

PhD project:

The start of the world as we know it – tracing the onset of coupling between the solid and fluid Earth

From the mantle to the surface and back

A three-year, fully funded, international PhD project in geochemistry of the Archaean Earth.

Scientific background

Earth, our dynamic planet, operates with a series of couplings between inner and outer portions that control most of the biogeochemical cycles. The composition of the atmosphere (and thus of the hydrosphere and the biosphere) is largely buffered by emissions from the mantle, via igneous activity. The composition of the mantle, at least in the most active portions of it, is modified by the influx of surface material (notably, sediments) buried into it. Arguably, this dynamism and the cycling of H₂O and CO₂ between minerals, melts and the hydrosphere and atmosphere is a feature that makes Earth unique amongst the planets, in that it creates the conditions required to support life but also allows major global features such as plate tectonics. It is also of key importance for fluid and element transfers through the crust, and thus for the formation of ore deposits.

Transfers from the solid to the fluid Earth take the form of gas and fluids, often carried towards the surface within magmas and as hydrothermal fluids, and it is well known that this largely controls the chemistry of the atmosphere, with major implication for surface redox conditions. Transfer from the surface to the mantle, or « recycling », is a bit more elusive but the chemistry of igneous rocks, formed at depth, preserves vital clues. The fluxes in both directions are intimately coupled. The composition of fluids released by magmas into the atmosphere is a function of the nature of the magmas, itself heavily influenced by the composition of the recycled component, which of course mirrors that of the atmosphere. In this project, we examine how changing conditions on Earth are reflected in the chemistry of Archaean magmas.

Granitoids from the TTG suite are thought to form by partial melting of buried altered volcanic rocks of broadly basaltic composition, previously erupted and altered under water and therefore reflecting surface conditions. Naturally these source rocks are not preserved. Thus, the alteration patterns of the Archaean Earth had a major impact on the nature of the material recycled, and must therefore be reflected in the composition of these granitoids. In the Barberton granite greenstone terrain, located in the Kaapvaal craton in South Africa (3.5-3.2 Ga) a change in the nature of sediments is documented at ca. 3.2 Ga, and a concomitant change of redox conditions has been suggested. TTG rocks formed both before, and after this date. Thus, the region offers a unique opportunity to understand how evolving alteration processes result in changes in the nature of the recycled component, and therefore on the composition of TTGs.

Three different sections from TTG to surrounding sediments pre and post -3.2 Ga will be investigated and sampled in detail. The samples will be characterized by Raman spectra of the organic matter, conventional major and trace geochemical analysis, as well as detailed petrographic and mineral chemical analysis. The low-grade metamorphic overprint will be described and quantified by phase equilibrium analysis. Isotope composition of S, Fe, Si, Ce and O will be measured by combining bulk and in situ methods like SIMS on single mineral (quartz, oxides, sulphides mostly). The data collected on both sedimentary rocks and TTG from the same age will constrain



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first the metamorphic influence on bio and redox cycles at that time but also provide new information on the TTG formation pathway, and thus on the onset of global couplings on Earth.

Details and organization

This thesis is part of a broader French-South African collaboration effort on Archaean Earth (see <http://bucomo.fr>). It will be an official “cotutelle” between Université Clermont Auvergne, France and Stellenbosch University, South Africa, resulting in a double degree granted conjointly by the two institutions. About 1/3 of the time will be spent in South Africa (Stellenbosch), and 2/3 in Clermont. In addition, a large analytical component (SIMS) will be performed at Lausanne, Switzerland. Provisionally, we expect the following schedule: (i) oct. 2021-oct. 2022 in South Africa (Sampling, sample preparation, petrography, characterization of the conditions of the alteration/metamorphic overprint); (ii) Oct. 2022 to Oct. 2024 in Clermont-Ferrand for analytical work, including frequent trips to Lausanne during 2023 for SIMS work.

Supervision team:

In Clermont: Main supervisor, Jean-François MOYEN (jean.francois.moyen@univ-st-etienne.fr). Collaboration with Maud BOYET (maud.boyet@uca.fr).

In Stellenbosch: Main co-supervisor Gary STEVENS (gs@sun.ac.za)

In Lausanne: Johanna MARIN-CARBONNE (johanna.marincarbonne@unil.ch)

Profile:

The successful candidate will be willing to travel and spend time in South Africa and in France. (s)he will be able to operate in English and should preferably understand at least some French. The thesis involves a field component, a petrology component and an analytical geochemistry component and the candidate should have experience in these aspects. In particular, a previous experience in geochemistry lab work is desirable.

Duration and date:

36 months, starting 1st October 2021 or as soon as possible thereafter

Salary :

“salaire mensuel brut” of 2135 € / month (*which should work out to 1500-1600 € after taxes, pension, health insurance etc., but the actual amount depends on individual situations*)

Contact and enquiries:

Application will be through the official CNRS website at <https://emploi.cnrs.fr/>

For enquiries, contact Jean-François MOYEN (jean.francois.moyen@univ-st-etienne.fr) or the other supervisors