Measurements at the Planetary Emissivity Laboratory in support of MARA and the TIR imager on the JAXA Hayabusa II mission. J. Helbert[1], A. Maturilli[1], M. Grott[1], J. Knollenberg[1], E. Kührt[1], T. Okada[2] and T. Spohn[1], [1]Institute for Planetary Research, DLR, Rutherfordstrasse 2, 12489 Berlin, Germany – joern.helbert@dlr.de, [2]ISAS/JAXA, Sagamihara, Japan.

Introduction: The JAXA Hayabusa mission returned in June 2010 the first samples collected in-situ on an asteroid surface. Hayabusa studied asteroid Itokawa from September 2005 for several months. The mission revealed many new details on the target asteroid [1,2].

Despite the scientific success of the mission one has to keep in mind that Hayabusa was an engineering mission built to test new technologies and concepts. Hayabusa II is a science mission building on the heritage of the Hayabusa mission taking into account the lessons learned.

Two important additions to the Hayabusa II mission are a thermal infrared imager build by JAXA on the orbiter and the lander element MASCOT (Mobile Asteroid Surface Scout) as a DLR contribution.

At the Planetary Emissivity Laboratory (PEL) at DLR we perform measurements on analog materials to explore the possibility of mineralogical studies with the thermal infrared imager and the radiometer MARA (MAscot RAdiometer) on MASCOT. We further support the MARA development with accompanying laboratory measurements.

MARA: The radiometer MARA is part of the MASCOT payload and will conduct in situ radiative flux measurements. The MARA sensor head consists of six individual channels and measures the radiative flux in the field of view using thermopile sensors coated with a black silver smoke absorber surface. Each channel is fitted with its own infrared filter, and a long-pass filter will be used to radiatively determine the surface brightness temperature, while a short-pass filter will be used to estimate the surface albedo. The remaining four channels are fitted with band-pass filters, which will be used for mineralogical investigations, and, furthermore, shall support the inversion of the kinetic surface temperature from the measured fluxes

The PEL: The Institute for Planetary Research has an expertise in spectroscopy of minerals, rocks, meteorites, and organic matter, build up in more than two decades. The available equipment allows spectroscopy from the visible to TIR range using bi-conical reflection and emission spectroscopy.

The laboratory experimental facilities (see Figure 1) consist of the main Planetary Emissivity Laboratory (PEL) to measure the emissivity of planetary analogue materials from 1 to 100 µm from low to very high (700K) sample temperatures, and the supporting spectrometer laboratory for reflectance, transmittance and low/moderate temperature emissivity measurements [3,4], sample preparation facilities and an extensive collection of rocks and minerals.

Figure 1: View of the main facility in the PEL

The Bruker VERTEX 80V FTIR spectrometer has a very high spectral resolution and resolving power, and can be operated under vacuum conditions to remove atmospheric features from the spectra. To cover the 1 to 100 µm spectral range, two detectors, a liquid nitrogen cooled MTC (1-16 µm) and a room temperature DTGS (16-100 µm) and two beamsplitter, a KBr and a Multilayer, are used.

The spectrometer is coupled to a planetary simulation chamber that can be evacuated to < 1mbar, while an automatic sample transport system allows maintaining the vacuum while changing the samples.

The Bruker A513 accessory is used to get bi-directional reflectance with variable incidence and emission angles between 13° and 85°. We measure at room temperature, under purge or vacuum conditions, in the 1 to 100 µm spectral range. In the same wavelength range a Bruker A480 parallel beam accessory allows us to measure transmission of thin slabs, optical filters, optical windows, etc., avoiding refraction and beams shifts.

The second instrument is the Bruker IFS 88 with an attached emissivity chamber, developed at DLR, for low to moderate temperature measurements. The chamber is purged with dry air to remove particulates, water vapor and CO_2, and cooled at 10° or 20° C (the temperature can be set to below zero when needed) [8, 9]. A Harrick Seagull™ variable angle reflection accessory mounted in the Bruker IFS 88 allows measuring bi-conical reflectance of minerals at room temperature, under purging conditions in the extended spectral range from 0.4 to 55 µm.

TIR observations with Hayabusa II: The thermal infrared (TIR) imager on Hayabusa II is building on the heritage of the LIR camera on Venus Climate Orbiter. It will image the asteroid surface with a broadband filter from 8-16µm. Its main purpose is to constrain the thermal physical properties of the surface.

