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Title: YEARLY REPORT FOR THE PERIOD Jan. 2018 – Jan. 2019 IC Project: w17_unedetection - "Simulation of underground nuclear explosions using the combined finite discrete element method" and "Fracture Formation and Permeability Evolution at in situ Pressure, Temperature and Stress Conditions"

Author(s): Rougier, Esteban
Knight, Earl E.
Euser, Bryan Jeffry

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IC Project: w17_unedetection - "Simulation of underground nuclear explosions using the combined finite discrete element method" and "Fracture Formation and Permeability Evolution at in situ Pressure, Temperature and Stress Conditions"

LA-UR-XX-XXXX

Principal Investigator: Dr. Esteban Rougier, EES-17, (505) 667-1733, erougier@lanl.gov
Co-Principal Investigator: Earl E. Knight, EES-17, (505) 667-5584, knighte@lanl.gov
Co-Investigator: Bryan Euser, EES-17, (505) 665-9492, beuser@lanl.gov

Scientific and Programmatic Impact:

Underground Nuclear Explosion Signatures Experiment (UNESE). Understanding the underlying physical processes associated with an underground nuclear explosion (UNE) can help with detection and identification of a suspected event. The Underground Nuclear Explosion Signatures Experiment (UNESE) is a collaborative effort between national laboratories aimed towards improving our understanding of physical and radiochemical signatures associated with a UNE. One primary objective of this effort is to perform hydrodynamic modeling of a UNE, with the purpose of estimating the extent of damage caused by such an event. Estimating the damage associated with an event is important for: a) detection of possible physical signatures at the surface of the earth such as fractures, spallation, and cratering and (b) damage to subsurface structures such as tunnels. Additionally, the damage produced by the hydrodynamic models play can be used to inform subsurface flow and transport models. The Combined Finite-Discrete Element Method (FDEM), implemented as an in-house code known as HOSS (Hybrid Optimization Software Suite), is used to model the damage associated with a UNE in various geological settings.

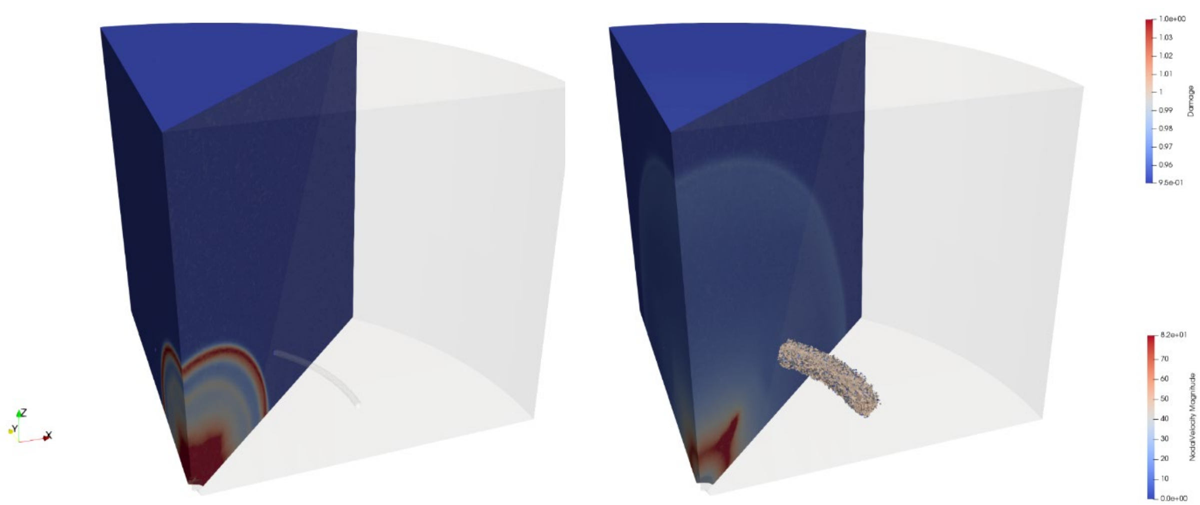

Figure 1: Simulation results illustrating the effect of a UNE on an underground structure.

