Aging of silica gels under subsurface conditions

Investigating syneresis, pH evolution, and dissolution behavior of hard silicate gels

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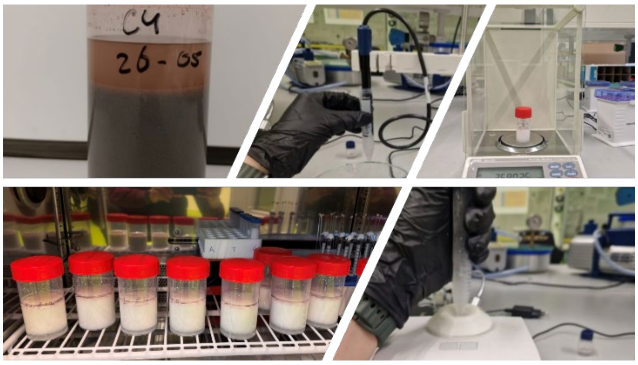

Project description

Project overview:

Silicate grouting is a well-established technique for improving soil strength and reducing permeability in sandy formations. The process involves injecting a mixture of sodium silicate, water, and a hardener into the soil, where it fills the pores and subsequently gels, forming a rigid network that binds sand grains together. While this technique is being used for a decades, its long-term stability under subsurface conditions remains poorly understood. This project focuses on understanding how silica gels evolve and degrade over time when exposed to water. The study aims to evaluate how the gel interacts with its surrounding environment and to quantify the impact of temperature and mixing ratio on chemical and structural aging.

Research objectives:

- Quantify gel syneresis (shrinkage) as an indicator of structural change.
- Evaluate pH variations in surrounding water to assess the gel's influence on groundwater chemistry.
- Measure dissolution rates and leaching of chemical components using Inductively Coupled Plasma (ICP) analysis.
- Determine mixing ratio and temperature effect on gel durability.

Methodology:

Silica gels will be prepared with varying sodium silicate–hardener mixing ratios and at different temperatures to reflect a range of grouting conditions. After gelation, the gels will be exposed to water to mimic subsurface saturation. Over several time intervals, water samples (effluents) will be collected to monitor chemical and physical changes. At each interval, three analyses will be performed: (i), gel weight measurement to calculate syneresis and quantify shrinkage, (ii), pH measurement of the effluent to evaluate how gel aging alters groundwater acidity, and (iii), ICP analysis of the effluent to determine silica dissolution rates and detect leaching products. These measurements will help identify degradation pathways and stability of silicate grouts.

Student role and expected outcomes:

The student will conduct laboratory experiments, perform measurements, and analyze the collected data. Tasks include preparing gel samples, managing water sampling schedules, measuring pH and mass changes, and assisting with ICP analysis preparation. The student will gain experience in geochemical experimentation, environmental monitoring, and data interpretation. The results will contribute to an improved understanding of the life cycle of silica-based soil reinforcement methods.

Job requirements

Basic laboratory experience, attention to detail (training will be provided).