Geological field study in Martian life simulation conditions

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1. Intro and key issues

In recent decades, the study of Martian geology has been one of the main aims of robotic exploration missions on Mars.

LIBS is a technique widely used during these missions to determine the chemical composition of a rock from a laser shot [1]. The instrument, mounted on a rover and remotely operated from Earth, is a major asset for understanding geological formations. But the instrument's method of operation also has several limitations:

- reduced number of laser shots
- reduced speed of rover movement
- difficulties of rovers to access certain rocky areas
- limited time of operation of the instrument allocated to the scientific team

Need: adapt traditional field geology techniques to prepare for future missions of extra-planetary geological exploration with human crews.

Crew 263 is a group of seven students from ISAE-Supaero which performed an analog Martian mission at the Mars Desert Research Station (MDRS) in the Utah desert (USA).

Fig.1 Mars Desert Research Station

Objective: show the advantages of using handheld LIBS analyzers for geological documentation by a human operator through an analog mission at the MDRS.

→ **Use of SciAps Z-903.**

Fig.2 Analog Astronaut handling a Z-903 during an EVA

Fig.3 SciAps Z-903 handheld LIBS analyzer

The analog astronauts had **minimal geological training.**

2. Utah as a Mars analog

Mars	Utah
Absence of internal planetary activity	On the North American plate: very few tangential tectonic deformations
Rock debris very well preserved	Presence of horizontal deposits of sediments encrusted with nodular sulphates
Thick formations of sulphate deposits nested in sedimentary matrix	Summerville formation: evidence of depositional environment

Similar geological context in terms of water cycle evidence preservation.

= Ideal analog to train astronauts for geological field documentation.

2 study cases:

1) Document the transition between Jurassic and Cretaceous geological eras (J2-K1)

2) Document the different types of sulphate deposits present in the Summerville Formation.

3. Field Study Results

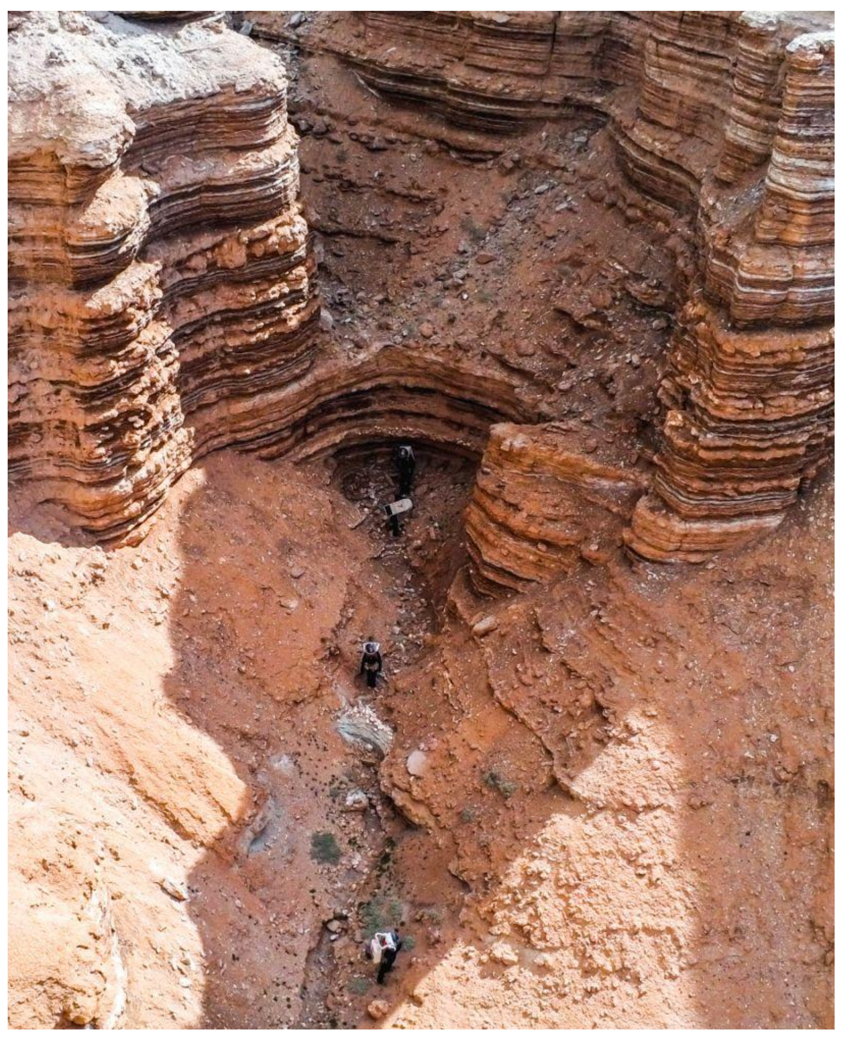

Fig.4 Analog Astronauts performing LIBS analysis in hilly places

1) LIBS shots in areas difficult to reach with a robotic arm :

- vertical analysis (up to 5 meters)
- analysis in canyon like areas (crevices, rock fracture)
- various altitude ranges reached (canyon, land, outcrops)

Table 1: EVA characteristic parameters during Crew 263's mission

	Average Number of LIBS shot per EVA	Average number of sample waypoints analyzed per EVA	Average EVA length [min]	Average distance covered during the EVA [km]
J2-K1 transition	10	3	60	1.4
Sulphate in Summerville	11	4	150	4

In comparison, Curiosity travelled 30 km in 10 years and one workspace is analysed per day.

