Ma_Miss and Terrestrial Mars Analogues

M.C. De Sanctis[1], S. De Angelis[1], E. Ammannito[1], T. Di Iorio[1], C. Carli[1], A. Frigeri[1], A. Boccaccini[1], E. Battistelli[2], R. Mugnolo[2], and the MA_MISS team
[1] Istituto di Astrofisica e Planetologia Spaziali (INAF-IAPS), Rome, Italy; [2] Selex Galileo, Campi Bisenzio (Fi), Italy; simone.deangelis@iaps.inaf.it

Abstract

The Ma_Miss instrument (Mars Multispectral Imager for Subsurface Studies) is a VIS-NIR spectrometer devoted to study the Martian subsoil within the ExoMars mission. This miniaturized spectrometer is integrated in the drilling system of the Exomars Pasteur Rover, and will investigate the Martian subsoil down to 2 m, in the spectral range 0.4 – 2.2 μm [1,2]. It will provide important information regarding the composition and mineralogy of the Martian subsoil, whose materials are expected to be less altered by erosion and other exogenous processes than surface rocks. With a view *to doing* laboratory spectroscopic measurements with the instrument breadboard, we performed preliminary laboratory measurements on possible Mars analogues using a spectrophotometer coupled with a goniometer.

2. Preliminary measurements of Mars analogues

With the final goal of a dedicated measurement campaign in the laboratory with the Ma_Miss_breadboard, preliminary measurements have been performed on terrestrial samples with a commercial spectrometer.

Reflectance spectra have been taken in the VIS and NIR range (0.35 – 2.5 μm) using a FieldSpec-Pro spectrophotometer coupled with a goniometer [3], with a 1 nm spectral sampling. It is possible to illuminate the sample (*i* = illumination angle) and to collect the emitted light at different angles (*e* = emission angle); here we configured the goniometer with i=30° and e=0°. The light source is a QTH lamp, producing a 0.5 cm^2 spot on the sample. LabSphere Spectralon optical standards have been used as white references. The analyzed samples are a Red Micritic Limestone (from Umbria, Italy) and a suite of different lavas from Aeolian Islands Arc (Sicily, Italy). The first sample is a carbonate rock, that is typical of deep-sea environments, the latter are volcanic rocks classified as basalts. All the samples have been analyzed both in the form of slabs and as powders. The sample powders have been previously prepared before of performing spectroscopic analyses; the powder has been sieved, in order to obtain five different grain sizes in the range d<100μm – d=800μm. The reflectance spectra are in fig.2, 3 and 4.

