T2.2-P5

Geophysical Imaging of an Uncollapsed Nuclear Explosive Test, Yucca Flat, Nevada

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Abstract

We present data and analysis of a seismic data collect at the HADDOCK underground nuclear explosive test in Yucca Flat, a sedimentary basin on the Nevada National Security Site, USA. HADDOCK was conducted in 1964 with an announced yield of less than 20 kt and depth-of-burial of 364 meters. The test is unusual in that the collapse of the test cavity did not reach the ground surface. As such, HADDOCK represents an opportunity to test advanced geophysical methods for detection and characterization of nuclear explosions that result in little-to-no surface expression. As part of the experiment (called Frey-Chimney), new high-resolution seismic and gravity data were acquired. The seismic experiment consisted of a hybrid 2D/3D array of approximately 1,000 2-Hz, 3-component geophones recording over 250 source points with two different seismic sources. The two seismic sources were the Seismic Hammer™ (SH, a prototype 13,000 kg weight-drop) and a much smaller accelerated weight-drop (AWD) used to supplement the SH-derived data with higher frequencies. In addition to the active-source data collection, pre-experiment ambient noise was collected on the array. Planned data analyses include processing for seismic reflections, body-wave and surface-wave velocity tomography, body-wave attenuation tomography, ambient noise tomography, and seismic cavity resonance detection.

Study Area

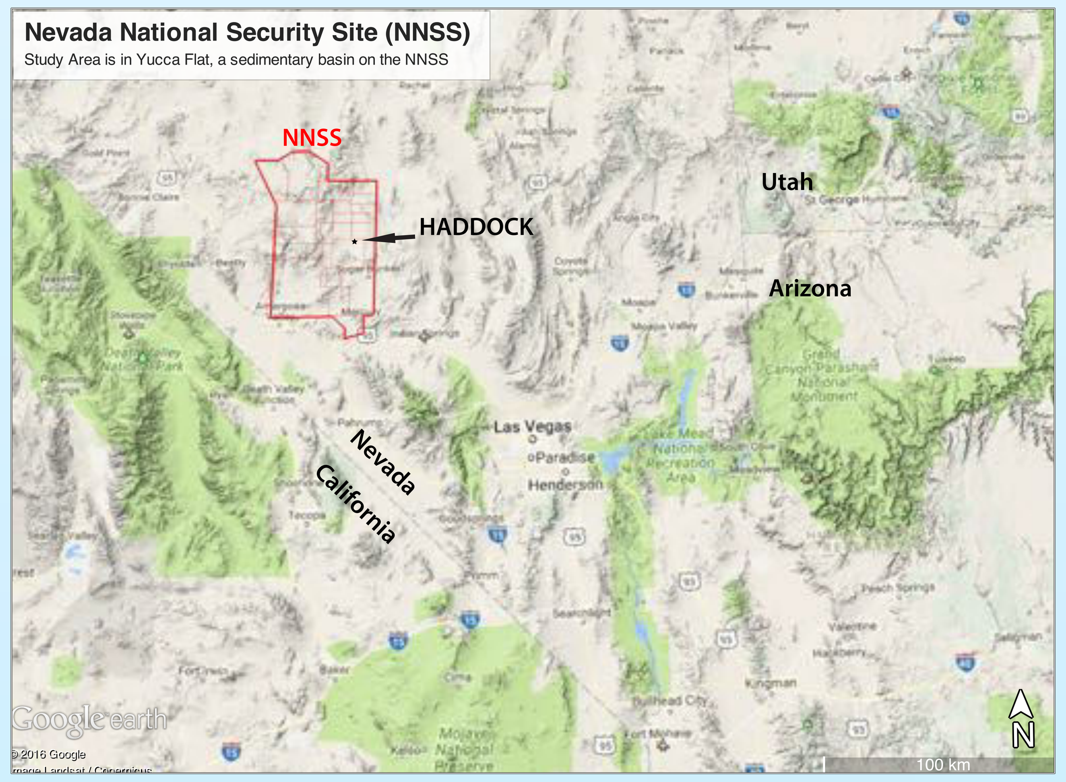


Figure 1. Nevada National Security Site and surroundings.

