VIS-IR imaging spectroscopy of Martian Meteorites. S. De Angelis[1], E. La Francesca[1], P. Manzari[2], M. Ferrari[1], M.C. De Sanctis[1], F. Altieri[1], E. Ammannito[2], J. Brossier[1], E. Bruschini[1], M. Formisano[1], A. Frigeri[1], L. Rossi[1]. [1]National Institute of Astrophysics, INAF-IAPS, via Fosso del Cavaliere, 100, 00133, Rome (Italy) (simone.deangelis@inaf.it); [2]Italian Space Agency – ASI-Rome.

Introduction:

The study of Martian Meteorites in the laboratory provides fundamental clues about the formation and evolution of Mars. Spectroscopic and geochemical investigations furnish insight both regarding the planet composition and evolution, as well as information related to secondary processes (i.e. aqueous alteration) [1,2] SNCs meteorites have compositions that are mafic to ultramafic [1,2] essentially basalts or basaltic cumulates. Nakhlites can be characterized by different levels of aqueous alteration and by the presence of phyllosilicates and other secondary minerals [1,2,3,4] Reflectance spectroscopic measurements, by using the VIS-IR hyperspectral imaging technique, have been performed in the C-Lab @INAF IAPS on a series of Martian meteorites, in the form of small fragments. Four shergottites, two nakhlites and one brown chassignite sample have been investigated in the VIS-IR range (0.35-5.1 µm) by means of the SPIM facility [5,6].

Setup and samples description: meteorites chips and fragments have been investigated with the Spectral Imager (SPIM) instrument in use at C-Lab laboratory at INAF-IAPS. The facility consists in an imaging spectrometer operative in the 0.35-5.1 µm-range [5,6], based on the laboratory spare of VIR instrument onboard Dawn mission [7]. The setup consists of two bidimensional focal planes, a CCD (0.35-1 µm) and an HgCdTe (1-5.1 µm) both hosted, together with the spectrometer, inside a liquid N_2 cooled Thermal Vacuum Chamber. The entry slit is 9x0.038 mm corresponding to a single acquired image on the sample of 256 px, with spatial resolution of 38 µm/px on the target. The sample to analyze is placed outside the TVC on a 3-axis motorized stage: by moving the target at 38 µm-steps and acquiring consecutive frames it is possible to construct an hyperspectral cube of 876 spectral bands and the desired number of lines.

Different Martian meteorites have been analyzed with the described setup. These are four Shergottites, two Nakhlite specimens and a Chassignite (see table 1). The samples were in form of chips and small fragments, most of them of very few mm in size (about 2-3 mm) and irregular. The largest sample (Shergottite NWA12269) was about 14x5 mm, embedded in an epoxy resin and with a cut plane surface suitable to be scanned.

Sample	*Classification*
NWA 12269	Shergottite
DaG 489	Shergottite
Sueilila 002	Shergottite
Zagami	Shergottite
NWA 998	Nakhlite
NWA 10153	Nakhlite
NWA 2737	Chassignite

Table 1. The analyzed samples and relative classification.

Measurements and Results: An example of acquired image is shown in figure 1. A composite RGB image is shown concerning the NWA10153 Nakhlite specimen. The image has ben constructed by acquiring 70 consecutive frames at 38-µm steps (dimension along vertical axis).

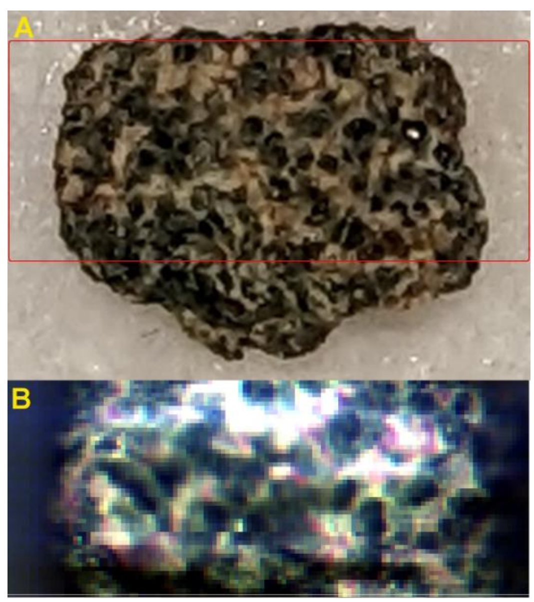

Fig.1. Photo (A) and RGB image (0.7-0.55-0.44 µm) (B) extracted from the hyperspectral cube acquired on the NWA10153 Nakhlite sample.

