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Multiscale modelling of CO2 storage in coal seams: an image-based modelling method

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CO2 geo-sequestration is a practical approach to achieve net-zero carbon target. Coal has become an optimal geological storage option due to its large adsorptive capability for CO2. However, one of the main challenges for successful CO2 geo-sequestration is the reduced injectivity that are caused by adsorption-induced swelling of coal matrix. In addition, its complex and heterogenous internal pore and fracture structure make the processes of gases adsorbing, desorbing, and transporting more complicated compared with conventional rocks. This work aims to gain insights about the gas transport behaviours in coal by developing a coupled model to simulate gas flow multiphysics as well as dynamic coal deformation.

This work develops an image-based 3D fracture network model, called Fracture Box Model (FBNM), which is directly derived from 3D images of real coal samples. In this model, each fracture is described by arrays of box elements such that the regional change of fracture opening widths can be preserved. FBNM is used to simulate viscous flow in fractures, gas diffusion in matrix micropores, gas exchange on coal surface, coal matrix deformation (due to sorption and thermal expansion). Compared with other fracture models (e.g. discrete fracture network), FBNM can simulate such complicated multiphysical gas transport more efficiently, but also be able to simulate corresponding coal matrix deformation. By comparing permeability results between direct simulation method with FBNM, it is found that FBNM can effectively estimate the permeability of original fracture networks, but requiring significantly less computational cost. To study the implications of gas types, effective stress, gas adsorption, and thermal expansion on coal permeability, gas injection pressures, gas types, coal seam temperatures are varied and investigated in the simulations.

The FBNM developed in this work is more preferable for complicated flow transport simulations where direct simulation methods are still challenging. It provides a promising framework which could be further developed for multiphase and multicomponent flow simulations for CO2 geo-sequestration projects.

Participation

In-Person

References

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