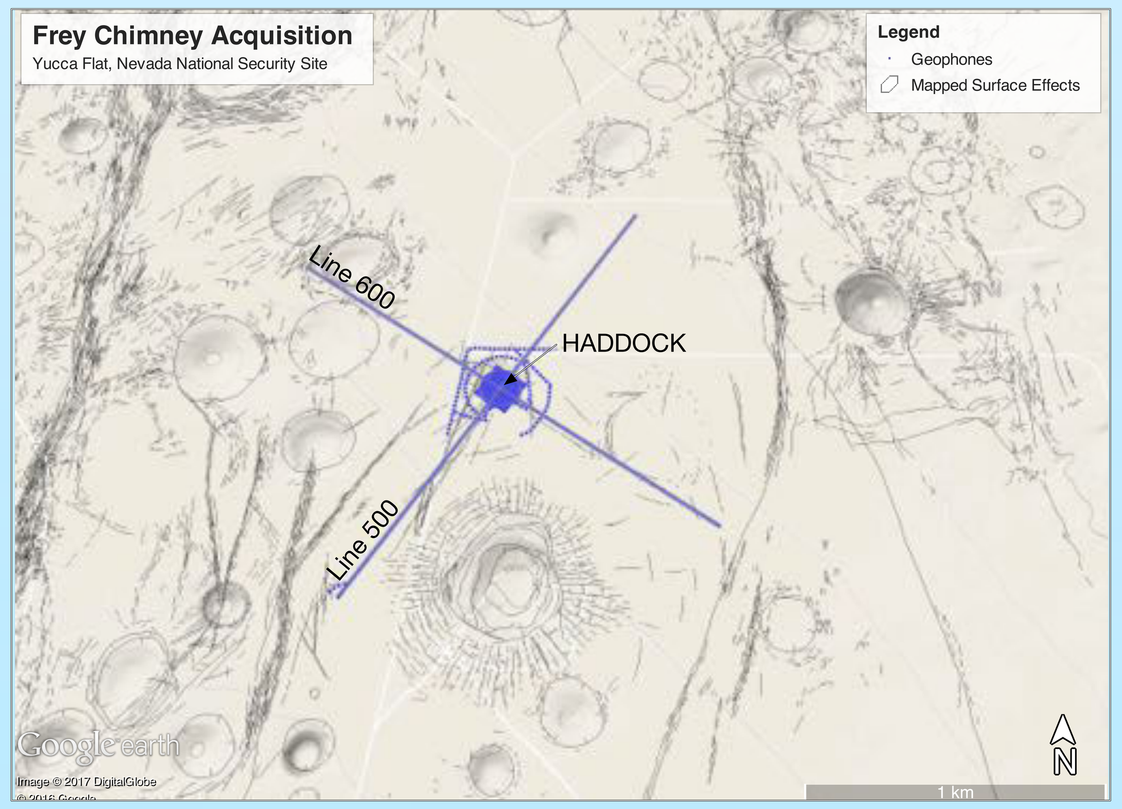


Figure 2. The Frey Chimney arrays. Blue dots are geophones spaced at 5- and 10-m intervals and seismic source points spaced at 15-m intervals