Basic Energy Science (BES). The IC resources allocated were also used for a Basic Energy Science project. The simulations are conducted in an effort to better characterize many aspects related to hydraulic fracture processes (e.g., fracture permeability). The fundamental physical processes associated with *in situ* fracture formation are explored using the FDEM; simulations of fracture initiation and propagation in shale rock at various confining pressure are used to characterize the relationship between fracture and permeability. The FDEM simulations replicate triaxial direct-shear coreflood experiments, where rock specimens are subject to various confining pressures while simultaneously being loaded in direct shear. The experimental system measures fracture-induced permeability, displacement, and applied axial stress under *in situ* confining stress conditions providing a rich data for comparison to simulation results. Additionally, under the umbrella of BES, fracture coalescence studies have been performed. These studies are promote better understanding how pre-existing fractures affect the formation of new fractures when subject to external loading. Simulated fracture patterns are directly compared to experimentally produced fracture patterns.

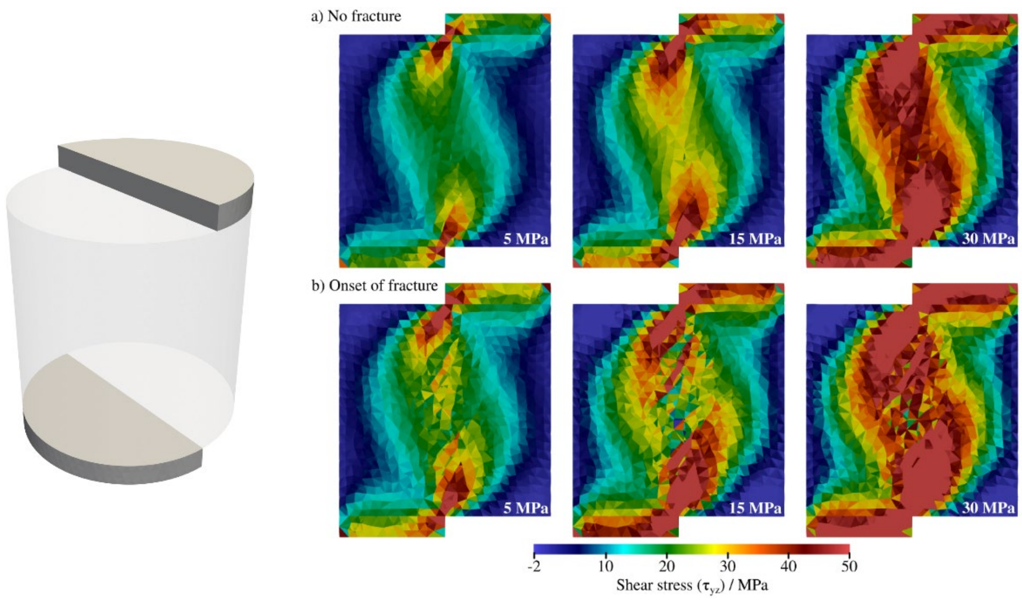

Figure 2: Illustration of the fracture induced during a triaxial direct-shear coreflood experiment, the confining pressure is 5MPa.

<u>Financial Impacts:</u>

Present: UNESE, BES
Future: UNESE spinoff, LDRD, Office of Science

<u>Summary of Computational Effort Accomplished:</u>

The allotted CPU hours have been used to help characterize damage processes in problems concerning underground nuclear explosions and hydraulic fracturing. Furthermore, the HOSS code is being verified and validated in the process of preforming the aforementioned simulations. The HOSS code will continue to improve and evolve with the resources provided by Institutional Computing.

The total number of CPU hours used in this project for the period of time listed above was: 1.4M