Fluidnet PhD project adverts

Project Title	ESR5: How mobile are fluids and melts in the lower continental crust?
University (where student will register)	The Open University, UK
Key words	Lower continental crust, fluids, mobility, noble gas, tracers
Supervisory team (including institution & email address	**PI: Prof Clare Warren (Open University, clare.warren@open.ac.uk)** **Co-I: Dr Alison Halton (Open University, alison.halton@open.ac.uk)** **Dr Daniil Popov (Open University, Daniil.popov@open.ac.uk)** **Prof Jan Wijbrans (Vrije Universitijt Amsterdam, j.r.wijbrans@vu.nl)**

Project Highlights:

- Training in high-precision analytical equipment including noble gas mass spectrometry, LA-ICP-MS and EMPA.
- Linking micro-scale to macro-scale processes
- Developing a model for fluid mobility in the lower continental crust

Overview:

The chemical evolution of volatile elements in the solid Earth, oceans and atmosphere is fundamental to explaining how and why the Earth developed into the life-sustaining body that it is today. Physical processes that cause chemical fractionation, such as melting, diffusion and advection, are intimately linked to this evolution. These physical processes are difficult to observe directly, but noble gases make ideal tracers because they are chemically inert and are not fractionated by chemical reactions. Argon has proved particularly useful as its major isotope, ^{40}Ar, is the main radioactive decay product of ^{40}K, one of the most abundant crustal elements. This decay forms the basis for the widely-applied K-Ar geochronometer.

Previous measurements and estimates of the Ar budget in the atmosphere, crust and mantle, alongside estimates of the K concentration of the bulk silicate Earth, suggest that up to a third of the ^{40}Ar produced by decay of ^{40}K over Earth history is ‘missing’ [1]. One key, commonly ignored, potential Ar reservoir is the lower continental crust (LCC).

Key to constraining the *retention* of noble gases in the LCC is determining their *mobility*. The aim of this project is to develop new methods for applying light noble gas (Ar, He, Ne) concentrations and isotopic ratios for tracing mobility in the lower crust, and for constraining the transport mechanisms and pathways (e.g. silicate melt, hydrous or other fluid, influence of tectonic strain). During this project these methods will be applied to lower crustal samples of different bulk composition, strain history and melting history. Noble gas concentrations and ratios in different K-bearing (hydrous) minerals and fluid inclusions in K-free (anhydrous) minerals will be compared. Mineral “dates” calculated from ^{40}Ar/^{39}Ar chronology will be compared with those derived from U-Pb zircon or monazite chronology to assess Ar loss or gain. These data will be used to constrain models of fluid reactivity and transport in the lower crust.

We expect to see significant differences in fluid mobility and reactivity between different lithologies and rocks that have melted or deformed during residence in the lower crust compared to rocks that have not. The $^{40}Ar/^{39}Ar$ chronology might show that timescales of fluid movement in the lower crust are short compared to the exhumation history. Together we expect all the data to constrain the time- and length-scales of fluid mobility in rocks of different bulk composition, strain history and melting history.

Methodology:

The successful ECR will collect and analyse lower crustal xenolith and outcrop samples from a number of different sources. These examples will constrain the chemical (metamorphic, melting and metasomatic) and physical (solid-melt-fluid interaction) pathways for noble gas mobility or retention in different lower crustal lithologies.

Detailed petrographic analyses and mineral chemistry determinations by EMPA will be coupled with trace element concentrations in individual minerals by LA-ICP-MS. Noble gas analyses will be conducted by *in-situ* by laser ablation at the Open University and by step-wise crushing at the Vrije Universitijt Amsterdam.

Training and skills:

FluidNet Early Stage Researchers (ESRs) are required to complete formal network training throughout their contract including secondments to academic and industrial partners and a cohort-wide field residential (Covid-permitting). In the first year, ESRs will be trained as a single cohort on research methods and core skills. Throughout the contract, training will progress from core skills sets to master classes specific to FluidNet research themes.

Specific training in fieldwork, sample preparation, $^{40}Ar/^{39}Ar$ geochronology, metamorphic petrology, thermodynamic modelling, analytical techniques and date reduction methods will be provided at the Open University, Vrije Universitijt Amsterdam and via external courses. In addition to scientific skills, the student will be trained in a variety of transferrable skills including public speaking, writing for a variety of audiences and dealing with large and incomplete datasets.

