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Modelling coupled microbial processes under multiphase and multichemical flow conditions

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Sequestration of anthropogenic carbon dioxide in deep geological formations, such as, saline aquifers, unmineable coal seams is a plausible way to reduce global greenhouse gas effects. Safety and performance efficiency of storage reservoirs are of utmost importance. Long-term containment of sequestrated CO2 can be achieved by preventing leakage and by ensuring further entrapment such as solubility-trapping and mineral-trapping. These processes can be enhanced by involving subsurface microbial community that restrict flows by forming biofilms and/ favours biomineralization.

Subsurface flows and reactions are complex and often involve multiple phases, chemicals and minerals as well as pressure and thermal gradients. To study such complex interactions, a numerical model has been developed under a coupled Thermal-Hydraulic-Chemical-Mechanical (THCM) framework including subsurface microbial processes and associated bio-geochemical reactions. The model deals with liquid flow, multicomponent gas flows, dissolved chemicals and suspended microbes flows in liquid phase, heat flow, biofilms and minerals growths, mechanical deformations and geochemical/bio-geochemical reactions. The model considers multiple species of biofilms (attached to solid phase) and suspended microbes (in liquid phase). The model predicts microbial growth by both respiration and fermentation. Microbes decay due to endogenous cell death, fluid shear, biocide decay etc. Attachment/detachment of cells to/from biofilm phase to suspended cells also alter their respective quantities. At high pH conditions, growth is favoured while at low pH it slows down. The presence of multiple chemicals, minerals and gas influence transport and availability of nutrients, substrates to microbes as well as facilitates various geochemical and bio-geochemical reactions.

In this presentation, applications of the model to simulate microbial growth in multiphase condition are presented. Flow of substrate in a solution containing multiple dissolved chemicals are considered. Therefore, the effects of microbial activities on solution composition and minerals (and vice-versa) in the system are envisaged. Overall impacts of microbial processes on thermal condition and flow properties of the medium are discussed.

References

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