PhD position at the University of Lorraine

GeoRessources Laboratory

Title : Mineralization of Nickel in saprolitic ore of New Caledonia : Dynamics of metal transfer and modeling of coupled geochemical and hydrodynamical processes

Context: Laterite nickel-ore formation in New Caledonia is classically assumed to be governed by supergene processes. However, this conceptual model fails to explain some recent mineralogical or structural observations. In particular, none of supergene models succeed to describe the heterogeneity of mineralizing distributions that could have been enhanced by several syntectonic pre-enrichment cycles. Actually, fluid flow and mass transfer processes are not purely downward at low temperature conditions, but can be also related to hydrothermal fluid circulations.

Objectives and work summary: The objective of this PhD thesis will be to develop a conceptual and numerical model giving a more accurate overview of the space and time distribution of mineralization within the fracture network. The efficiency of supergene alteration processes on the gradual enrichment of nickel will be compared with dissolution-precipitation processes driven by seawater circulation under hydrothermal conditions in the ophiolite bedrock. The work will partially rely on the existing analytical data and multi-scale observations (TEM, SEM...) on historical relations between the different mineral phases. On the basis of these data, two numerical approaches will be considered:

- A geochemical modeling of fluid-rock interactions (e.g., Phreeqc) taking into account the role of several parameters (e.g. temperature, pressure, fluid chemistry, primary and secondary paragenesis) will be performed. The sequence of dissolution-precipitation phenomena induced either by supergene or by hydrothermal processes will be evaluated as a function of the nature and source of the percolating fluids and compared with the observed mineralogy.
- In a second step, a numerical simulator coupling this geochemical description with mass transfer and fluid flow within the rock formation will be developed. Time and space changes of the fracture network geometry due to stress-state variations and the related impact on local permeability and porosity will be particularly investigated. Different scenarii (propagation of the lateritic dissolution front, hydraulic fracking induced by upward fluid circulations) will be considered and numerical predictions will be compared to in situ observations. This second part will follow the Phd thesis of M. Faivre (funded by Labex R21/Regional council of Lorraine).

Student profile: The candidate must be a highly-motivated and self-directed person with a recentuniversity master degree (or equivalent) in computational mechanics, reservoir engineering, geology, geochemistry, civil engineering, or other relevant fields. A solid background in geochemistry and a strong interest for modelling water-rock interaction processes are required. He or she may demonstrate fundamental knowledge of solid and fluid mechanics principles governing the behavior of porous and fractured media and motivation for work at the interface between disciplines. An experience in developing numerical methods, particularly finite element and/or finite volume and using geochemical codes would be an asset. The candidate will need to be fluency in English and in French (or willingness to learn French).

Funding: This PhD will be funded by the LabEx RESSOURCES21 which was selected by the French Ministry of Research and Education in the framework of the "Laboratoires d'Excellence" initiative. RESSOURCES21 proposes an integrated scientific and educational approach to the understanding, exploitation and environmental management of strategic metal resources for the 21th century. This PhD project is funded for 3 years, starting on October 1st 2014 (Net salary, including social security: ~ 1 500 €/month).

Applicants should send via email a Curriculum Vitae and the names and email addresses of two references to:

Fabrice Golfier (MCF HDR, fabrice.golfier@ensg.univ-lorraine.fr)

Michel Cathelineau (DR CNRS, michel.cathelineau@univ-lorraine.fr)

Laurent Truche (MCF, laurent.truche@univ-lorraine.fr)