IN-SITU RAMAN, LIBS AND MÖSSBAUER SPECTROSCOPY OF SURFACE MINERALS AT JAROSO RAVINE AND RELATED AREAS IN SIERRA ALMAGRERA (ALMERIA-SPAIN).

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Introduction: The Jaroso Hydrothermal System (JHS) located in Sierra Almagrera (Almeria-Spain) is an extremely interesting late-volcanic episode, and the "Jaroso Ravine" (of approximately 2 km × 4.5 km) is the best outcrop where the mineralization and alteration processes, associated with the JHS, have attained the maximum surface expression. Jaroso Ravine is also the world locality type of Jarosite an iron-bearing sulphate, which contains hydroxyl inside its structure $[(K,Na,X+1)Fe3+(SO4)2(OH)6]$ and which was first discovered on Earth in 1852.

Jarosite was also detected unambigously at Meridiani Planum on Mars by Miniaturised Mössbauer spectrometer onboard the MER's rover Opportunity [2-3].

Sierra Almagrera is a metamorphic massif with an NE-SW axis. It is composed of graphitic phyllites, quartz rich phyllites and quartzites, with a paragenesis of quartz, muscovite, and graphite and, to a lesser extent, biotite and garnet. Mineralization occurs as veins with mineralogical zonation. Among the main species detected [1] oxy-hydroxides (hematite, goethite), carbonates (calcite, siderite) and sulfates of Fe and Ba (*jarosite*, alunite, barite); sulfides and *sulfosaltsulfides (*pyrite, sphalerite, chalcopyrite, marcasite).

The peculiar spatial and temporal coalescence of volcanism, tectonism, mineralizing hydrothermal episodes and intense evaporitic events (Mediterranean saline crisis) in this area and in particular the JHS, which is responsible for both the Jaroso ores (especially rich in Jarosite), and the Las Herrerias sulfate-rich laminates could be exploited, as a volcanic related model for early Mars.

In this work we describe the results obtained from an in-situ mineral analysis using Raman, LIBS and Moessbauer techniques during a field trip performed in this area in September 2009.

Experimental: Raman spectroscopy was performed in-situ at the field on samples without any preparation using a portable i-Raman spectrometer from *B&W TEC Inc*. Spectral resolution was ~5cm-1. The spectrometer was adapted to work in field conditions. The excitation used was a 532nm wavelength laser (Proptotype II for ExoMars misison) with about 25mW power on the sample and a spot diameter of 100µm. The LIBS spectrometer used is the Porta LIBS 2000 system from Stellar NET inc also adapted for field experiments. The LIBS is illuminated by a pulsed laser at 1064 nm and the spectromenetr covers the spectral range 350-850nm.

Results : In Figure 1 a weathered outcrop inside the Jaroso Ravine containing the original material but also significan amounts of alteration deposits is depicted.

Figure 1 . A weathered outcrop inside the Jaroso Ravine measuring about 5 meters long.

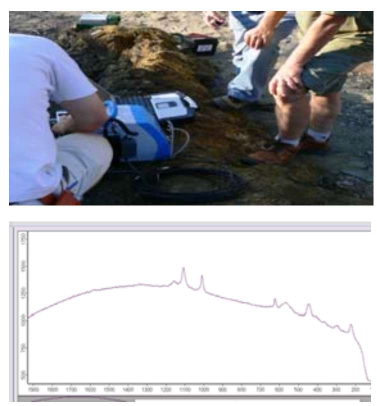

Figure 2. Raman spectrometer working at the field (top) and one of the spectra obtained at the outcrop (bottom). Jarosite is clearly identified.

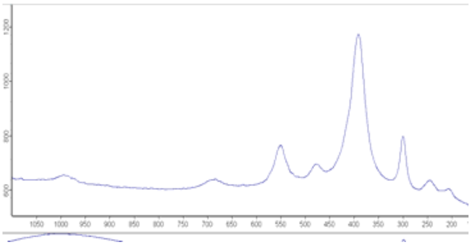

Figure 3: Raman at other spots in the outcrop detected pure goethite.

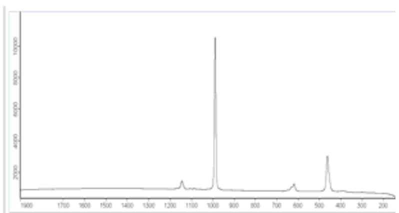

Figure 4. Raman in-situ analysis of a massive piece near the outcrop. Pure barite is identified.

Mössbauer spectrometer was also placed at different spots on the outcrop. The results obtained are shown in Figure 5.

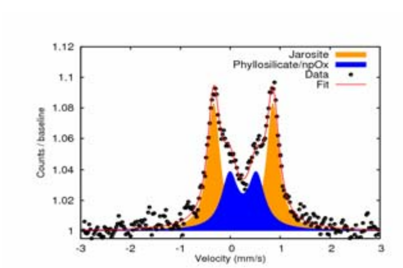

Figure 5. In-Situ results from the Mössbauer spectrometer MIMOS II on the weathered outcrop (see above). Jarosite and a Phyllosilicate/nanophase-oxide (npOx) could be identified.

LIBS spectra were also taken at different spots and in particular from the original material after some shots removing the coating of jarosite. Figure 6 show a spectrum obtained in-situ. Ca is clearly detected consitent with fillite as the base material as Raman detected.

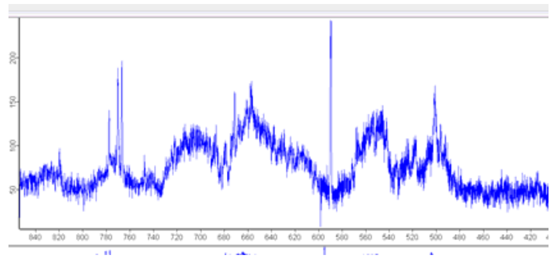

Fig. 6. LIBS spectrum taken at the outcrop of Figure 1.

References

[1] Martinez-Frias, et.al. 1991
[2] Klingelhöfer et al., Science 306 (2004) 1740-1745,
[3] Klingelhöfer, G., Hyperfine Interactions 158 (2005) 117-124
[4] Fleischer et al., Journal of Physics, accepted.
[5] Klingelhöfer et al., Journal fo Geophysical Research (JGR) 108, E12 (2003) 8067

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