Research Development Fund – Fall 2023 Application

Application Title: Material mechanical testing at a range of unprecedented pressure, temperature, and strain rate conditions

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RDF Amount Requested ($): 1,963,605.09

Executive Summary

A better understanding of the deformation of geomaterials (e.g., rocks, soils, etc.) and engineering materials (e.g., metals, polymers, etc.) is crucial for addressing societal issues, including natural geological hazards, energy production, water resource management, waste isolation, global warming, space exploration, and national defense. A recent improvement in geophysical monitoring networks by seismometers and global navigation satellite systems at the Earth's surface has discovered much smaller deformation events, which are non-destructive and undetectable by humans. Yet, the mechanics of these new types of subsurface deformation phenomena and their relationship with regular sometimes devastating earthquakes are not fully understood. High demand for sustainable energy has led one to investigate alternative sources of renewable energy, such as enhanced geothermal systems (EGS), and engineering solutions for the safe geological storage of energy sector byproducts (e.g., CO_2 and high-level nuclear waste). In addition to geomaterials, other heterogeneous materials such as novel metallic alloys such as multi-principal component alloys, granular solids formed from agglomerations of discrete particles of nearly any material, and particle-polymer composites are extensively used in environments with complex and dynamic loading conditions. Conventional methods of studying their dynamic response are largely unconfined, uniaxial compression yet, models and applications require consideration of increasingly complex stress states relevant to performance demands in hypersonic and terminal effects applications.

To address such critical scientific and engineering problems, laboratory mechanical testing is a potent tool that can investigate the mechanical responses of materials at pressure, temperature, and strain rate conditions. This RDF application seeks funds to enhance deformation capabilities at a broad, and unprecedented range of pressure, temperature, and strain rate conditions. The plan includes (1) acquiring a high-pressure, high-temperature triaxial deformation system (up to 200 MPa and 200°C) with in-situ physical properties measurements, (2) acquiring a medium-pressure, low-temperature triaxial deformation system (up to 70 MPa and -15 to 150 °C), (3) upgrading the low-pressure, low-temperature triaxial deformation and oedometer systems, (4) installing the walk-in temperature-control chamber (–20 to 60°C) that can host a system to deform a larger sample size (i.e., tens of centimeters) than typically used in other deformation testing systems, (5) upgrading the high-temperature three-dimensional polyaxial loading system, (6) acquiring a confined Hopkinson bar (up to 200 MPa), and (7) acquiring an optical fiber Interrogator for in-situ strain measurements. The collaborative efforts on enhancing the testing capabilities existing in four different units can strengthen the overall research enterprises on material deformation in Brazos County and help the university be globally positioned to lead cutting-edge multidisciplinary research. This RDF will also help us prepare for large-scale funding opportunities at NSF, DOE, NASA, and DOD by accelerating collaboration across and outside the campus.