EMISSIVITY SPECTRA OF SOME PHYLLOSILICATES IN THE [3, 50] µm SPECTRAL RANGE FROM THE BERLIN EMISSIVITY DATABASE (BED). A. Maturilli and J. Helbert, Institute for Planetary Research, DLR, Rutherfordstrasse 2, 12489, Berlin, Germany (alessandro.maturilli@dlr.de)

Introduction: Hydrous minerals as phyllosilicates class have been detected on Mars by the OMEGA instrument, onboard the ESA Mars Express mission [1, 2]. These minerals can keep the record of the interaction of martian pristine rocks with water. The OMEGA analysis found a limited range of mineralogy (Fe/Mg and Al smectite), located only in ancient terrains [3]. The very recent measurements of the CRISM instrument, onboard the NASA MRO mission, show that the phyllosilicate mineralogy on Mars is wider, giving evidence of kaolinite, chlorite, illite or muscovite, and hydrated silica. Furthermore, nontronite, saponite, and in less amount, chlorite are the most common smectites [3].

Actually, still another instrument is observing Mars from orbit: the PFS on Mars Express, measuring the emerging Mars radiation in the SWC from 1 to 5 µm and in the LWC from 5 to 45 µm.

For the interpretation of the remote sensing measured data an emissivity spectral library of planetary analogue materials is needed. The Berlin Emissivity Database (BED) presented here is focused on relatively fine-grained size separates, providing a realistic basis for interpretation of thermal emission spectra of planetary regoliths, and is therefore complimentary to existing thermal emission libraries.

Spectral Library: The Berlin Emissivity Database (BED) is a spectral library containing the emissivity measurements of several planetary analogues. It contains currently entries for plagioclase and potassium feldspars, low Ca and high Ca pyroxenes, olivines, elemental sulphur, common martian analogues (JSC Mars-1, Salten Skov, palagonites, montmorillonite, hematite, goethite), phyllosilicates (several kaolinites, chlorite, illite, some nontronites, saponite, talc, biotite), garnets, feldspathoids, and a lunar highland soil sample measured in the wavelength range from 3 to 50 µm as a function of particle size. For each sample, the spectra of four well defined particle size separates (<25 µm, 25-63 µm, 63-125 µm, 125-250 µm) are measured with a 4 cm^{-1} spectral resolution. These size separates have been selected as typical representations for most of the planetary surfaces [4, 5].

Laboratory set-up: The instrumentation is located in the Planetary Emissivity Laboratory (PEL) at the Institute for Planetary Research (PF) of the German Aerospace Center (DLR) in Berlin, Germany. It consists of a spectrometer attached to an external emissivity device. The Bruker VERTEX 80v spectrometer, has a very high spectral resolution (better then 0.2 cm^{-1}), and a resolving power of better than 300,000:1, and can be operated under vacuum conditions. To cover the to 16 µm spectral range, a liquid nitrogen cooled MTC detector, a KBr beam-splitter, and a KBr entrance port are used. The 16 to 50 to µm spectral range is measured using a room temperature DTGS, a Multilayer beam-splitter, and a CsI entrance port.

The emissivity device is composed of the sample chamber, a double-walled box with three apertures: a 15 cm squared door used to insert the cup in the box, a 5 cm rounded opening through which the beam is directed to the spectrometer and a 5 cm opening facing the attached blackbody unit. A heater is placed in the chamber and is used to heat the cup with samples from the bottom. The thermal radiation emitted normal to the surface by the sample or the blackbody is collected by an Au-coated parabolic off-axis mirror and reflected to the entrance port of the spectrometer.

A pump circulates water at a constant temperature in the volume between the inner and outer walls of the chamber. The surfaces of the box are painted with black high emissivity paint. The chamber is purged with dry air to remove particulates, water vapour and CO_2. Further details can be found in [6, 7].

Validation of the measurements: An exhaustive suite of tests has been performed to study and characterize our experimental setup. Among these, the repeated measurement of the same target is a meaningful test for the investigation of the instrument stability. Eleven measurements of the same target, a cup containing the 125-250 µm grain size separate of quartz at 180° C, has been repeated, with a time interval of 5 minutes between each shot.

Figure 1 shows the calibrated emissivity for all the 11 measurements (each in a different colour), together with the average over all the calibrated data. The picture clearly prove the stability of our set-up, especially when considering that the whole 3 to 50 µm spectral range is covered operating the instrument with the two detectors, the beam-splitters and the entrance windows in two different days.

