PHOBOS REGOLITH SIMULANT FOR MMX MISSION: SPECTRAL MEASUREMENT FOR REMOTE TARGET IDENTIFICATION AND DECONVOLUTION SYSTEM TRAINING

M. D'Amore[1], A. Maturilli[1], H. Miyamoto[2], T. Niihara[2], M. Grott[1], J. Knollenberg[1], J. Helbert[1], N. Sakatani[3], K. Ogawa[4]

[1]Institute for Planetary Research, DLR, Rutherfordstrasse,[2]Dept. Systems Innovation, University of Tokyo, Tokyo 113-8656, Japan; [3]Institute of Space and Astronautical Science, Japan Aerospace Exploration Agency, 3-1-1 Yoshinodai, Sagamihara, 252-5210, Japan; [4]Department of Planetology, Kobe University, 1-1 Rokkodaicho, Nada, 657-8501 Hyogo, Japan [1]contact author: mario.damore@dlr.de

Abstract

The two natural satellites of Mars, Phobos and Deimos are both important targets for scientific investigation. The JAXA mission Martian Moons eXplorer (MMX) is designed to explore Phobos and Deimos, with a launch date scheduled for 2024. The MMX spacecraft will observe both Martian moons and will land on one of them (Phobos, most likely), to collect a sample and bring it back to Earth. The designs of both the landing and sampling devices depend largely on the surface properties of the target body and on how its surface is reacting to an external action in the low gravity conditions of the target. The Landing Operation Working Team (LOWT) of MMX started analyzing previous observations and theoretical/experimental considerations to better understand the nature of Phobos surface material, developing a Phobos regolith simulant material for the MMX mission. At the Institute for Planetary Research of the German aerospace Center (DLR) in Berlin we performed a spectral characterization of the Phobos regolith simulant. Those data will be used to train an Artificial Neural Network (NN) to produce a system that could rapidly classify data during the mission and for endmember decomposition.

Material Preparation

Raw material was crushed into very fine particles, which are mixed with carbon nanoparticles and polymer organic materials.

They were then mixed under wet condition and dried completely

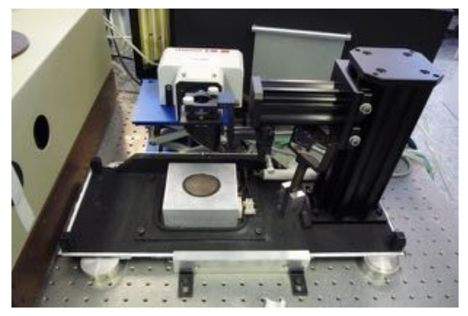
We have received 10 kg of UTPS-TB (estimation was 1Kg for grain-size range) and produced different grain-size fractions of the material

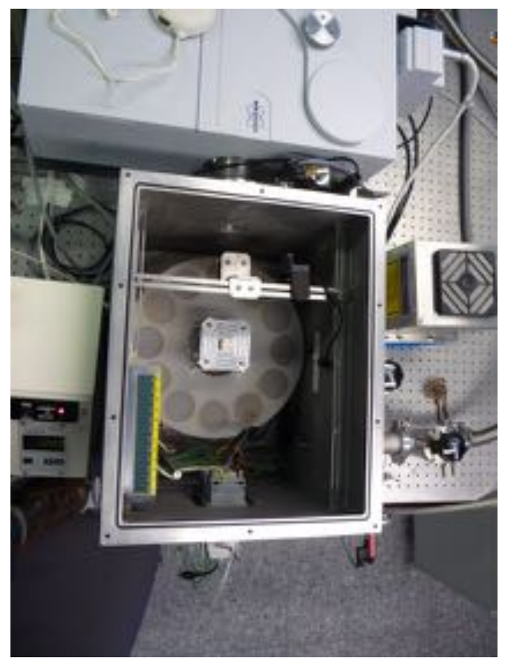
UTPS-TB, Tagish lake based
~62% Mg-rich phyllosilicates
~7% Mg-rich olivine
~8% Magnetite
~9% Fe-Ca-Mg carbonates
~10% Fe-Ni sulfides
~3% Organic

