EMISSIVITY SPECTRA OF ANALOGUE MATERIALS AT MERCURY T-P CONDITIONS. A. Maturilli[1], J. Helbert[1], I. Varatharajan[1], H. Hiesinger[2] [1]Institute for Planetary Research, German Aerospace Center DLR, Rutherfordstr. 2, 12489 Berlin, Germany – alessandro.maturilli@dlr.de, [2]University of Münster, Germany.

Introduction: The MERTIS (MErcury Radiometer and Thermal infrared Imaging Spectrometer) instrument onboard the ESA/JAXA BepiColombo mission (launch is scheduled for 2018) is designed to identify rock-forming minerals, to map the surface composition, and to study the surface temperature variations with an uncooled microbolometer detector in the hot environment of Mercury. MERTIS is an advanced IR instrument combining a push-broom IR grating spectrometer (TIS) with a radiometer (TIR) sharing the same optics, instrument electronics and in-fight calibration components for a wavelength range of 7-14 and 7-40 µm, respectively.

At the Planetary Spectroscopy Laboratory (PSL) we measured emissivity spectra in vacuum (0.7 mbar) for a large suite of Mercury surface analogue materials in the MERTIS spectral range (7-14 µm) for sample temperatures from 100°C to above 400°C.

Set-up description: Figure 1 shows the optical table at PSL, where two identical FTIR instruments (Bruker Vertex 80V) are operating in an air-conditioned room.

Figure 1. Laboratory set-up at the PSL.

One spectrometer is equipped with aluminum mirrors optimized for the UV, visible and near-IR, the second features gold-coated mirrors for the near to far IR spectral range. An external chamber is attached to the second spectrometer to measure the emissivity of solid samples. A shutter allows separating the spectrometer from the external chamber, that can be evacuated to the same pressure as the spectrometer. If needed, an optical window (vacuum tight) can be mounted at the entrance of the emissivity chamber to operate while keeping the external chamber at ambient pressure under purged air or under inert gases. Sample targets are brought to measuring temperature using an induction heating system. For this reason our sample cups and heating surfaces are made of stainless steel. Our high efficiency induction system heats the samples to temperatures from 320K up to 900K. A sample caroussel driven by a very precise stepper motor (computer controlled) allows measuring several consecutive samples without breaking the vacuum. A large number of temperature sensors in the emissivity chamber allow monitoring the temperature of the sample as well as of several points at the equipment and chamber. A webcam is mounted in the emissivity chamber to monitor the heated sample and its vicinity. For more details, see [1, 2, 3, 4]. The same set-up, slightly modified is also used in [11].

Mercury analogues collection: Most recent results from MESSENGER‘s X-Ray Spectrometer, Gamma-Ray Spectrometer, and Neutron Spectrometer [5] have been used to compile the list of Mercury analogues. Average surface composition falls very close to the komatiite–boninite boundary. The surface of Mercury is mainly composed of Mg-rich orthopyroxene and plagioclase; plagioclase and orthopyroxene dominate the surface materials, with lesser amounts of clinopyroxene, sulfides, olivine, and silica (at lower abundances than olivine). Our collection of analogues contains olivine, enstatite, labradorite, augite, komatiite (see [6]), tektite, anorthoclase, bytownite, L-chondrite, albite, hypersthene, diopside, quartz, nepheline, graphite, a lunar simulant JSC-1A, and many sulfides. Emissivity spectra of sulfides in particular are described in [7].

Emissivity Measurements: Mercury regolith is mostly composed of very fine particles, therefore we selected the samples to be measured from our collection in the smaller fraction, being < 25 µm. Each sample was poured in a stainless steel cup and placed in the external emissivity chamber, in a position ready for measurement. Temperature sensors were put in contact with the sample emitting layer and with the sample cup, to monitor its heating properties. The emissivity chamber was then evacuated and when stable vacuum was reached (0.7 mbar), the induction system was switched on for heating the samples. Each sample was carefully and slowly heated to reach 100°C, 200°C, 300°C, and 400°C, with different sample surface temperature simulating different insulation properties (time of day and/or latitude) on Mercury surface.

