BI-DIRECTIONAL REFLECTANCE OF ASTEROID, COMETARY AND SOLAR SYSTEM SMALL BODIES (SSSB) ANALOGUES AT LOW-TEMPERATURE ENVIRONMENTS. A. Maturilli[1], J. Helbert[1], Y.M. Rosas Ortiz[1, 2], T. Michalik[1], K. Otto[1] [1]Institute of Planetary Research, German Aerospace Center DLR, Berlin, Germany, [2]Technische Universität Berlin, Department of Aeronautics and Astronautics, Berlin, Germany. Alessandro.Maturilli@dlr.de

Introduction: The Institute for Planetary Research of the German Aerospace Center (DLR) has gained considerable expertise in spectroscopy of minerals, rocks, meteorites and organic matter. At the Planetary Spectroscopy Laboratory (PSL) a wide range of planetary surface analogue materials are routinely analyzed [reference to PSL abstract]. PSL provides unique capabilities in measuring transmittance, reflectance, and emissivity of fine-grained powder, bulk materials and coatings at temperatures up to 1000K across the whole wavelength range from UV to far-infrared.

A set up for the characterization of asteroid analogues by means of emission and reflectance spectroscopy is already available [1] and reflectance spectra at room temperature are routinely measured [2]. To meet current and future research ambitions at PSL, the extension of the capabilities towards low-T reflectance measurements has been started. PSL is already operating a test setup cooled by liquid nitrogren and using the internal sample chamber of a Bruker VERTEX 80V, with the final goal of developing a compact low-temperature vacuum chamber for bi-directional reflectance measurements.

This will allow the characterization of analog materials for icy moons, asteroids, comets, and solar system small bodies (SSSB) at low-temperature environments.

Low temperature spectroscopy: Maximum daylight temperature at the surface of Ceres is estimated to be 235K [3], the surface temperatures distributions on Vesta is from 40K to 248K [4], and the surface temperatures of Asteroid 21 Lutetia reaches a maximum value of 245K [5].

Pronounced spectral effects at the lowest temperature of 80K are shown by Moroz et al. [6] in reflectance spectra of olivine and orthopyroxene, which are very common rock-forming minerals in the Solar System. The temperature dependence of the reflectance spectra at the primitive surface of Ceres has been addressed by Beck et al. [7].

Setting up a system for reflectance spectroscopy experiments at cryogenic temperatures represents a unique opportunity for the PSL to support the data interpretation for current and future missions.

Experimental setup: At PSL, there are currently two instruments equipped with external chambers to measure emissivity, while instrument internal sample compartments are used for bi-directional reflectance. The sample compartment of our spectrometer with aluminium mirrors has been used to simulate the low-T chamber and a cooling sample container has been developed and adapted to the reflectance unit. The icy-samples have been cooled down to 190K using a full controlled freezer and they have been kept cool during measurements using liquid nitrogen.

Technical Approach: During the concept phase, various cooling systems have been examined [8]. In our chamber, we expect to reach a cryogenic temperature within the range of 70K – 100K.

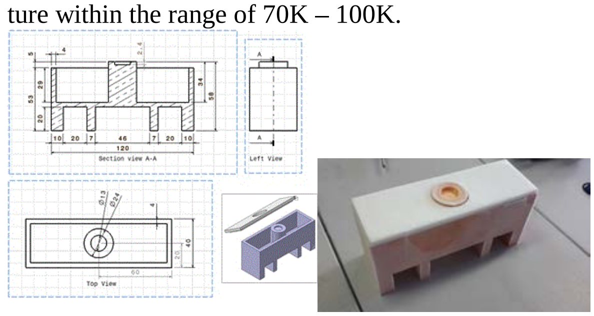

Figure 1. Cooling Sample container for preliminary experiments

Test Measurements: We have been testing our preliminary set-up in the last months, mainly to gain confidence with the sample preparation and conditioning procedures, and with the successive steps regarding the spectroscopic measurements of cold samples.

Icy planets, in particular Jupiter's moon Europa, have attracted the scientific interest due to the likely presence of oceans under their crust with the potential to support life. Preliminary data indicate that sulphate hydrates are especially important on hydrous worlds, and are expected to be important extra-terrestrial salts.

