

Post-doctoral position

Study of reactive transport clogging and unclogging mechanisms in *in situ* recovery exploitation

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Context

Orano Mining and MINES ParisTech share joint research projects for the understanding, quantification, and hydrogeochemical simulation of *in situ* recovery mining. This technique is defined as the extraction of a metal from its host formation by the circulation of chemical solutions (*e.g.* sulfuric acid) using injection and extraction wells from the surface. The metal is separated from the pregnant solution in a surface plant; the solution is then readjusted in reagents and circulated again in the well field. More than 50% of uranium world production is produced by ISR. The reactive transport code HYTEC, developed at MINES ParisTech, is used to simulate the coupled flow, transport, and geochemical processes during exploitation, in 3D, at the production block scale (*ca.* 60 wells). The simulation workflow was developed on and is now used in production at the Katco uranium mine (Kazakhstan).

Reacting fluids are very concentrated in dissolved elements, due to gangue mineral dissolutions and multiple circulations. High concentrations can lead to secondary mineral precipitations, notably in the vicinity of production wells, where clogging can seriously damage wells productivity. Based on samples analyses from Katco and reactive transport simulations, Vergnaud (2000) showed the role of mixing from different flow lines and proposed improvement actions.

Proposed work

The study is composed of two main parts: clogging mechanisms, unclogging processes.

1. Clogging mechanisms

The geochemical model for clogging was obtained based on indirect sampling and saturation indices. The model has to be strengthened. Experimental data from specific column tests experiments will be used to improve the geochemical model. Then, the model will be used in 3D at the block scale: adjustment on production data for the upscaling from the plug scale to the well field.

2D simulations performed by Vergnaud (2000) will be extended in 3D, in order to better take account the impact of spatial variability (permeability, mineralogy) on the composition of different flow lines and the development of well clogging. In this step, several problems need to be tackled: control on the mesh size to accommodate clogging at the centimeter scale around producing wells and spatial variability at the 10 meter scale, relationship between precipitation and permeability in representative element volume simulations.

3D simulations will be used to test operational scenarios, identify situations prone to clogging (local geology, exploitation conditions), and propose mitigating methods.

2. Unclogging

Clogging is a current problem on many producer wells. Several recovering techniques are already performed on site: mechanical and chemical cleaning. These techniques have varying impacts on well performance: durable or short-lived recovery of flow rates, and sometimes very little improvement.

Data from past operations can be used to better understand unclogging processes: *e.g.* wormholing or on the contrary homogeneous dissolution could explain the difference in behaviors. This analysis will complement the clogging models developed in the first part of the study.

Profile

Young PhD or engineer, with experience in geochemistry, mineralogy, hydrogeology or reservoir engineering. Previous experience in reactive transport simulation would be appreciated.

Teamwork is essential, in a project between the academy and industry.

Practicality

This 18-month project is a collaboration between the Geosciences Department at MINES ParisTech and Orano Mining. The work is funded by Orano Mining, in a contract with ARMINES (MINES ParisTech operator for contract research), for a duration of 18 months. Salary depending on diplomas and previous experience.^[1]_[SEP]

The work is located between Orano Mining premises in Chatillon (92) and MINES ParisTech in Fontainebleau (77). One or several missions to Katco mine in Kazakhstan possible, depending on the needs and acquired results.