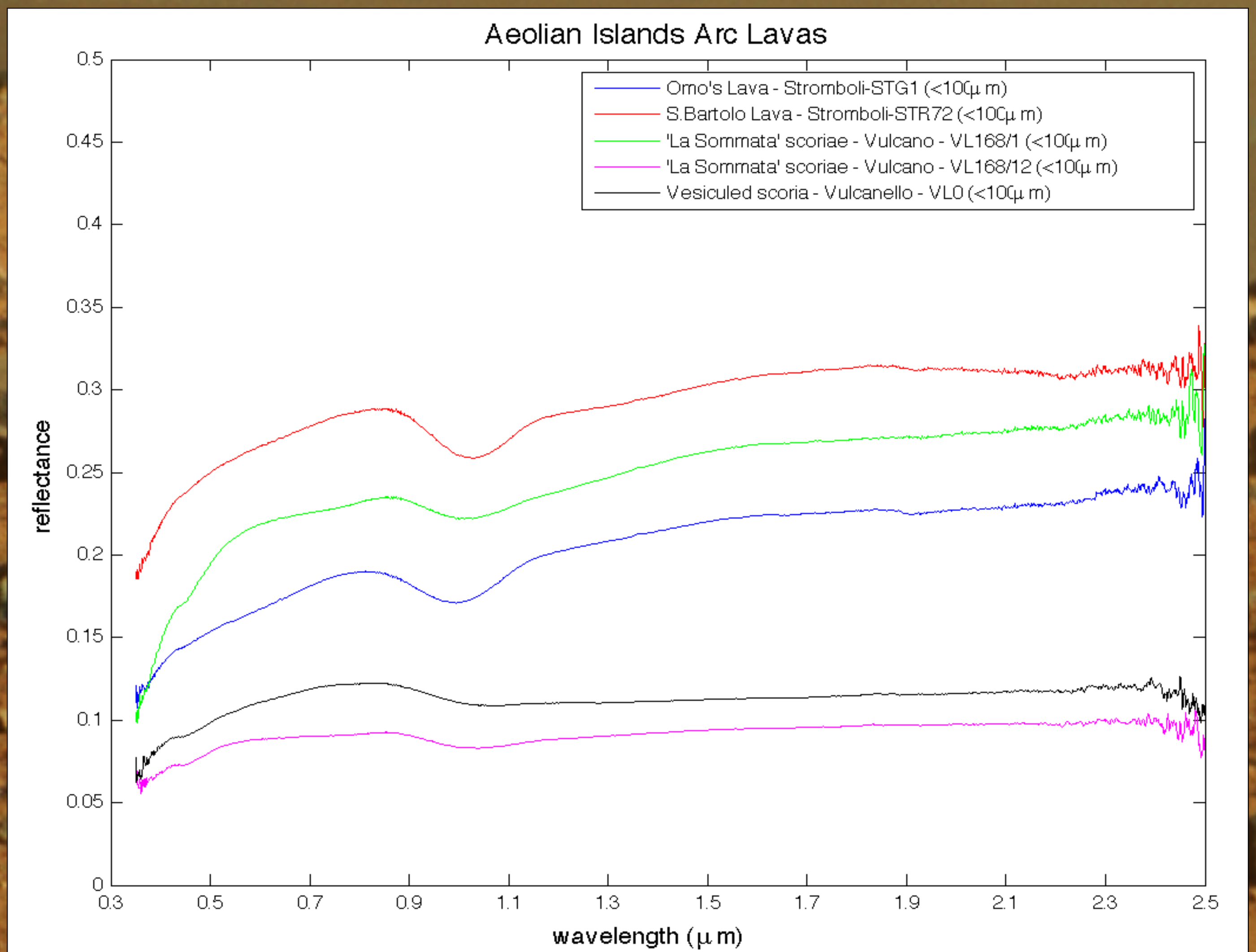

Fig.3. Reflectance VNIR spectra of Aeolian Islands Lavas (origin: Sicily, Italy). The first three samples (Omo, S.Bartolo and La Sommata (VL168/1)) have a deeper olivine absorption band in the 1-μm region, than the other two samples.

1. The Experiment

Ma_Miss miniaturized spectrometer is completely integrated within the ExoMars drill; it will produce multispectral imaging of the borehole wall excavated by the drilling system. The Optical Head of the instrument, which is protected from debris by a sapphire window, has two tasks: it is used to illuminate the borehole wall with an illuminating spot of 1 mm on the target, and to collect the scattered light from a 100 μm spot on the target. A box placed on the external wall of the Drill Box houses the spectrometer, the VNIR detector and the electronics. Optical fibers and an optical rotary joint are used in order to transmit the signals from the Optical Head to the spectrometer through the various elements of the drilling system. The spectrometer can produce *ring images*, by acquiring spectra during the drill rotation, or *column images*, by acquiring during the drill translation. The translation movement proceeds through steps that are equal to the observation spot. The collection of many adjacent ring images is useful in order to reconstruct a precise multispectral image of the borehole wall, thus obtaining information about the chemical composition, structure and mineralogy.

