Exploring the Surface Mineralogy of Mercury with MERTIS@BepiColombo: FTIR Laboratory Work to Build a Database

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Introduction:

- The ESA/JAXA BepiColombo mission will arrive at Mercury in 2025.
- Onboard is the MIR (mid-infrared) spectrometer **MERTIS** (Mercury Radiometer and Thermal Infrared Spectrometer) to map spectral features in the 7-14 µm range (spatial resolution ~500 m) [3-5].
- The **IRIS** (InfraRed spectroscopy for Interplanetary Studies) laboratory produces spectra for the mineralogical interpretation of the data [1,2].

Spectral Laboratory: The IRIS laboratory offers a wide range of instruments:

- Mainstay is a Bruker Vertex 70v optimized for MIR studies of powdered bulk samples under low vacuum using a variable geometry (A513) stage.
- A Bruker Vertex 80v allows studies over the range from UV to MIR.
- Thermal and emission high-vacuum extensions allow studying samples under realistic conditions.
- A Bruker Hyperion 3000 FTIR microscope for MIR studies with 2 µm resolution will be comissioned this year.
- Additional spectroscopy is done using a OceanOptics micro-Raman system.

Our Current Work: covers several areas important for the interpretation of the expected spectra. Examples are:

- Natural and synthetic analogs [6-8] (with *Institut für Mineralogie, Münster*).
- Rock end-member studies [9, 10] (with *Institut für Mineralogie, Münster*).
- Space Weathering [11,12] (with *Physikalisches Institut, Münster* and *Mach Institut (EMI), Kandern*).
- Gas/rock interactions [13] (with *Institut für Mineralogie, Münster*).
- Spectra and Data Processing, Quantitative spectral unmixing and surface modeling [14-17] (with *TU Dortmund*).

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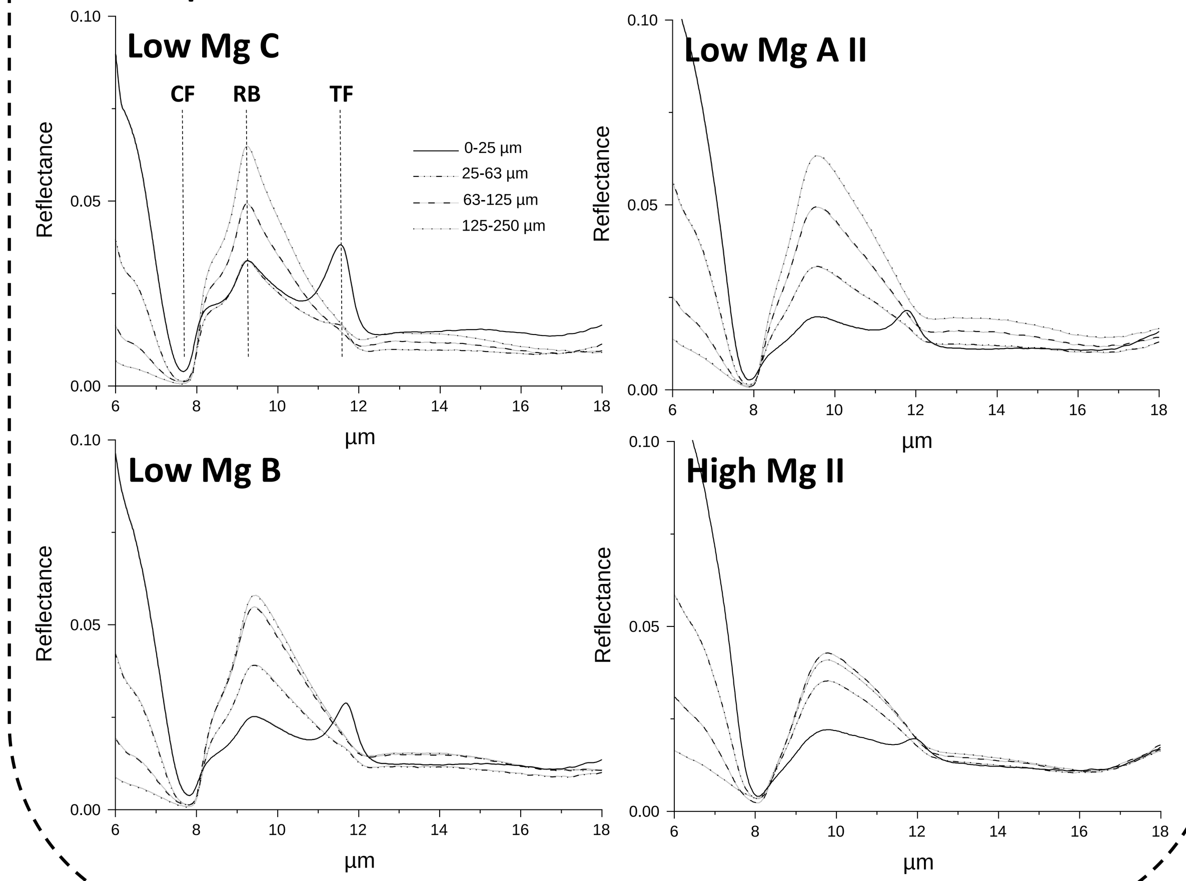
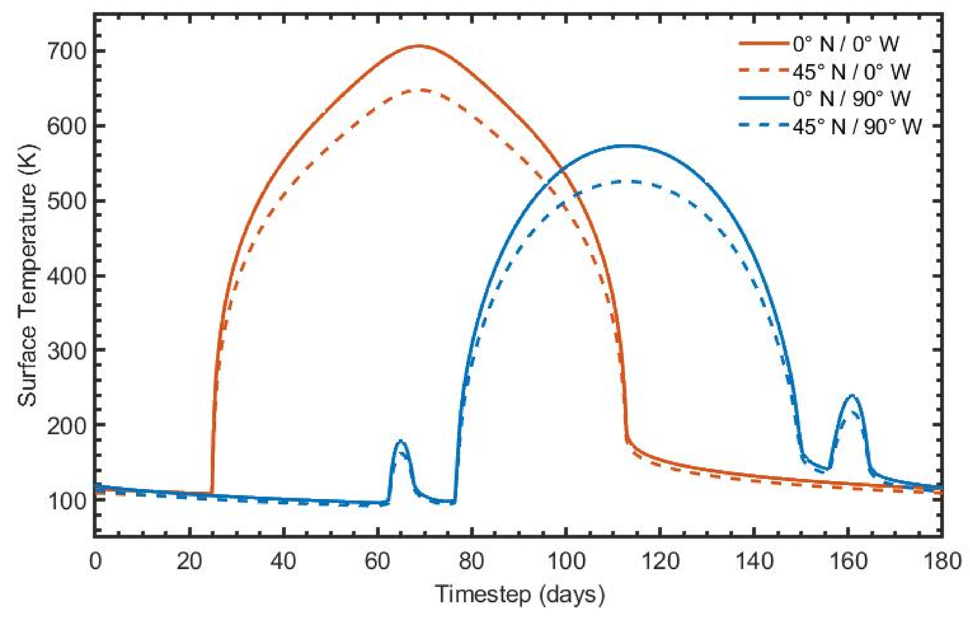
Natural & Synthetic Analogs