The School of Environment, Earth and Ecosystem Sciences has a thriving postgraduate community. Online teaching opportunities including teaching on OU undergraduate modules and Massive Open Online Courses (MOOCs) are available via the OU Virtual Learning Environment.

Partners, collaboration and secondments:

Secondments to FluidNet partners of up to 8 weeks form part of the network plan.

Secondments of 6-8 weeks are currently planned with ThermoFisher to gain experience in technical instrument development and industry, and with MaP to gain experience in spinning gout university research in a commercial setting.

Short laboratory visits are currently planned with Prof. J Wijbrans, Amsterdam, to carry out mineral crushing experiments and Dr Leo Kriegsman, Naturalis Biodiversity Centre, Utrecht, for lower crustal petrology and fluid-rock reaction modelling.

These secondments may change as the project develops and depending on the career interests of the ESR.

COVID-19 Resilience of the Project:

Any fieldwork will be conducted in Europe and will follow Government Guidelines on Covid-19 mitigations. Specific fieldwork sites can be changed if local regulations change. If fieldwork cannot be conducted at all then samples can be sourced from colleagues and other collections.

The Open University and the Vrije Universitijt have detailed Covid-19-safe working and operating procedures in place; we expect all labs to remain open and operational within the detailed local guidance.

Further reading:

1. Allègre, C.J., Hofmann, A. and O'Nions, K., 1996. The argon constraints on mantle structure. *Geophysical Research Letters*, *23*(24), pp.3555-3557.

2. Lowenstern, J.B., Evans, W.C., Bergfeld, D. and Hunt, A.G., 2014. Prodigious degassing of a billion years of accumulated radiogenic helium at Yellowstone. *Nature*, *506*(7488), pp.355-358.

3. Ballentine, C.J. and Burnard, P.G., 2002. Production, release and transport of noble gases in the continental crust. *Reviews in mineralogy and geochemistry*, *47*(1), pp.481-538.

4. Jackson, C.R., Shuster, D.L., Parman, S.W. and Smye, A.J., 2016. Noble gas diffusivity hindered by low energy sites in amphibole. *Geochimica et Cosmochimica Acta*, *172*, pp.65-75.

Further Details:

Applicants should have a strong background in metamorphic geology or igneous geology and petrology and enthusiasm for lower crustal studies. Familiarity with at least one of the methodological approaches would be desirable but is not required.

The successful applicant will join well-established teams researching Dynamic Earth processes at the Open University in the UK and the Vrije Universitijt Amsterdam in the Netherlands.

Further details of the FluidNet consortium and project are available at https://www.fluidnet.eu/.

Shortlisted candidates will be invited to participate in the kick-off (virtual) workshop to be organized at the end of March 2021. Successful candidates for the PhD positions will be enrolled in the graduate programmes of FluidNET network partners' universities. Admission and terms of employment are based on EU Horizon2020 guidelines and local policies of participating universities.

Please contact **Prof. Clare Warren (clare.warren@open.ac.uk)** for further information.

Eligibility:

1.Mobility rule: Applicants may not have lived for more than 12 months out of the prior 36 months in the country where they wish to take up the fellowship,

2. Early Stage Researcher rule: Applicants must be in their first four years (full-time equivalent) of their research careers counted from the start of their MSc (or equivalent) research project, and not yet have been awarded a doctoral degree, and

3. Admission rule: At the time of enrolment applicants must be in the possession of a diploma that is recognized prerequisite for entering a PhD programme in the country of application. In the UK this is a Batchelor's degree at the equivalent level of a 2:1 classification; for FluidNet an MSc is preferred.

During the registration, applicants will need to prove that they are eligible for the programme.

Applications should include:

- A covering letter that includes:
    - Your motivation to study for a PhD in general
    - Your interest in this project in particular
    - The project-specific skills, aptitude and experience you bring to the research
- An academic CV containing contact details of two references who can comment on your academic abilities
- English language proficiency documentation/evidence
- And an Open University overseas application form.

Applications should be sent to Ms. Olivia Acquah at STEM-EEES-PhD@open.ac.uk **by 12 noon on Monday 1st March 2021.**