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A fully coupled hydro-mechanical modelling for describing gas transport in coal matrix

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Coal bed methane (CBM), also known as coalbed gas, has drawn much attention lately as an alternative energy resource. Production curves of CBM reservoirs are very different, however, from the ones of hydrocarbon conventional reservoirs (Wang et al., 2011). As emphasized by several studies (Mostaghimi et al., 2017), transport and poromechanical properties of coal are strongly driven by topological and morphological features of its pore space.

The cleat-matrix system compartmentalizes the transport and mechanical properties of coal. Knudsen and surface diffusions prevail in the nanometer-sized pores of the matrix, while molecular diffusion and two-phase Darcy flow occurs mainly within the cleat network. All these transport mechanisms induce mechanical couplings related to both (i) the pore pressure changes which may alter the effective stress and consequently impact the bulk volume of the coal and (ii) the sorption processes which contribute to swell or shrink the coal matrix (Bertrand et al., 2017). The inherent couplings between the physical processes at stake and the multiscale features of coal need to be explored further to better assess the macroscopic response of the coal matrix and the sorption induced volumetric deformation.

We present a 3D model coupling a discrete element model and a pore network model specifically developed to describe the different diffusion mechanisms involved in coal matrix as well as the associated adsorption induced deformations. The material is assumed to be saturated with gas and diffusion occurs through the combination of Knudsen diffusion within the pore space, surface diffusion at the solid surface, and adsorption-desorption at the pore-solid interface. The model is hydro-mechanically coupled in the sense that changes in pore pressure produce hydrostatic forces that deform the solid skeleton, while deformation of the pore space induces pore pressure changes that promote interpore flow. Sorption induced deformations are taken into account by considering an additional pressure term related to the concentration of gas within the medium (the so-called solvation pressure). The implemented transport models are verified against analytical solutions describing diffusion in porous media with and without sorption-desorption, and a comparison is made with a swelling experiment performed on a coal specimen to illustrate the relevance of the proposed approach for describing adsorption induced deformation.

Participation

In-Person

References

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