Field Data Acquisition

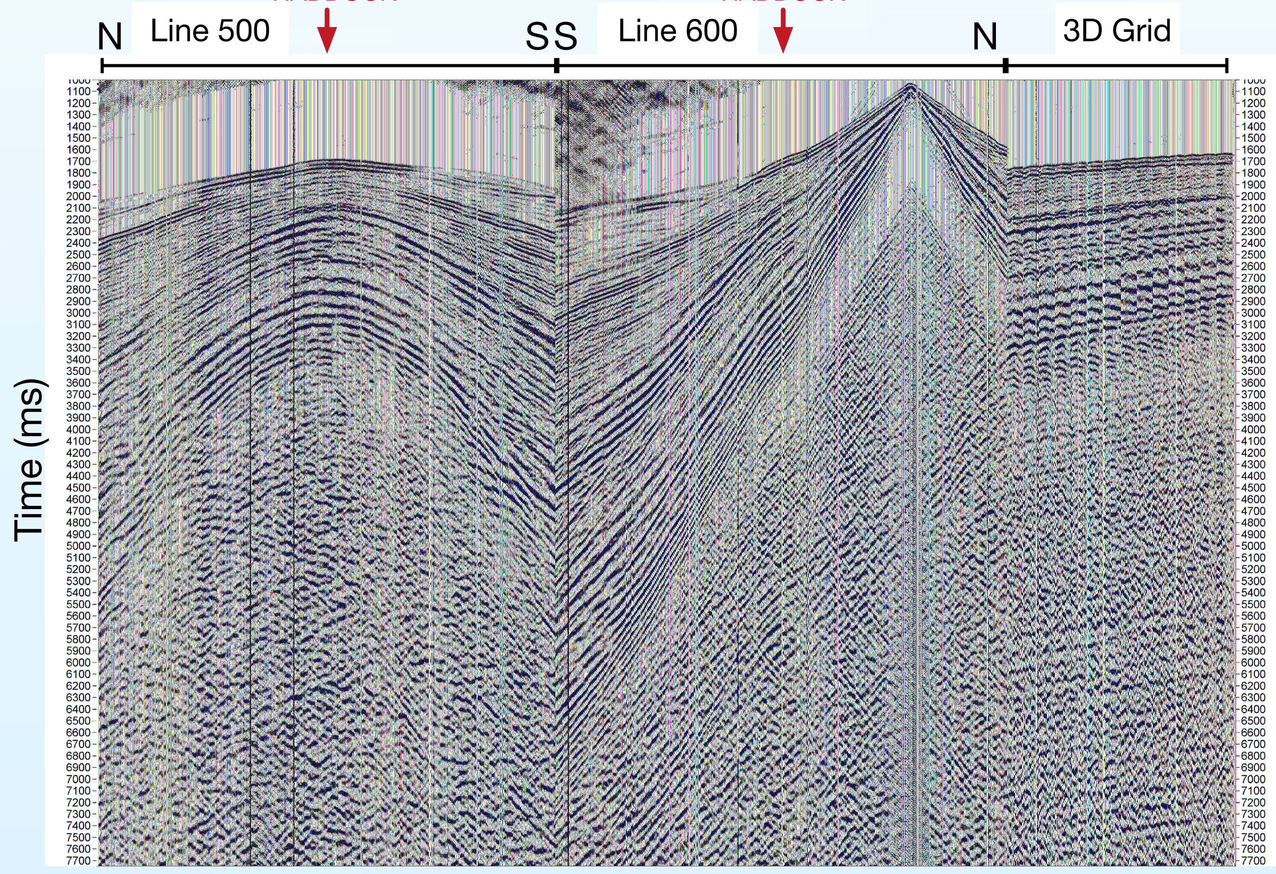


Figure 3. Raw shot gather from a single Seismic Hammer™ hit on vertical geophones. AGC applied.

Recording Parameters

Recording Mode	Continuous
Shot Record Length	1 s pre-event, 8 s p
Sampling Rate	2000 Hz
Stacks per AWD point	5 vertical, 10 polarized shear
Stacks per Hammer point	8 minimum
Continuous Data Volume	> 50 Tb

Acquisition Geometry

Linear Array Spacing	5 meters
Grid Array Spacing	10 meters
Source Spacing	15 meters
AWD Source Points	139
Hammer Source Points	286

Equipment

Source 1	US Alliance P/S100 AWD
Source 2	HH Seismic Seismic Hammer™
Receivers	1,000 Sunfull 2-Hz Triaxial geophones
Recorders	1,000 iSeis Sigma

Figure 4.
(Above) Seismic Hammer™
(Bottom Left) AWD
(Bottom Right) Recorder and geophone