However the TIR is also ideally suited for mineralogical studies. The broadband filter will not allow studying individual features, however the variation in absolute flux might give some indication on compositional variations.

At the landing site the MARA instrument will provide us with more detailed spectral information. The four bandpass filters and the two broadband filters will allow assessing for one location the mineralogy in more detail. This will provide important ground truth for the TIR imager on the orbiter.

Laboratory measurements: We have been supporting the MARA development by measuring the filter materials over a wide spectral range.

Now we have started measurements of a suite of minerals to assess the capabilities of MARA in identifying rock-forming minerals. Figure 2 shows an example of spectra for an olivine and a clinopyroxene sample in two grain size fractions each. The locations of the four MARA bandpass filters are indicated. As can be seen the spectral placement of the filters allows constraining the position of the emissivity maximum similar to the approach used by DIVINER on LRO (Lunar Reconnaissance Orbiter) [5] and to assess the depth of the transparency features beyond 10µm.

A detailed survey of a set of analog materials is currently ongoing. Based on these different techniques for identifying minerals based on only four spectral points and the information from the broadband filters are evaluated.

Summary: The capability of Hayabusa II to image the surface in the thermal infrared spectral range and the multi-spectral capabilities of the MARA instrument on the MASCOT lander will allow to get a first assessment of the mineralogy of the target asteroid during the orbital phase.

The PEL is currently performing laboratory measurements helping to optimize this assessment and devising an optimal strategy for the mineralogical identification.

References: [1] Fujiwara A. et al (2006) *Science,* 312*,* 1330–1334. [2] Abe, M. et al. (2006) *Science,* 312*,* 1334-1338. . [3] Maturilli A. et al. (2006) *PSS*, 54, 1057-1064. [4] Maturilli A. et al. (2008) *PSS*, 56, 420-425. [5] Greenhagen, T. et al. (2010) *Science*, 329, 1507-1509.

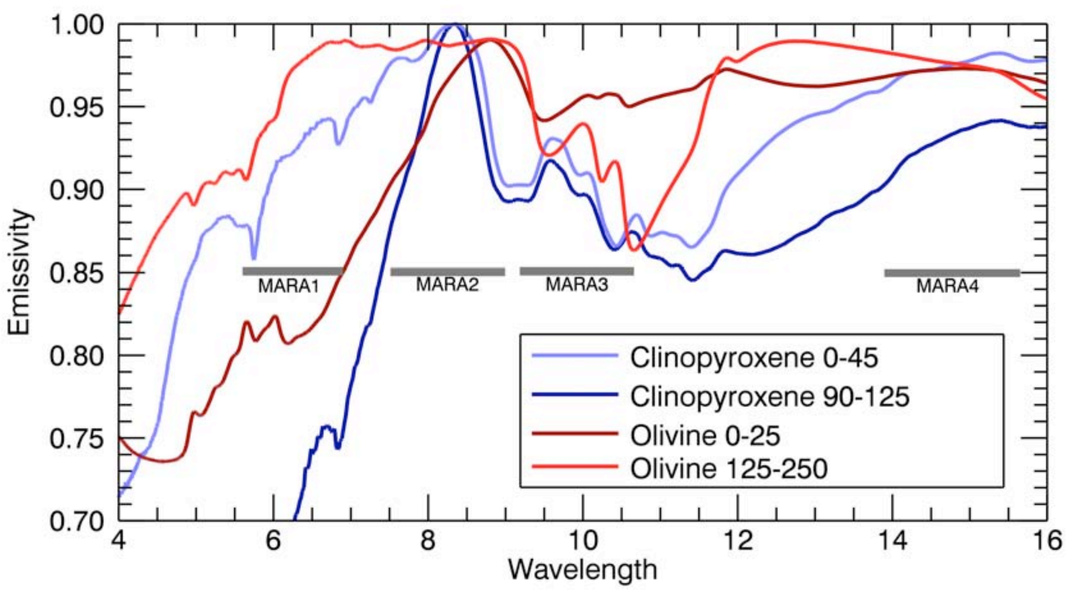

Figure 2 Spectra of olivine and clinopryoxene in two grain size fractions - the locations of the MARA mineralogical filters are indicated