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The acoustic signature of underground chemical explosions during the Source Physics Experiment

Leiph Preston* Daniel C. Bowman* Roger Waxler† Rod Whitaker‡ Kyle R. Jones* Sarah Albert* Katherine Aur*

*Sandia National Laboratories †National Center for Physical Acoustics ‡Los Alamos National Laboratory

Introduction

Phase I of the Source Physics Experiment (SPE) consisted of **six non-nuclear chemical explosions in granite.** The experiment was designed to produce **a high quality, multiparameter geophysical data set** to facilitate the development of **physics-based models** of signals from buried explosions. Infrasound characterization emerged as one of the primary goals of the experiment, and an eight element acoustic network was deployed for that purpose.

Network

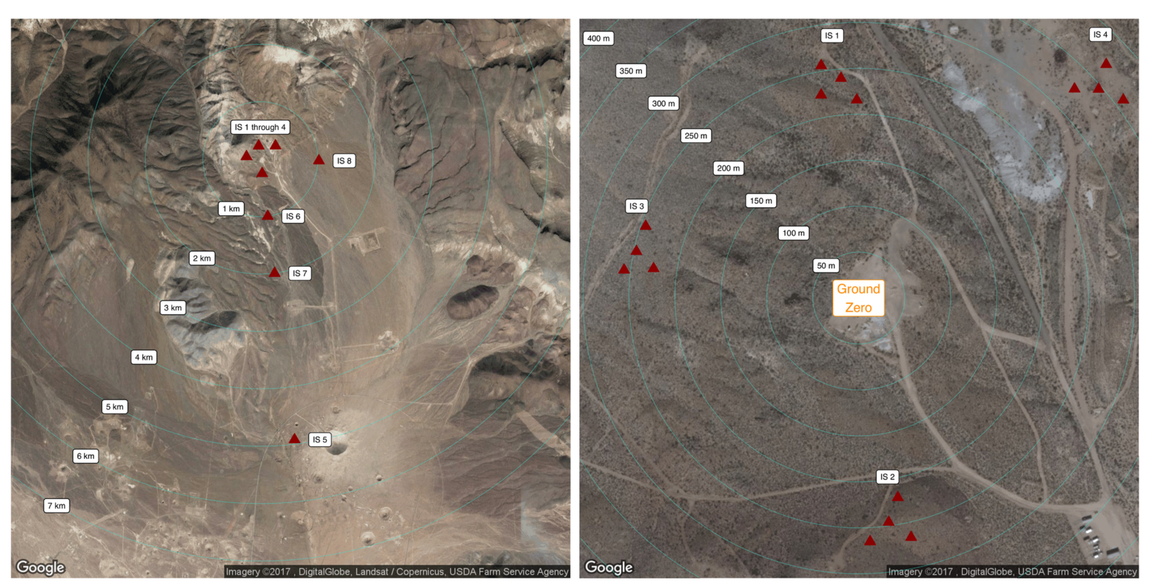

Figure 1: Far view of the eight infrasound stations deployed during the SPE (left) and close up view showing individual array elements (right).

Infrasound sensors were placed 200 m to 5 km from the explosion epicenter. Each station consisted of four sensors approximately 30 m apart. Sensors consisted of Inter-mountain Labs microphones (SPE-1 and SPE-2) replaced with Hyperion microphones (SPE-3 through 6). Wind mitigation consisted of porous hoses and high frequency shrouds. Most microphones at stations IS-1 through IS-4 were replaced with seismically decoupled versions for SPE-5 and SPE-6.