Sieved Fractions
< 400 µm
400 – 500 µm
500 µm – 1.6 mm
1.6 mm – 2 mm
2 mm – 3.55 mm
3.55 mm – 4 mm

- Albedo of the particles is very low with some bright minerals intermixed in the grains
- Calculated grain density is 2.8 g cm^{-3}, density of the pressed material is 1.4 g cm^{-3}, density of the granular material is 0.78-0.83 g cm^{-3}, so there is considerable micro- and macro porosity.
- Particles are very angular and show many small pits

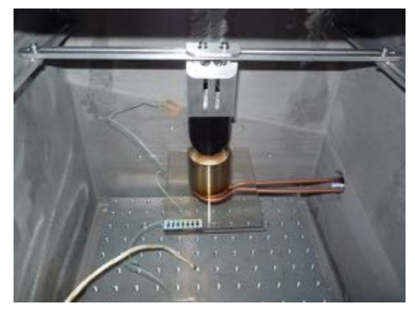
Spectral Measurements





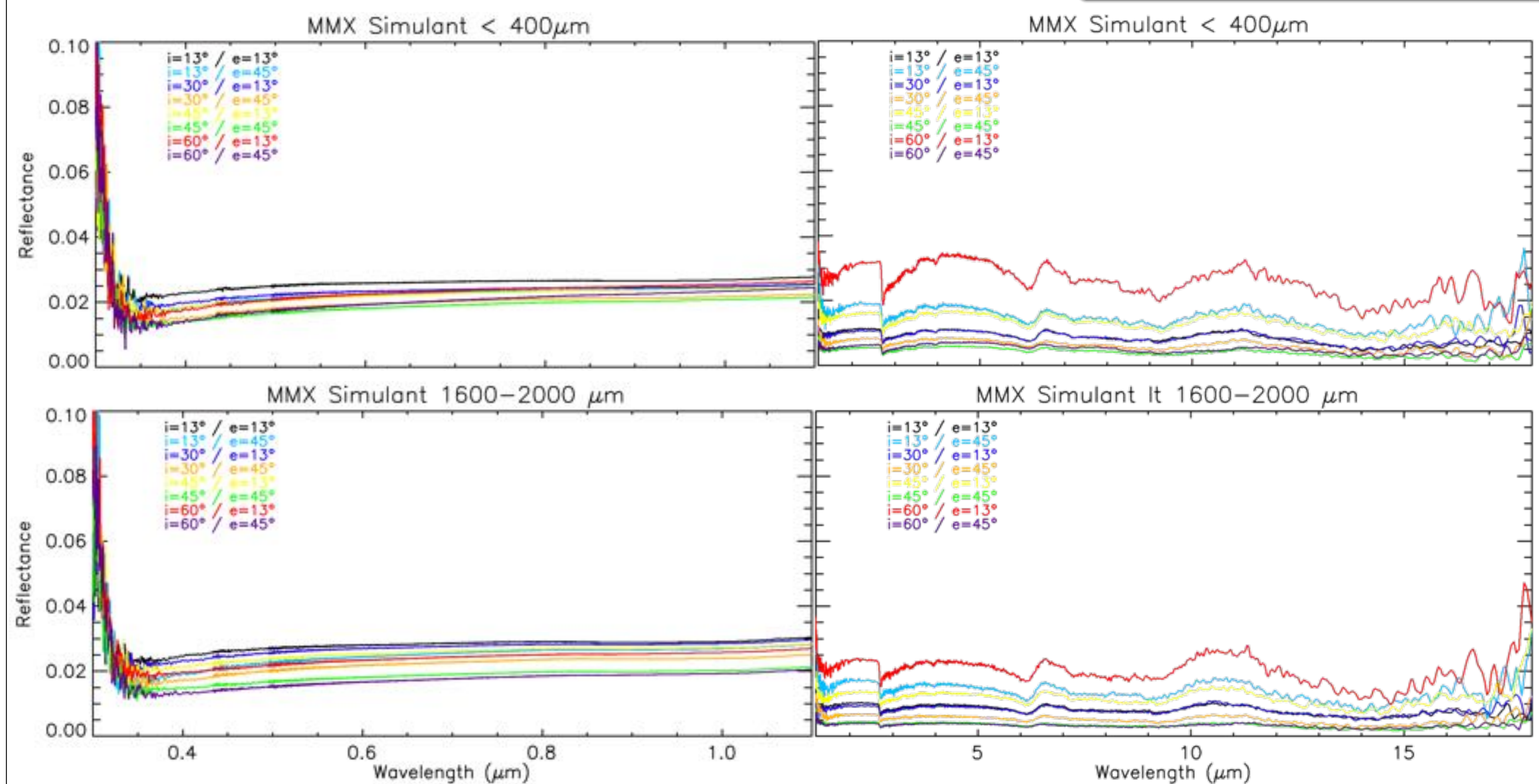
Instrument Bruker Vertex 80V (under vacuum) coupled via a shutter with evacuated emissivity chamber containing blackbody, stepper motor, sample holding carousel, webcam, and an induction system to heat the samples from 320K to above 900K. Complementary reflectance and transmission measurements via dedicated hardware units in 0.4 to 200 µm spectral range.

