Enhanced Geothermal Systems

An enhanced geothermal system (EGS) is a renewable energy technology that extracts energy from a naturally occurring heat source. Many naturally occurring heat sources are under impermeable rock and EGS technology is used to access these resources through ‘hydraulic stimulation’. EGS technology injects a fluid under high pressure, typically water, down into the rock subsurface, fracturing the rock and enabling access to the thermal reservoir. One of the challenges in this technology is mineral precipitation, e.g. formation of carbonates or low solubility sulfates, that can block pores and hence hinder extraction. This project aims to understand how the precipitation (nucleation) of these minerals occurs in different rock types.

Sodium Sulfate Nucleation

Sodium sulfate (\(\text{Na}_2\text{SO}_4\)) is a model system used in standard testing of the soundness of rock types, as it rapidly crystallises out of solution to form hydrates, such as sodium sulfate decahydrate \(\text{Na}_2\text{SO}_4(\text{H}_2\text{O})_{10}\), commonly called mirabilite, and metastable sodium sulfate heptahydrate \(\text{Na}_2\text{SO}_4(\text{H}_2\text{O})_7\). Crystal nucleation from solution is most likely to occur at the interface between the salt solution and the rock. The interface will play an important role in determining which hydrate is formed and its nucleation rate. This PhD project will take a combined experimental and simulation approach to understand the nucleation of sodium sulfate at different rock surfaces.

Experiment

Isothermal nucleation rates will be measured experimentally using a high-throughput nucleation setup [1,2]. Experiments will be repeated in the presence of different mineral types, such as quartz, mica, etc. The resulting hydrate or crystal structures will be measured using IR or Raman spectroscopy. The effect of crystal growth inhibitors will also be investigated using these techniques and X-ray diffraction to investigate the effect on the solid salt formed.


Simulation

Simulations can provide molecular-level insight into the formation of hydrates at the nanometer-scale that is not accessible by experiment. Classical molecular dynamics (MD) simulations will be used to predict the structure of the salt solution near the rock interface. The solution structures will be analysed to obtain concentration profiles, order parameters, etc. and their variation near the interface. This insight will provide understanding about why nucleation differs in different rock types.

The student will have access to the high performance Archie-WeSt supercomputer and will gain expertise in using a Linux environment, and MD software, such as LAMMPS.

Why do a PhD with us at Strathclyde?

The PhD studentship is fully funded and covers tuition fees and annual stipend at the level agreed by the UK’s Research Council organisation, UK Research & Innovation. It includes a generous £20k budget to facilitate your research e.g. for computer and equipment facilities, lab consumables, data collection, conference and training course travel. The student will be based in the Faculty of Engineering, one of the largest and most successful engineering faculties in the UK, and the largest in Scotland. The student would be supervised by an interdisciplinary team, including Dr Andrea Hamilton in Civil and Environmental Engineering (CEE), Dr Karen Johnston, in Chemical and Process Engineering (CPE), and Prof Jan Sefcik, CPE.

Eligibility and how to apply

We are looking for a highly motivated person to undertake multidisciplinary research. The 4-year studentship is available from October 2020 and is open to UK/EU citizens who should have a good degree in a relevant science/engineering discipline. To apply please complete an online application: https://but.mis.strath.ac.uk/pguserprofile/control/enterDetailsPage.