Identification of Ca-phosphate grains in North West Africa 8657 Martian meteorite by VIS-IR micro-imaging spectroscopy.

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Introduction

Martian meteorites represent currently the only chance to validate the spectral and chemical data collected by remote sensing and rovers of the ongoing and next missions to Mars. In fact, in the view of the next rover mission Exomars 2020 those measurements will be helpful for the interpretation of the high spatial (120µm) resolution data from the MaMISS miniaturized spectrometer that will observe the Martian subsoil in the visible and near infrared range (VNIR, 0.4-2.2 µm). In this abstract, we anticipate some findings of the study of North West Africa 8657 shergottite by the Spectral Imager SPIM, spare of VIR onboard the Dawn mission [1,2]. Merrillite ($Ca_9(Na,Fe,Mg)(PO_4)_7$) occurs as both primary and secondary Ca-phosphate mineral in martian meteorites and therefore presumably also on Mars and is important for exploring the differences in geologic processes between Earth and Mars, and for the astrobiological implications of phosphates occurrences since they are present in ATP, DNA, RNA and phospholipid membranes on Earth [3].

Instrument Setup:

A slab of 1 cm x 0.5 cm of NWA8657 shergottite was acquired by SPIM. The imaging spectrometer installed in SPIM is a spare of the spectrometer on Dawn spacecraft. It works in the 0.22-5.05 µm spectral range, with a spatial resolution of 38x38 µm on the target. Spectral data validation was performed by scanning electron microscope SEM-EDS at Dicatech-Politecnico di Bari.

Results:

The average spectral profile of the slab is characterized overall by the absorption features at 1 and 2 µm diagnostic of pyroxenes, that are the dominant phase; another phase is constituted by maskelynite. Spectra are also affected by a weak blue slope that is generally a typical feature of slabs [4]. Different minor and accessory mineralogical phases were found, some of them occurring preferentially as absorbers in the VIS while others showing features in the NIR range. In particular, we focused the attention on those grains that showed absorption in the NIR-IR range.
Apathite is one of the accessory phases found in shergottites, therefore the spectral features of apathite (2.8; 3.47; 3.98; 4.03; 1.4, 1.9, 3 µm) were mapped on the image of the slab by a spectral feature fitting procedure (Fig.1).

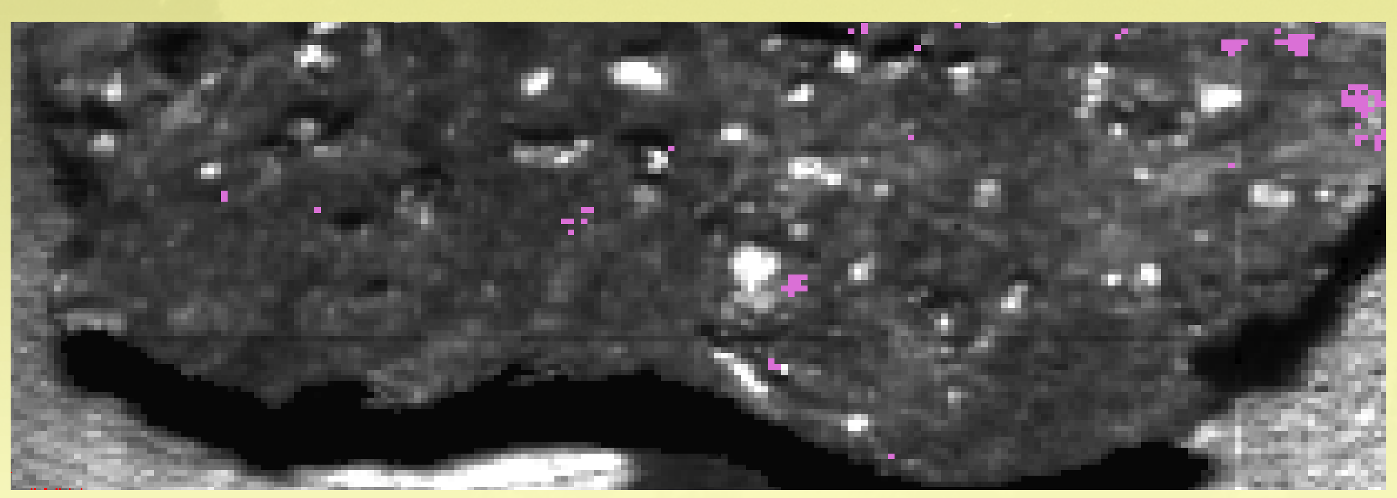

Fig.1 Mapping of apathite spectral features on NWA8657 shergottite slab.