Instrument Bruker Vertex 80V (under vacuum) coupled with air purged and water cooled emissivity chamber to heat the samples from 20° C to 180° C.

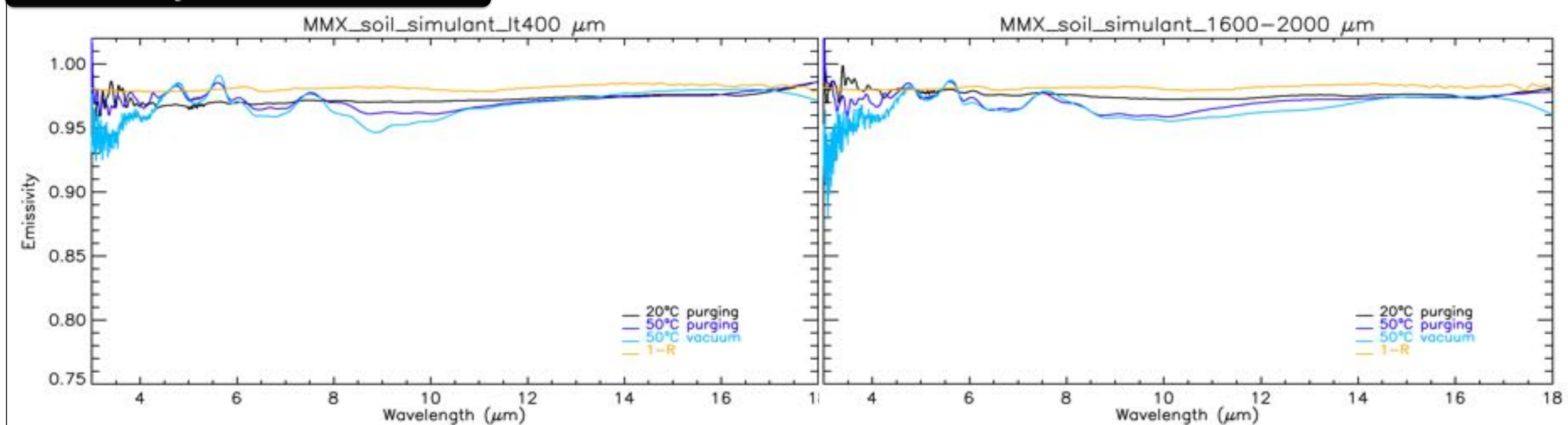


Complementary reflectance and transmission measurements via dedicated hardware units in 0.2 to 200 µm spectral range.

