Investigating and modeling a semi-industrial-scale pilot of an innovative chemical method for uranium in situ recovery

Keywords

New in situ recovery, pilot modeling, environmental impact, reactive transport

Thesis context

In situ recovery (ISR) has recently become the leading mining technique for uranium production, particularly for roll-front deposits occurring in moderately deep aquifers. Compared to conventional techniques such as open-pit and underground mining, ISR is faster to implement, more cost-effective, and has a smaller environmental footprint. However, the geological complexity of the reservoir and variability in mineralogy from one to another make it difficult to ensure the economic efficiency of traditional ISR operations.

ORANO is one of the leading companies in uranium exploration and mining, with 35 years of experience in ISR. The company is actively exploring new ISR methods to ensure technical and economic feasibility while also minimizing environmental impact. Recent laboratory tests on ore samples from Uzbekistan have shown encouraging results. A large-scale pilot, planned for 2026-2027, is expected to provide key insights into the feasibility of this new geochemical technique under real geological conditions.

For the past twenty years, the Center for Geosciences of Mines Paris PSL and ORANO Mining have been developing a deterministic approach to simulate ISR operations and aquifer remediation using the reactive transport code HYTEC (Lagneau et al., 2019). The model is based on a 3D geological model (porosity/permeability maps and distribution of reactive mineral phases) coupled with a geochemical model describing the interactions between the leaching solution and the mineral phases (e.g. Collet et al., 2022). In addition, the geometry of the well-field is fully described as well as operating scenarios.

Collet, A., Regnault, O., Ozhogin, A., Imantayeva, A., Garnier, L. (2022). Three- dimensional reactive transport simulation of Uranium in situ recovery: Large-scale well field applications in Shu Saryssu Bassin, Tortkuduk deposit (Kazakhstan). Hydrometallurgy, 211, 105873. https://doi.org/10.1016/j.hydromet.2022.105873

Lagneau, V., Regnault, O., Descostes, M. (2019). Industrial Deployment of Reactive Transport Simulation: An Application to Uranium *In situ* Recovery. *Reviews in Mineralogy and Geochemistry* 85 (1): 499–528. doi: https://doi.org/10.2138/rmg.2019.85.16

Thesis objectives and approaches

This PhD thesis aims to understand, model and optimize a new alternative ISR technique based on an innovative chemical method.

The relevant physical and geochemical processes will be discriminated by modeling available column experiments at the lab scale as well as on-going production pilot tests. These tests are

performed at large-scale on the ISR mining site in Uzbekistan. The developed model will be then applied to optimize the process under operational conditions.

For such purposes, the project will require frequent exchanges between Orano Mining and Mines Paris PSL. In addition, missions will be organized at the mining site in Uzbekistan.
The PhD will also involve participation in major conferences and workshops, as well as the publication of research in international journals in the fields of applied geochemistry and mining sciences.

Supervision

PhD advisor: De Windt, Laurent, Prof, Center for Geosciences, Mines Paris PSL
Co-supervisor: Sin, Irina, Center for Geosciences, Mines Paris PSL
Co-supervisor: Hocquet, Sebastien, Orano Mining

Required skills

- Master's degree in sciences and/or engineering with background in geochemistry, reservoir engineering or environmental sciences
- Strong interest in physicochemical modeling
- Strong motivation for teamwork with the industrial partners
- Excellent written and verbal communication skills in English

Contract

36-month fixed-term contract by Mines Paris – PSL.

Contacts

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HOW TO APPLY

Please send the following documents to the above contacts (pdf format):
- CV and a brief cover letter
- Any supporting research documents (internship report, publications etc.)
- Recommendation letters/referee contacts