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]German Aerospace Center, Berlin, Germany (mario.damore@dlr.de); [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, Kobe, 657-8501 Hyogo, Japan

Introduction: 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 [1].

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.

Phobos regolith characterization: The composition of Phobos regolith still remains controversial despite decades of telescopic and remote based observations. Reflectance spectrum of Phobos is generally featureless and very dark, with at least two major spectral units identified (a red and a blue unit). Visible to near infrared spectroscopy study show that the moons' surfaces resemble D- or T-type asteroids or carbonaceous chondrite [2]. The origin of the two Mars moons is still debated: current hypotheses are that Phobos and Deimos formed in situ in Mars orbit or by capture of asteroidal bodies originating outside the Mars system [2]. A recent study [1] showed that the spectral characteristics of both the blue and red units are not that different from each other, and their reflectance spectra are mostly similar to those of Tagish lake and CM2 chondrites.

Mechanical properties of the surface soil (bearing capacity, bulk frictional coefficient, and other parameters) are crucial parameters for designing a lander/sample collector, and also for a good scientific understanding of surface processes active on Phobos. The mechanical properties of Phobos regolith are poorly constrained because of the difficulty in estimating the particle sizes, particle size-distributions, the packing density of the regolith and other frictional parameters. Thermal inertia values indicate that the average particle diameter is expected to be <2mm in most regions. Earth-based radar observations of Phobos, as well as previous studies on the Moon and Itokawa particles, help better modelling of the Phobos surface properties. Accounting for these considerations, we assume that the regolith structure of Phobos has at least three layers; (1) a thin uppermost layer (<3cm in depth) of micron-scale dusts accumulated at extremely low density, (2) a 10cm- to 3m-depth regolith layer with particles accumulated at relatively higher porosity, and (3) a >10m-depth regolith layer with lower porosity.

A Tagish Lake-based simulant (UTPS-TB) was produced in the University of Tokyo (UT) by crushing and Mg-rich phyllosilicates (asbestos-free serpentine), Mg-rich olivine, Magnetite, Fe-Ca-Mg carbonates, Fe-Ni sulfides into very fine particles, and then mixed with carbon nanoparticles and polymer organic materials. The mixing happened as first under wet condition; the mixture was then successively completely dried to adapt the compressible strength to that of Tagish Lake.

Spectroscopic measurements: The Planetary Spectroscopy Laboratory (PSL) of DLR in Berlin is a spectroscopic facility providing bi-directional and hemispherical reflection, transmission and emission spectroscopy of target materials. Bi-directional reflectance of samples is measured with variable incidence and emission angles between 13° and 85°, for sample temperature 170K to room temperature, under vacuum conditions, covering the 0.2 to above 200 μm spectral ranges. Two integrating spheres allow measuring hemispherical reflectance of samples under purging in the entire PSL spectral range. An external emissivity chamber (working under vacuum) features high efficiency induction system heating the samples to temperatures from 320K up to 900K [3]. At PSL we measured the Phobos simulant material sieved in 3 different

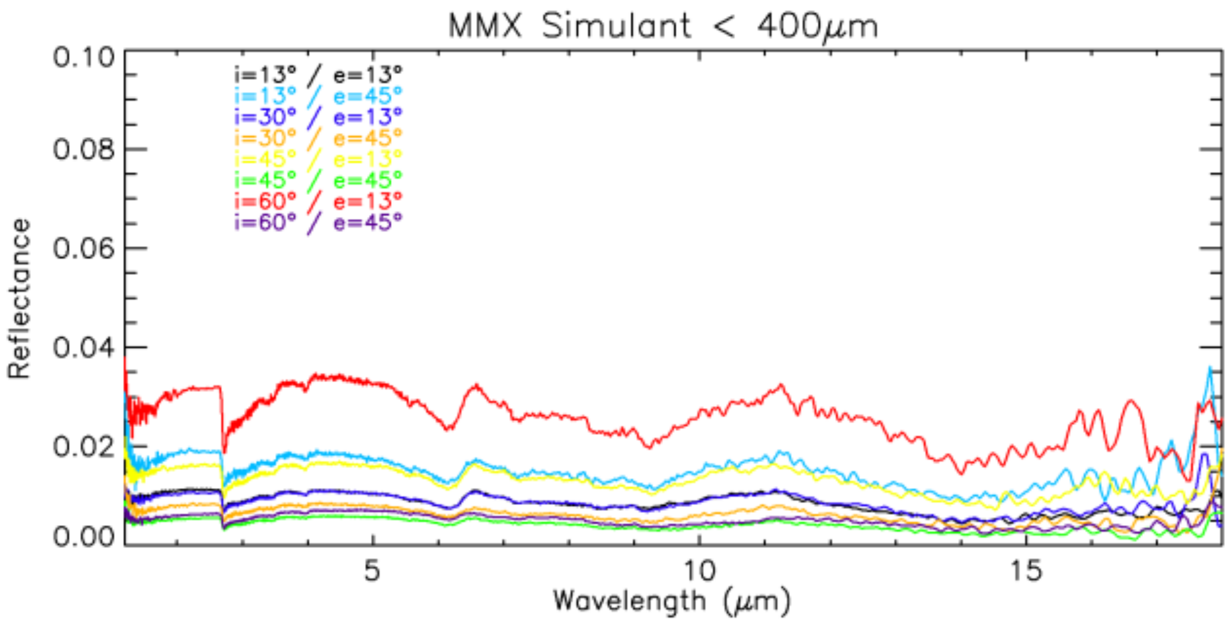

Figure 1. MMX simulant (< 400 μm grainsize) bidirectional reflectance spectra under various illumination angles.

grain size ranges: 400-500 μm, 1.6-2 cm, 3.55-4 cm. For each size separate, emissivity was measured in vacuum for sample temperature 320K (50°C). Bi-directional reflectance was measured under several phase angles conditions for sample temperatures between 170K (-100°C) and room temperature in the whole UV to FIR spectral range [4]. Hemispherical reflectance was measured under purging conditions on the sample at room temperature in the whole UV to FIR spectral range. Figure 1 shows the bi-directional measurements taken on the finer MMX sample for several illumination angles.

Conclusion and future works: The data acquired in laboratory essentially consists of physical- and spectral parameters and labels describing the sample, like the kind of material used.

The (label, data) pairs are the classic input of NNs. The exact kind of NN to be used will be explored (Deep NN, Recurrent NN), depending on the exact number of parameter to be mapped in the networks, needed time to training and so on. Once the topology of the NN has been choose, the system could be tuned feeding it with the laboratory (label, data) pairs. The final system could accept in input a data point from remote measurement and predict the label, that must obviously belong to the set that he has already met during training. The hypothesis is that the training dataset closely match or at least reproduce the variability of the remote target.

This could be used to rapidly classify data during the mission (onboard) for an efficient selection of the sampling site during the orbit around the target. As a side science product, various type of NN are used in literature for blind signal source separation, that, in remote sensing, is the well know endmember decomposition.

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).