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Numerical modelling of CO2 sequestration in coal-seams based on a parallel hybrid discrete fracture –dual porosity model

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Coal-seams or coal deposits are not only critical to global energy supply but also recognized as a potential reservoir/ target formation for geologic carbon dioxide CO2 storage. Detailed understanding of coal-CO2 interaction and assessment of reservoir performance are fundamental for successful design and operation of coalbed CO2 storage strategies. Coalbeds are complex porous media consisting of multi-scale fracture networks and multi-pore matrices. Coal matrix blocks are generally separated by well-defined, small-scale fractures or cleat network inherent to the material, whereas large-scale fractures are associated with hydraulic fractures or geological fault lines. Numerical modelling of subsurface fluid flow, reaction, and mechanical deformation in coal deposits, in such discrete but inter-connected system of domains, especially for large spatio-temporal problems, are challenging and computationally expensive. Therefore, implementation of robust numerical techniques is essential for efficient and accurate solutions.
By focusing on fluid conductivity regimes or separate flow regions, an advanced hybrid discrete fracture – dual porosity (HDF-DP) model is developed on a coupled thermo-hydraulic-chemical-mechanical (THCM) modelling framework. In the model, large hydraulic conduits are simulated as discrete fractures while the cleats and matrices are simulated, combinedly, under a dual-porosity system. In the numerical procedure, large fractures are idealized as lower-dimensional geometric objects and discretized by lower-dimensional interface elements, such as, lines (1D) in 2D planar domains or 2D planes in 3D volumes, however share the same nodes at the interface elements between two continua. In the model, Galerkin finite element method is used for spatial discretization and a fully implicit mid-interval backward difference time-stepping algorithm is used for temporal discretization. Furthermore, the model is parallelized using a hybrid message passing interface/ open multi-processing (MPI & OpenMP) scheme to reduce computational time. The model is applied to investigate carbon dioxide storage in coal-seams accounting realistic subsurface conditions. For large-scale simulations, significant reduction of simulation runtime was achieved using the parallel HDF-DP model. To demonstrate accuracy of the model, predicted results were compared against an in-situ field dataset on coalbed methane production obtained from literatures. The model predicted results agreed well with the field-data highlighting its utility to studying complex subsurface processes regarding carbon storage and/ coalbed methane recovery.

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References

Time Block Preference

Time Block B (14:00-17:00 CET)

Participation

In person

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