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Time-lapse imaging of fine particle movement in porous materials

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Particulate flow in porous materials is a common phenomenon and also one of the big challenges in flow dynamics. As one example, fines migration within porous rocks may block the pores and reduce the permeability, leading to formation damage in subsurface reservoirs. Varied physical and chemical parameters causing fines migration have been widely studied in many subsurface applications such as geothermal exploitation, oil and gas extraction and carbon storage. However, the directly imaged evidence of porous structure changes and formation damage is still limited, which makes the theoretical understanding of particulate flow challenging. This research has applied a combination of two-dimension (2D) in-situ time-lapse radiography and three-dimension (3D) X-ray tomography imaging techniques under in-situ sample environment to directly image and characterise the fines migration and deposition in porous materials.

Time-lapse imaging experiment was performed at a high flux X-ray tomography scanner at National X-ray Computed Tomography facility with within an in-house designed and 3D printed high-pressure flow cell. A course-porous (pore size around 80-120 μm) and a fine-porous (pore sizes around 40 μm) sandstones and mix-size sintered glass beads (half pores around 80-120μm and half pores <50μm) to form porous bed to analogue three different porous structure systems. A suspension fluid contains calcium carbonate powder (12μm) flew through the porous bed and deposited inside and on top of the porous samples and this progress was captured using time-lapse radiography images. X-ray tomography was performed before and after the experiment to quantify the pore structure change and the deposition of particles. The results show that fine particles tended to fill the pores evenly in the well-connected pore structure with larger pores (around 40-60μm) transformed to small pores(20-40μm). Both internal and external filter cake were formed. While in the poorly connected porous structure, pores filled the preferred flow pathways first and formed the external filter cake. This imaging experiment quantified the fines migration deposition and migration within the porous materials and the effects of pore structure controls spatially and temporally. The results have improved the theoretical understanding of fine particles migration and deposition within varied porous structure and will have wide applications in subsurface engineering, materials sciences and material engineering.

Participation

In-Person

References

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Primary authors: Ms SHI, CHENZI; Dr MA, LIN; Prof. TAYLOR, KEVIN

Presenter: Ms SHI, CHENZI

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