The Department of Civil and Environmental Engineering at the University of Houston presents...

CIVE 6111 Graduate Seminar

How much of the transient friction of geological shear zones can be explained using granular physics alone?

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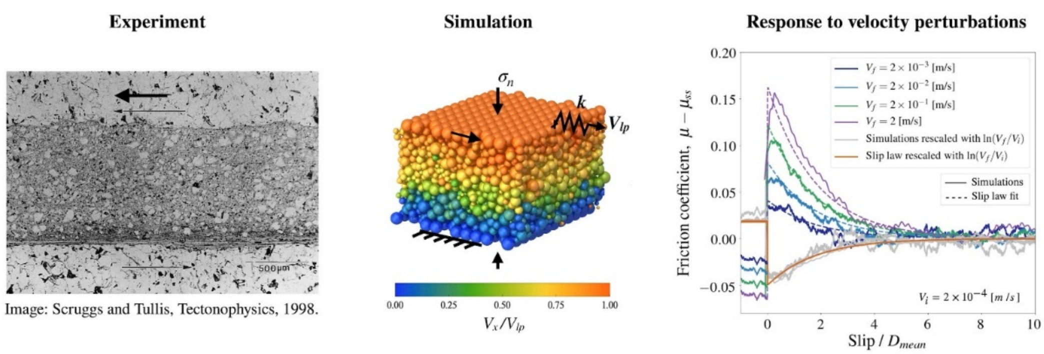
Classroom Business Building (CBB) - Room 124
Zoom Link: https://uh-edu-cougarnet.zoom.us/j/94936378602

Abstract
Geological shear zones exhibit a curious transient response to perturbations in sliding velocity, that comprises an immediate change ("direct effect") in friction upon perturbations, followed by a gradual evolution of friction toward its steady-state at the new velocity. This transient response goes under the umbrella of Rate- and State-dependent Friction (RSF), and it controls the initiation of numerous geological instabilities with a frictional origin (e.g., earthquake nucleation, landslides, sliding of glaciers). Yet the underlying physics of the transients continues to be debated. The conventional wisdom is that the RSF behavior arises from the time-dependent plastic flow or chemistry at microscopic contact points in the shear zone, however, mathematical models developed based on this idea cannot capture important features observed in the lab. Motivated by observations that faults and other shear zones in the Earth are invariably filled by fragmented rock (gouge) and sediments, here I explore an alternative model in which variations in friction derive simply from granular rearrangements in a localized shear zone, with no rate- or state-dependence at individual grain-grain contacts. I investigate the behavior of the model in simulated laboratory experiments in which a granular layer is subjected to large variations in slip rate, known as "velocity-stepping" protocols, and in "slide-hold-slide" protocols, long used to measure the amount of frictional strengthening (healing) that occurs during fault "holds". I find that the model accurately describes important features that are almost universally observed in laboratory data. I next use the energetic properties of the model to explain the physics governing the emergence of the direct effect in the model. I will conclude by discussing the implications of the study for the origins of transient friction of faults, and if time allows, will discuss some of our ongoing and future research directions for further probing the physics governing the rheology of geomaterials with potential applications in forecasting Earth's near-surface processes and hazards.



Bio
Behrooz Ferdowsi (he/they) is an Assistant Professor (Sept. 2021 - present) in the Department of Civil and Environmental Engineering at the University of Houston, where he leads a newly established research group on the rheology of Earth materials and physics of Earth's near-surface processes. He obtained his PhD in Civil, Environmental and Geomatic Engineering from ETH Zurich in Switzerland and his MSc in Civil Engineering from Tehran Polytechnic in Iran. In his PhD research, he worked on understanding the mechanism of triggering of stick-slip instabilities in sheared granular materials using computational methods. For his first postdoctoral appointment, he was based jointly in the Department of Earth and Environmental Science at the University of Pennsylvania and in the National Center for Earth-surface Dynamics at the University of Minnesota. During this period, he worked on the granular physics of sediment transport in fluvial (rivers and streams) systems and on further understanding the physical basis of the empirical transport laws used for modeling the evolution of landscapes over geological timescale. This is followed by his second appointment as a Harry H. Hess postdoctoral fellow of the Department of Geosciences at Princeton University, during which he primarily worked on understanding the physical origin of an empirical constitutive modeling framework for transient rheology of rocks and other geological materials, known as the rate- and state-dependent friction. Dr. Ferdowsi's research interests are at the interface of granular and soft matter physics, computational physics, and physics-based modeling and quantitative studies of near-surface geological and geophysical processes.