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Modelling of some nonlinear processes in deforming and reacting porous saturated rocks

Lyudmila Khakimova (1), Yury Podladchikov (2), and Artem Myasnikov (1)

(1) Skolkovo Institute of Science and Technology, Moscow, Russian Federation , (2) University of Lausanne, Lausanne, Switzerland

A lot of processes in rock mechanics are far from being understood today despite all the advancements in the current modelling technologies. Even more, as far as we know, the progress in some geomechanical disciplines became much slower than 20 or even 10 years ago. That paradox is because of the fact that in last decades researches and engineers were often happy enough with mutually unrelated approaches: geochemistry, geomechanics and reservoir hydrodynamics were not considered as three components of one compound. Now people understood that it should do this but they can not, simply because each of the processes become complicated too much and there is no theory, or, at least an approach, which would simplify them consistently. In what follows we propose such an approach. To be more specific, we present the next step in our modeling which is based on a unified approach for reactive-thermal-fluid transport in deforming porous media.

The way we treat the thermal coupled fluid flow, rock nonlinear deformation and chemical reactions are suitable for prediction of geological and petroleum processes at different scales, such as oil and gas migration, CO_2 capture and storage, physical, chemical, and thermal EOR optimization. The model takes into account multi-phase fluid flow, all main nonlinear processes in a visco-elastic-plastic porous matrix, and treats porosity and permeability evolution. However, the main emphasis in the present study is put on reactions, which may be either homogeneous or heterogeneous.

Reactions are calculated based on Gibbs minimization technique allowing for any possible reaction for considered chemical species at local equilibrium. Partitioning between components in fluid and solid phases are also caused by the diffusion of chemical species and phase flow leading to changes in composition, thereby self-consistently accounting for local effective composition which is then used in the calculation of thermodynamic equilibrium. The proposed method was verified against the standard flash procedure in the case when Gibbs potential is derived from an equation of state; the set of classical examples from reacting gas dynamics; and classical solutions for a shock-induced detonation process and slow combustion. After that, the technique was validated against experiments in the combustion tube and applied to fundamental and industrial problems. The brightest examples of the studies are in-situ combustion during an unconventional oil field development and laboratory investigation of oil oxidation processes and combustion front propagation during the experiments in combustion tube. We will show also how do some of them work.