Hypothesis

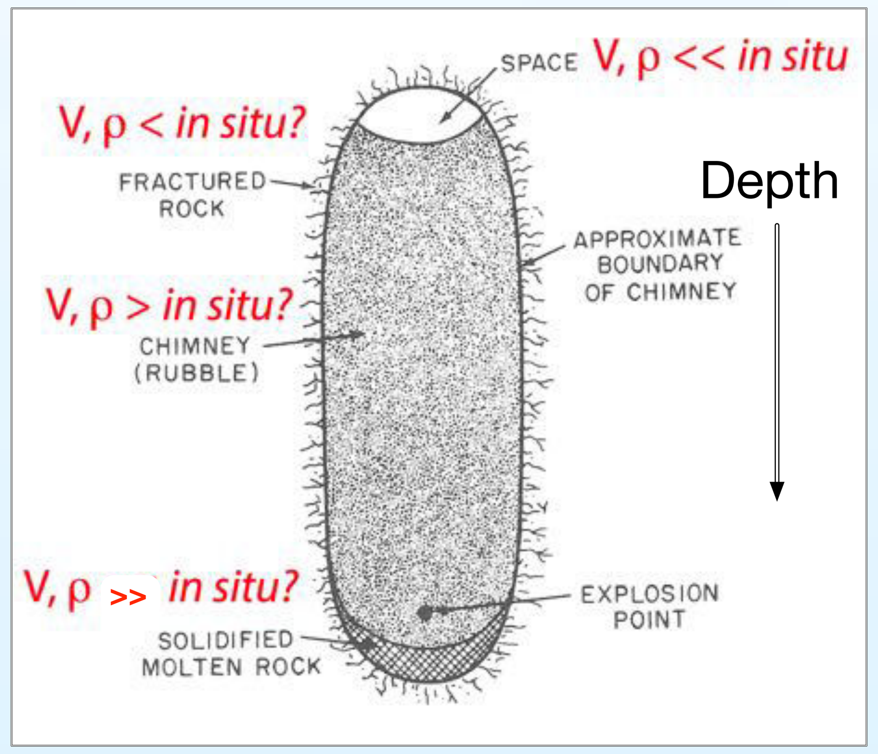


Figure modified from *"The Effects of Nuclear Weapons, Third Edition"*, Glasstone and Dolan (eds.), Figure 2-103

Figure 5. Proposed geophysical anomaly of partially collapsed test

Since this is the first large-scale seismic investigation of a partially collapsed nuclear cavity in a basin environment, the observed geophysical effects on the surrounding geology are somewhat uncertain. Following Figure 5., we propose that the detonation point will be surrounded to some unknown radius by a **damaged zone** with **reduced seismic velocity,** a **chimney** with **increased seismic velocity**, and a **possible super-adjacent void**, with **reduced seismic velocity**. The nature of the chimney is especially uncertain and the geophysical behavior likely changes with depth and constituent material (volcanic tuff or alluvium).

