Sulfidogenesis and Perchlorate Control: Novel Mesoscale Tank Experiment and Reactive Transport Modeling

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Biogenesis of sulphide through microbial sulphate reduction (a.k.a souring) is detrimental to oil reservoir operations. A better understanding of souring and treatment is therefore a high priority. Subsurface biogeochemical cycling at the field-scale is controlled by a complex interplay between hydrological, geochemical and biological processes. Mesoscale tank experiments can help to bridge the gap in complexity and understanding between well-constrained column experiments, and the interpretation of field data.

In this study, a novel mesoscale tank experiment is coupled with reactive transport modelling to understand the effects of heterogeneities on souring and perchlorate treatment. Fluid and solid samples collected during/after the experiment were analysed for isotopic, geochemical and microbial information that revealed the spatiotemporal evolution of key chemical and biological species in the 3-D system. Perchlorate is an effective inhibitor of sulfidogenesis, and microbial community analysis indicated shifts in community composition as a result of perchlorate treatment.

Experimental data provided information for the development and validation of a 3-D reactive transport model. The model captured the spatiotemporal trends of the chemical species and microbial populations that emerged as a result of feedbacks between microbes, flow and the minerals; and elucidated the relative role that each perchlorate inhibition mechanism played. In addition, simulations revealed the important role of heterogeneity in governing system flow characteristics, which in turn control system scale sulphate reduction rates and provide critical insights to the design of field-scale souring control strategies in oil reservoirs.