

Hydromechanical Response of Jointed Rock Masses and Proppant Packs in Energy Geosystems

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Dr. Shahrzad Roshankhah is an Assistant Professor at the University of Utah's Department of Civil and Environmental Engineering. Her presentation will be at 9:00 Central Time on Thursday, May 28, 2026. The topic is "Hydromechanical Response of Jointed Rock Masses and Proppant Packs in Energy Geosystems."

Abstract

Hydraulic fracturing in naturally fractured reservoirs often exhibits hydromechanical behaviors that deviate from those predicted for homogeneous, intact rocks. In this webinar, I will discuss a series of experimental and numerical studies investigating how fracture-network geometry, rock matrix properties, and proppant characteristics govern fluid-driven fracture evolution, pressure mobilization, and permeability preservation in energy geosystems. This presentation will focus on three coupled scientific questions: (1) Why can naturally fractured rocks exhibit higher breakdown pressures than homogeneous intact rocks? (2) Does higher mobilized pressure necessarily produce longer stimulated fractures, and what governs this behavior? and (3) How do particle size distribution, shape, and breakage control the hydromechanical behavior and permeability evolution of proppant packs?

Results from my team's laboratory experiments on shale and transparent PMMA analog specimens will demonstrate how bedding-plane slip and hydraulic fracture-natural fracture (HF-NF) interactions alter fracture evolution and pressure response during high-rate fluid injection. High-resolution monitoring techniques, including digital image correlation and neutron tomography, provide insight into fracture initiation, fluid migration, deformation localization, and evolving internal structure during stimulation. I will further present hybrid finite-discrete element method (FDEM) simulations, implemented in Irazu, to investigate coupled hydromechanical behavior under Utah FORGE enhanced geothermal

system (EGS) conditions and Uinta Basin CO₂ sequestration conditions. We show that, contrary to common expectations but consistent with field observations, naturally fractured rocks may require higher breakdown pressures than intact rocks. We hypothesize that this is because rock block interlocking can increase the shear strength and stiffness of the rock mass. The simulations demonstrate that higher mobilized pressure does not necessarily translate to longer stimulated fractures. Instead, the relative permeability of the rock matrix and natural fracture network governs whether the system behaves in a leak-off-dominated or toughness-dominated regime.

Because stimulation efficiency ultimately depends not only on fracture creation but also on maintaining fracture conductivity, this webinar will also discuss the hydromechanical behavior of particulate packs relevant to proppant applications. Our experimental and numerical studies show how particle size distribution, shape, and breakage govern pack settlement, stress transfer, stiffness evolution, and permeability degradation under elevated stress conditions. While packs composed of larger and angular particles can achieve higher initial permeability and maintain permeability under uniaxial loading, these particles may also exhibit greater breakage potential, producing fine fragments that clog pore space and accelerate permeability loss. The findings provide mechanistic insight into the coupled fracture-flow behavior of naturally fractured reservoirs and particulate media and have direct implications for the design and optimization of hydraulic fracturing, enhanced geothermal systems, and geological carbon storage operations.

Biography

Dr. Shahrzad Roshankhah is an Assistant Professor at the University of Utah's Department of Civil and Environmental Engineering. Her research involves laboratory and numerical simulations to model the coupled thermal, hydraulic, and mechanical behavior of geomaterials. She is the recipient of the 2025 CAREER award from the National Science Foundation for investigating the hydromechanical behavior of jointed rock slopes. Her research on geological CO₂ sequestration and proppants for enhanced geothermal systems has been funded by the US Department of Energy through two projects. In 2025, she was selected as an early-career research fellow of the US National Academies of Sciences, Engineering, and Medicine to extend her work on offshore energy safety. Before joining the University of Utah, Shahrzad taught civil and geotechnical engineering courses at the California State University, Long Beach, and was a research scientist at Caltech, where she studied the behavior of hydraulic fractures in naturally fractured rocks, as well as the elastoplastic behavior of impacts in particulate flows. Shahrzad received her Ph.D. degree from Georgia Tech and her M.S. degree from the Amirkabir University of Technology, both in geomechanics. Shahrzad has over six years of industry experience in civil and geotechnical engineering and holds a Professional Engineering license in the State of Utah.