EPSC Abstracts
Vol. 12, EPSC2018-926, 2018
European Planetary Science Congress 2018

Appraisal of lithologies and biosignatures using the ExoMars 2020 CLUPI instrument: blind tests using simulated mission observational conditions

Keyron Hickman-Lewis (1,2), Steven Pelletier (3), Frédéric Foucher (1) Fabio Messori (4) and Frances Westall (1)

(1) CNRS Centre de Biophysique Moléculaire, Rue Charles Sadron, 45071 Orléans, France, (2) Dipartimento di Scienze Biologiche, Geologiche e Ambientali (BiGeA), Via Zamboni 67, 40126 Bologna, Italy, (3) Université François Rabelais de Tours, 37000 Tours, France, (4) Università degli Studi di Modena e Reggio Emilia, 41121 Modena, Italy.

Abstract

The objective of the ExoMars 2020 mission will be the characterization of an ancient Martian locality with high potential for both former habitability and the exceptional preservation of physical and chemical biosignatures. The payload will include a drill producing cores from the subsurface, which will be imaged at high-resolution by the CLose UP Imager (CLUPI), an approximation of a geologist's hand lens. CLUPI will image with a maximum resolution of 7µm/pixel the physical character of the extracted core, from which immediate detailed geological observations can be made. In this study, we produced core samples of Mars-analogue rocks from the International Space Analogue Rockstore (ISAR) and, using a camera with observational settings prescribed to those of the CLUPI instrument, attempted a full characterisation of the samples. These samples were of lithologies, and featured biosignatures, analogous to those known or proposed for Mars. Images were taken in PanCam- and CLUPI-representative conditions. These images were analysed in a "blind test" against a directed analytical 'questionnaire' by a group of scientists. Their conclusions are indicative of the potential of the CLUPI instrument to make fundamental geological assessments of samples prior to their analysis by the Pasteur Instrument Suite.

1. Introduction

Astrobiology on Mars has a long and intriguing history; since the *Viking* missions of the mid-1970s, a number of subsequent spacecraft have explored the planet with explicit objectives relating to the detection of life. The ESA-Roscosmos ExoMars 2020 missions [1,2], to be launched in 2020, will target an ancient locality on Mars within which past (Noachian) habitability would have been possible. More than 3.5 Ga have passed since the deposition of these rocks and, despite the apparent possibility for enhanced lithological preservation on Mars, the most appropriate analogue for planetary habitability over such great geological time and at microbial scales is the early Earth [3,4].

The International Space Analogue Rockstore (ISAR; [5]) was created as a tool for mission preparation, including geological samples representative of the expected lithologies on Mars, and examples of samples from the early Earth within which biosignatures of putative chemosynthetic origin are preserved. These biosignatures, though often enigmatic in their morphological preservation, present traces that can be identified as biogenic in origin. Chemosynthetic pathways represent the most likely metabolic affinities for putative extinct (or extant) Martian life [2,3].

A selection of eight of the ISAR samples relevant to Martian geology [5] and astrobiology were chosen for use in this "blind test".

2. The CLUPI "Blind Test 2.0"

When cores are taken by the ExoMars 2020 rover, the first step of geological analysis will be conducted by the CLUPI instrument, which will essentially function as a geologist's hand lens [6]. From these analyses, *conducted on core samples*, will come the initial interpretations of the small-scale (textural and rock fabric) geology of the sample, and the initial estimation of morphological biosignatures that may be preserved within. These initial findings will guide the strategy of analysis to be undertaken by the Pasteur Instrument Suite.

Following the undertakings of the first "blind test" [7], the objectives of this new "blind test" concern the direct appraisal of the cores collected by ExoMars 2020. The observation of samples in core form will add further limitations to the possibility for imaging and interpretation. Cores were produced of representative size (3cm x 1cm) to those that will be produced during the mission and were imaged using a camera setup imitating the conditions of imaging of PanCam and CLUPI. A set images of the cores were taken in different lighting conditions and at a range of resolutions including the maximum expected for the CLUPI instrument (7µm/pixel; [6]).

An analytical 'questionnaire' was designed and sent, together with the images and a set of Raman spectra, to a group of scientists. These data were sent sequentially such that the scientists could modify and develop their ideas as more data became available. This 'questionnaire' probed for initial observations of mineralogy, texture, sedimentary structures and biosignatures, together with fundamental geological observations including grain size, grain morphology, secondary alteration phases and features, impacts of porosity, deformation and microtectonics, and finally an estimation of the identity of the sample.

The results of the questionnaire showed that, although biosignatures and sedimentary structures could be challenging to successfully identify in the limited image set, many of the fundamental geological observations were made with success. The analytical workflow suggested by the questionnaire is clearly an appropriate approach to be taken in preliminary analyses. When combined with the detailed analytical work to be conducted by the remainder of the Pasteur Instrument suite, a truly detailed appraisal of the palaeoenvironment and geological history should be feasible.

3. Summary and Conclusions

The "Blind Test 2.0" has measurably added to the findings of the first "blind test" by introducing limitations in findings that will be incurred by the nature of the sample, i.e. it is more difficult to make concrete geological conclusions from a sample with core-like dimensions as opposed to a hand sample. To this end, discussions of the shortcomings in observation of small samples imaged in limiting conditions are critical to the geological interpretation, particularly for heterogeneous samples, for which CLUPI may be unable to representative image. The limitations of image resolution and the challenge in detecting primitive biosignatures add further constraints to our observations.

Nevertheless, the positive outcome of the "Blind Test 2.0", i.e. that many detailed geological, textural and mineralogical observations can be made from only the PanCam and CLUPI images together, is indicative of the utility of this instrument in the payload, particularly in initial guiding observation of the samples taken. Together with recent findings that aspects of palaeoenvironmental reconstruction may be achieved through morphometric analysis of the shape parameters of grains within the resolution limits of CLUPI [8], the images taken will provide important evidence for geological interpretation.

The "Blind Test 2.0" is just one in a series of planned tests of CLUPI together with the other instruments in the Pasteur payload, the results of which combined will continue to guide the the sampling and analysis stratagem of the ExoMars 2020 rover. Testing campaigns such as these will define if, and how, putative Martian biosignatures may be detected in samples collected at the surface of Mars.

Acknowledgements

We gratefully acknowledge the support of CNRS, CNRS, and the MASE project. We further thank the group of scientists who kindly volunteered as subjects against whom our 'questionnaire' was tested.

References

[1] Vago, J.L., et al., 2015. Sol. Sys. Res. 49, 518–528.

[2] Vago, J.L., et al., 2017. Astrobiology 17, 471–510.

[3] Westall, F., et al., 2015. Astrobiology 15, 998–1029.

[4] Cabrol, N.A., 2018. Astrobiology 18, 1–27.

[5] Bost, N., et al., 2012. 39th COSPAR Assembly, p.223.

[6] Josset, J.-L., et al., 2017. Astrobiology 17, 595–611.

[7] Bost, N., et al., 2013. Planet. Sp. Sci. 82–83, 113–127.

[8] Kapui, Zs., et al., in press. Planet. Sp. Sci.