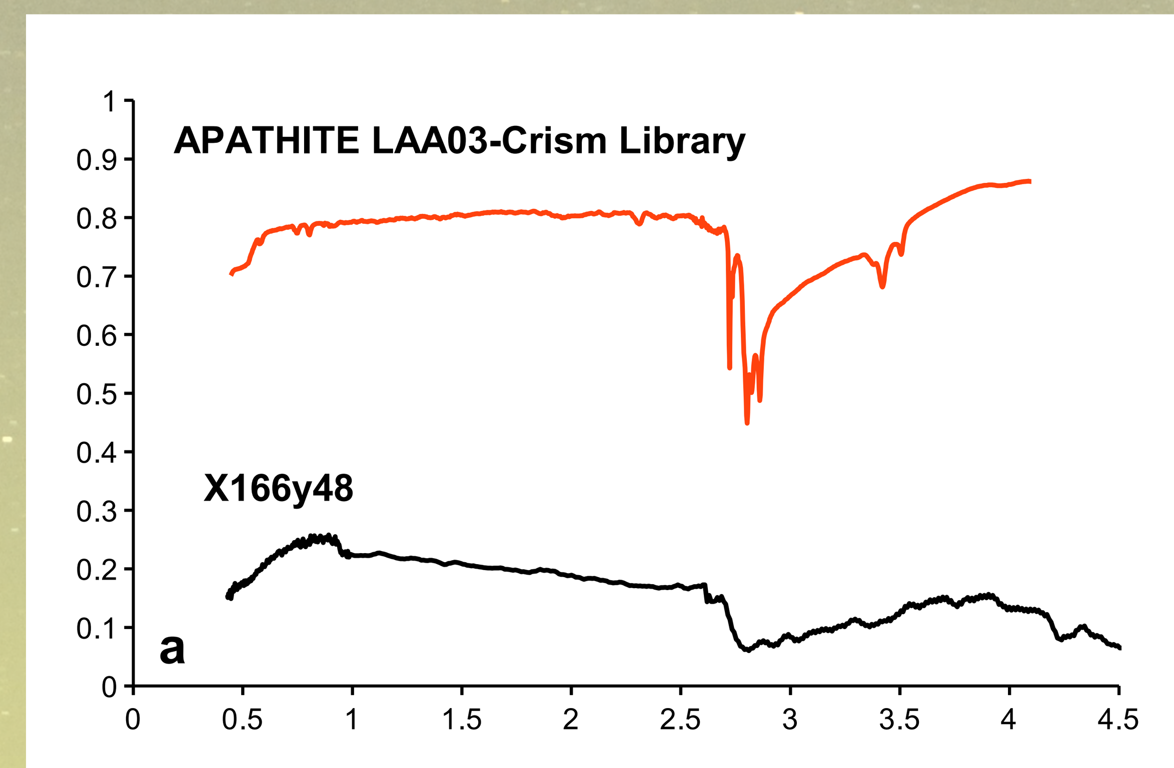

Fig.2 Pixel spectrum related to one grain and comparison with apathite spectrum from CRISM library.

In the measured slab, apathite-like spectra (for example Fig.2) occurred in few distinct pixels and pixel clusters. These spectra do not show the 1.4 and 1.9 micron features and have weak features at 3.98-4.03 microns. The grains characterized by these spectra were interpreted as apathite grains.
The apathite absorptions map on the slab (Fig.1) was useful for investigating by SEM-EDS on all the grains corresponding to those pixel showing the apathite like absorptions.
As indicated in EDS spectrum 7 and table (Fig.3) the composition of these grains is typical of merrillite. Merrillite is a mineral not yet fully studied by means of VIS-IR spectroscopy technique because of its scarceness.

