THE BERLIN EMISSIVITY DATABASE (BED): A COLLECTION OF EMISSIVITY SPECTRA FOR PLANETARY ANALOGUE MINERALS.

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Introduction: Mineralogical composition study of planetary surfaces is mostly performed by means of remote sensing infrared spectroscopy. The interpretation of measured spectra should take advantage of laboratory measurements of analogue minerals.

The Berlin Emissivity Database (BED) is focused on relatively fine-grained size separates to provide a realistic basis for the interpretation of remote senseing thermal emission spectra of planetary regoliths. The Berlin Emissivity Database (BED) currently contains emissivity spectra of plagioclase and potassium feldspars, low Ca and high Ca pyroxenes, olivine, elemental sulphur, Martian analogue minerals, and volcanic soils measured in the wavelength range from 7 to 22 µm as a function of particle size. For each sample the spectra of four particle size separates ranging from <25 to 250 µm are measured, with a spectral resolution of 4 cm^{-1}.

Sample preparation and instrument setup: The BED spectral library contains entries in well-defined grain size ranges: <25 µm, 25-63 µm, 63-125 µm, and 125-250 µm. The minerals are fragmented (magnetic impurities are removed), and then ground in a centrifugal ball mill. The resulting particles are wet- or dry-sieved, depending on their nature. For most of the samples, chemical composition is derived by X-ray fluorescence analysis. Four aluminium cups are filled with the different grain size fractions, and then stored in an oven at 90° C for several hours, to reduce the amount of adsorbed water.

Fourier transform infrared spectrometer Bruker IFS 88, purged with dry air and equipped with a liquid-nitrogen-cooled HgCdTe (MCT) detector is used to collect spectra, all with a spectral resolution of 4 cm^{-1}. The sample chamber (external to the spectrometer), is maintained at a constant temperature by water circulating between its inner and outer walls. The spectrometer and the chamber are purged with dry air to reduce water vapour and CO_2 spectral features in the measurements. Figure 1 shows the instrument setup at the DLR laboratory in Berlin.

Attached to the sample chamber is black body equipment, with temperature accuracy ± 0.5°C, stability ± 0.2°C, cavity uniformity ± 0.3°C at 300°C, and emissivity 0.999 ± 0.001. The blackbody at 60°C and 90°C is measured every day to determine the instrument response function, while a gold standard measurement provide an estimate of the instrument total reflected energy.

Figure 1. The emissivity device room at the DLR Institute for Planetary Research in Berlin, Germany.

Calibration: The spectra in the BED library are calibrated following the one-temperature method described in [1], enabling to account for all the energy contribution with a measurement for each sample at only one temperature. The instrument response function is derived from two blackbody measurements. The sample temperature is defined as the highest value of the brightness temperature. Instrument energy, reflected energy, and environmental energy are calculated and removed from the measured radiance using the calibration measurements, so that the sample emissivity can be computed as the ratio between the sample radiance and a calculated blackbody radiance at the sample temperature. The accuracy of this method is within 2% emissivity in most of the cases [2].

Documentation and data: The BED library will be soon available online in digital form at http://www.dlr.de/pf/de/bed.html. A permanent six-digit number - USI (Unique Sample Identifier) is assigned to each new sample after preparation. This helps to avoid problems of reclassification when the same sample is measured again in the future. The USI gives access to all spectra of this sample available in the database as well as to a Sample Information Package (SIP), containing all the information on mineral identification, sample preparation, chemical analyses, sample history, and measurement parameters.

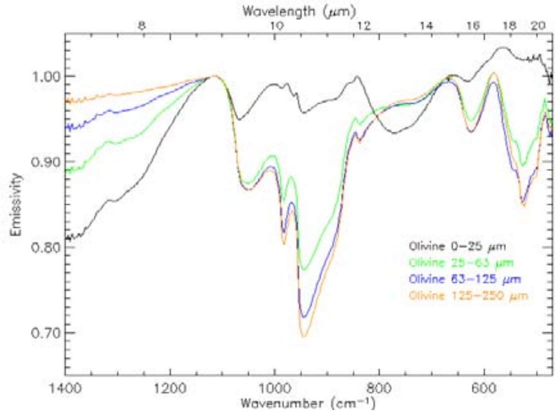

Figure 2. Emissivity spectra of olivine separates.

Complementary to the existing emissivity spectral libraries (ASU and ASTER), the BED database contains spectra for the small grain sizes for a wider spectral range. Figure 2 shows, as an example, the emission spectra of the four olivine (San Carlos forsterite Fo_{90}) separates from the BED library. For this mineral, the Christiansen maximum occurs at 1115 cm^{-1} (or around 8.9 µm), while the principal emission minima (Reststrahlen bands) in the 850-1100 cm^{-1} region are due to stretching of Si-O bonds in the SiO_4 tetrahedra. The positions and shapes of these bands are strongly affected by particle size, so that the spectral contrast is noticeably reduced for the finest particles. A separate emissivity minimum (Transparency feature) appears in the spectrum of the fine-grained sample (<25 µm) around 770 cm^{-1}. The spectral features at wavenumbers lower than 600 cm^{-1} are due to increasing noise, while the weak narrow band around 667 cm^{-1} and the features at wavenumbers higher than 1300 cm^{-1} result from residual CO_2 and water vapour in the sample chamber, respectively.

Conclusion and outlook: Currently the BED library contains spectra of more than 20 minerals in the previously described grain size ranges. The major part of the current datased is composed by the list of Mercury analogues, containing minerals likely to be found on the surface of Mercury [3], to be used for the interpretation of data from the MERTIS instrument on the ESA BepiColombo mission. Similar lists will be compiled for Mars and the Moon too.

We are currently working to upgrade our laboratory facilities: a new Bruker VERTEX 80v spectrometer has been installed at the DLR Institute of Planetary Research in Berlin. This instrument has a very high spectral resolution (better then 0.2 cm^{-1}), resolving power of better than 300,000:1, and can work under vacuum conditions providing optimal conditions for Mercury and Lunar analogues measurements. New detectors and beamsplitters will allow us to extend the spectral coverage to 1 to 50 µm. Figure 3 shows the new instrument in the DLR laboratory, in Berlin.

Figure 3. The new Bruker VERTEX 80v on the optical bench at the DLR Institute for Planetary Research in Berlin, Germany.

A study for the design of the new emissivity chamber is currently performed: the chamber will allow measuring cold and hot (up to 700K) samples even under vacuum conditions, following the methodologies for measurements and calibrations described above.

References: [1] Maturilli A., Helbert J., Witzke A., Moroz L. (2006) *PSS 54, 11,* 1057-1064. [2] Maturilli A., Helbert J., Moroz L. (2006) *PSS, in press.* [3] Helbert J., Moroz L., Maturilli A., Bischoff A., Warrell J., Sprague A., Palomba E. (2006) *ASR, in press*.