EFFECT OF GRAPHITE ON EMISSIVITY AND REFLECTANCE SPECTRA FOR MERCURY SURFACE SIMULANTS. A. Maturilli[1], J. Helbert[1], G. Alemanno[1], M. D'Amore[1], I. Varatharajan[1] and H. Hiesinger[2], [1]Institute of Planetary Research, German Aerospace Center DLR, Berlin, Germany [2]Westfälische Wilhelms-Universität Münster, Germany (alessandro.maturilli@dlr.de).

Introduction: Until almost a decade ago Mercury was considered by some scientists to be very similar to the Moon. Both are small rocky bodies in the inner solar system with thin exospheres and no large scale traces of recent geological activity. However Mercury's surface reflects much less sunlight than the Moon, making it an extremely dark body. To explain the reasons for this difference, significant abundances of iron and titanium (and their oxides) were proposed for the Hermean surface after the first NASA MESSENGER flyby of Mercury. But once in orbit around the planet, the NASA MESSENGER GRS instruments found very small abundances of iron, confirming earlier ground-based spectroscopy observations, and virtually no titanium. Therefore neither of the elements can account for this diversity. Recent analysis of MESSENGER data acquired for the darkest regions of Mercury's surface suggest that the unknown darkening material could be carbon, in particular as the mineral graphite [1] whose abundance in the darker regions is predicted to be 1 to 3 wt% higher than the surroundings.

Previous Study: Last year at the Planetary Spectroscopy Laboratory (PSL) of the Institute of Planetary Research (DLR, Berlin) we measured reflectance spectra of graphite from UV to TIR spectral range (0.2 to 20 µm) under several phase angles. Reflectance spectra of samples were measured fresh and after heating (100° to 400° C, step 100° C) in vacuum for 8 hours. Reflectance spectra of komatiite (chosen as Mercury surface simulant, after [2]) was measured alone and mixed with few % of graphite to reproduce the results from [1], following the same procedure as for graphite.

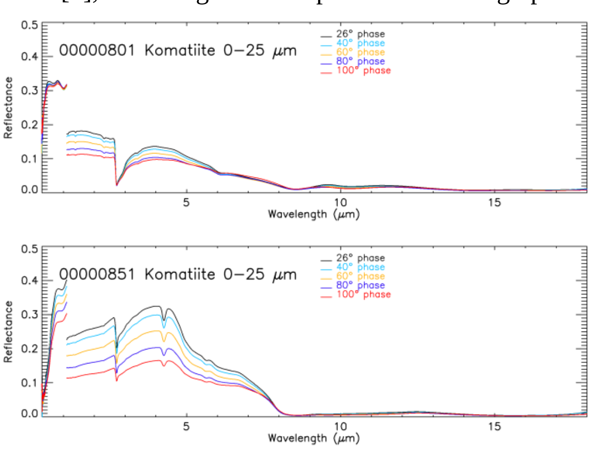


Figure 1. Mercury surface analogue Komatiite spectra (upper fresh, lower after 2 times at 400°C in vacuum).

Figure 1 shows reflectance for the fresh and heated sample of Mercury surface simulant Komatiite. Figure 2 shows spectra for the Komatiite/graphite mixture. Absolute reflectance values in the 2 channels shown are scaled for better visualization.

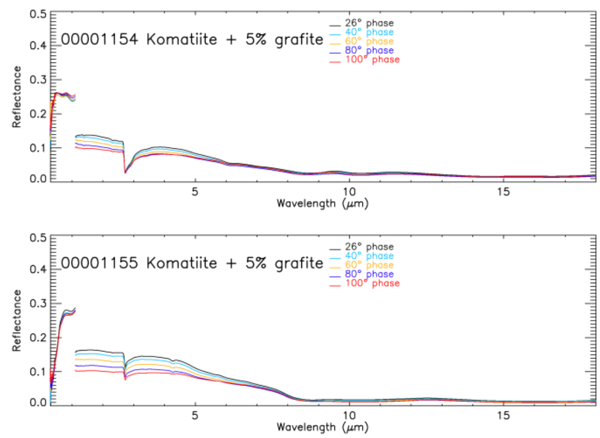
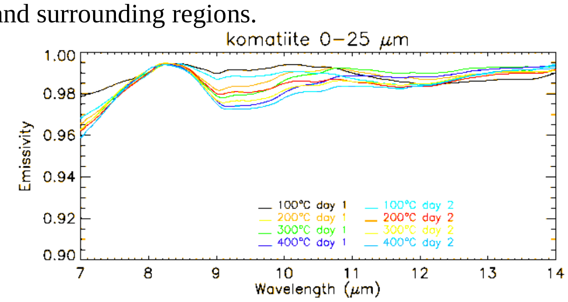


Figure 2. Mercury surface analogue Komatiite + graphite (5% in weight) spectra (upper fresh, lower after 2 times at 400°C in vacuum).

