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3-D electrical imaging of mesoscale rock damage patterns from underground chemical explosions

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Atmospheric gas detection is a primary means for detecting and verifying underground nuclear explosions. Subsurface gas migration is governed by a complex system of unknown variables, including the interaction between geology, explosion-induced stresses and corresponding rock damage patterns that provide primary gas flow pathways. The U.S. is conducting a series of highly instrumented mesoscale experiments that provide an opportunity to better understand the interaction between source strength and location, natural variations in rock competency, explosion-induced rock damage, and gas migration. Rock damage is imaged in 3-D using a novel combination of water injection, draining, heating and drying combined with time-lapse electrical resistivity tomography. Corresponding measurements of induced gas breakthrough times at discrete points in exterior monitoring wells are being used to understand how rock damage is influenced by local geology, and how it influences gas migration away from the source point. Results show that the influence of geologically weak zones on rock damage and gas flow are comparable to the influence of source strength and location. This result has important implications for larger scale underground explosions, and how those explosions interact with geology and alter gas migration flow paths and travel times to the surface.

Promotional text

This work discusses subsurface properties and how they interact with underground explosions to govern gas-phase breakthrough times and locations at the surface. Results provide insights that should be considered in detecting nuclear explosions through atmospheric gas sensing.

Primary authors: Mr JOHNSON, Tim (Pacific Northwest National Laboratory (PNNL), Richland, WA, USA); Mr KNOX, Hunter (Pacific Northwest National Laboratory (PNNL), Richland, WA, USA); Mr STRICKLAND, Chris (Pacific Northwest National Laboratory (PNNL), Richland, WA, USA); Mr LOWREY, Justin (Pacific Northwest National Laboratory (PNNL), Richland, WA, USA); Ms JOHNSON, Christine (Pacific Northwest National Laboratory (PNNL), Richland, WA, USA); Mr ROBEY, Eric (Sandia National Laboratories (SNL), Albuquerque, NM, USA); Mr INGRAHAM, Mathew (Sandia National Laboratories (SNL), Albuquerque, NM, USA); Ms CHOJNICKI, Kirsten (Pacific Northwest National Laboratory (PNNL), Richland, WA, USA)

Presenter: Mr JOHNSON, Tim (Pacific Northwest National Laboratory (PNNL), Richland, WA, USA)

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