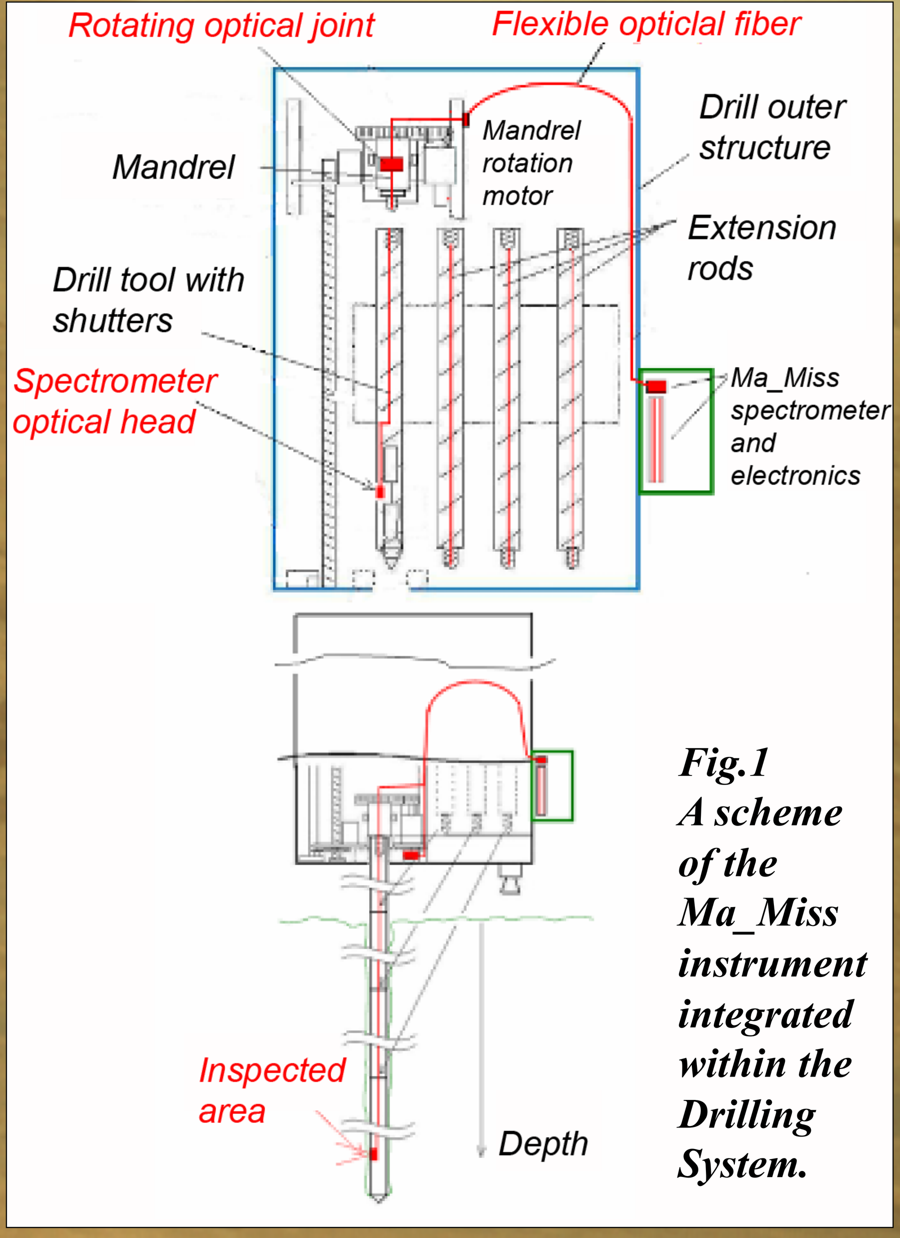

***Fig.1** A scheme of the Ma_Miss instrument integrated within the Drilling System.*

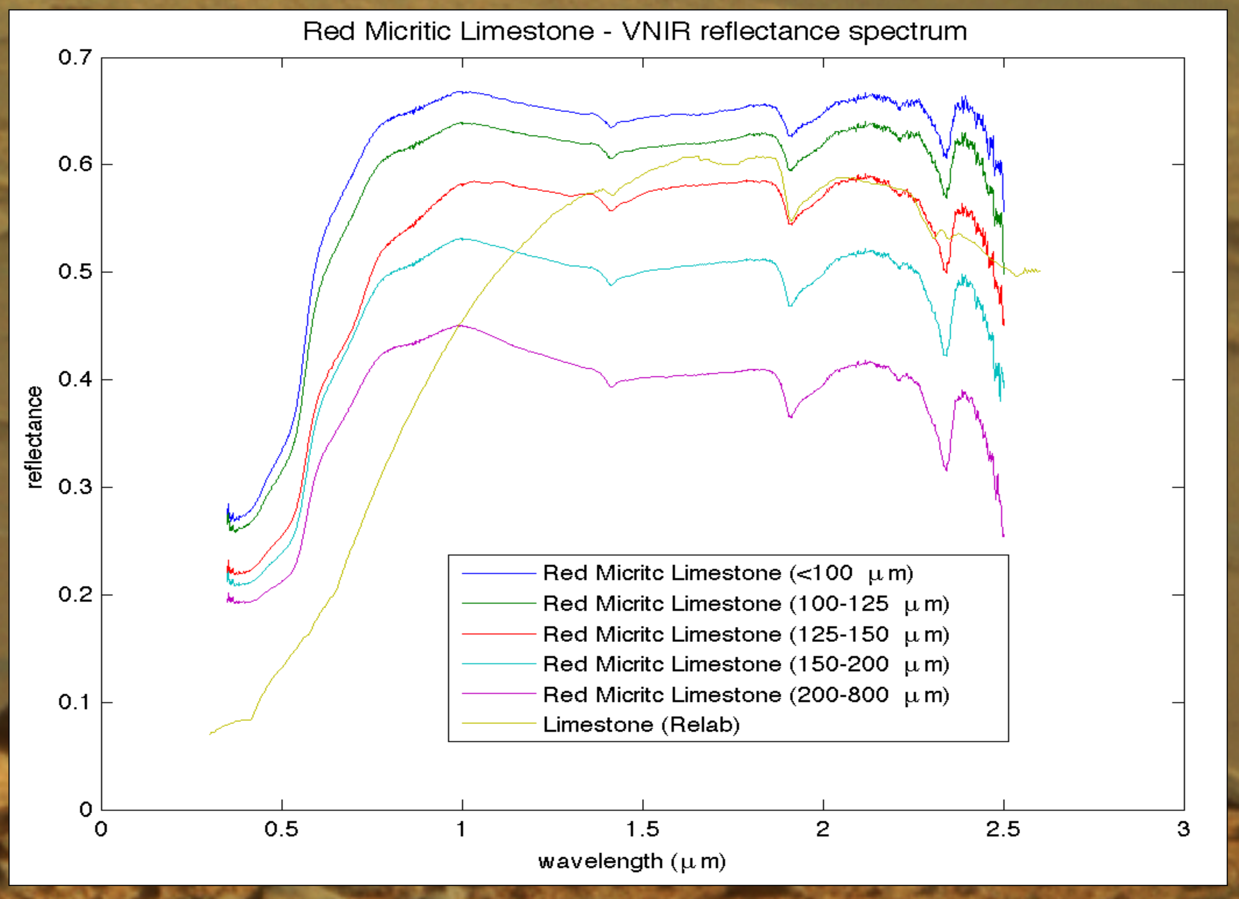

Fig.2. Reflectance VNIR spectra of a Red Micritic Limestone (origin: Umbria, Italy). The absorption bands λ_{C1} to λ_{C6}, from 2.54 to 1.88 μm, due to calcite are well observable. The 1.4-μm band is probably due to the H_2O content in the sedimentary rock. The reference RELAB spectrum is LI-EAC-001.

