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Impact of wellbore treatment fluids on calcium carbonate attachment in MICP grouted sands

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The interest in developing microbial induced carbonate precipitation as a cement alternative in oil and gas wells stems from the fact that this biotechnology can penetrate pore networks that conventional cement grouts cannot due to their high viscosity. Currently MICP is under investigation as a potential wellbore barrier technology to mitigate hydrocarbon leakage through a) micro-channels in the cement matrix b) micro-annuli as a communication pathway between the casing and the wellbore cement sheath c) and compromised wellbore cement sheaths. A major concern of this grouting technology is how to guarantee long-term well integrity. In particular, wellbore treatment fluids and multiphase subsurface fluids may interfere with carbonate production and/or attachment, thus compromising the integrity of the wellbore repair. In this research, we investigate the impact and influence of hydrocarbons and of currently available state-of-the-art wellbore treatment fluids and determine how these affect the performance of our “biomineral-seal” in the subsurface.

Biologically mediated calcium carbonate precipitation on grain surfaces within a sandy porous media, is known to cause several effects. Carbonates that precipitates in pore throats can form bridges in between the individual sand grains which results in increased strength of the porous media and some reduction in permeability. Carbonate biominerals that precipitate on grain boundaries within the pore space provide additional grain roughness, which leads to an increase in nucleation sites for further precipitation of calcium carbonate crystal polymorphs. Continued biomineral treatment results in a decrease in rock porosity.

The impact of hydrocarbons and other well-bore treatment fluids on biomineralization processes at the microstructural scale, including bacterial attachment and subsequent carbonate precipitation are largely unknown. In this experimental study, we explore the effect of biomineralization on the microstructural and physical properties of a series of batch cemented sand samples at elevated temperatures and pressures in the presence of hydrocarbons. We also explore, for the first time, the effect of wellbore treatments fluids.

We use Micro X-ray computer tomography to compute pore-structural properties (porosity, permeability, specific surface area and volume fraction of calcite attached to the sand grains). To investigate the attachment of precipitated carbonate and bacterial cells (entombed in calcium carbonate) to grain boundaries or calcium carbonate (free-floating) precipitated within pores, Scanning Electron Microscopy with Energy Dispersive X-Ray Spectroscopy (SEM-EDS) are deployed. In parallel, calcium carbonate crystal polymorphology is evaluated by X-ray diffraction (XRD) and, in case of hybrid crystal polymorphology, by Transmission Electron Microscopy (TEM).

Ongoing experiments focus on 1) investigating the survival of *S. pasteurii* in particular wellbore environments with well-known drilling fluids, corrosion inhibitors and hydrocarbons 2); identifying fluids that might negatively impact on attachment of calcium carbonate 3); the influence of key fluids on crystal polymorphology.

References

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