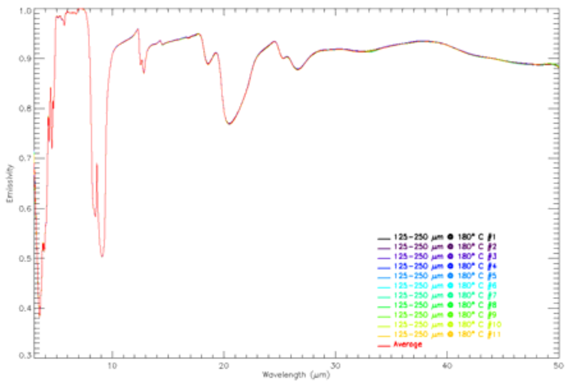

Fig. 1 Repeated measurements of a 125-250 µm quartz sample at 180° C.

By means of such kind of repeated measurements, we can estimate the standard deviation of our calibrated data, as shown in Figure 2. It is evident from the picture how limited is the error on our measurements, always well below 0.1% across the whole spectral range, except for the region between 3 and 4 µm, where the noise level is higher, due to the blackbody radiation approaching the zero value, at the samples operational temperature (180° C).

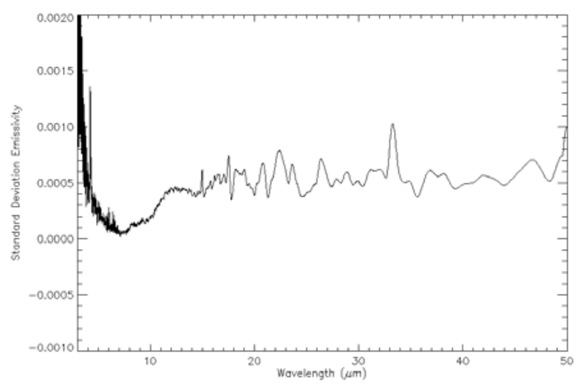

Fig. 2 Standard deviation for the repeated measurements of a 125-250 µm quartz sample at 180° C.

Future measurements at 500° C will allow us to extend the spectral range to at least 1 µm, providing the scientific community a unique new set of data.

Emissivity of phyllosilicates: As an example of the numerous spectra of phyllosilicates present in the BED library, we discuss the emissivities of our 4 standard grain sizes of the Fe/Mg rich saponite endmember, shown in Figure 3. A serie of diagnostic maxima and minima in emissivity occur in the 3 to 30 µm spectral region, while the rest of the spectra is almost flat and featureless. The Cristiansen feature (a maximum in emissivity) is located at 8.04 µm, corresponding to 1244 cm^{-1}, in agreement with previous studies [8]. The bands depth strongly depends on the grain sizes, this is a well known already described phenomena. The large adsorption band around 10 µm (1000 cm-1) is due to Si-O stretching, while the Mg_3OH bending vibration is observed at 15.15 µm (660 cm^{-1}). To note is the series of bands between 10 and 14 µm, in particular the change in shape, depending on the grain size, of the band at 11 µm and the shift in the band center position for the 12 µm feature. The 6.94 (1440 cm^{-1}) feature could be due to ammonium substitution in the mineral [9].

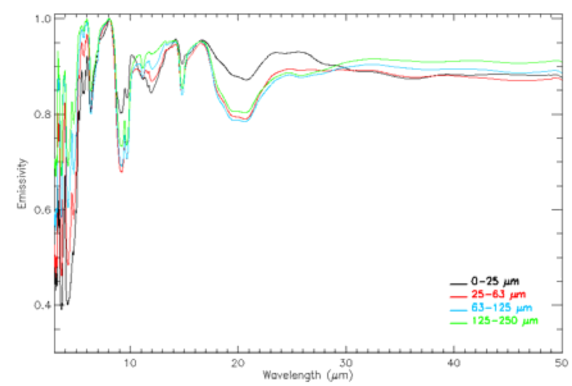

Fig. 3 Emissivity spectra of saponite in the 4 BED grain sizes.

Outlook: The spectral library has been built to analyse the PFS measured spectra, especially for the LWC channel. The first step of this process is to search for confirmation of the OMEGA and CRISM results using the PFS data, and then use the large database of martian measurements for new investigations. However, the spectral range covered by the BED data could be of primary importance to understand the PFS SWC, OMEGA and CRISM measurements in the 3 to 5 µm spectral region.

The activity in the lab will be focused on understanding the spectral influence for different degrees of hydration in the martian analogue minerals.

References: [1] Bibring J. P. et al. (2005) *Science, 307*, 1576-1581. [2] Poulet F. et al. (2005) *Nature, 438*, 623-627. [3] Mustard J. F. et al. (2008) *Nature, doi:10.1038/nature07097*. [4] Hiesinger H., Helbert J., et al. (2008), *submitted to PSS*. [5] Helbert J. et al. (2007) *ASR, 40*, 272-279. [6] Maturilli A. et al. (2006) *PSS, 54*, 1057-1064. [7] Maturilli A. et al. (2008) *PSS, 56*, 420-425. [8] Koeppen W. C. and Hamilton V. E. (2005) *JGR, doi:10.1029/2005JE002474*. [9] Glotch T. D. et al. (2007) *Icarus, 192*, 605-622.