# Fluidnet PhD project adverts

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| **Project Title** | **ESR6: How and how quickly do critical metals mobilise in the mid-lower continental crust?** |
| **University (where the applicant will register)** | The Open University |
| **Key words** | Lower crust, critical metals, metamorphism, anatexis |
| **Supervisory team (including institution & email address** | **PI: Prof Clare Warren (Open University, clare.warren@open.ac.uk)**<br><br>**Co-Is: Dr Barbara Kunz (Open University, barbara.kunz@open.ac.uk),**<br>**Dr Tom Argles (Open University, tom.argles@open.ac.uk)**<br>**Dr Leo Kriegsman (Naturalis, leo.kriegsman@naturalis.nl)** |

**Project Highlights:**

- Developing a model for the mobility of critical metals during metamorphic and metasomatic processes in the lower crust
- Linking micro-scale to macro-scale processes
- Training in high-precision micro-analytical techniques such as LA-ICP-MS and EMPA.

**Overview**

Critical metals such as lithium, beryllium, tantalum, caesium, tin and tungsten are regularly mined from granites and granitic pegmatites. These elements were originally sourced in the mantle but their enrichment in deposits at the surface today suggests crustal processes have operated to concentrate them. Most enriched granites and pegmatites are highly peraluminous, suggesting they formed via mica-melting reactions from metapelitic protoliths [1,2]. The processes and mechanisms by which these elements are transported and (re-)cycled within and through the crust by igneous, metamorphic and even sedimentary processes to form economic scale deposits at the surface are as yet poorly constrained [3].

A key question in the formation of critical element deposits is the extent to which they require unusual "unusual" combinations of metamorphic and magmatic activity or a "Goldilocks" combination of circumstances. It is well known that the crust is compositionally heterogeneous, both in critical element abundance and fertility to melting. Many regions of economic deposits of critical metals appear to be associated with systems where multiple phases of crustal melting have taken place over geological time. The first step in constraining critical element cycles is therefore to constrain the crustal sources, sinks and transport mechanisms by which metamorphic, fluid and melt reactions can 'prime' the crust and later mobilise the elements of interest. The structure of certain metamorphically reactive minerals such as micas and tourmaline have been identified as accommodating critical metals [4].

The main aims of this project are to:

- determine the bulk rock and main mineral hosts for a variety of critical elements in lower crustal rocks of different bulk composition to do mass balance estimates;
- constrain the metamorphic, fluid and melt reactions that 'prime' the crust for the generation of critical-element-rich silicic melts

- constrain the transport pathways (e.g. grain boundary percolation, shear zones, veins; in hydrous fluids or melts) of critical element mobilisation in the mid-lower crust;
- constrain the length scales and timescales of critical element mobilisation in the mid-lower crust.

The ultimate aim is to build a model of the pressure-temperature-composition-fluid controls on the 'priming' processes in the middle to lower continental crusts and that allow the volume of mass transfer and the transfer rate to be assessed. This will include rocks that have not previously interacted with a melt or fluid, as well as those that have, to determine whether these interactions concentrate the metals we are interested in in the fluid or solid material and to determine the enrichment factors per cycle of interaction. Samples will be chosen to constrain the chemical (metamorphic, melting and metasomatic) and physical (solid-melt-fluid interaction) pathways to critical metal enrichment at different crustal depths.

**Methodology:**

Field examples will be chosen by the successful candidate in conjunction with the supervisors that cover middle and lower crustal examples where sources and sinks can be linked and which both host and don't host known mineral deposits, e.g. the European Hercynian/Variscides, Erzgebirge, Black Forest and Cornwall.

Detailed petrographic analyses and mineral chemistry determinations by EMPA will be coupled with bulk-rock major element analyses by XRF and trace element compositions by solution ICP-MS. Trace element concentrations in individual minerals will be determined by LA-ICP-MS.

**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, the 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 scientific training will include safe fieldwork planning, rock preparation (crushing, mineral separation/picking, thin-section making), data collection using a variety of cutting-edge geochemical instruments, and interpretation using a variety of chemical and statistical plotting methods.

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 Prof. T. Wagner, Rheinsch Westfällische Technische Hochschule Aachen to conduct LA-ICP-MS fluid characterization and tracer/provenance studies, and the La Palma Research Centre to gain experience in the metals resources industry.

Short laboratory visits are currently planned with Prof. J. Connelly, ETH (Switzerland), for thermodynamic modelling training and Dr Leo Kriegsman, Naturalis Biodiversity Centre (the Netherlands), for lower crustal petrology and melt-rock reaction training.

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

**COVID-19 Resilience of the Project:**

All 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 has detailed Covid-19-safe working and operating procedures in place with the possibility of remote access and training on several of our instruments; we expect all labs to remain open and operational within the detailed local guidance.

**Further reading:**


1. Clemens, J.D., Helps, P.A. and Stevens, G., 2010. Chemical structure in granitic magmas—a signal from the source. *Earth and Environmental Science Transactions of the Royal Society of Edinburgh*, *100*(1-2), pp.159-172.
2. Petr Černý, David London, Milan Novák; Granitic Pegmatites as Reflections of Their Sources. Elements ; 8 (4): 289–294. doi: https://doi.org/10.2113/gselements.8.4.289
3. Wolf, M., Romer, R. L., Franz, L., & López-Moro, F. J. (2018). Tin in granitic melts: The role of melting temperature and protolith composition. Lithos, 310, 20-30.
4. Bea, F., Pereira, M. D., & Stroh, A. (1994). Mineral/leucosome trace-element partitioning in a peraluminous migmatite (a laser ablation-ICP-MS study). Chemical Geology, 117(1-4), 291-312.
5. Tichomirowa, M.; Gerdes, A.; Lapp, M.; Leonhardt, D.; Whitehouse, M. The Chemical Evolution from Older (323–318 Ma) towards Younger Highly Evolved Tin Granites (315–314 Ma)—Sources and Metal Enrichment in Variscan Granites of the Western Erzgebirge (Central European Variscides, Germany). Minerals 2019, 9, 769.
6. Clemens, J., & Watkins, J. M. (2001). The fluid regime of high-temperature metamorphism during granitoid magma genesis. Contributions to Mineralogy and Petrology, 140(5), 600-606.


**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 UK and the Naturalis Biodiversity Centre (mineralogy group, with formal ties to Utrecht University) 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 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.**