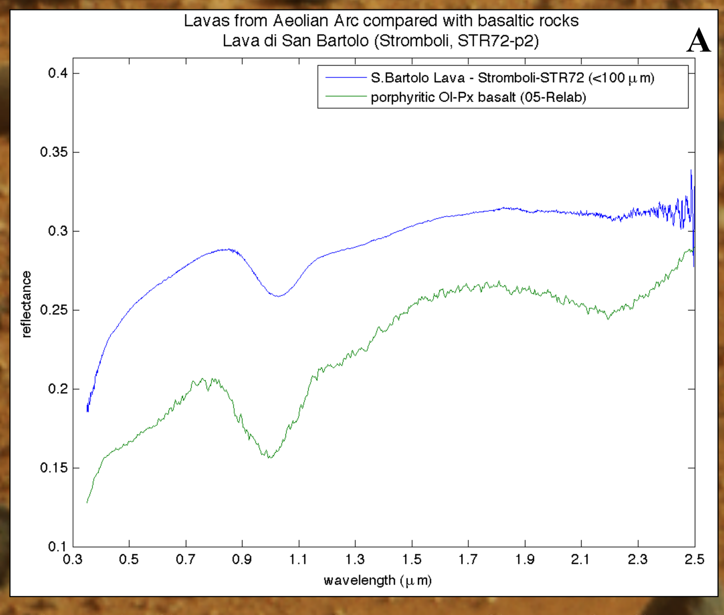

Fig.4A. San Bartolo Lava (Stromboli) compared with Porphyritic Olivine-Pyroxene Basalt. The two samples are powders. The RELAB spectra (green line) is LS-JBA-032. The RELAB sample has a deeper absorption band in the 2-μm region, probably due to a different pyroxene composition, than the S.Bartolo sample.

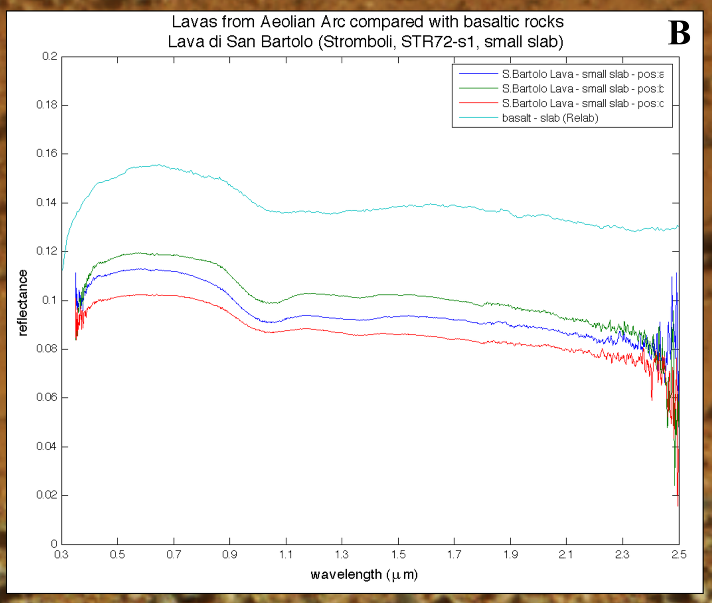

Fig.4B. San Bartolo Lava (Stromboli) compared with Basalt. The two samples are slabs. The RELAB spectra (cyan line) is JB-JLB-298, and it has been shifted by a factor +0.05 along Y-axis for clarity. The spectra on the S.Bartolo Lava (small slab) have been taken in three different positions.

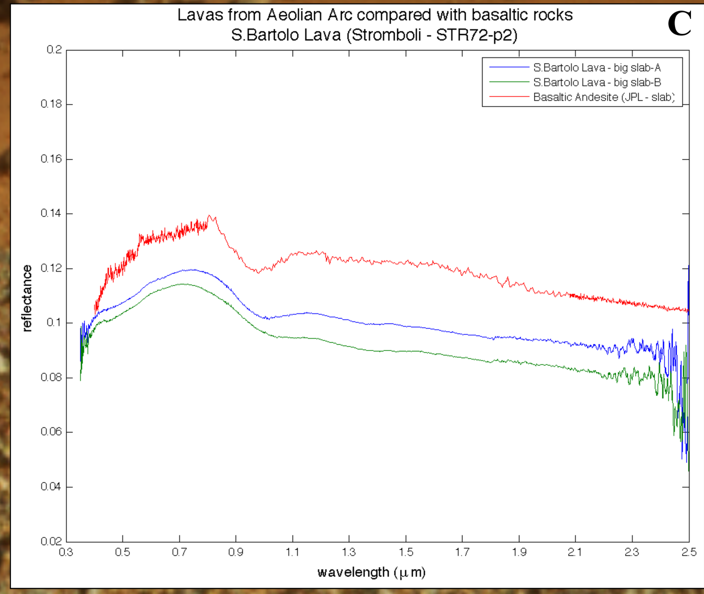

Fig.4C. San Bartolo Lava (Stromboli) compared with Basaltic Andesite. The two samples are slabs. The spectra on the S.Bartolo Lava (big slab) have been taken in two different positions. The JPL spectrum [5] is in red line.

