PhD position in BRGM (French Geological Survey)
October 2025 – September 2028

Mineral and geothermal resources of magmatic brines: numerical modeling of multi-phase and multi-component flow

We are seeking a highly motivated and technically skilled PhD candidate to join our research team. The successful applicant will work on a project at the intersection of scientific computing and geosciences, with a focus on magmatic systems and magmatic brines.

Context

Sub-volcanic brines are saline, metal-rich hydrothermal fluids that originate from magmatic processes at depths of a few kilometers below volcanoes. These fluids are often highly concentrated in metals (up to several Mt of copper and other critical metals), hot (up to magma temperature) and under high pressure. As they migrate through fractures and porous rocks, often in the roots of volcanic systems, their physical state change from supercritical, liquid, gas, diphasic... and they can eventually concentrate and deposit metals in some location. Moreover, in addition to their metals content these brines also offer significant geothermal potential (Blundy et al., 2021; https://doi.org/10.1098/rsos.202192)

The ANR-funded "MAGBRINES" project (2024-2028), coordinated by ISTO (Orléans) combines geochemistry, petrophysics, thermodynamics, molecular dynamics and numerical modeling to better understand the formation and behavior of these brines, considering the volcanoes of the West Indies (Martinique, Guadeloupe and Dominica).

This PhD thesis is dedicated to numerical modeling of the formation and flow of these multi-phase, multi-component brines. Only a few teams in the world have studied magmatic brines, but they have simplified the fluid composition (Weis et al., 2014 https://doi.org/10.1111/gfl.12080) or the physical properties of embedding rocks (Afanasyev et al., 2018 https://doi.org/10.1016/j.epsl.2018.01.013), and have not studied their metallogenic potential. The ComPASS code, developed at BRGM (Orléans) and at Université Côte d'Azur (Nice), is well-suited to tackle this problem (Armandine Les Landes, et al. 2025, https://doi.org/10.1016/j.cageo.2024.105752), but will require further development to simulate such extreme physics. In particular, we will use laws to describe physical properties of the fluid that will depend on its chemical composition and will take into account specific values obtained in the Magbrines project. As the problem

will be highly nonlinear, especially around the critical point, specific development may be necessary to help convergence of the solution. If time permits, a simple precipitation model will be implemented to take into account the dynamic effect on permeability which is very important in such geological systems.

Job / Offer description

The understanding of the formation and behavior of magmatic brines requires to account for realistic physical properties of natural fluids at high pressures and elevated temperatures. In the supercritical domain, fluid (brines) properties (density, viscosity, heat capacity) show sharp changes in their evolution with temperature and pressure. The co-existence of vapor and liquid in magmatic brines should also be investigated. In addition, when several components are considered, processes of dissolution and precipitation may occur depending on pressure and temperature conditions, thus involving dynamic changes in matrix permeability.

Electrical signatures of magmatic brines from the West Indies (Martinique, Guadeloupe, Dominica) are currently being acquired by BRGM. One scientific challenge of this thesis will consist in the comparison between these data and the results from numerical simulations of magmatic brines. Geothermal and metallogenic potentials of magmatic brines will be investigated once electrical data are correctly reproduced by numerical simulations.

The PhD candidate will work mostly at BRGM (Orléans) with appropriate computing tools (ComPASS code) and may spend a few weeks at INRIA University Côte d'Azur for collaboration.

Type of contract: temporary .
Job status : Full.
Hours per week : 35
Envisaged starting date: 01/10/2025
Work location: BRGM, 3 Av. C. Guillemin, BP 36009, 45060 Orléans Cedex 2, France
What we offer: 2200 euros gross/month

Qualifications, required research fields, Required education level, Professsional skills, other research requirements:

Key Technical Skills and Qualifications:

- Strong programming skills are essential. Proficiency in **Python** and/or **C++** is highly desirable.
- Solid background in **scientific computing**, including numerical modeling, data analysis, and algorithm development.

- Knowledge of **geosciences**, particularly related to **magmatic systems** or **mineral resources**, is a strong asset, but not mandatory.
- A Master's degree or Engineering degree in computer science, applied mathematics, (geo)physics, numerical geology or a related field.

Additional Skills and Attributes:

- **Perseverance** and **resilience** to meet the demands of a doctoral program.
- Strong **analytical and critical thinking** skills.
- Good **communication skills**, both written and oral, in English.
- Ability to work in a collaborative, interdisciplinary environment.

This PhD opportunity is ideal for a candidate passionate about applying computational tools to understand complex Earth systems.

To apply for this PhD offer, the candidate will send by email a short CV, a copy of his/her master thesis (if available), and a letter explaining his/her motivations to:

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