THE EXOMARS 2020 MISSION: AN EARTH ANALOGUE EXAMPLE OF THE SEARCH FOR CHEMOTROPHIC BIOSIGNATURES

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Introduction: The ExoMars 2020 mission aims at searching primarily for traces of past life within a specific geological context. The potential landing sites, Oxia Planum, Mawrth Vallis and Aram Dorsum represent a variety of sediment types and geological settings including clay lithologies and volcanoclastic sediments of Early Noachian to Hesperian and later ages. Those deposited during the period of most likely habitability, *i.e.* Noachian to Early Hesperian, are of most interest. These volcanic, altered volcanic and probably chemical sediments were deposited in anoxic environmental conditions similar in many respects to those reigning on the early Earth, at least from a microbial perspective [1-3]. However, given the lack of long-term habitability of the isolated and temporally distant habitats, it is unlikely that, if life did emerge on the planet, it evolved beyond a chemotrophic metabolism [4]. Understanding of the preservation of chemotrophic life forms and their fossilized signatures in lithified (cemented) sediments is greatly aided by study of suitable terrestrial analogues formed under similar conditions to those of Early Mars. Such analogues will also be very useful for testing the ExoMars 2020 instrument payload in order to make the best exploitation of the results *in situ* on the martian surface.

The ExoMars 2020 mission has a highly complementary instrument suite enabling complete geomorphological and geological evaluation of the site of interest down to the microscopic level, including a spectral panoramic, high resolution and close-up cameras, ground penetrating radar, long range IR, µ-IR and Raman spectrometers, and GC plus LD-MS [Vago et al., 2017]. Biosignature evaluation will be made on the basis of geological context, microscopic study of potential biostructures of concentrations of carbon in the sediments, as well as by IR and Raman determination of the presence of carbonaceous matter and LD-MS and GC-MS identification of carbon molecules and eventual chiral signatures [3].

Early Archaean (3.5-3.4 Ga) analogues and fossilized chemotrophic organisms: Early Archaean volcanic sediments altered in aqueous environments and influenced by hydrothermal fluids are excellent analogues for early Mars [1,4,5]. Deposited in similar anoxic conditions, they host fossilized traces of chemotrophic life forms [1,4,5]. Chemolithotrophs colonized the surfaces of volcanic grains, altered to phyllosilicates, while chemoorganotrophs formed spiky colonies in hydrothermally-precipitated, siliceous chemical sediments, as well as cannibalizing the remains of lithotroph colonies of the volcanic grain surfaces. However, while the lithotrophs appear to have been fairly widespread in their distribution, even in relatively oligotrophic waters (*i.e.* poor in nutrients), the distribution of the organotrophs was distinctly controlled by their vicinity to nutrient-rich hydrothermal fluids.

These primitive organisms were preserved by rapid encapsulation in a mineral cement (silica in this case) resulting in a variety of biosignatures: (1) the physical remains of cells, colonies of cells, biofilms, (2) degraded organic carbon either associated with the fossils of disseminated in the fine-grained argillaceous or chemical sediments, (3) as corrosion tunnels in the surfaces of volcanic grains.

For the ExoMars payload, while individual fossil-cells are too small to be identified directly (<1µm), colonies in the form of clots or biofilms could be observed microscopically as dark patches or layers within martian sediments. The presence of carbon associated with potential biosignatures would be revealed by Raman and IR spectroscopy and the structure of the carbon molecules, including their chirality would be revealed by the MS techniques. As noted above, geological context is essential for correct biosignature identification and would be also provided by the rover instrument suite.

Conclusions: The Early Archaean volcanic and chemical sediments are excellent analogues for Noachian Mars. The fossil chemotrophic biosignatures they contain reinforce their utility as Noachian-Mars analogues. Tests of the ExoMars instruments with these rocks will greatly enhance the science return of the ExoMars 2020 mission.

References: [1] Westall et al., (2011) *Planet Space Sci 59*, 1093–1106. [2] Westall, F. et al., (2013) *Astrobiology, 13*, 887-897. [3] Vago, J. et al., (2017) *Astrobiology*, in press. [4] Westall, F. et al. (2015) *Astrobiology, 15*, 998–1029. [5] Westall, F. et al., (2015) *Geology, 43*, 615–618.

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