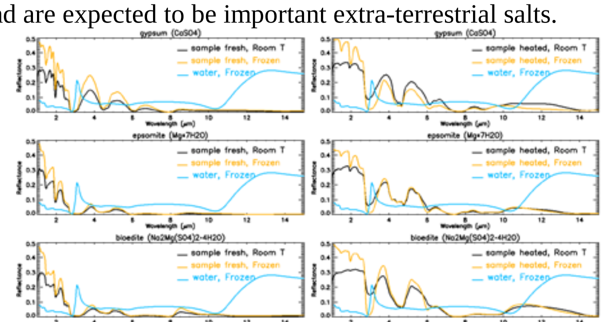

Figure 2. Low-T reflectance of salts

Reflectance spectra of an accurately selected group of minerals were collected at different temperature, to investigate the role of chemical substitutions (cations as well anions) and of the amount of water molecules on spectral features. Figure 2 shows the measurements on 3 differently hydrated salts taken at sample temperature of 273K and 190K, on fresh sample and sample after heating at 800K in vacuum.

The near-IR reflectance spectra of olivines vary considerably with composition. Olivine shows strong absorption near 1 µm, which is composed of three major overlapping absorptions. Each feature is due to absorption by divalent iron in distorted crystallographic sites. As the bond lengths and angles and symmetry of the crystallographic sites in the olivine structure change with divalent iron content, so do the strengths and positions of the near-IR absorptions, giving rise to significant change in the overall band shape [10]. Many authors studied the effects of temperature on the spectra of olivine and other mafic minerals (e.g [11, 12]), highlighting the bandcenter shift of the 1 µm band with temperature. We performed a similar experiment, repeating reflectance measurements on a olivine sample, starting at 170K and letting the sample slowly heating to reach room temperature after 3 hours. Figure 3 shows the results of our measurements.

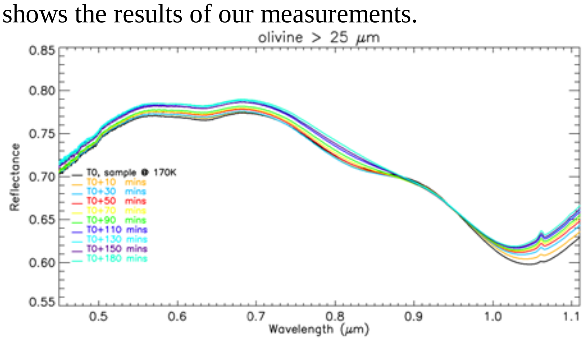

Figure 3. T-dependence of 1 µm band of olivine

Pitted terrains on Vesta occur in and/or around relatively young craters and they have been linked to volatile loss. Pitted terrains distributed around the Marcia crater on asteroid Vesta show a higher reflectance and stronger pyroxene absorptions with respect to their immediate surrounding. At PSL we scheduled laboratory experiments (structural and spectral), conducted to elucidate the process creating these enhanced spectral features [13]. Hypersthene, montmorillonite, and carbon black are used as terrestrial analogues for the Vestan regolith. The samples were mixed and the mixtures were then either mixed with liquid water and frozen or put on top of a water ice layer. Mixtures without any sort of water were also prepared in the same way for comparisor. Figure 4 shows our preliminary results.

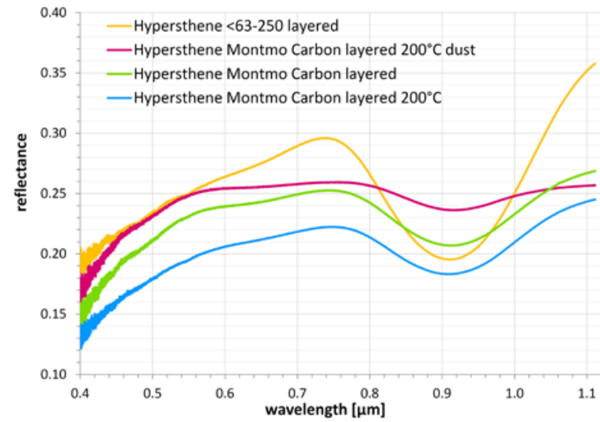

Figure 4. Reflectance of Vestan analogue materials.

Summary and Conclusions: Laboratory spectroscopy investigations of SSSB analogues are key to support the interpretation of remote sensing data returned by the interplanetary missions.

A compact low-temperature reflectance chamber for FT-spectroscopy experiments at the PSL is currently under development. The expected cryogenic temperature to reach is approximately within the range of 70K – 100K. The current and future missions to moons, comets, and asteroids indicate the high potential usage of this development, which may result in many scientific or even commercial applications.

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