Contribution ID: **170** Type: **Oral Presentation**

Advancements in suction-induced fractures in multiphase porous media: Phase-field and data-driven multiscale modeling

Tuesday, 1 June 2021 16:10 (15 minutes)

Whether naturally- or artificially-induced due to human activities, decreasing or increasing of suction in multiphase-fluid-saturated porous materials can lead to enormous changes in their thermo-hydromechanical properties. In this, both the mathematical description and the numerical modeling of the coupled problem present a challenging task. The presentation considers the following two instances related to suction-induced fractures. (1) The drying-induced fracturing, which occurs due to increasing of the capillary pressure (air pressure minus water pressure) in low-permeable, unsaturated porous materials. (2) The micro-cryo-suction-induced fractures, which can be observed in saturated and unsaturated porous materials under freezing conditions.
In both cases, the macroscopic modeling of the induced fractures is based on continuum porous media mechanics extended by a diffusive phase-field fracture method. For the drying-induced fractures of unsaturated porous media, one has to deal with more than one pore fluid (e.g., water and air). In this case, the mechanical behavior can be expressed by using Bishop's effective stress principle, which considers the total stress, the capillary pressure, and saturation degree. For the micro-cryo-suction-induced fractures in saturated porous media, the water freezing is treated as a phase-change process. This is modeled using a different phase-field approach, in which the thermal energy derives the phase change and, thus, leads to occurrence of micro-cryo-suction due to the formation of the ice phase.
In addition to the continuum mechanical modeling and the conventional constitutive relations, machine learning (ML) presents a powerful tool in bridging the gap between the micro and the macro scales. In this, we employ self-designed/self-improved neural networks, which can be trained using datasets of microscale simulations, to produced constitutive relations for the macroscopic scale simulations. For instance, ML via deep recurrent neural networks (RNN) allows to generate of path-dependent retention curve models, which can capture the challenging hysteresis behavior. Numerical examples will be presented and include qualitative and quantitative comparisons with experimental data.

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Time Block Preference

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

References

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Session Classification: MS7

Track Classification: (MS7) Mathematical and numerical methods for multi-scale multi-physics, non-linear coupled processes