Abstract:

This study investigates the fundamental issues of chemo-geomechanics related to emerging engineering problems of underground energy solutions and safety – including unconventional shale hydrocarbon production, enhanced geothermal systems, geological sequestration of CO2 – where cracking plays an important role across length and time scales. The technique of hydro-fracturing has been widely used in many countries after the development of horizontal drilling for extraction of subsurface energy in the form of e.g. hydrocarbon and heat. For those unconventional tight low-permeability carbonate reservoirs, acidizing treatment is often incorporated as an enhancement of crack propagation. Acidizing assisted hydro-fracturing, during or after the treatment phase, is a highly nonlinear coupled dynamic process that involves several physical/chemical processes occurring concurrently and affecting each other. We are particularly interested in the modelling of crack propagation into a stressed medium subject to fluid pressurization and meanwhile being affected by the chemically aggressive environment. This presentation shows our unique approach of tackling this problem by considering the effect of micro-fracturation enhanced chemical shrinkage, in both the normally defined elastic and plastic domains of rock behaviour. Local reactive transport processes of minerals relating to an evolution of distribution of hydrogen concentration are coupled with the mechanical degradation via upscaling to a representative elementary volume. To this end, a general framework of reactive chemo-elasto-plasticity is formulated, based on which, boundary value problems simulating typical scenarios encountered in hydraulic fracturing will be investigated, with an emphasis on the feedback mechanisms between the coupled multiphysics involved processes and the evolution of matrix permeability.