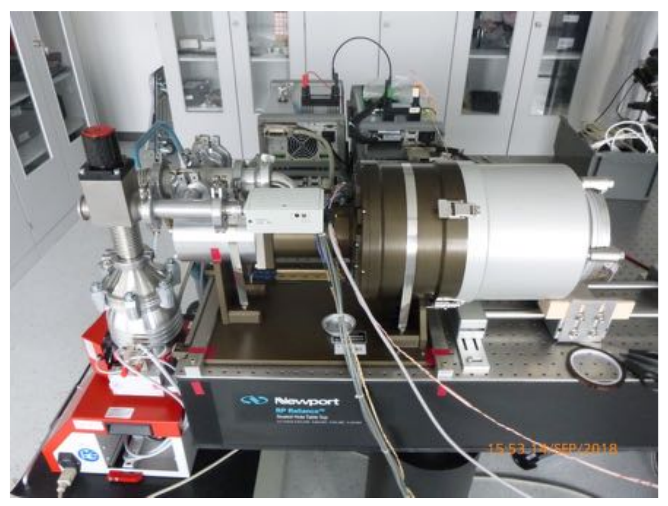
UV-VIS / MIR bi-directional reflectance



MIR emissivity

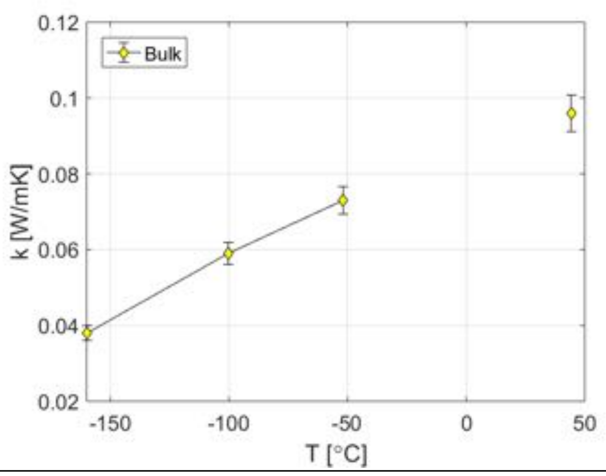


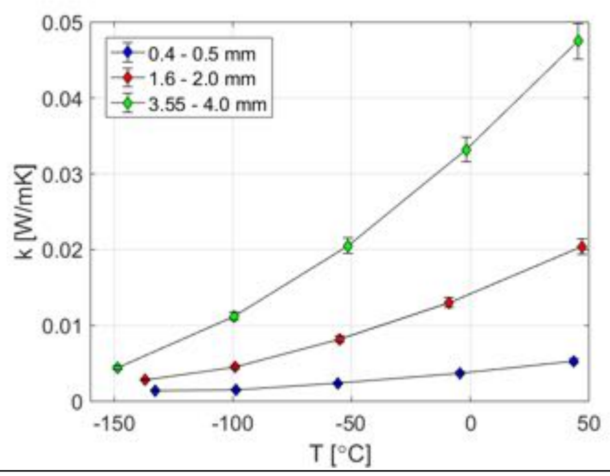
Thermal Conductivity



Thermal conductivity of the UTPS-TB is low even for the bulk material and < 0.1 W m-1 K-1 between -150° C and +50° C. This is likely due to the significant micro-porosity.

Granular material shows the expected temperature and grainsize dependence.





Conclusions - Measurements

- Spectral and thermophysical characterization of the UTPS regolith simulant (JAXA MMX + MARA on MASCOT – H2) is performed at DLR.
- 6 grain size ranges, from < 400µm to 3.55-4 mm investigated.
- UV-VIS-MIR bidirectional reflectance measured for several illumination angles. Spectra almost featureless in the whole range independently from grain size fraction
- MIR emissivity measured under purging and vacuum at low T (20° C and/or 50° C): tiny spectral features identified, no apparent grain size influence on emissivity spectra.
- Thermal conductivity is low even for the bulk material (micro-porosity). Expected temperature and grainsize dependence confirmed in the observed granular material.

Conclusions – Neural Network

We attempt to train a CNN using a suite of laboratory emissivity, to create a pre trained model to investigate its performances on the simulant measurements presented here. We underestimated the raw machine power needed to this task, and even after 4 days of grid searching we weren't able to converge to an optimal suite of parameter for model selection.

Intermediate preliminary result show an 85% accuracy in recovering the class of unknown measurements. We need to further extend the database to include the regolith simulant component and run a more extensive parameter optimization.

References

[1] Miyamoto, H., et al., LPSC 49th, Abstract #1882, (2018). [2] Fraeman, A. A., et al, Icarus 229, 196–205 (2014). [3] Maturilli A, et al., EPSC, Abstract#880 (2018). [4] Maturilli A, et al., EPSL, 398, 58-65, (2014).