Project title: Water-rock reaction on Mars - as seen through Earth analogues

Project code: OU27

Host institution: The Open University

Theme: Dynamic Earth

Key words: fluid rock interaction, hydrothermal, noble gases, Mars

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Project Highlights:
- Fluid alteration on Mars and Earth: It’s all about basaltic rocks
- Noble gases: pioneering new measurements
- Hydrothermal systems, driving forces for element mobility

Overview:
This project will use mineralogy and mass spectrometry to understand water-rock interactions, mineral formation, element mobility and volatile budgets in mafic rocks from Germany. These rocks are analogues for clay formation processes on Mars and on Early Earth. With a focus on the most recent finding of an impact-generated hydrothermal system by the Mars Exploration rover Opportunity at Endeavour crater, and the discovery of mudstones on at Gale Crater by the Mars Science Laboratory rover, understanding the detailed volatile and element pathways in aqueous alteration is more important than ever. Working at two universities with vibrant and internationally recognized research communities, and collaborating with Germany, this project is set out to create a more in depth understanding of processes on Mars - with potential for the application to the Early Earth.

Mafic and ultramafic rocks make up large parts of Mars and Earth. On Earth, they form the magmatic component of the ocean floors and at the mid-ocean ridges provide well-studied sites for the study of hydrothermal alteration. However they are also found on the continents where they are subject to a very different, i.e., less saline, alteration environment. Alteration products formed in continental environments are less well studied than the marine counterparts yet are highly relevant to understanding processes on Mars. The similarities are in weathering, diagenesis and subsurface fluid processes. The heavy noble gases (Ar, Kr, Xe) provide trace volatiles in such environments, whose sources, pathways and sinks have been intensely investigated in meteorites for the typical components found in them, but have not yet been investigated in detail for water-rock interaction based processes. This study offers an opportunity to make inroads into our understanding of alteration and its effect on the evolution of volatile budgets and element mobility on early Mars, and the early Earth.

This work will pioneer the combination of detailed mineralogical with heavy noble gas investigations by applying a method which is well established in meteorite research. This work aims to understand the element mobility, alteration mineral formation conditions and volatile reservoirs in rocks relevant to the evolution of early Mars and Earth. It will help to assess the effects of such alteration on the habitability of the surface and subsurface of these two terrestrial planets in the Noachian/Hadean times, the time to which we can track back the beginning of life on Earth.

Fig. 1. $^{129}$Xe/$^{132}$Xe vs. $^{84}$Kr/$^{132}$Xe in noble gas measurements from the Martian meteorite Lafayette, corrected for Earth atmosphere contamination (‘air’). Martian atmosphere as measured by Viking and in the EET 79001 meteorite. Mars interior component ‘Chassigny’ as measured in the Martian meteorite Chassigny, and ‘air’ indicating the composition of the Earth’s atmosphere, which is outside this diagram. Within uncertainties, the data suggest that Lafayette’s noble gases are a mixture of ‘Chassigny’ interior component and elementally fractionated Martian atmosphere (EFM) with $^{129}$Xe/$^{132}$Xe of ~8. For details of the data sources and more, see: Schwenzer and
Methodology:
In detail, this project will seek to

1. Provide a detailed mineralogical and geochemical account of the nature of alteration of mafic rocks from a range of environments from the Variscan in Germany (Odenwald/Saxothuringian Zone, and Lahn Dill Syncline/Rhenohercynian Zone) and – if desired - the UK, to deduce the specific alteration conditions (eg., temperature, fluid chemistry).

2. Pioneer the measurement of heavy noble gas signatures of minerals within alteration phases to understand the pathways and host minerals of volatiles.

3. Collate geochemical data to test and refine existing hydrothermal models to quantify the concentrations of elements acting as nutrients in the hydrothermal fluid and the environmental conditions for microbial life.

Training and skills:
The student will be trained in optical microscopy, electron microprobe and noble gas mass spectrometry, to the level of independent user. In addition, field work will provide planning and sampling skills. With the international nature of the project, team work and collaboration is an essential aspect of the work. Special emphasis will be on the oral and written communications skills, ranging from e-mail and phone negotiations, to conference presentations, report writing and publication in peer reviewed papers.

Partners and collaboration
This project will be in collaboration with Prof. Thomas Kirnbauer, Technische Hochschule Georg Agricola, Bochum, Germany, and Prof. John Bridges, University of Leicester, UK.

Possible timeline:
Year 1:
October to March: literature review on heavy noble gas studies and familiarization with the noble gas laboratory, followed by setting up for the Kr/Xe measurements and method development. Petrologic investigation of the samples already collected.

Year 2:
Petrology, mineralogy and detailed geochemistry of the samples, with special emphasis on the detailed mineralogy (TEM) and the noble gas measurements and data reduction.

Year 3:
Application of the noble gas measurements to a wider variety of samples, and application of the results to the wider context of terrestrial and Martian water-rock reactions

Further reading:

Further details:
Students should have a strong background in Earth or planetary sciences or a related field and enthusiasm for laboratory work and data analysis. Experience of with mass spectrometry or ultra-high vacuum is desirable. The student will join a well-established team researching into fluid rock interaction on Earth and Mars and working within the world leading Ar-laboratory at the Open University. Please contact Dr. Susanne P. Schwenzer for further information susanne.schwenzer@open.ac.uk

Applications should include:
- a cover letter outlining why the project is of interest and how their skills match those required,
- an academic CV containing contact details of three academic references
- and an Open University application form, downloadable from:
  http://www.open.ac.uk/students/research/sites/www.open.ac.uk.students.research/files/documents/Application%20form.docx

Applications should be sent to STEM-EEES-PhD-Student-Recruitment@open.ac.uk by 5 pm on 25th January 2017