P2.3-232

Series of Chemical Explosive Experiments with Subsurface Noble Gas Transport and Atmospheric Releases

Michael Foxe[1], Joe Morris[2], and the PE1 Experiment Team[3]

1. Pacific Northwest National Laboratory
2. Lawrence Livermore National Laboratory
3. https://doi.org/10.2172/2345984

Pacific Northwest NATIONAL LABORATORY

INTRODUCTION AND MAIN RESULTS

On October 18th, 2023, we executed an experiment with the detonation of 13.58 metric tons of Composition B along with gaseous and particulate tracers to understand pressure-driven transport through the subsurface.

This experiment was followed by venting tunnel gases into the atmosphere for local transport and detection.

A borehole drilled back into the cavity produced by the explosion is planned. Additionally, we have also implemented other stand-alone atmospheric release experiments

Acknowledgements:
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PNNL-SA-215702

SnT 2025
8 SEPTEMBER ONLINE DAY
9 TO 12 SEPTEMBER AT HOFBURG PALACE, VIENNA & ONLINE
CTBT: SCIENCE AND TECHNOLOGY CONFERENCE

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P2.3-232

Pre-Experiment | Seconds | Minutes | Days | Years

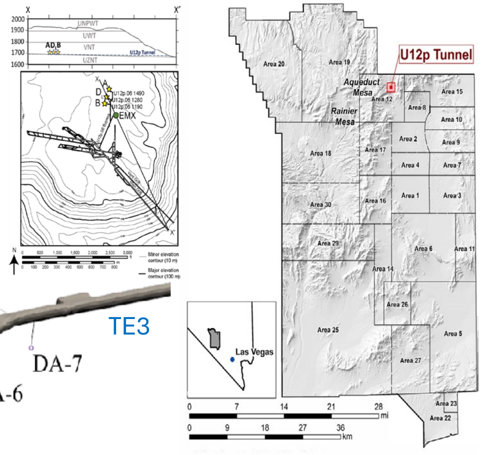
Experiment Plan and Motivation

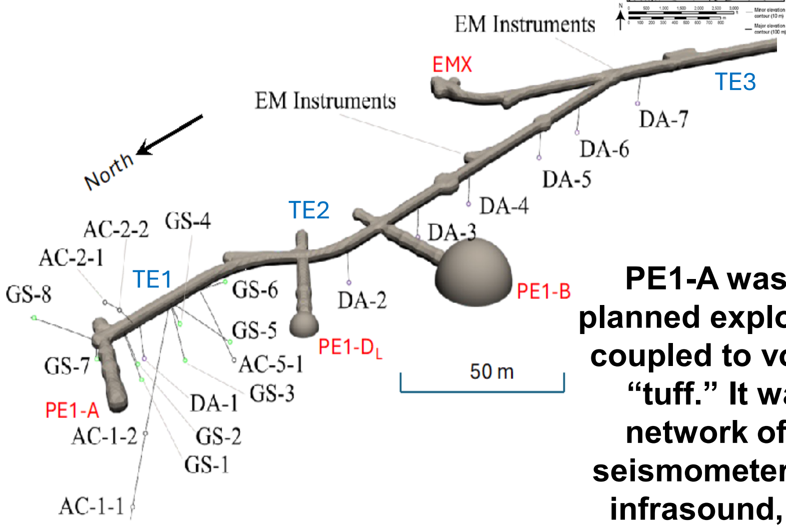
- **Field Scale Experiments (FSE) using chemical explosives can provide insights into signals from a nuclear explosion and improving monitoring capabilities.**
- **The Physics Experiment 1 (PE1) combines atmospheric releases, high explosive experiments, and electromagnetic source experiments.**

Experiment	Source	Key Diagnostics	Measurement Locations
METEX: METeorological EXperiment	Smoke	Met Video	Out to 5 km
REACT: RElease ACTivity **METREX**: MEt and TRacer EXperiment	Xe-127 & Xe-133 Smoke Balloon tracer	Radionuclide Met Video	Out to 5 km Out to 5-10 km
A, B, D_L: Subsurface high-explosive experiments	13,580 kg Comp B High Explosives + • Xe-127 or Xe-133 • D_2O • Tritium Gas (HT) • Stable tracers DU, I • HE byproducts • Geogenic gases	Seismic Acoustic Radionuclide Electromagnetic Met Video	Cavity Borehole Tunnel Apron Mesa NNSS site Beyond
EMX	Electromagnetic Source	Electromagnetic	Tunnel Mesa

Testbed Location and Layout

The PE1 testbed is located in Aqueduct Mesa P-Tunnel (U12p) of the Nevada National Security Site (NNSS).





PE1-A was the first of three planned explosions and was fully coupled to volcanic rock, called "tuff." It was recorded on a network of accelerometers, seismometers, magnetometers, infrasound, and gas sensors.

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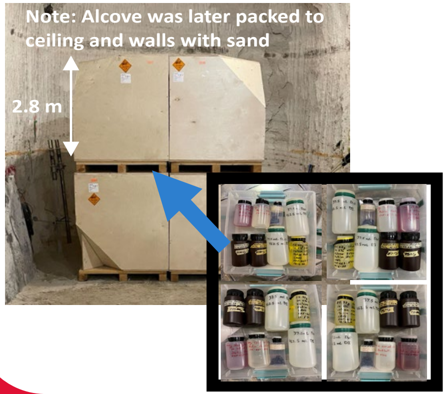
High-Explosive Source + Tracers

PE1-A used 13,580 kg of Composition B chemical explosives, detonated with tracer gases placed at the center on October 18th, 2023.
Diagnostics indicated symmetrical, complete detonation.

