Contribution ID: **668** Type: **Oral Presentation**

Phase-field modeling for multiphase flow and geomechanical processes

Tuesday, 20 May 2025 08:30 (30 minutes)

Phase-field models have proven to be effective simulation tools for describing interfacial processes at computationally feasible scales. Recent applications of these models include simulating the nucleation and propagation of hydraulic fractures in geological formations, as well as the behavior of fluid-fluid interfaces during flow through permeable media. The phase-field approach seeks to upscale interface dynamics by developing a continuum representation that diffuses sharp interfaces across several grid blocks or elements within a computational mesh.
The governing equations are formulated using appropriate variational principles or thermodynamic descriptions of the system. In this work, we present a phase-field formulation for thermo-hydro-mechanical hydraulic fracturing, with applications in geothermal energy production, and in the migration and seafloor venting of hydrocarbons. Additionally, we introduce a fugacity-based phase-field model for multiphase, multicomponent flows, applied to pore-scale simulations in the context of CO2 and hydrogen storage in porous formations. We also address the challenges of bridging scales in these models.

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References

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Session Classification: Invited Lecture

Track Classification: (MS27) Invited & Plenary Speakers