GAS PROPAGATION THROUGH POROUS MEDIA FILLED WITH YIELD-STRESS FLUID

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ABSTRACT

We use computational methods to study propagation of bubbles inside porous media filled with yield-stress liquid, given the pressure difference across the porous layer. The main motivation for this study comes from the potential for greenhouse gas emissions. In oil sands tailings ponds, the by-products of the extraction of bitumen from oil sands are stored over many decades. The pond slurries, known as Fluid Fine Tailings and Mature Fine Tailings (FFT/MFT) are complex suspensions, rheologically characterised as thixotropic yield-stress fluids. These fluids provide the interstitial liquid within the coarse sand layer that forms underneath, at the bottom of the pond. Anaerobic micro-organisms within the fluid degrade the by-products and create both carbon dioxide and methane. The objective of this research is to provide understanding on how gas generated in the lowest coarse sand layer may propagate to the surface. The underlying research motivation is environmental, i.e. emissions estimation and control.

We use a pore-throat methodology to model the porous media. We develop an algebraic description in the form of a closure law that relates flow rates and displacement efficiency to the fluid properties and applied pressure drop, considering gas motion along an axisymmetric pipe (throat), filled with yield-stress fluid. This is used as the building-block for a meso-scale network model of the coarse sand layer. Gas propagation behaviour is then solved using a gas-liquid hydraulic closure model. This type of model allows us to impose both statistical distributions (e.g., throat size, length, etc.) and background physical variations (e.g. initial conditions for the gas, depth-wise aging of the liquid properties). In this way we can build a picture of the system response of the coarse sand layer, understanding how gas generated in the interstitial liquid might percolate upwards.

Acknowledgement: This research was made possible by funding from NSERC and COSIA/IOSI (project numbers CRDPJ 537806-18 and IOSI Project #2018-10).