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Assessing formation damage in-situ using X-ray computed tomography

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The flow of sub-surface suspensions, and the controls on mobilisation, transport and deposition of a suspended load are important in natural (ground water migration, hydrocarbon migration, pollutant transport) and industrial (nuclear waste storage, CCS, hydrocarbon recovery) applications. In all of these areas we seek to understand how and when a suspended load moving through porous media will be deposited at pore throats; and how this can change permeability, flow pathways, and ultimately prevent further fluid migration. The inherent complexity of pore networks makes particle migration difficult to predict. Formation damage describes processes of deposition from a suspended load that reduce the permeability and porosity of a host rock. The processes that lead to formation damage are challenging to quantify because of the dynamics and opaqueness of host systems, requiring pore scale processes to be studied via bulk measurements of inlet/outlet pressure and particle concentration measurements. Formation damage commonly occurs during subsurface drilling, due to the drilling fluid changing system chemistry which liberates host rock particles and acts as a source for a relatively high-volume fraction suspended load. We use bespoke in situ flow cells with a combination of high speed x-ray radiography and x-ray computed tomography to image and quantify how particles suspended in a single-phase fluid behave in real time. We show how and where mobilisation, transportation, and deposition from the suspension occurs, how they are related to flow rates, particle volume fraction, and the (evolving) local pore-network geometry. We also compare the observed behaviours to CFD simulations through the same pore network to verify the simulations accuracy. This information can then be used to make informed decisions when choosing drilling fluid constituents to limit formation damage. In the future we aim to observe how salinity and pH impacts formation damage processes.

Participation

In-Person

References

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