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Permeability evolution of fractured sorptive porous materials

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Fractured sorptive geomaterials (FSG) are ubiquitous in geological systems such as coal, shale and chalk. The solid matrix of FSG can adsorb species in gas or liquid form, the process of which is often accompanied by the deformation and micro- structural alternation of the matrix. Such coupling is further obscured by the presence of fracture network, introducing complex fracture–matrix interactions. Predicting the hydromechanical properties of FSG is of particular importance for the production of coalbed methane (CBM) which requires the assessment of coal permeability under varying pressure and stress conditions. This study attempts to investigate the interplay between adsorption, deformation, and permeability evolution of coals. The novel concept of adsorption stress popularized in material science research is adopted here to construct a mechanistic theory describing sorption-induced deformation of coals. The constitutive theory is implemented in a finite element (FE) scheme and then adopted for describing coal matrix in a FE model of coal–fracture system. The model is calibrated for San Juan coals and applied to simulate a typical methane depletion test. It is observed that, depending on the competing effect between desorption-induced fracture opening and poroelastic compaction, the predicted permeability curve may be monotonically increasing (rising type) or decreasing (decline type), or may exhibit reduction first and then increase (rebound type) during gas depletion. Such competition is found to be controlled by the volume ratio, the permeability ratio, and the stiffness ratio between the matrix and the fracture elements. The prediction covers a wide range of permeability data obtained from laboratory tests and field observations.

Participation

In-Person

References

Zhou, X., Liu, S. and Zhang, Y., 2021. Permeability evolution of fractured sorptive geomaterials: a theoretical study on coalbed methane reservoir. Rock Mechanics and Rock Engineering, 54(7), pp.3507-3525.

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