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Experimental evaluation and modeling analysis for kinetics of MICP and EICP processes

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It is essential to find reliable methods for plugging and abandoning hydrocarbon wells in order to minimize the risk of hydrocarbon leakages in the future. To that end, clogging the near wellbore areas by microbially/enzymatically induced calcite precipitation (MICP/EICP) can be considered as an efficient sealing method for hydrocarbon wells. Different mechanisms such as nitrate reduction, urea hydrolysis, or sulphate reduction can provide favorable conditions for biomineralization, from which the hydrolysis of urea is the focus of this research. In this study, through a set of batch experiments, Sporosarcina pasteurii (S.P.) is cultured in closed serum bottles with limited oxygen availability. The growth media in these systems are in contact with three different porous materials: cement, diatomite, and chalk. This is used to analyze the fluid-rock interactions in systems which are an approximate representative of the MICP/EICP scenarios in subsurface porous media. The capability of the targeted samples in providing nucleation sites for the new precipitates, and acceleration of the precipitation process is discussed. This is followed by an experimental and modeling analysis of the reaction kinetics. The concentrations of Ca2+ and ammonium are measured over time, and the change of the pH values is recorded in the batch experiments. Next, the kinetics of urea hydrolysis and calcium carbonate precipitation in different systems are quantified by applying a geochemical model, using the PHREEQC package. In the experiments, the distribution of the precipitates attached to the surface of the different minerals are categorized by taking SEM images. The finding of this research can provide insight on the suitability of MICP/EICP for clogging the carbonate formations and optimizing the large-scale bio-clogging scenarios.