From Warm and Wet to Cold and Dry on Mars: Ancient Environments as seen from a Rover Perspective

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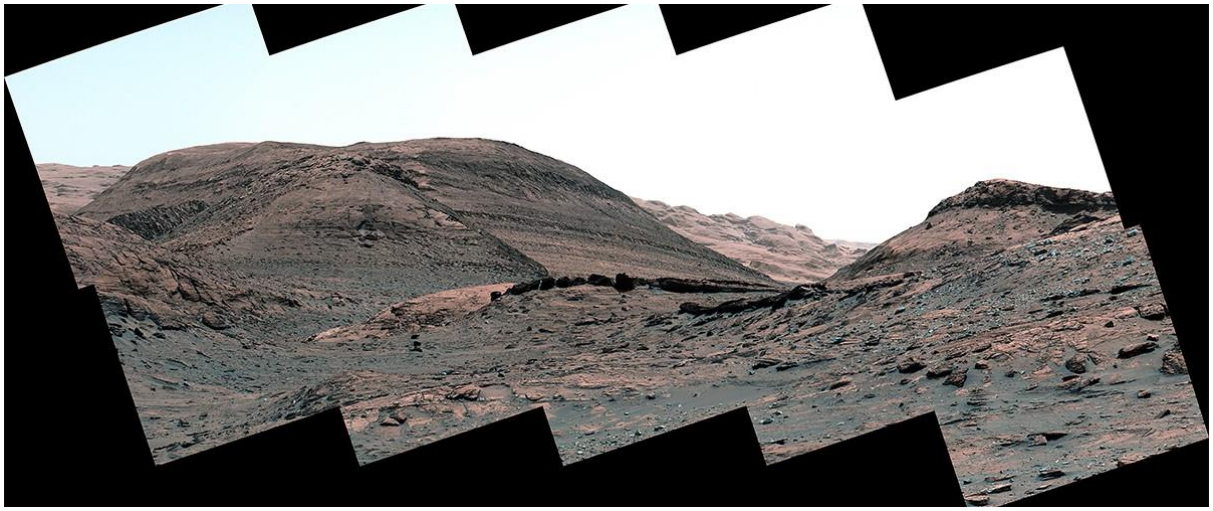

Project highlights:

- Taking part in the current exploration of Mars: The NASA Curiosity and NASA Perseverance rovers are exploring Mars as you read this. Curiosity is currently exploring the transition from a wet Mars to a more dry Mars and evaporation environments. This project will use rover-based data and other sources of information (e.g., Martian meteorites and terrestrial analogues) to understand alteration processes and habitability of Mars
- The research will be carried out through geochemistry and thermochemical modelling, determining the environmental conditions during water-rock reaction processes at the rover landing sites, especially at the transition from a warm and wet to a cold and dry Mars.
- This project will allow the student to become an experienced user of a wide range of software, e.g., for thermochemical modelling, and gain knowledge about environmental processes shaping habitability of a planet. During the project they will join the Martian research community, including mission teams, and be part of the lively Martian geochemistry, geomorphology and astrobiology community at the OU.
- This project is carried out with the University of Leicester. Supervisors are embedded in active or future Mars missions, including rover operations and planetary protection.

Project description:

Recent landed missions - from the NASA MER rovers Spirit and Opportunity to the polar lander Phoenix and most importantly the NASA rover Curiosity – have all found alteration minerals, predominantly clays, sulfates, in the sediment at their landing sites. Curiosity has reached the Sulfate Unit, which will be a major focus of this studentship. The NASA Perseverance rover is exploring Jezero Crater, and the ESA ExoMars Rosalind Franklin rover will be launched in 2028. Alteration minerals, and their formation, are very important to the geochemistry of the Martian surface; moreover, based on orbital investigations, alteration minerals, especially clay, carbonates and sulfates are predicted at the ExoMars site identified at the NASA Mars2020 landing site. This PhD will be using information obtained about Martian alteration minerals, especially from the Curiosity rover mission within the Sulfate Unit, to contribute to answering two important questions that all Mars exploration has in common: What were the environmental conditions at this site? And was this site habitable? These are questions central to rover-based exploration of Mars.

This PhD is embedded in a collaboration between the University of Leicester, UK, and the Open University, within a group of researchers who study planetary mineralogy and geochemistry as well as planetary protection, and are part of the Curiosity science team. The overall project will cover all aspects of mineralogy and petrology, reaction pathways of water-rock interaction and the effect on the ancient habitability of the site.

A central objective of the work is to work with data from active rover missions and use geochemical data to understand the mineralogy and chemistry of rocks before and after water-rock reactions. Those data will then be used to decipher reaction pathways between the unaltered host rock and the alteration mineral assemblage, resulting in a definition of environmental parameters, such a composition of the fluid during alteration, pH and temperature. This will allow to define the environmental conditions and aid rover mission data interpretation and the planning of future missions, especially from a planetary protection perspective.

The successful candidate will be able to work with data from active missions, interact with the international Mars science community, and will be embedded in the planetary research at the School of Physical Sciences and at AstrobiologyOU. The main task of the PhD itself will focus on thermochemical modelling of the reaction pathways of specific host rock – alteration assemblage pairs recently investigated on Mars. This work will be based on expertise gained from previous modelling of alteration pathways and Ca-sulfate transport vein formation within Martian environments, but will be unique in the accuracy achievable when working with detailed ground truth data. The results from the modelling will be the basis of the habitability assessment of this Martian site, which can - depending on the interests of the student - include applying Gibbs energy calculations to the modelled conditions to find out which metabolisms would be possible in the setting, and how much biomass could theoretically be produced.

References:

1. Grotzinger, J. P., et al. (2015): Deposition, exhumation, and paleoclimate of an ancient lake deposit, Gale crater, Mars – Science, 350: doi: 10.1126/science.aac7575.

2. Bridges, J. C., Schwenzer, S. P., Leveille, R., Westall, F. Wiens, R., Mangold, N., Bristow, T., Edwards, P., Berger, G. (2015): Diagenesis and clay formation at Gale Crater, Mars, Journal of Geophysical Research, 120: doi: 10.1002/2014JE004757.
3. Schwenzer, S. P., Bridges, J. C., Wiens, R. C., Conrad, P. G., Kelley, S. P., Leveille, R., Mangold, N., Martin-Torres, J., McAdam, A., Newson, H., Zorano, M.P., Rapin, W., Spray, J., Treiman, A. H., Westall, F., Fairén, A. G., and Meslin. Y.-P. (2016): Fluids during diagenesis and sulfate vein formation in sediments at Gale Crater, Mars, Meteoritics and Planetary Science, 51: 2175–2202; doi: 10.1111/maps.12668.
4. Turner, S. M. R, Schwenzer, S. P., Bridges, J. C., Rampe, E. B., Bedford, C. C., Achilles, C. N., McAdam, A. C., Mangold, N., Hicks, L. J., Parnell, J., Fraenab, A. A., and Reed M. H. (2021): Early diagenesis at and below Vera Rubin ridge, Gale crater, Mars, Meteoritics and Planetary Science, in press, doi: 10.1111/maps.13748.