ARMA Future Leader Webinar Series

Every Two Weeks on Fridays 9-10 AM MT (11 AM -12 PM ET)

Determination of the Crustal Friction and State of Stress in Deep Boreholes Using Hydrologic Indicators

Dr. Xiaodong Ma, University of Science and Technology of China

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https://westernuniversity.zoom.us/j/99355457319

Abstract

In this presentation, I will explore the interconnectedness between two very fundamental topics that interest the geomechanics community: the friction (and fluid flow) of fractures and faults, and the in situ state of stress of the brittle crust. Building on the link between them, we hypothesize that the knowledge of fractures/faults hydraulic conductivity (albeit appears to be erratic) may illuminate crustal friction and in situ stress. By utilizing a novel, data-driven technique, binary logistic regression, we re-examine four data sets that examine the relationship between shear-slip fracture criticality and hydraulic conductivity (fluid flow) in the Earth's brittle crust. Our analysis statistically confirms the applicability of Coulomb frictional failure theory with laboratory-derived rock friction (often referred to as Byerlee's law). Moreover, it demonstrates, for the first time, that the knowledge of whether pre-existing fractures are hydraulically conductive or not can be used to determine the orientation and relative magnitudes of the three principal stresses. We demonstrate that the method matches independently determined information about stress orientation and relative magnitude in the four case studies. Thus, it has the potential to enable a new, relatively simple method for in situ stress determination in relatively impermeable,

fractured rock masses. This could potentially benefit a wide variety of scientific and engineering applications in the subsurface, e.g., scientific drilling, quantifying fault criticality, geothermal energy development, and CO2 sequestration.

That said, our study could be further improved should more relevant data become available. The data sets used in this study are the only ones accessible to us. It is the intention of this presentation to motivate the sharing and standardization of existing data and the collection of new data. As we show, simple inputs of data and data-oriented interpretation could lead to better understandings of fault/fracture friction and crustal stress, we consider this contribution is timely, topical and of significance in the current ‘big data’ era.

Biography

Dr. Xiaodong Ma (PhD, 2014, University of Wisconsin-Madison) is currently a professor at the Department of Geophysics, University of Science and Technology of China (USTC) and affiliated with the Deep Space Exploration Lab (DSEL). Before returning to China, he conducted research and teaching at Stanford University and ETH Zürich. He is interested to connect rock mechanics fundamentals (e.g., friction, poroelasticity, time-dependency) with geo-engineering applications (e.g., geo-resources, geo-hazards and geo-structures), through the main research theme related to crustal stress and its spatio-temporal variations. He combines laboratory and field observations, physics-based models and data analytics to tackle modern challenges of geomechanics. Dr. Ma was an ARMA Future Leader (class of 2018), and he received the Inaugural Distinguished Service Award in 2020.