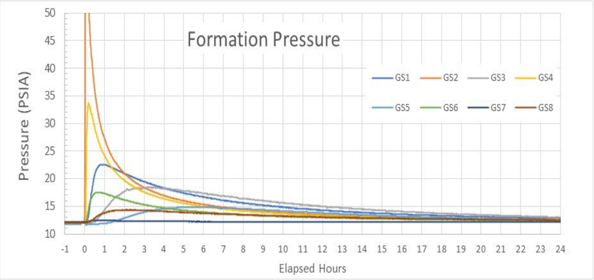


Tracer	Form
Xe 127	^{127}Xe gas
Tritium	HT/T_2 gas
Iodine	I_2 metal
Cesium	CsCl
Neodymium	$Nd(NO_3)_3$
Tellurium	$Te(OH)_6$ powder
Uranium	$UO_2(NO_3)_2$
Deuterium	D_2O

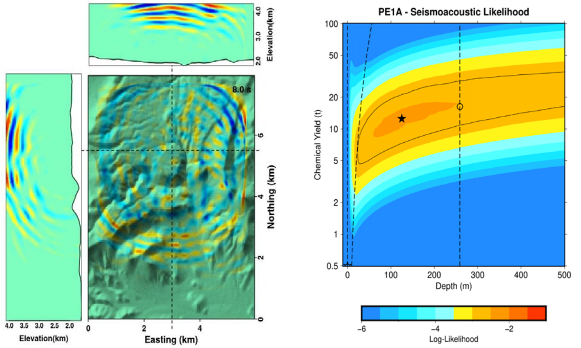
High Explosive Driven Shock Wave and Pressure Pulse

The shockwave impacted the confinement plug, shifting the end of the plug over 2”, but no prompt venting of gases or particulates.

Pressure from the HE was observed via pore space and micro fractures at boreholes shortly after the detonation.



Seismoacoustic waves were observed for 100s of kilometers and provided an accurate identification of the event.



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The views expressed here do not necessarily reflect the opinion of the United States Government, the United States Department of Energy, or the Pacific Northwest National Laboratory

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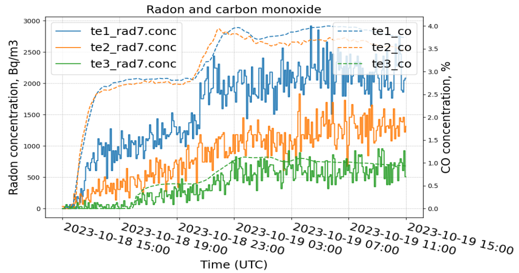
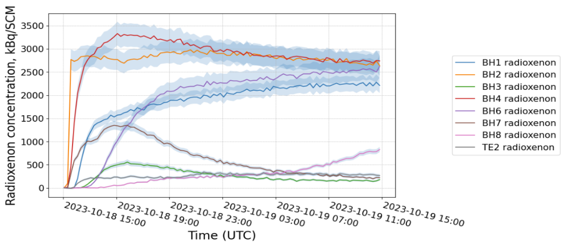
Formation and Tunnel Gas Transport

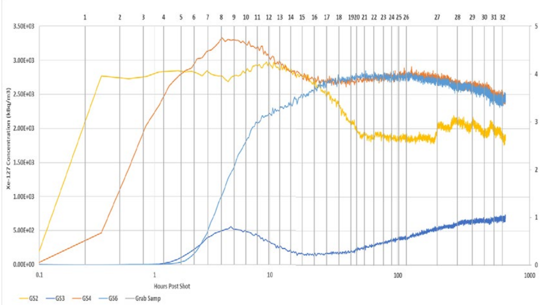




Gases flowed quickly through the volcanic tuff, into the tunnel, and then down the length of the tunnel to be observed at tunnel environment stations TE-1, TE-2, and TE-3 (see testbed layout).

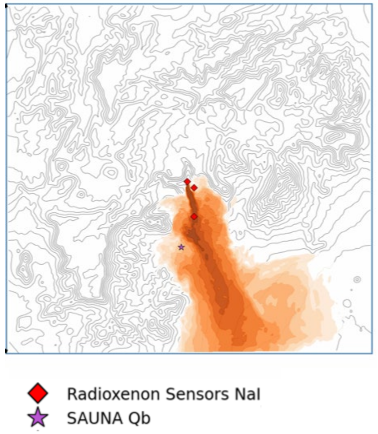
Gas, water, and particulate grab samples were collected following the gas phase experiment:

- **192 gas grab samples from 6 locations.**
- **Integrated water samples from each gas line.**
- **Air filter collections from within the tunnel.**

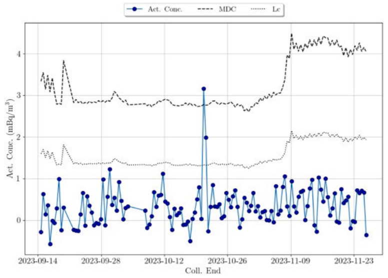


Atmospheric Transport

Venting of the tunnel released gases into the atmosphere that traveled over complex terrain.

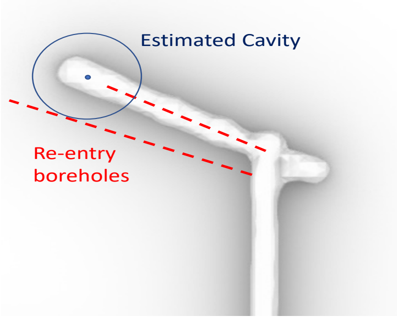


Radioxenon was detected on sensors 3.5 km away.



Drill Back Sampling

In a few years, drill backs through the confinement plug and the damage zone will characterize the distribution of gases and rock damage.



Drill back samples are expected for each high explosive experiment.

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