Acknowledgments

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Wave Forms

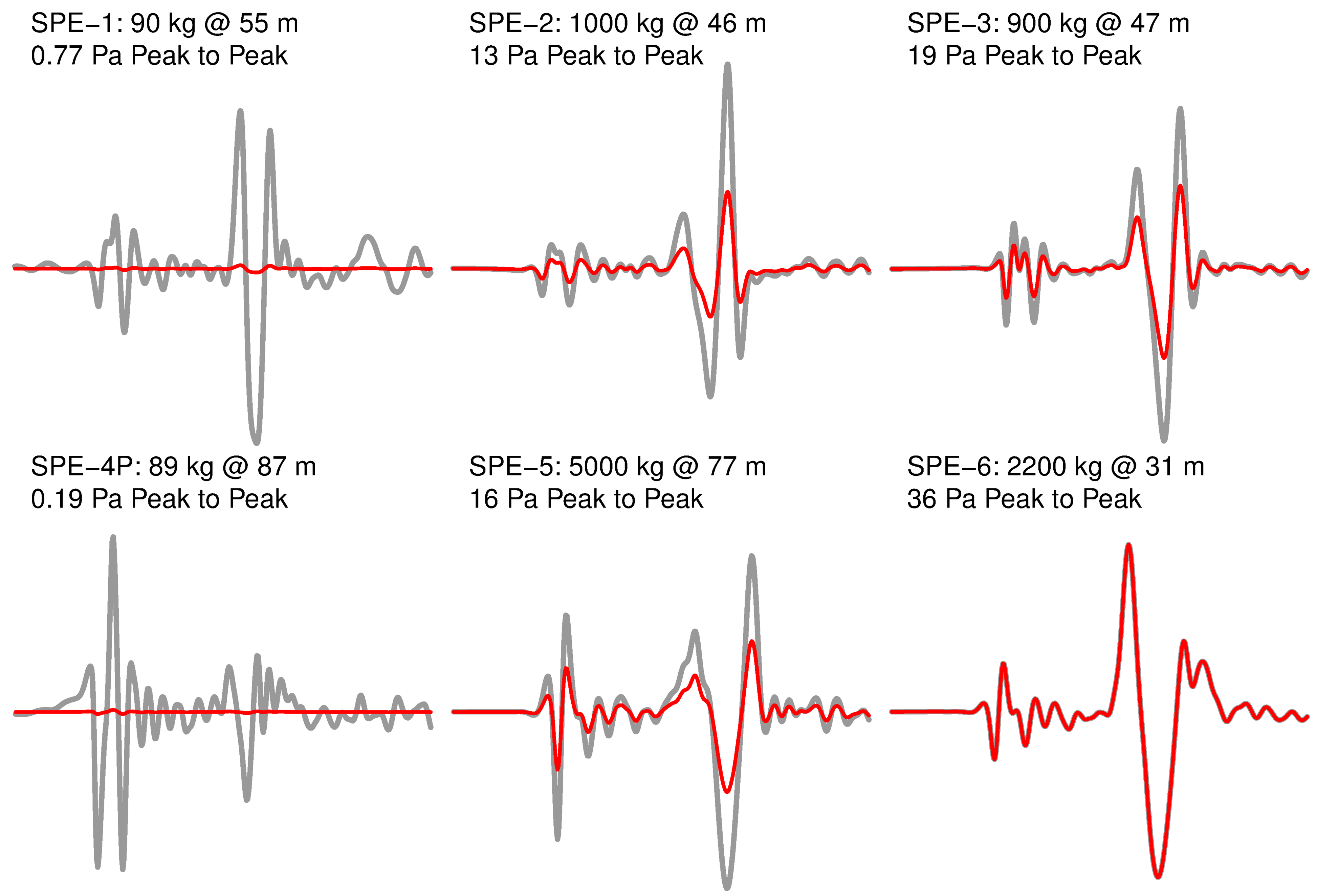

Figure 2: Infrasound recorded at station IS-3, approximately 250 m from the epicenter. The red line is scaled to the maximum amplitude recorded during the series. Shot weights are in TNT equivalent.