2) Documentation work on the field :

Fast decision-making on samples to be collected/analysed in the site.

Pre-analysis on the environment is possible by on-field documentation

Aid to documentation

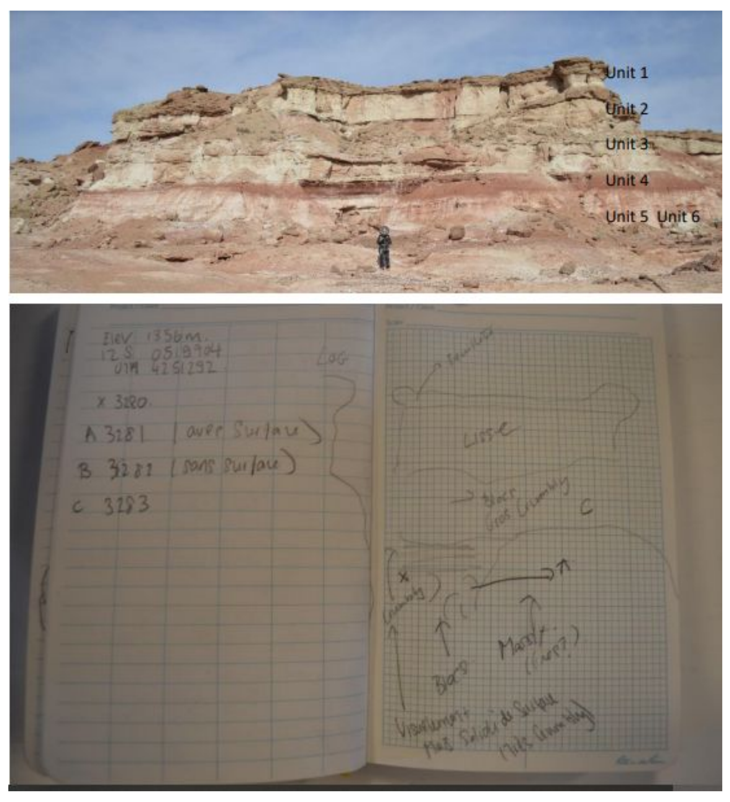

Fig.5 Work on the field. Sketch of an outcrop and identification of 6 units. Samples analyzed with the Z-903 are referenced next to the sketch.

3) **Portable LIBS advantages :**

- Low weight (1.97 kg)
- Small volume (27.3x7.3x21.9 cm)
- Easy to carry (Fig.6)
- Li-Battery last for >2h

Fig.6 Gearing situation of the astronauts during an EVA.

4) **On field decision making:**

- Discrimation of areas that are out of the scope of the study (e.g quick identification of sulfur in rocks for Study Case 2): possible through the *GeoChem App*
- Direct visualization of the spectrum

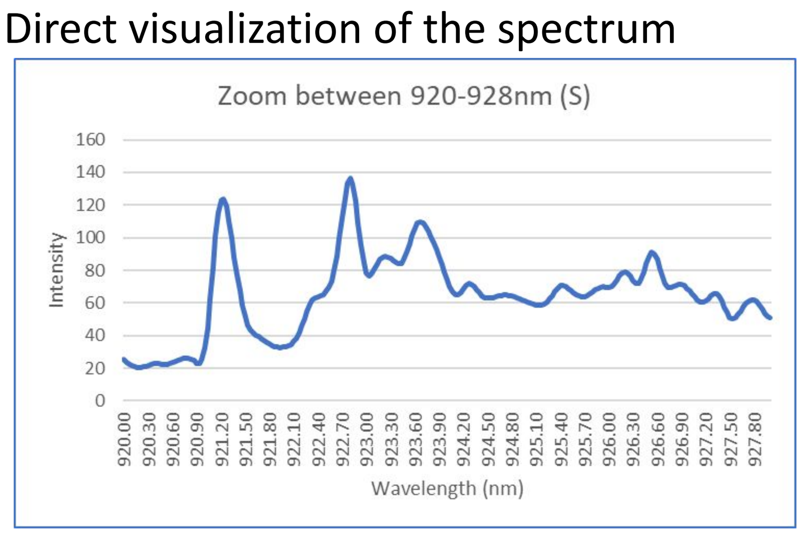

Fig.7 Zoom at S wavelength for a spectrum of LIBS shot in Satinspars

Fig. 8 Satinspar in the Summerville formation analysed with the Z-903

Conclusion: The field study carried out clearly shows the advantages of the portable LIBS operated by an astronaut in the identification of formations of interest and decision-making in the field.

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Reference

[1] S.Maurice et al., ChemCam activities and discoveries during the nominal mission of the Mars Science Laboratory in Gale crater, Mars (2016, Royal Society of Chemistry) [2] Angela L.Coe, Tom W. Argles, David A. Rothery, Robert A. Spicer, Geological Field Techniques, Ed. Angela L. Coe (2010, Wiley Blackwell edition)