Postdoctoral position

Mineral Scaling and Mechanical Stresses on Geothermal Corrosion

Project description:

The postdoctoral position will take place in the frame of the GeoSteelCor project (2021-2025), funded by the French agency ANR. The project partners are INSA-Lyon (MATEIS Labooratory), Ecole des Mines de St-Etienne (Georges Friedel Laboratory) and Institut de la corrosion (St Etienne site) associated through the CorTEx platform. The project concerns the study of the durability of materials in geothermal systems, in particular the study and understanding of corrosion in such environments. This project should thus contribute to the development of geothermal energy as a promising way to reduce greenhouse gas emissions in global energy production. Due to the high corrosivity and scaling ability of geothermal fluids, selecting proper metallic materials is a big challenge for its reliable development. One of the leading scientific issues of the project is the understanding of the crack initiation and propagation mechanisms in the confined space at the mineral scale/steel interface. The new experimental platform CorTEx gives a unique chance to reproduce the temperature and pressure range of geothermal plants (up to 300 °C and 200 bar). Advanced electrochemical, and local post-mortem tests will be performed for a more in-depth knowledge of the under-deposit corrosion and cracking mechanisms. The main issue of the project is the implementation of innovative and efficient material solutions to increase the safety and reliability of geothermal energy production.

Postdoctoral missions:

Impact of brines compositions, field conditions on scale formation and localized corrosion

The mineral deposits are characterized using methodology developed in the MATEIS laboratory (INSA Lyon), based on electrochemical measurements of the mineral deposits' kinetics, corrosion resistance, and physical and chemical properties.

The stability of mineral deposits and their kinetics of growth play an essential role in corrosion mechanism and affect the system sensitivity to corrosion under stress (chemical, environmental, mechanical). Two important features must be taken into account: the nature of the substrate and the composition of the geothermal medium. Concerning the nature of the substrate, two materials are chosen as representative metallic pipes used in geothermal energy: stainless steel (AISI 316 SS) and carbon steels (API J55 and P110). A critical parameter is the substrate's mechanical surface state since it influences the growth of scales (in chemistry, thickness). Therefore, two surface preparations will be considered: an industrial roughness (ground surface) or lab-scale roughness (polished surface). Concerning the environment for scale generation, conditions will mimic Icelandic, German or French geothermal media (common major elements but different ratios). The element saturation indexes and the mineral scales stability will be calculated as a function of temperature with the Phreeq-c model. The results will be confronted with experimental results based on physical and chemical analysis.

The formation of representative scales will be controlled by a thermal gradient at a metal surface/solution interface, simulating a heat exchanger using lab experiments. Depending on the temperature and pressure level, laboratory glass cells or the CorRTEx flow loop will be used to tune the saturation and stability limits of scales. A parametric study is planned within this task, exploring: the material features, surface preparation, scaling conditions, temperature, and pressure in the CorRTEx loop and the laboratory tests.

Given the facilities available in the MATEIS laboratory, the candidate will have access to SEM-EDX, conventional powder X-ray diffraction (with Rietveld method, Topas software), micro Raman microscopy, X-ray µtomography. Finally, if necessary, FIB-SEM cross-sections will be used.

To fully understand the metal's electrochemical behavior covered by mineral scales, multi-scale electrochemical measurements (available at MATEIS) are also planned to depict corrosion mechanisms and to gather kinetic information by classical electrochemical measurements (polarization curves, Electrochemical Impedance Spectroscopy (EIS)) and local electrochemical measurements (Scanning ElectroChemical Microscopy , local EIS), and electrochemical microcells will be scheduled to highlight the reactivity heterogeneities in the mineral deposits.

The expected results will help to understand (i) kinetics of scale formation at different test conditions, (ii) composition of the scales and (pseudo-)passive (oxide) layer, (iii) localized corrosion mechanisms addressing (pseudo-)passive films and mineral scales formation, which allows adapting localized corrosion models to geothermal environments.

Candidate profile:

The candidate may have a strong background in surface science and engineering, but knowledges in corrosion. He or she will ideally have skills in electrochemical techniques and physicochemical characterization (surface analysis). The candidate will have English writing and project work abilities.

Financing: ANR

Net Salary: 2230€ / month

Duration:18 months from November 1, 2021

Laboratory: INSA LYON, MATEIS UMR CNRS 5510 Laboratory, CorrIS group, 69621 Villeurbanne cedex, France
Specialty**:** Corrosion – Surface engineering –Materials science

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MATEIS is a Materials Science laboratory at the intersection of disciplinary fields, mainly in chemistry, physics and mechanics. The MATEIS laboratory studies the three classes of materials (metals, ceramics, polymers) and their composites by integrating the characteristics in volume, surface and interfaces. The project will be supervised by CorrIS (Corrosion and Surface Engineering) team which focuses its research activities on the surface properties of materials, more particularly on the reactivity of surfaces and interfaces, the physicochemical properties of surfaces and their optimization. It develops experimental methodologies that allow it to characterize surfaces and their behaviors and propose material solutions (e.g. surface treatments, architectural coatings).