- We synthesized glass with typcial compositions expected from mantle and crust formation processes on Mercury [18,19]
- Spectra of size fractions 0-25 µm, 25-63 µm, 63-125 µm and 125- 250 µm were made.
- All spectra show the characteristics of glassy material with only one, broad Reststrahlen Band (RB) between 9 - 10 µm.
- RB, Christiansen Feature (CF), and Transparency Feature (TF) shift depending on their Si and Mg compositions.

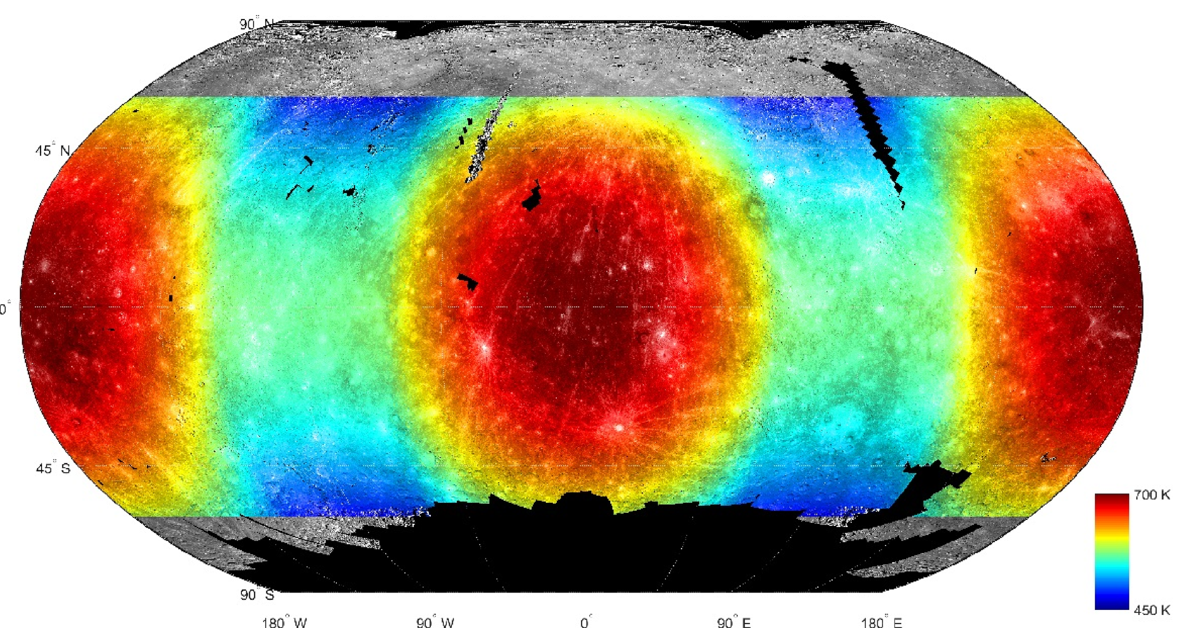


Surface Modeling: Temperature Estimation Surface of Mercury

- We calculated surface temperatures using a refined version of the numerical thermal model [16]
- The surface of Mercury undergoes large temperature variations each diurnal period. At the equator temperatures vary between less than 100 K during the night up to 700 K at local noon [17].



(Top) Surface temperatures as a function of local time at different locations. Solid lines: Equator, dotted lines: 45° N. Red: 0° N; blue 90° W. During perihelion Mercury's orbital velocity exceeds spin rate, which results in a secondary sunrise and sunset at 90° longitudes.



(Top) Global map of local maximum surface temperatures with a resolution of 16 pixel per degree superposed on the albedo map. Red: temperatures >600 K.

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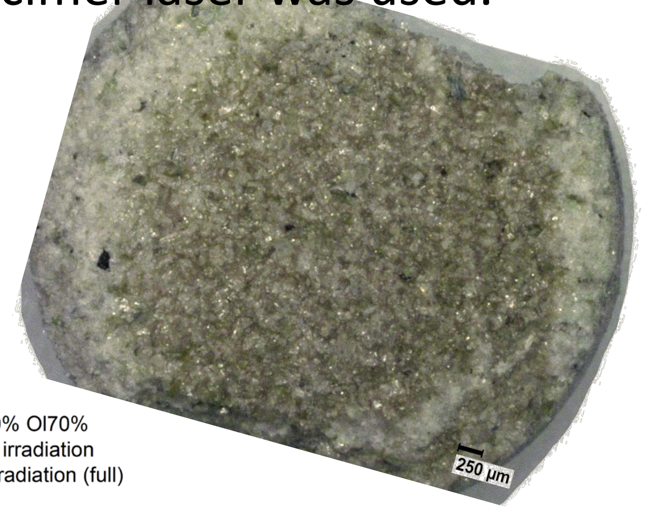
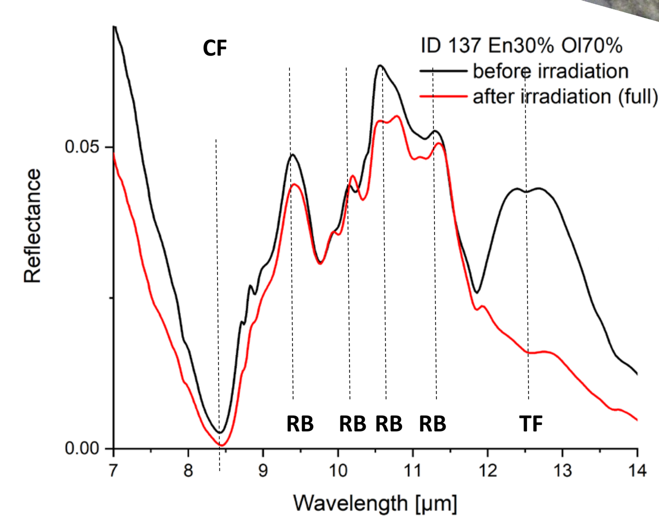
Space Weathering

- Pulsed-laser irradiation was applied in order to investigate the effect of SW processes caused by macro to micro impactors [20].
- A 193 nm ArF UV excimer laser was used.



(Left) Image of the sample surface of the mixture En70/Ol30 after irradiation with an energy density of 2.45 J/cm² for each 10 ns pulse with 3 shots per point.



(Left) Due to comminuting the sample by pressing the pellets, the TF becomes visible in all IR spectra made before irradiation (Fig. 3).
→ After irradiation the TF disappear.

- Effects of micrometeorite impacts are also investigated using shock-recovery experiments of porous minerals.
- IR Studies of San Carlos Olivine (Fo_{87}) under local peak pressures of ~60 Gpa show mosaicicsm, undulose grains, and melt.

(Top) SEM-front view of opened ARMCO Fe cylinder. Dark material is olivine (Ol), cylinder material is bright. Scale bar is 500 µm. Dark grey arrow (left side) signifies the direction of the shock wave.

Rock End-Members

- One focus is on crystalline feldspar samples
- The influence of the Al,Si distribution was investigated [9,10]
- The spectral shape is strongly affected by the degree of order which can be derived from the reflectance spectra
- This opens the chance to investigate the thermal evolution history of the hermean surface and to distinguish order related and other effects, e.g., shock, influencing the spectra