A SET OF LABORATORY ANALOGUE MATERIALS FOR THE MERTIS INSTRUMENT ON THE ESA BEPICOLOMBO MISSION TO MERCURY.

J. Helbert[1], L.V. Moroz[1,2], A. Maturilli[1], A. Bischoff[2], J. Warell[3], A. Sprague[4], E. Palomba[5], [1] Institute for Planetary Research, DLR, Rutherfordstrasse 2, D-12489 Berlin, Germany, joern.helbert@dlr.de, [2] Institute of Planetology, University of Münster, Wilhelm-Klemm-Strasse 10, D-48149 Münster, Germany, [3]Department of Astronomy and Space Physics, Uppsala University, Sweden, [4]Lunar Planetary Laboratory, University of Arizona, USA, [5]Institute for Interplanetary Space Physics - INAF, Rome, Italy

Introduction: The MERTIS (Mercury Thermal Imaging Spectrometer) instrument on the ESA mission BepiColombo will study the surface of Mercury in the wavelength range from 7 to 14 µm. The analysis of the MERTIS data will be posing a number of significant challenges. To facilitate the development of analytic tools, support planned ground based observations and support a cross calibration with other instruments on BepiColombo and MESSENGER, a list of Mercury analogue materials was compiled [1]. This set of analogue materials is based on our current knowledge of the surface composition of Mercury and includes plagioclase and potassium feldspars, low Ca and high Ca pyroxenes, olivine, elemental sulfur and as an extraterrestrial analogue a lunar highland soil sample.

Exploring Mercury: After a hiatus of more than 30 years two spacecraft are slated to explore Mercury. While the NASA mission MESSENGER is already on its way to Mercury, the ESA mission BepiColombo will follow with a planned launch in 2013. Both spacecraft carry comprehensive sets of instruments aimed at understanding the surface composition of Mercury. On BepiColombo, the imaging spectrometer MERTIS will study the surface of the planet in the thermal infrared wavelength range [2], SYMBIO-SYS will study the surface in the NIR and VIS ranges from 0.4 to 2 µm [3]. On MESSENGER, the MASCS instrument will cover the wavelength range from 0.3 to 1.45 µm. Also, the Mercury Dual Imaging System (MDIS) on MESSENGER has color filters and 2 clear filters between 400 and 1100 nm for studying the soil maturity and mineralogy as well as for stereo imaging [4]. This will be complemented by a suite of x-ray, γ-ray and neutron spectrometer on both spacecraft which will analyze the elemental composition of the surface of Mercury [4].

The high surface temperature and the general notion that the surface of Mercury might be rich in feldspars and poor in FeO were the driver for the development of MERTIS. MERTIS is an IR-imaging spectrometer based on the pushbroom principle. It covers the spectral range from 7-14 µm at a high spectral resolution of up to 90 nm which can be adapted even along an orbital track, depending on the actual surface properties to optimize the S/N ratio. MERTIS will globally map the planet with a spatial resolution of 500 m and a S/N of at least 100. For a typical dayside observation the S/N ratio will exceed 1000 even for a fine-grained and partly glassy regolith. MERTIS will map 5-10% of the surface with a spatial resolution higher than 500 m.

The interpretation of the data returned by MERTIS will pose a number of challenges. Not only is our knowledge about the surface composition very limited, but we also know little about the texture and the physical properties of the regolith. Therefore it is highly important to use the time until BepiColombo will arrive at Mercury to conduct a thorough scientific preparation including the measurement of a wide range of laboratory emissivity spectra of terrestrial and lunar silicates.

The intent for the set of analogue materials presented here is to define a baseline and a standard for future work. This will include studies on grain size effects, physical alteration and mixing effects. It will also support the interpretation of ground-based observations of Mercury.

Analogue materials: We have compiled a basic set of analogue materials based on our current knowledge of the surface composition of Mercury [1]. This set includes plagioclase and potassium feldspars as suggested by the TIR observations. The potassium feldspar is included as a possible source for the potassium detected in the exosphere of Mercury. Low Ca and especially high Ca pyroxenes are suggested by the recent NIR observations. The existing observations in the TIR and in the VIR/NIR wavelengths region indicate a low likelihood for Fe-rich olivine. Therefore an iron-poor olivine has been included. Elemental sulfur is a possible alternative explanation for the radar bright deposit in the polar regions of Mercury. Finally as an extraterrestrial analogue a lunar highland soil sample is included.

Little is known about the grain size distribution of Mercury's regolith. The low spectral contrast observed in TIR spectra of Mercury might indicate a fine grain size on the order of a few tens of microns. The samples are prepared in four different grain size separates ranging from 0 to 250 µm to cover the expected grain size distribution on the surface of Mercury.

The list of analogue materials (minerals and a lunar soil sample) selected for laboratory studies supporting MERTIS development/calibration and interpretation of the future results is given in Table 1. The samples are labeled as MA (MERTIS ANALOGUE) 1-9 for future reference. For detailed information see [1].