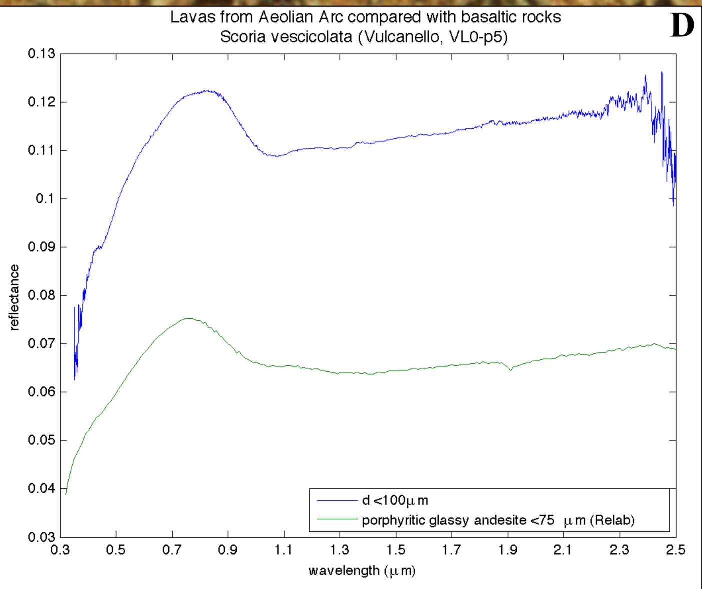

Fig.4D. Vesiculed Scoria (Vulcanello) compared with Porphyritic Glassy Andesite. The two samples are <100μm powders. The RELAB spectra (green line) is WM-MBW-001D.

3. Summary and conclusions

The Ma_Miss miniaturized imaging spectrometer, integrated within the drilling system of the ExoMars Pasteur Rover, will investigate the Martian subsoil down to 2 m; the spectrometer will acquire multispectral images of the borehole walls, thus obtaining precious information about the composition, structure and mineralogy of the less altered materials of the Martian subsoil. With a view to doing laboratory tests with the instrument breadboard on terrestrial Mars analogues, several preliminary laboratory measurements have been performed with a carbonate rock and volcanic samples, using a spectrophotometer.

Acknowledgements

The Italian Space Agency (ASI) has funded the experiment.
This research utilizes spectra acquired by J.B.Adams, J.L.Bishop, E.A.Cloutis and M.B.Wyatt with the NASA RELAB facility at Brown University.

References

[1] Coradini, A., et al.: MA_MISS: Mars multispectral imager for subsurface studies, Advances in Space Research, Volume 28, Issue 8, p. 1203-1208, 2001.
[2] De Sanctis M.C., et al: *MICRO IMAGING SPECTROMETER FOR SUBSURF ACE STUDIES OF MARTIAN SOIL: MA_MISS*, 43rd Lunar and Planetary Science Conference, 2012
[3] Coradini, A., Conti, S. et al. *MILLBILLILLIE: Reflectance spectroscopy*, 2005, Asteroid, Comets, Meteors – IAU Symposium 229, Rio de Janeiro, 7-12-2005.
[4] Preti G., et al: *SPECTROMETERS AND IMAGING CAMERAS FOR PLANETARY REMOTE SENSING*, IAC- 11.A3.5.7, 2011
[5] Baldridge, A. M., S.J. Hook, C.I. Grove and G. Rivera: *The ASTER Spectral Library Version 2.0*. Remote Sensing of Environment, vol 113, pp. 711-715, 2009