Emissivity spectra for the same set of samples was measured in vacuum (< 0.8 mbar) for successive steps of surface temperatures from 100°C to 400°C in the TIR spectral range (1 to ~ 18 µm) in preparation for analysis of data collected by the Mercury Radiometer and Thermal Infrared Spectrometer (MERTIS), a spectrometer developed by DLR, jointly with the Wilhelms Universität in Münster, on board of the ESA BepiColombo Mercury Planetary Orbiter (MPO) on its way to Mercury since October 2018 [3].

In Figure 3 we show the TIR emissivity spectra of pure Komatiite, graphite, and their mixture (graphite is 5% in weight). Spectra were measured along 2 consecutive days to reproduce day and night insulation conditions on Mercury. Effects of graphite mixed to Komatiite can be seen in the Christiansen Feature (CF) and surrounding regions.



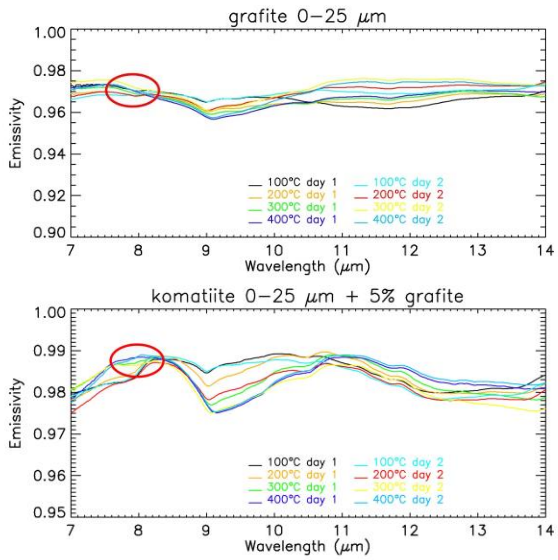


Figure 3. Emissivity spectra for the 3 Mercury analogues measured in vacuum at 100°, 200°, 300°, and 400° C over the MERTIS spectral range. Graphite spectral feature is highlighted in the region around 8 µm.

Current Study: Following up on the study performed last year on the spectral effect of graphite mixed with a mercury simulant soil, we concentrated this year on the effect of graphite on reflectance and emissivity spectra of pure minerals (chosen among the list of mercury analogues) when mixed with 5% graphite. Minerals were selected following the list we already published in [5]: among them, we selected Inosilicates (enstatite and diopside), Plagioclase feldspars (albite, labradorite and bytownite), Alkali feldspars (microcline, orthoclase), and a forsterite Fo_{90}.

The MESSENGER mission discovered that Mercury is richer in volatiles than previously expected. This is especially true for sulfur (S), with an average abundance of 4 wt%. It has been proposed that sulfur in the interior of Mercury is brought to the surface through volcanic activity in the form of sulfides as slag deposits in Mercury hollows and pyroclastic deposits. In the case of Mercury, the effect of thermal weathering affecting the spectral behavior of these sulfides must be studied carefully for their effective detection. To continue with our study, we selected some synthetic sulfides including MgS, FeS, CaS, CrS, TiS, NaS, and MnS [6]. For each sample pure and with 5% graphite mixed, we performed emissivity measurements in the thermal infrared range for sample temperatures from 100 °C to 400 °C (step 100° C), covering the daytime temperature cycle on Mercury's surface. In addition, we measured the spectral reflectance of fresh and thermally processed sulfides over a wide spectral range (0.2–20 µm) and under several phase angles [6].

This spectral library facilitates the detection of sulfides in the presence of graphite by past and future missions to Mercury by any optical. Emissivity measurements in this study will support the MERTIS instrument on the ESA/JAXA BepiColombo mission, while the reflectance of these samples in 0.2–20 µm at various phase angles will support the interpretation of measurements from past (MDIS, MASCS on MESSENGER) and future missions (SIMBIO-SYS on BepiColombo).

Summary and Outlook: At the Planetary Spectroscopy Laboratory (PSL) of DLR in Berlin we measured emissivity spectra of graphite for sample temperatures from 100° to 400° C, simulating several heating/cooling (Mercury day and night) cycles. Emissivity for Mercury simulant Komatiite (pure and mixed with 5 wt. %) was measured under the same conditions. We extended the set of spectral data already available by adding emissivity measurements of several pure minerals (chosen as analogues for the Mercury surface) mixed with the “standard” 5% amount of graphite.

Reflectance spectra for all the fresh and heated samples were measured from UV to TIR spectral range for a large range of illumination angles.

We plan to conclude this systematic study with a follow-up experiment, where it is planned to continue this study using different graphite samples and a finer graphite sample (g.s. < 10 µm) to better simulate the predicted very fine particles to be found on Mercury surface. We will monitor the influence of heating temperature on the spectral features of our samples to understand the effect of impact heating on the graphite layer beneath the Martian crust, as explained in [1].

References:

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