Preliminary Results

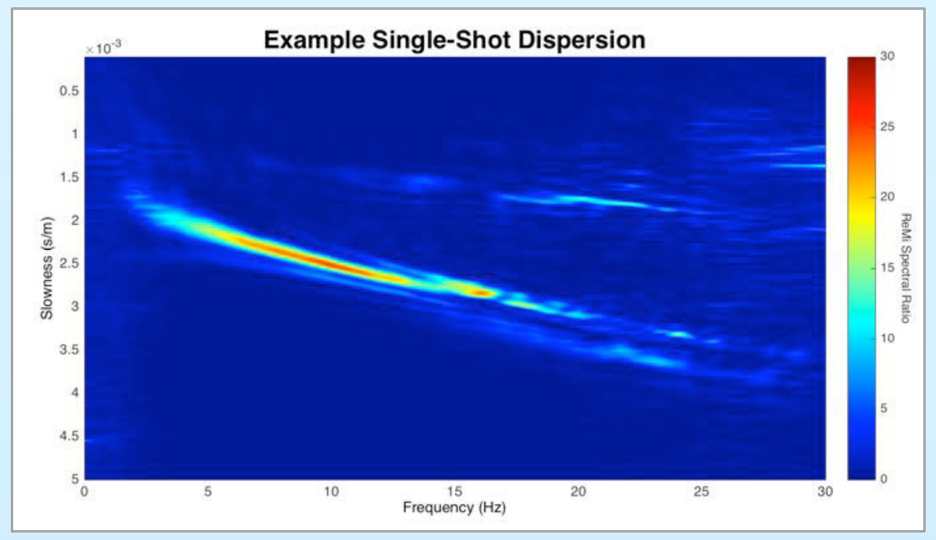
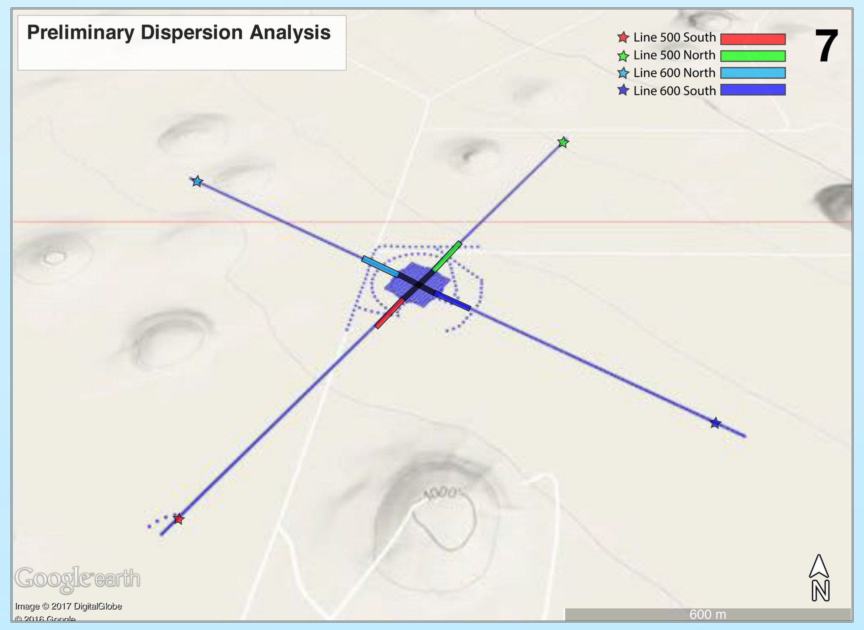
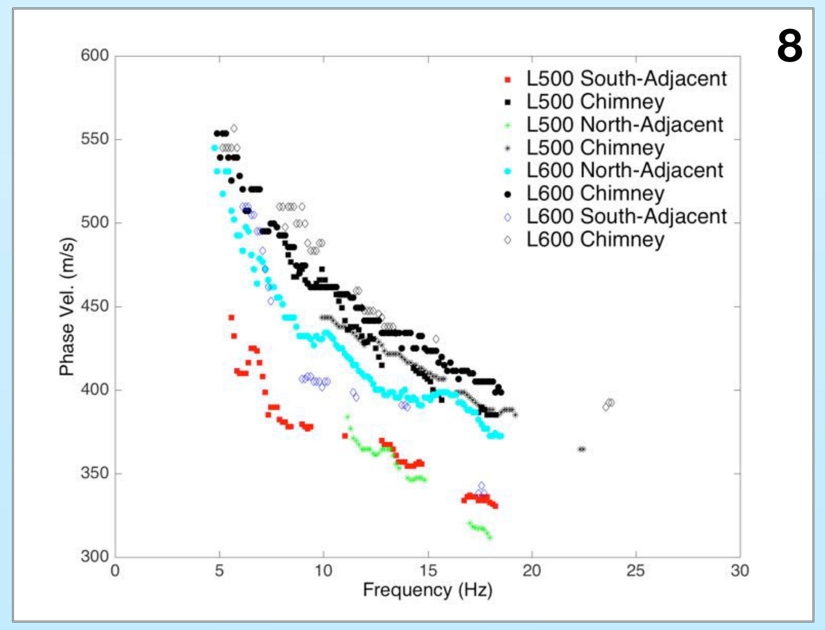


Figure 6. Surface-wave dispersion on undisturbed Yucca Flat

The Seismic Hammer™ creates prodigious surface waves, as can be seen in Figures 4 and 6. One of our first tasks is to invert surface wave dispersion for regions inside and outside the chimney region (see below).





Figures 7 and 8. First dispersion analysis results

Four shot records (out of over 2,200) were analyzed for the regions of Lines 500 and 600 both adjacent to and above the chimney region. We observe that all the chimney-adjacent profiles (Figure 7) show lower surface-wave phase velocity than those over the chimney region (Figure 8). This is a preliminary result using a tiny fraction of the data, but it is encouraging for when we analyze the entire data set (including body-wave tomography, seismic reflection, gravity, etc.)

Acknowledgements

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