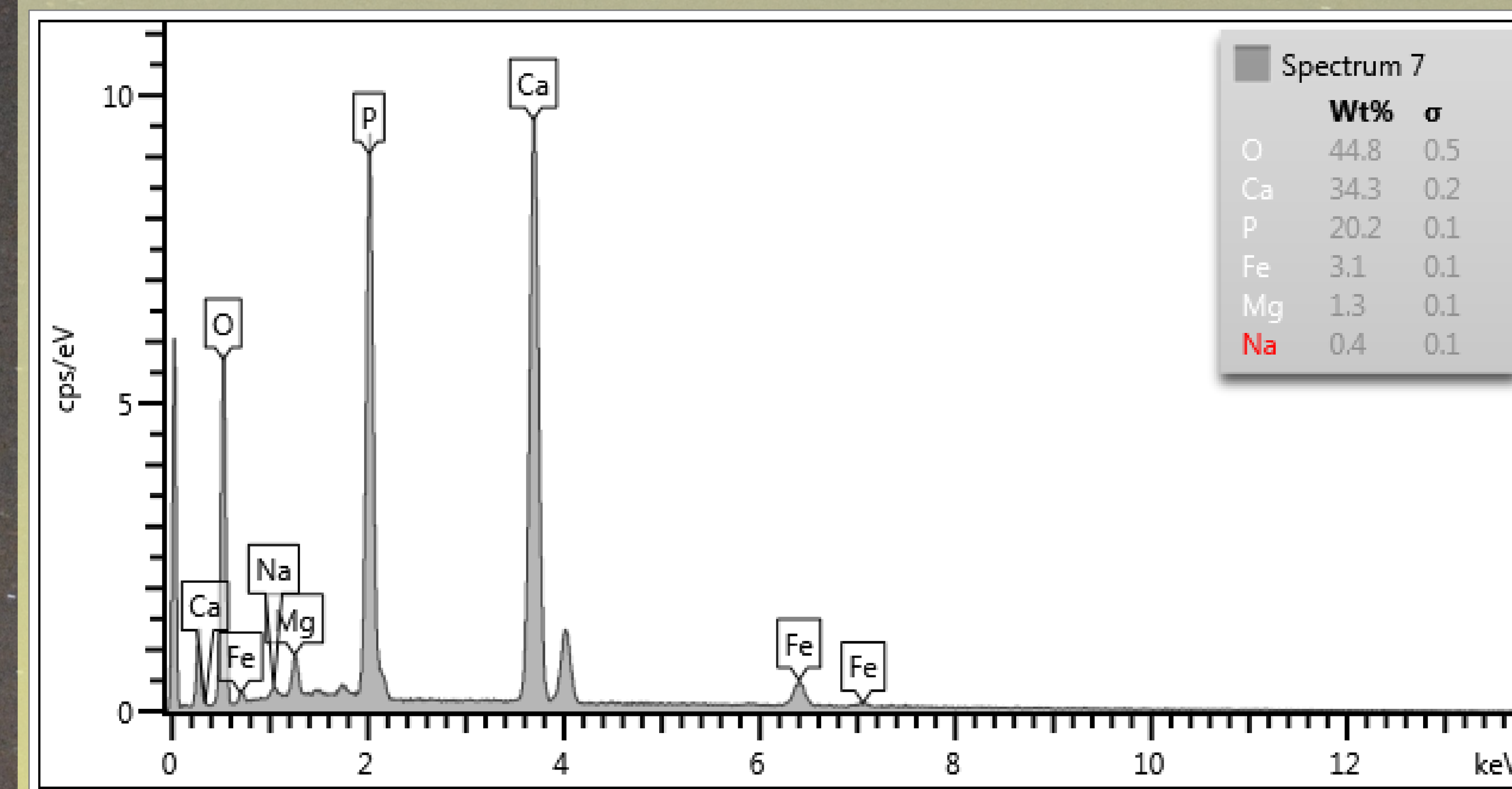

Fig.3 EDS spectrum of a merrillite grain.

Conclusions:

The high spatial and spectral resolution of SPIM offers the possibility to reveal spectra of minerals like merrillite that usually does not occur as a discrete mineral phase on Earth, and therefore need to be synthesized from a similar terrestrial mineral, eg. whitlockite (natural or synthetic), through dehydrogenation.[6]
More important, the spectral measurements directly on minerals from the same rock- in this case a martian meteorite- would mean investigations on minerals that have the same paragenesis or suffered the same sedimentary- metamorphic processes. This, in turn, improves the unmixing models used for explaining remote sensed data and our comprehension of the conditions under which the minerals have formed or have re-equilibrated, in the view of Mars and planetary relevant studies.

References: [1] De Angelis S., et al., *Rev. Sci.Instrum., 86, 2015.* [2] De Sanctis M.C., et al., *Space Sci. Rev., 163, 329-369, 2011.*[3] Westheimer, F.H., (1987) *Science, 235 1173-1178.* [4] Harloff & Arnold, (2001), *PSS, 49, 191-211.* [5] Lane M. D., et al., *Lunar and Planetary Science XXXVIII, abs#2210, 2007.* [6] Adcock C. T. et al., *American Mineralogist, 99 (7), 2014.*