Post-doctoral position – Use of natural geological analogues to define favorability criteria for the formation of unconformity-related uranium deposits (Saskatchewan, Canada)

Context: The Université de Lorraine, the Institut Terre et Environnement de Strasbourg (ITES) and Orano Mining are collaborating within the framework of the Industrial GeomIn 3D Chair, sponsored by Orano Mining and the French National Research Agency, in order to develop new tools for the exploration of uranium deposits in the Athabasca Basin (Canada). The research strategy aims at establishing an integrated 3D geomodel reconciling geological and geophysical inputs.

The Athabasca Basin is considered the world benchmark for unconformity-related uranium deposits with examples such as Cigar Lake or McArthur River showing grades above 15 weight % uranium on average. The formation of such geochemical anomalies required the conjunction of highly efficient chemical and physical processes which have been scientifically investigated for more than 50 years. The commonly accepted metallogenic model considers that **these deposits result from massive circulations of fluids originating in the basin (brines) focusing in structural and physicochemical traps located at the intersection between graphitic-rich structures rooted in the basement (called graphitic conductors) and the unconformity surface of the Athabasca Basin**. The deposits are thus spatially associated with the unconformity between the basin and the basement, and **the location of the mineralization depends on the structural framework, the circulation paths of the fluids, and the precipitation mechanisms**.

The circulation of hydrothermal fluids at the basin/basement interface is controlled by the properties of geomechanics, hydrogeology, thermal conductivity, permeability and porosity. The structural reactivation of graphitic conductors, associated with generation of secondary-order drainage structures at basin/basement interface, is thus a key process for the mobilization of fluids from their reservoirs and then their circulation along drainage structures at different scales. Uranium then precipitates massively from these mineralizing fluids by interaction with reducing agents such as solids rocks or fluids present along the graphitic conductors. These mineralization processes are sensitive to local fluctuations of pressure and temperature conditions which cause transient fluids circulations whose duration and periodicity are very poorly constrained. **These extremely rich but very small-volume mineralization therefore result from transient circulations of fluids at the basin-basement interface in the context of the tectonic reactivation of structures inherited from the basement.**

Several unknowns limit our scientific understanding of the formation mechanisms of these deposits, and therefore, our ability to define the favorability criteria that can be applied in exploration. In order to progress this topic, **we propose an innovative approach based on the use of natural, fossil and active, hydrothermal analogues, for which the conditions that have operated or are operating are known and have been defined.**

Research plan: The study will mainly be carried out during 3 main phases:

- **Phase 1.** State of knowledge on the selected natural analogues. The objective is to establish a state of the art of favorability criteria for the creation and sustainable functioning of the selected hydrothermal systems. This will involve bibliographic synthesis and the organization of workshopsin the lab and in the field, bringing together qualified experts on natural analogues. The aim is to establish criteria for determining the time, place and processes that lead to the onset of mineralizing episodes. The notions of duration and cyclicity as well as the identification of the causes which initiate and localize these fluid pulsations is considered a priority for the understanding of the systems and therefore their transposition to U deposits.
- **Phase 2.** Using knowledge from Phase 1, work in the field, on core rock samples and in the lab targeting the natural analogues will be carried out in order to refine models of their duration and temporality parameters, and mechanical, chemical and physical properties. Thematic priorities will be defined according to the bibliographic analysis of phase 1. This work will be carried out in Nancy and with the collaborating teams.
- **Phase 3.** Summary of favorability criteria of selected analogues and definition of new exploration guides for uranium deposits. This work will be done in collaboration with PhD students of the GeomIn3D Chair working on the Athabasca Basin. This work will open new perspectives in terms of structural analysis of the Athabasca basement and thermo-hydro-mechanical modeling.

The two proposed natural analogues are: (1) current geothermal sites, natural and stimulated, and (2) the hydrothermalized and mineralized zones at basin/basement unconformity located in Europe and of the Permo-Triassic age.

Required profile : You recently completed a Ph.D. in geosciences, preferably in connection with one of the targeted natural analogues, aimed at understanding the functioning of one of these hydrothermal systems. Field experience or knowledge on drill core study will be considered a plus. Knowledge of the approaches and laboratory techniques applicable to the study of

hydrothermal circulations and related mineralization in the targeted geological contexts is a prerequisite. You should be willing to work with a team of academic and industry collaborators. You are self-motivated, autonomous, keen to work on and to propose new ideas.

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Employment conditions : The post-doctorate will start in the first quarter of 2022. The gross monthly salary will be between 2,600 and 4,200 euros depending on the experience of the candidate. The contract will be for 24 months (with the possibility of extension depending on the results). An evaluation will be carried out by the steering committee of the GeomIn 3D chair after the first six months.

Working conditions: The post-doctorate will be carried out at the Université de Lorraine, within the GeoRessources laboratory. Missions will be carried out in the laboratories of partner research teams (in France and abroad). Missions to Orano Châtillon and Orano Canada in Saskatoon will allow efficient coordination with the industrial partner.

GeoRessources is part of the Université de Lorraine (http://welcome.univ-lorraine.fr/), which is one of the leading higher education institutions in Europe with more than 55,000 students and 60 research laboratories. The Université de Lorraine is ranked 13th in the Shanghai 2021 ranking in the "Mining and Mineral Engineering" category, the leading European university in this field of activity. The Department of Earth Sciences is one of the largest in Europe, with 4 laboratories hosting more than 300 researchers and 1000 students. GeoRessources is the French academic benchmark laboratory for the study of deposits, with nearly 200 people (http://georessources.univ-lorraine.fr/), with long-term collaborations with large mining and oil companies. It is considered one of the reference centers for academic research on uranium deposits, with more than 40 years of research on this subject. The group of laboratories in Nancy have represent one of the most comprehensive network of instrumental facilities dedicated to geosciences in France, including geomechanics, petrophysics, tomography, geochemistry, microscopic characterization and in-situ chemical and isotopic analysis (LA-ICP-MS and ion microprobe).

Application: The application must be received before January 1, 2022. It will include the following documents: (i) a cover letter mentioning research experiences and areas of interest, (ii) a detailed curriculum vitae including a list of publications, (iii) the names, addresses and telephone numbers of two referees, (iv) the thesis manuscript. It should be sent by email to: Julien Mercadier (julien.mercadier@univ-lorraine.fr)