A selection of representative spectra extracted from the cube is shown in fig.2. A certain spectral (and compositional) variability is observed when looking at the spectra. These are mainly dominated by pyroxene and olivine absorptions, as indicated by (i) the 1-µm band that appears shifted in the 0.9-1.1-µm range and with variable shape and width, (ii) the VIS reflection peak that occurs at slightly different locations in the 0.6-0.9-µm range, (iii) the second pyroxene band occurring near 2.2-2.3 µm, indicating a Ca-rich (augite) composition. Additional absorption bands are related to the presence of hydrated minerals/phyllosilicates (bands at ~2.7 µm and 3 µm) plus some amount of adsorbed water. Moreover almost all spectra are also characterized by the presence of the carbonate absorption at 3.4-3.5 and 4 µm. Finally in a number of spectra absorption bands occur near 3.1, 3.17 and 3.22 µm: a further in-depth investigation will be done in order to attribute such bands.

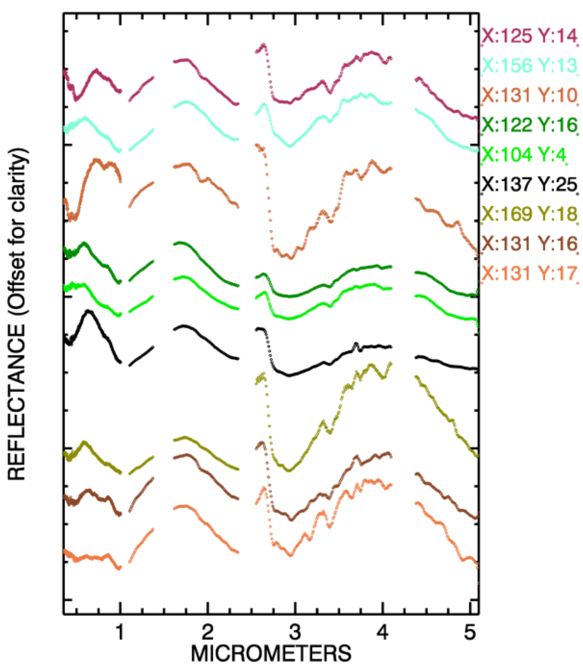

Fig.2. Selection of representative spectra of NWA10153, extracted from the cube. Data at 1.5 and 2.5 µm are cut because of instrumental artifacts, while data at 4.2 µm are cut because of CO_2 absorption.

Conclusions and Future Work:

High spatial resolution spectroscopic analyses of Martian meteorites in the visible and near-infrared are a powerful tool to investigate in detail meteorite composition. Such investigations can provide important clues on the formation and thermal history of these Martian samples and of their parent body, and moreover provide laboratory reference data for supporting the interpretation of future remote-sensing and rover data. Future investigations will concern for example the characterization of phyllosilicate and carbonate phases in Nakhlites, as well as the use of additional techniques such as Raman microscopy to better characterize the samples.

References: [1] Udry A. et al. JGR Planets 125 2020. [2] Treiman A H et al PSS, 48 1213 1230 2000 [3] Hicks L.J. et al. Geoc. Et Coscmoc. Acta, 136 194 210 2014. [4] Bishop J. L. et al. 80th Met. Soc. 6115 2017. [5] Coradini A. et al., Vol. 6, EPSC-DPS2011-1043, 2011. [6] De Angelis S. et al., Rev.Sci.Instr. 86, 093101, 2015. [7] De Sanctis M.C. et al., Space Sc. Rev., 163:329–369, 2011.

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