Spectral Collection: In the wavelength range (7-14 µm) which will be investigated by the MERTIS spectrometer, several very diagnostic spectral features can be identified. Their evolution with surface temperature (that can also be predicted and modeled) have been already described in many scientific publications [3, 8, 9, 10, 12]. In this paper we show the emissivity spectra measured for 3 endmembers of the Mercury analogue collection, at the 4 already described increasing surface temperatures: komatiite from Barberton (Fig.2), tektite (Fig. 3), and olivine (Fig. 4), all of them in the size fraction < 25 µm.

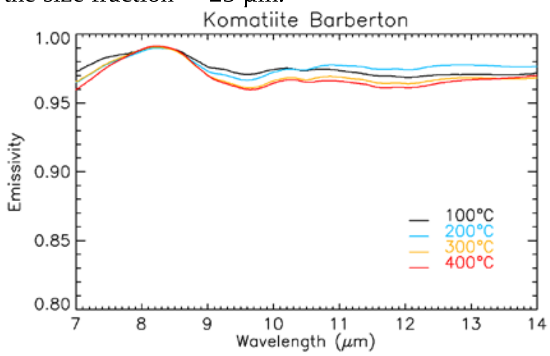

Figure 2. Emissivity spectra for a Barberton komatiite < 25 µm, measured at PSL.

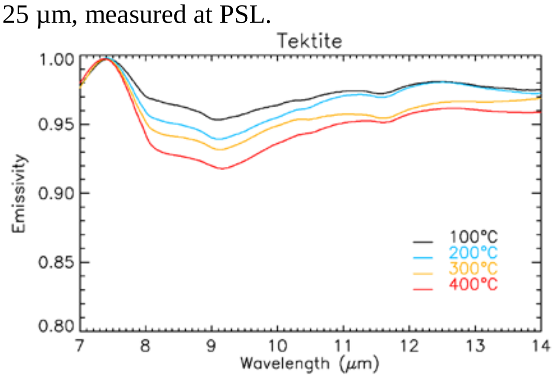

Figure 3. Emissivity spectra for a tektite < 25 µm, measured at PSL.

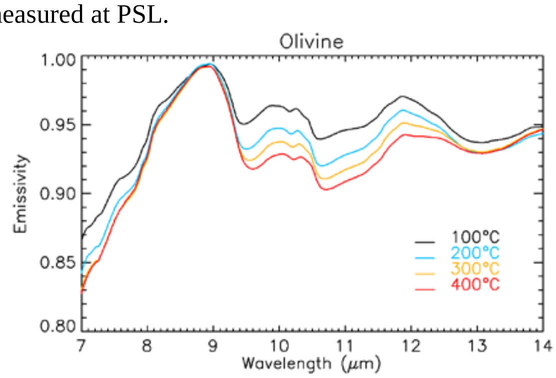

Figure 4. Emissivity spectra for an olivine ($Fo_{\#89}$) < 25 µm, measured at PSL.

These 3 entries show the strong diagnostic capabilities of the spectral signatures characteristic for the MERTIS spectral range: one can see variations in the position and shape on the CF (emissivity maxima) below 9 µm, in the shape of the Reststrahlen band (9-11 µm), and in that of the Transparency region (around 12 µm) for the 3 different materials, and the temperature dependence of some of them (c.f. the Reststrahlen bands for olivine [9, 10]).

Conclusions and Outlook: MERTIS on Bepicolombo will be the first spectrometer to observe the hot surface of Mercury in the thermal infrared wavelength range (7-14 µm), where very diagnostic features will help the detection of minerals composing the Hermean surface. These features are temperature dependent to a varying degree, therefore their spectral behavior is influenced by local insolation conditions. To prepare an adequate spectral database for MERTIS, at the Planetary Spectroscopy Laboratory (PSL) we measured emissivity spectra in vacuum for a large suite of Mercury surface analogue materials for sample temperatures from 100°C to above 400°C. The spectral library for Mercury analogues is completed by reflectance measurements on the same samples, fresh and after been heated in vacuum, covering the whole spectral range from 0.2 to 200 µm.

See more information on the PSL website: http://www.dlr.de/pf/desktopdefault.aspx/tabid-10866/19013_read-44267/

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