How to Find Life on Mars:
Investigating biological potential and putative biosignature formation.

Supervisory team: Karen Olsson-Francis, Susanne Schwenzer, Vic Pearson.

Project Highlights:

- Guaranteed funding from the UK Space Agency.
- Conduct Mars analogue experiments using state-of-the-art simulation facilities to investigate biosignature formation.
- Support the Mars2020 mission by evaluating the biological potential of locations within Jezero Crater.
- Develop expertise in mineral biosignature formation by combining geochemistry with microbiology.

Overview:
The Mars2020 Perseverance Rover mission is focused on investigating Jezero Crater to find signs of life (biosignatures) preserved in rocks laid down when the environmental conditions were conducive to life. Previous missions have found evidence of palaeo-habitable environments on Mars during the Noachian period (4.1–3.7 Ga), including an ancient salt-bearing lake at Gale Crater where water-rock interactions could have provided energy exploitable by life. Orbital data for Jezero Crater shows the prevalence of water over geological time, as illustrated in Figure 1, so water-rock interactions may have provided energy for metabolic processes here too.

One group of microorganisms that may have benefitted from this energy are chemolithoautotrophs. They catalyse inorganic chemical reactions through reduction-oxidation (redox). Numerous redox-active elements exist on Earth, e.g., iron, sulfur, carbon, and nitrogen. The availability of these chemical species is a limiting factor in controlling microbial populations. The feasibility of chemolithoautotrophic metabolisms on Mars has been researched extensively, including at AstrobiologyOU. Now, with the Perseverance rover depositing the first set of samples for sample return, it is important that this is evaluated for Jezero Crater in detail.

To ground-truth any theoretical results, laboratory-controlled simulations are required to mimic the physicochemical conditions identified at the landing site. They are essential to identify secondary alteration minerals produced uniquely by biotic processes that could be detectable by instruments onboard the Perseverance rover, e.g., SHERLOC and SuperCam, and be used as biosignatures.

Therefore, the aims of this studentship will support the Mars2020 mission by: 1) designing laboratory-based simulation experiments to evaluate the biological potential of locations within Jezero Crater as defined by their mineralogical and stratigraphic characteristics; 2) identifying plausible geochemical biosignatures specific to locations within the Crater using laboratory-based simulations.

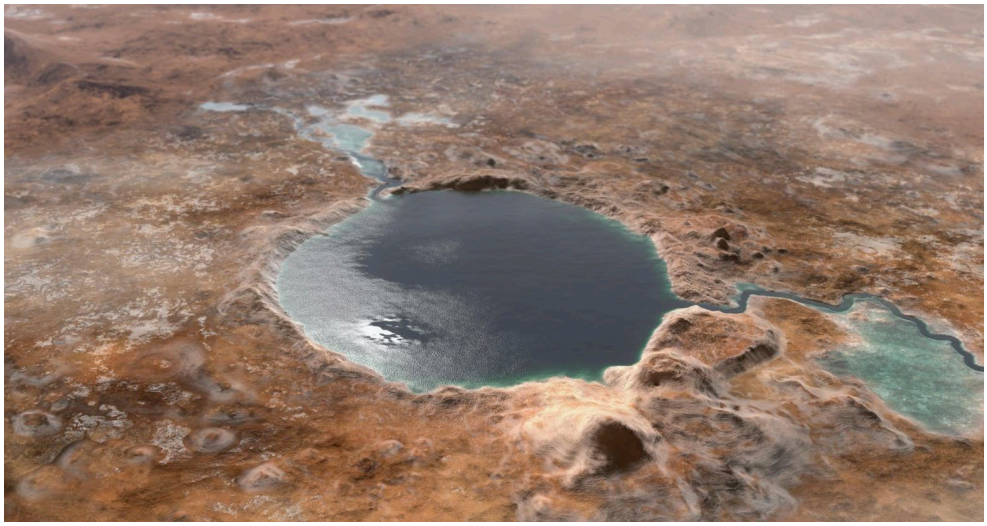

Figure 1. An illustration of Jezero Crater, showing what it may have looked like billions of years ago on Mars. Credit NASA/JPL-Caltech.

Methodology:
The student will: 1) Undertake abiotic laboratory simulation experiments utilising published pre-landing and new post-landing data as released to the Planetary Data System; 2) Undertake equivalent biotic laboratory-based simulation experiments using a chemolithoautotrophic community from a terrestrial analogue site (characterised as part of an ongoing study within the group); 3) Use geochemical techniques, such as FEG-SEM-EDS and Raman, to characterise secondary alteration minerals formed during the simulation experiments.

Training and skills:
The student will receive training in geochemistry and microbiology analyses, and in running environmental simulation experiments. The student will also benefit from bespoke training organised by the School (Earth, Environment and Ecosystem Sciences, EEES) and by AstrobiologyOU, including mandated training, such as health and safety and laboratory skills. They will benefit from being a member of a cross-school research group, with relevant in-house training offered as part of the NERC-funded CENTA and SEPnet schemes. AstrobiologyOU also offers dedicated training events and seminars, including CV-writing support, managing budgets and fellowship writing training. AstrobiologyOU is committed to identifying teaching opportunities for any student that desires them and offering public engagement opportunities to support communication skills development.

Possible timeline:
Year 1: Perform a literature review and design the physio-chemical conditions for the environmental simulation experiments.

Year 2: Obtain training in geochemical and microbiology analyses and run the simulation experiments. Present results at a national conference.

Year 3: Prepare and submit a manuscript regarding biosignature formation. Write and submit thesis. Present data at an international conference.

Further reading:
Farley, K.A., Williford, K.H., Stack, K.M. Bhartia R, Chen, A., de la Torre, Hand, K., Gore, Y., Herd., C.D.K., Hueso R., Liu Y., Maki J.N., Martinez, G., Moeller, R.C., Nelessen, A., Newman, C.E., Nunes, D., Ponce and Wiens R.C. (2020). Mars 2020 Mission Overview. *Space Science Review* 216, 142.

Westall, F., Loizeau, D., Foucher, F., Bost, N., Betrand, M., Vago, J., & Kminek, G. (2013). Habitability on Mars from a Microbial Point of View. *Astrobiology*, 13(9), 887–897.

Olsson-Francis, K., Ramkissoon, N. K., Macey, M., Pearson, V. K., Schwenzer, S. P. and Johnson, D. N. (2020) Simulating microbial processes in extraterrestrial, aqueous environments. *Journal of Microbiological Methods*, 172, 105883.

Further details:
Students should have a strong background in geochemistry/ mineralogy/planetary science and an interest in microbiology. The successful student will join the well-established AstrobiologyOU (more details will be found here) and a vibrant postgraduate community at The Open University. To be eligible for funding, the student must be classed as a home student based on the UKRI definition – for more information please refer to: PHD STUDENTSHIPS | School of Environment, Earth and Ecosystem Sciences | School of Environment, Earth and Ecosystem Sciences (open.ac.uk)

Please contact Karen Olsson-Francis (karen.olsson-francis@open.ac.uk) for further information.

Applications should include:

- a cover letter outlining their motivation for doing a PhD, why this specific project is of interest and how their skills (technical and transferable) match those required of this project,
- an academic CV containing contact details of three academic referees,
- an OU application form, downloadable from: https://www.open.ac.uk/students/research/system/files/documents/application-form-uk.docx

Applications should be sent to **STEM-EEES-PHD@open.ac.uk** **by 12pm (noon) on 22nd February 2023.** Interviews will be held week commencing 6th March 2023.