Internal number	**Mineral**	**Subclass, group, formula**
MA 1	Andesine-Labradorite (An_{47-52})	Tectosilicate, plagioclase feldspar $(Ca,Na)(Al,Si)AlSi_2O_8$
MA 2	Oligoclase	Tectosilicate, plagioclase feldspar $Na(Ca)AlSi_3O_8$
MA 3	Anorthite	Tectosilicate, plagioclase feldspar $CaAl_2Si_2O_8$
MA 4	Orthoclase	Tectosilicate, potassium feldspar $KAlSi_3O_8$
MA 5	Enstatite En_{85}	Inosilicate, orthopyroxene $(Mg,Fe)SiO_3$
MA 6	Diopside	Inosilicate, clinopyroxene $Ca(Mg,Fe)Si_2O_6$
MA 7	Forsterite Fo_{90}	Nesosilicate, olivine $(Mg,Fe)_2SiO_4$
MA 8	Sulfur	Element, non-metal, S
MA 9	Apollo 16 soil sample 62231	Mature lunar soil

Table 1: Summary of the Mercury analogue (MA) materials

Planned laboratory studies: The acquisition of the spectral emission database of analogue materials of variable particle sizes will be the major part of our laboratory studies. Spectral contrasts of thermal emission features are significantly affected by particle size variations [5]. Unlike the ASU thermal emission spectral library [6], our database will be focused on relatively fine-grained size separates (Table 1), providing a realistic basis for interpretation of thermal emission spectra of planetary regoliths.

The spectral emission of all size separates between 7 and 22 µm will be acquired using an emissivity chamber attached to the Brucker IFS88 FTIR spectrometer. The equipment, calibration, measurement procedure, and examples of thermal emission spectra have been described in detail by [7].

Along with the thermal emission measurements of the pure analogue materials, we plan to perform thermal emission spectral studies of several mineral mixtures of various particle sizes. This is necessary to evaluate and possibly to improve the existing spectral deconvolution techniques, such as linear deconvolution [8]. The ultimate goal of these studies will be the development of a reliable spectral deconvolution technique, which would enable us to derive mineral modal abundances from the MERTIS thermal emission spectra of the mature Mercury regolith.

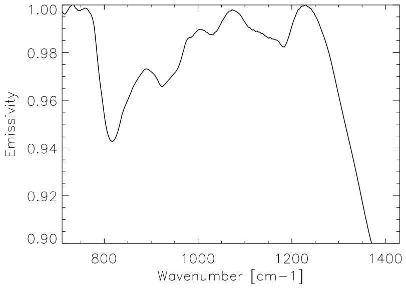

Figure 1: Spectrum of anorthite (MA 3 - 0-25 µm grain size separate) for the spectral range of MERTIS

Physical environment may significantly affect spectral emissivity (e.g., [9]). We plan to improve our experimental setup to perform thermal emission spectral measurements at low pressures. The possible existence of an emittance excess at 5 µm for Mercury indicate the existence of a significant thermal gradient in the dayside regolith [10,11].

Conclusions: The definition of this basic set of analogue materials is the starting point for intensive laboratory studies addressing for example grain sizes effects, physical alteration and effects of temperature gradients within the regolith. The sample list presented will form the core of a spectral library - focused on relatively fine-grained size separates (Table 1), providing a realistic basis for interpretation of thermal emission spectra of planetary regoliths.

The set of analogue materials presented here is primarily prepared for MERTIS. However, since all samples will be well characterized, this set is ideally suited for cross-calibration between the instruments addressing the surface composition of Mercury, namely the NIR channel of SYMBIO-SYS on BepiColombo but also the MASCS instrument on MESSENGER. Using a common set of samples for cross-calibration especially of instruments working in different wavelength ranges will generate a synergetic effect for the actual measurements obtained at Mercury. In the future this might even be extended to the instruments using different techniques like for example the x-ray spectrometer MIXS on BepiColombo.

References: [1] Helbert, J. et al. (2006) *AdvSR*,submitted. [2] Helbert et al. 2005 (2005) *LPS XXXVI* #1753 [3] Capaccioni et al. (2004) *DPS meeting #37*, #57.02. [4] Gold et al. (2001) *PSS* Planet. Space Sci., 49, 1467-1479 [5] Hunt and Vincent (1968) JGR 73, 6039-6046 [6] Christensen, P. (2000) *JGR* 105, 9735-9740 [7] Maturilli, A.et al. (2006) *PSS* submitted. [8] Ramsey and Christensen (1998) *JGR* 103, 577–596 [9] Logan, L. and Hunt, G.R. (1970) JGR 75, 6539-6548 [10] Emery, J.P. et al. (1998) *Icarus*, 136, 104-123 [11] Cooper, B. (2001) JGR 106, E12, 32803-32814