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Hyper-spectral measurements of Terrestrial Mars Analogues with the SPIM facility

S. De Angelis (1), M.C. De Sanctis (1), E. Ammannito (2,1), T. Di Iorio (3), P.Manzari (1)
(1) Institute for Space Astrophysics and Planetology, IAPS-INAF, Rome Italy, (2) University of California Los Angeles – IGPP (CA-USA), (3) ENEA, UTMEA-TER, Roma, Italy, (simone.deangelis@iaps.inaf.it)

Introduction

The SPIM facility is a laboratory VIS-IR spectrometer developed to support spaceborne observations of rocky bodies of the Solar System. Currently this laboratory setup is used to support the DAWN mission [1], which is in journey towards the asteroid 1-Ceres, and to support the 2018 Exo-Mars mission in the spectral investigation of Martian subsurface. The main part of this setup is an imaging spectrometer that is a spare of the DAWN Visible InfraRed spectrometer (VIR) [2]. The spectrometer has been assembled and calibrated at Selex ES and then installed in the facility developed in the INAF-IAPS laboratory in Rome. The goal of SPIM is to collect data to build spectral libraries for the interpretation of the space borne and in-situ hyperspectral measurements of planetary materials. Given its very high spatial resolution combined with the imaging capability, this instrument can also help in the detailed study of minerals and rocks. In this paper the instrument set-up is first described, and then a series of spectroscopic measurements is reported.

1. The SPIM facility: setup

A schematic view of the instrument set-up [3] is in figure 1. The spectrometer installed in SPIM covers the 0.22-5.05 μm spectral range, with 38x38 μm of spatial resolution on the target. Two bi-dimensional focal plane arrays, one for the visible between 0.22 and 1.05 μm (spectral resolution of 2 nm) and one for the IR between 0.95 and 5.05 μm (spectral resolution of 12 nm) allow to obtaining the spectral coverage. Thanks to the alignment of the bi-dimensional focal planes with the spectrometer's 9 mm slit axis, it is possible to acquire the target's image of 0.038x9 mm at different wavelengths. The spectrometer and the IR detector need to be cooled at 130K and 80K, respectively, in order to reduce the background noise due to thermal emission. To avoid vapour condensation when at the operative temperature, the spectrometer has been installed inside a thermo vacuum chamber (TVC) chilled by liquid nitrogen. The optical layout of the spectrometer is based on an Offner configuration. SPIM acquires hyper-spectral cubes observing the target moving on a scanning sample holder.

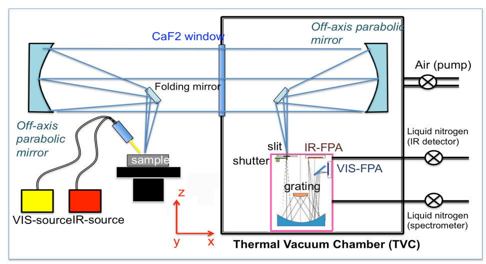

Figure 1: Picture of SPIM facility setup.

The sample holder is composed of a three axis translation stage. All stages are motorized and programmed via PC. In order to perform a hyper-spectral cube, the scanning system moves the target with a step of ΔX=38 μm for each signal acquisition in the direction across the slit axis (X axis). The value of the step matches the width of the slit in the X axis (38 μm); the slit length (Y axis) is 9 mm. The number of steps is a parameter that depends mainly on the sample type and size, and on the surface properties of the target. When analyzing a heterogeneous rock, in order to investigate the spectral diversity of the surface, a scan size of at least 10 mm (along X axis) is necessary, corresponding to hundreds of steps. When analyzing homogeneous targets (fine powders), a few steps are enough (tens of steps). Two lamps provide the light sources for the VIS channel (a QTH lamp, 120 W) and the IR channel (108 W). The illuminating system supports two distinct optical fibres; the illumination angle is set at about 30° with respect to the normal to the sample surface.

2. Visible and Infrared spectroscopy with SPIM

Here we report first preliminary measurements on a series of terrestrial and extraterrestrial samples. The analyzed samples are a carbonate (red micritic limestone, from Umbria/Italy), two basalts from Stromboli (Aeolian Islands/Italy) and the Martian Meteorite Chassigny. All analyzed samples are in powder form. The carbonate (CAL1 in the fig. 2) has been grinded from representative rock fragments and then sieved in 7 different grain sizes (d<36μm, 36-75, 75-100, 100-125, 125-150, 150-200 and 200-800 μm). The two basalts from Stromboli (STG1, “Lava dell’Omo” and STR72, “Lava di San Bartolo”, fig.3) are <100 μm in size and Chassigny is <250 μm in size (fig.3). 10 adjacent lines (see section 1) have been acquired on six finer grain sizes for CAL1 sample,, while 50 lines have been acquired from the coarsest grain size (200-800 μm). In case of STG1 and STR72 lavas, 50 lines have been acquired. Finally, 10 adjacent lines have been acquired from Chassigny powder. The spectra of CAL1 are in figure 2. They are characterized by CO_3 absorption bands in the NIR at 1.9 (superimposed with water), 2.2, 2.35 and 2.55 μm, while in the Mid-IR they are characterized by two bands at 3.4 and 3.9 μm. The strong absorption at 3 μm is due to water, while the absorptions near 0.7 and 0.9 μm in some spectra are perhaps due to Fe^{3+} (charge transfer).

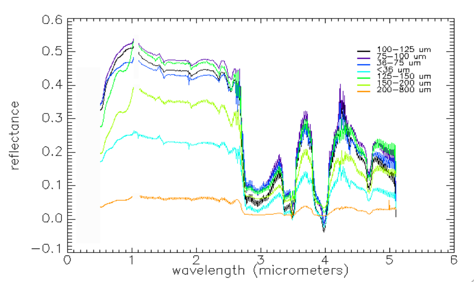

Figure 2: VNIR reflectance spectra of Red Micritic Limestone (CAL1) at 7 different grain sizes.

The spectra of the two basalts and Chassigny are in figure 3. Both STG1 and STR72 are characterized by low reflectance (10-20%) and by the absence of strong absorption bands, except for the water band at 3 μm and the Fe^{2+} absorption at 1 μm superimposed to a blue (negative) slope. Finally the spectrum of Chassigny, which is, from a petrologic point of view, a dunite, is characterized by the strong Fe^{2+} absorption at 1 μm, and by the water band at 3 μm.

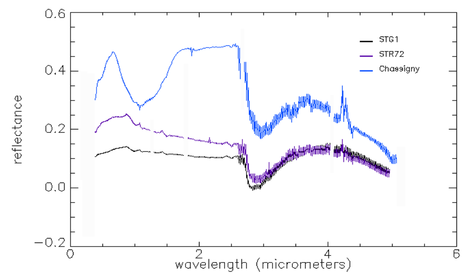

Figure 3: spectra of three volcanic rocks. STG1 (Lava dell’Omo, basalt from Stromboli/Aeolian Islands), STR72 (Lava di San Bartolo, basalt from Stromboli) and the Martian Meteorite Chassigny (dunite)

3. Conclusions

The SPIM facility is a VIS-IR imaging spectrometer that is used in support of missions to Solar System rock bodies. The high spatial resolution (38 μm) allows to study in great detail minerals and rocks both of terrestrial and extraterrestrial origin.

Acknowledgements

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