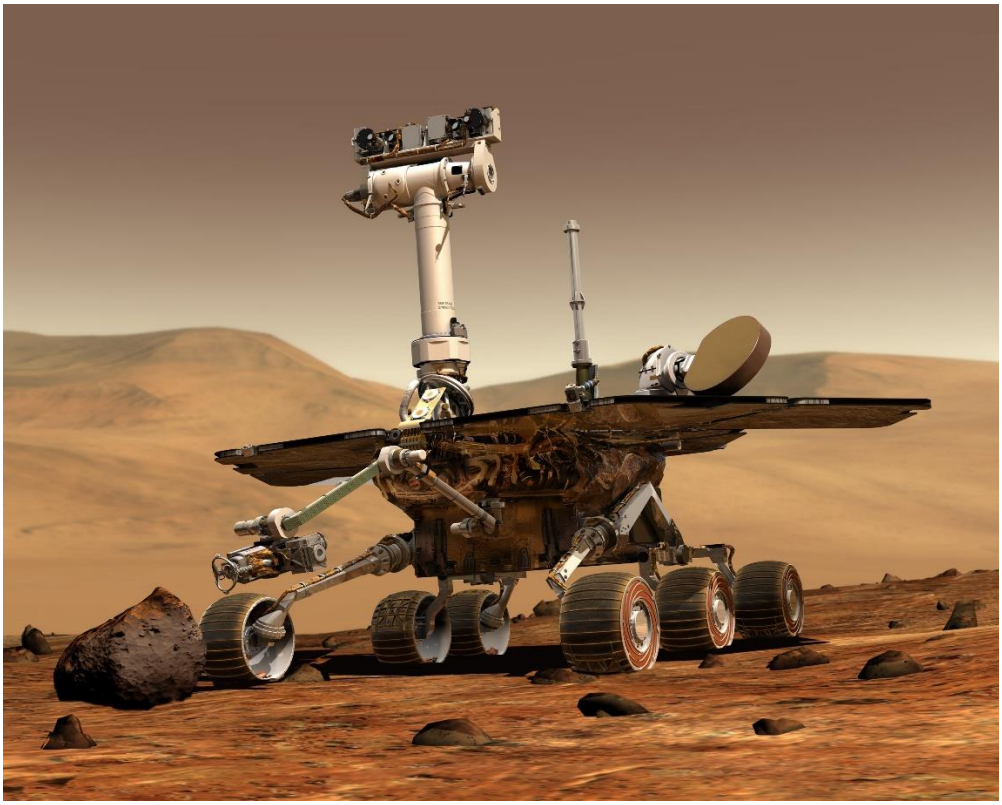
Preparing for Mars sample return – oxygen isotope analysis of Martian meteorites

Supervision team: Dr Richard Greenwood, Professor Mahesh Anand and Dr Susanne Schwenzer

Lead contact: Richard Greenwood (richard.c.greenwood@open.ac.uk)



The Martian meteorites (NWA 7034 and pairs) that will be studied during this project have a similar composition to the rocks on Mars studied by the NASA Spirit Rover at Gusev Crater (Image credit: NASA).

Project highlights:

- A training opportunity that will provide an early-career scientists with the key scientific and analytical skills relevant to the NASA/ESA Mars Sample Return initiative
- Isotopic investigation of samples that are known to be derived from the surface layers of Mars
- Opportunities to develop new analytical techniques relevant to Martian meteorites
- Participation and travel to relevant international conferences
- Full funding for this studentship has already been obtained from the UK Space Agency

Project description:

One of the major reasons for returning Martian samples to Earth is to be able to analyse them using sophisticated laboratory techniques that cannot be flown on spacecraft [1]. Careful preparation and planning are required in advance of Mars Sample Return (MSR) to ensure

that the maximum amount of information is extracted from these very important materials [2]. Equipping early-career scientists with the scientific understanding and technical skills required to maximize the benefit from MSR is a particularly high priority. These are not easy tasks, and they take time. We are fortunate to have in our sample repositories a range of Mars-derived materials that can be used to prepare for MSR.

This studentship will provide a training opportunity that is relevant to the science aims of MSR. It will also involve developing the sample-handling techniques needed once Martian samples are returned to Earth. Oxygen is a key element present in the Martian hydrosphere, lithosphere and atmosphere. Isotopic analysis of oxygen in Martian samples can be used to fingerprint critical processes involving the interaction of gases, fluids and rocks. These processes will help us to understand whether Mars is, or ever was, a habitable planet. But this information is not easily extracted from Martian rocks. We have developed a series of techniques that allow us to remove well-defined, small amounts of material from Martian samples and then to analyse their oxygen isotopic composition to a high level of precision. These techniques will allow us to understand both global and local scale processes on Mars. The information extracted from these samples will help us to understand how the Martian atmosphere and hydrosphere interact on a planet-wide scale and also how hydrothermal interaction between rocks and fluids occurred more locally.

Prior to the arrival of MSR materials, it is important that we make use of appropriate analogues to trial and refine our techniques and protocols. This studentship will make use of a range of available and relevant Martian samples to undertake oxygen isotope measurements that are both scientifically relevant and that help to optimize techniques ahead of MSR. In particular, a detailed investigation will be undertaken on the Martian breccia NWA 7034 which shows a close compositional similarity to surficial Martian rocks and soils, as analysed at Gusev Crater by the NASA Spirit Rover and by the Mars Odyssey Orbiter [3]. Other Martian samples showing clear evidence of interaction between rocks and fluids, such as the nakhlites and ALH 84001, will also be examined.

References:

1. Beaty DW, Grady MM and iMARS Working Group (2008) Preliminary Planning for an International Mars Sample Return Mission: Report of the International Mars Architecture for the Return of Samples (iMARS) Working Group. Available online at https://mepag.jpl.nasa.gov/reports/iMARS_FinalReport.pdf.
2. Meyer M.A. et al. (2022) Final Report of the Mars Sample Return Science Planning Group 2 (MSPG2). Astrobiology 22, Supplement 1 https://www.liebertpub.com/doi/pdf/10.1089/ast.2021.0121
3. Agee C.B. et al. (2013) Unique Meteorite from Early Amazonian Mars: Water-Rich Basaltic Breccia Northwest Africa 7034. Science 339, 780-785 https://www.science.org/doi/10.1126/science.1228858