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Scaled Physical Modeling of CO2 Cyclic Injection Process in A Heterogeneous Unconsolidated Sandstone Formation using Additive Manufacturing and Geotechnical Centrifuge Technologies

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To integrate the complex interplay of mechanics of gaseous solvent injection, reservoir deformation, and near-wellbore formation collapse, we designed and manufactured a highly-instrumented scaled laboratory experiment, capable of simulating and monitoring the cyclic CO2 injection process in heavy oil reservoirs at in-situ conditions. In this work, we present the application of a 2-meter beam geotechnical centrifuge for scaled physical modeling of multiphase flow (i.e. live heavy oil) in a 3D printed rock specimen under different triaxial stress states.

The new centrifuge cell consists of a vertical loading system to emulate overburden, an 8-arm horizontal loading system to induce stress anisotropy, and a production unit to collect the produced fluids and the collapsed sand grains. Heterogeneity was included in the 3D printed porous rock in the form of high permeability channels near the perforations of a scaled wellbore within the physical model. The sample was first saturated with water, followed by dead oil and live oil. The 500 kg setup was spun at 30 times the gravitational acceleration (approximately 120 revolutions per minute) before opening the wellbore and initiating the fluid production.

Upon the completion of the test, the 3D printed sample was taken for physical inspection. Changes in initial fluid saturation and the rock structure were observed around wellbore and high-permeability channels due to the stress concentration. The findings highlight the key role of coupled flow and geomechanics processes in understanding of the porous media. Moreover, the new experimental tool enables one to study the multi-phase flow in deformed porous media at different scales and more representative in-situ stress boundary conditions.

Participation

In-Person

References

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