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Modelling reactive two-phase flow: challenges and implications

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The ongoing warming of Earth's climate is about to trigger significant change in global sea-level and temperature distribution. Among first evidence is the thawing of hydrate-rich subsurface sediments leading to the potential release of large amounts of greenhouse gases into the oceans and the atmosphere. We hypothesise sea-level and water temperature variations to trigger abrupt changes in the stability of natural systems leading to the spontaneous localisation of flow and deformation. The sedimentary stacks we consider represent fluid saturated deformable porous environments described by interacting thermal, hydrological, chemical and mechanical processes. Resolving the multi-physics interactions or coupling is vital in order to accurately predict the rapid, non-linear and non-trivial evolution of natural systems in fragile equilibrium.

We here investigate how interactions among chemical, hydrological and mechanical processes lead to the spontaneous localisation of flow. We employ a novel numerical modelling framework based on the iterative implicit pseudo-transient method to understand how the relative role of reactions and pore fluid distribution impacts the local deformation in saturated porous media. Resolving strongly coupled multi-physical systems is challenging because accurate results require high resolution calculation in space and time.

Our study aims at better understanding how external forcing parameters such as e.g. pressure and temperature may lead to abrupt changes in the dynamic of complex systems. Ultimately, such investigations should permit further assessment of the longer term evolution and stability of natural systems.