we obtained all possible band ratios for each of the 28 mixture spectra.

In the next step, the band ratios for each synthetic mixture were correlated with the modal mineralogy for 6 phases (Glass, Forsterite, Diopside, Plagioclase, Enstatite and Quartz) available for each of the 28 mixtures. Thus, we identified the band ratios with the highest correlation to a mineral phase (**Table 1**).

Data Processing: Routines for data processing were developed in Python. For the programming, we used the Pandas, NumPy, SciPy, and Matplotlib Python open source packages [8-11].

Results: For all six phases, remarkably high correlations r = 0.89 – 0.99 were found (r=correlation coefficient) already in the first run**. Table 1** presents the wavelength ranges for the two bands of the highest correlations of each mineral phase.

Table 1: Band pairs BAND 1 and BAND 2 (range of each band in µm) for which the strongest correlations were found when ratio was calculated. r = correlation coefficient. ID = database identification number.

Phase	r	BAND 1	BAND 2
ID 158 Glass	0.89	8.49-10.41	8.84-10.59
ID 249 Forsterite	0.97	7.96-8.84	7.53-9.19
ID 22 Diopside	0.96	9.19-12.08	7.18-9.63
ID 28 Plagioclase	0.94	12.16-12.86	12.78-13.83
ID 53 Enstatite	0.98	7.18-12.43	7.18-13.83
ID 13 Quartz	0.99	7.18-8.31	7.35-8.40

Figure 1 shows the band ratios for some of the phases, which are controlled by different spectral features. For ID 249 Forsterite, the ratio bands cover mainly the Christiansen Feature (CF), a characteristic reflectance low, small shifts of this position will affect the relative band intensities. In the case of ID 28 Plagioclase, the grain-size sensitive Transparency Feature (TF) provides the best band ratios. For ID 53 Enstatite, wide ranges of the spectrum are required for a sensitive ratio, while the best band ratio for glassy material centers around the single main Reststrahlen Band (RB).

Summary and Outlook: We have modeled a series of band ratios based on synthetic laboratory spectra for the use on hermean surface spectra. In the next step, we will use these ratios to produce mineral maps of the hermean surface using the processed MERTIS emissivity spectra of the 5th flyby.

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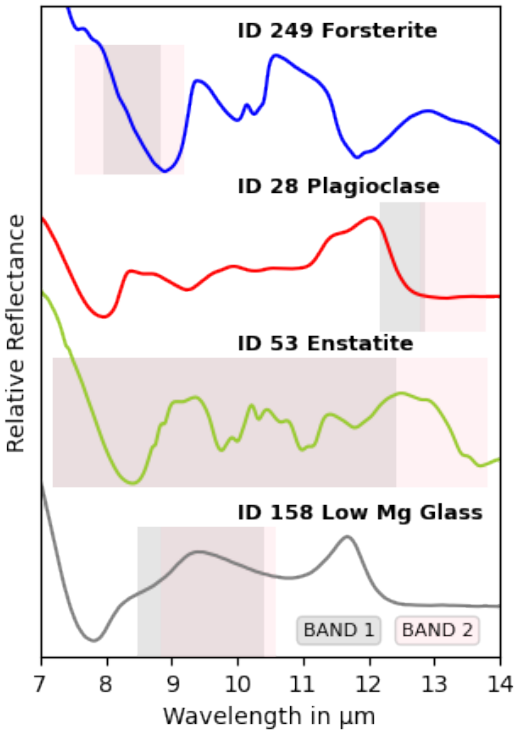

Figure 1: Comparison of laboratory spectra. For presentation purposes we show reflectance. The light gray and pink shaded areas indicate the range for the two bands having the strongest correlation with the mineral phase (**Table 1**). ID = database identification number