Developing a deep fluid sampler for exploration of critical raw materials

Geotop research centre • McGill University, Université du Québec à Montreal, Université du Québec à Chicoutimi, Institut National de la Recherche Scientifique

Fluids are the main transporting agent for elements in the crust, but their transporting capacity varies greatly. Aqueous fluids display huge variability in their physico-chemical properties, including pH, RedOx potential, and types and concentrations of ligands. As a result, fluids are selective carriers, and control, to a large extent, the segregation of elements in the crust. Knowledge of fluid compositions and transporting capacity is thus critical to understand element mobilisation, transport, segregation, and concentration into resources of metals and other critical resources such as He and H_2. This research project seeks to design and construct a sampler and sensor module to sample deep crustal fluids and measure their physico-chemical conditions *in-situ* during sampling. We focus on the potential of deep fluid compositions in exploration for critical raw materials in Quebec, and to study geothermal systems as sources of heat and energy. The project is funded by FRQNT and a collaborative effort with Derena Geoscience, Groupe Minier Windfall, the Iceland GeoSurvey, and the Landsvirkjun geothermal company, and students will be co-supervised by members of the research team consisting of Kim Berlo (McGill), Geneviève Bordeleau (INRS), Daniele Pinti (UQAM), Vincent van Hinsberg (McGill) and Julien Walter (UQAC).

We invite applications for two fully-funded graduate student opportunities hosted by the Geotop research centre (www.geotop.ca):

PhD1: *Element transport by deep crustal fluids*

This project focuses on gaining a fundamental understanding of the metal content of deep crustal fluids in different geological settings. This provides essential information for ore genesis models and their use in predictive exploration by clarifying how elements are mobilised, and the fluid fluxes and time needed for ore formation. The project combines full chemical characterisation of retrieved deep fluids with thermodynamical modelling to determine how the elements are speciated and transported, and the saturation state for each element. We will target different geological settings and reservoir host rocks to determine the impact of these on fluid compositions and transporting mechanisms, focusing on relatively cold fluids in mafic and felsic rock lithologies of the low geothermal gradient Canadian Shield in the Abitibi region of Quebec and high temperature magma-impacted fluids in young mafic crust in northern Iceland. This will be combined with experimental simulations to test hypotheses and interpretations derived from the deep fluid samples. These experiments will be run in hydrothermal autoclaves and rocking cold-seal pressure vessels at the experimental facilities of UQAC, INRS and McGill that allow for imposing desired conditions of *P, T*, pH and RedOx.

We invite applicants with an MSc degree in the geosciences and relevant research experience in geochemistry and/or petrology, as well as a keen interest in critical metals, crustal fluids and thermodynamic modeling. This is a fully funded 3-year PhD position with a start date of early 2026. For questions, please contact Dr. Vincent van Hinsberg (hinsberg@eps.mcgill.ca).

PhD2: *The use of deep fluids compositions as exploration vector for critical metals, He and H_2*

This PhD project will explore the viability of well and borehole fluids as an indicator of the presence of ore deposits, and, from multiple wells, to vector in to these, and thereby develop a novel tool for exploration of critical raw materials. The student will use compositional analyses of retrieved deep fluids from multiple boreholes around a known ore deposit in the Abitibi region of Quebec to validate the use of these fluids as an exploration tool. She/he will then apply this methodology to other wells and boreholes in collaboration with Derena Geoscience and other exploration partners in targeted exploration for critical metals.

We invite applicants with an MSc degree in the geosciences and relevant research experience in geochemistry and/or petrology, as well as a keen interest in critical metals, analytical method development and crustal fluids. This is a fully funded 3-year PhD position with a start date of early 2026. For questions, please contact Dr. Vincent van Hinsberg (hinsberg@eps.mcgill.ca).

Both students will work with the research team to complete the design of the sampler and sensor module, support their construction, and calibrate the sensors for the conditions encountered at depth using the high-*PT* experimental equipment of the PIs, and develop the analytical protocols needed for a full chemical characterisation.