Signal Characteristics

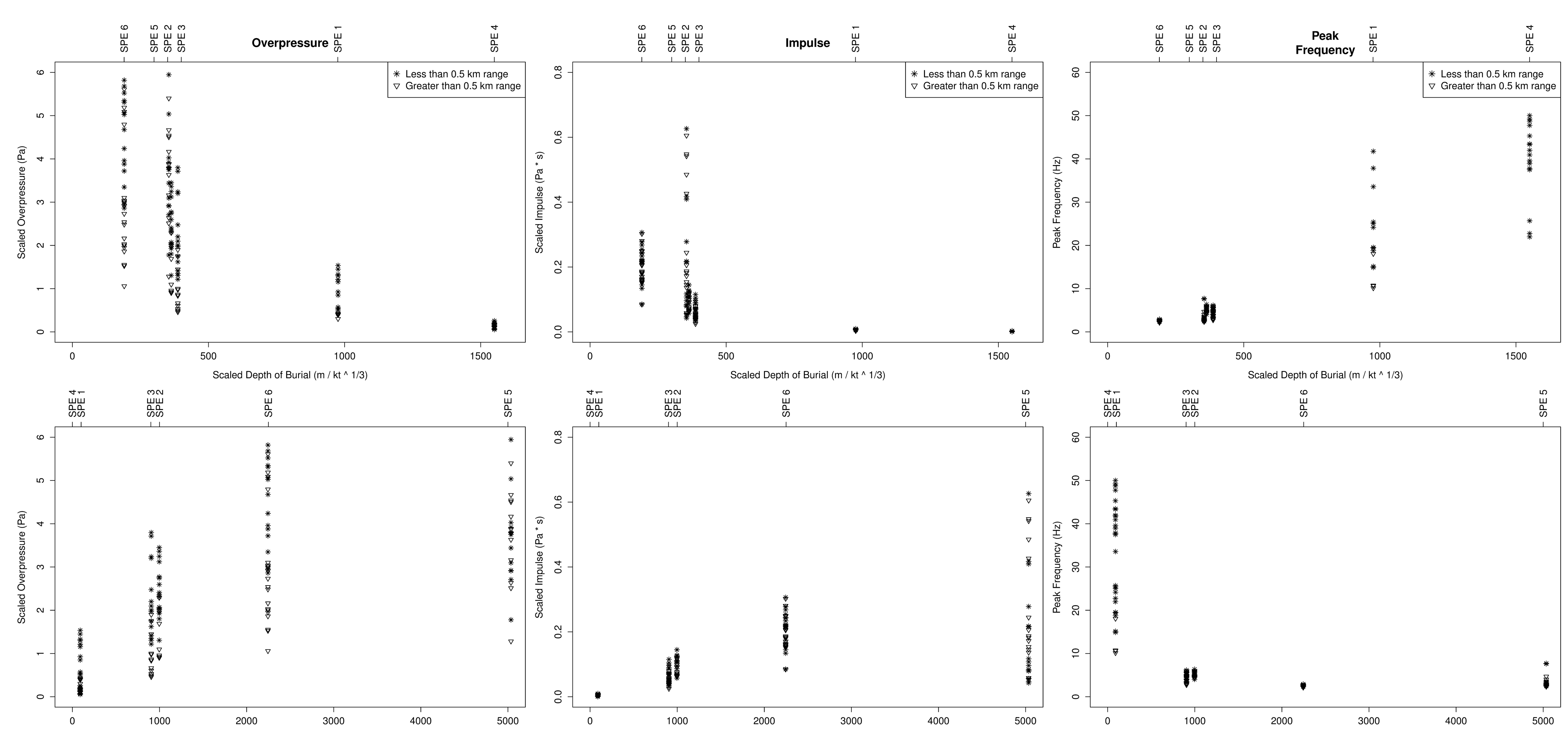

Figure 3: Overpressure, impulse, and peak frequency for each sensor that had an identifiable signal. Overpressure and impulse were scaled to 1 km from the epicenter assuming a geometrical attenuation of $1/r$, where r is distance from source.

Source Inversion

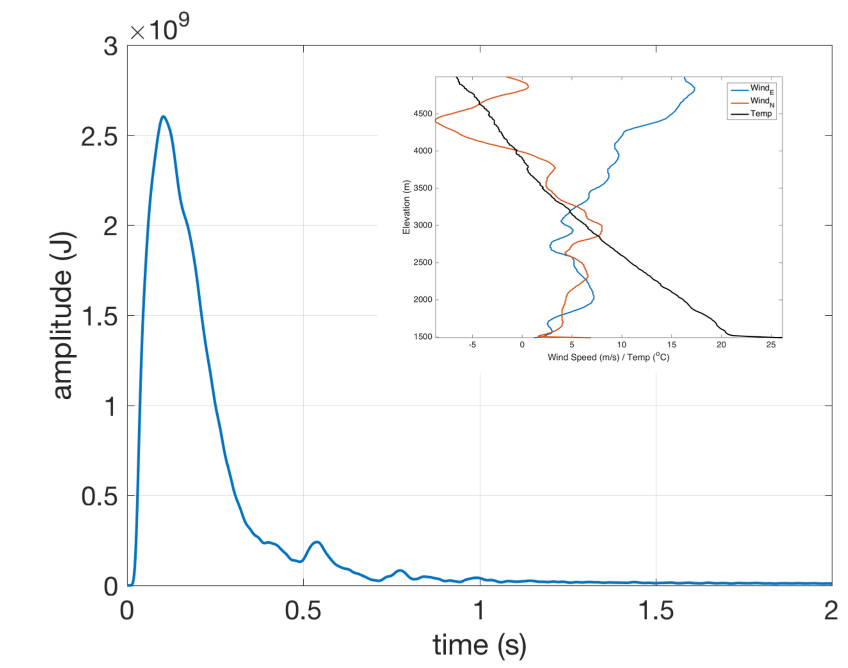

Figure 4: Acoustic source-time function for SPE-1 calculated using frequency-domain inversion of pressure signals and a 3-D synthetic Green's function.

Rayleigh Integral

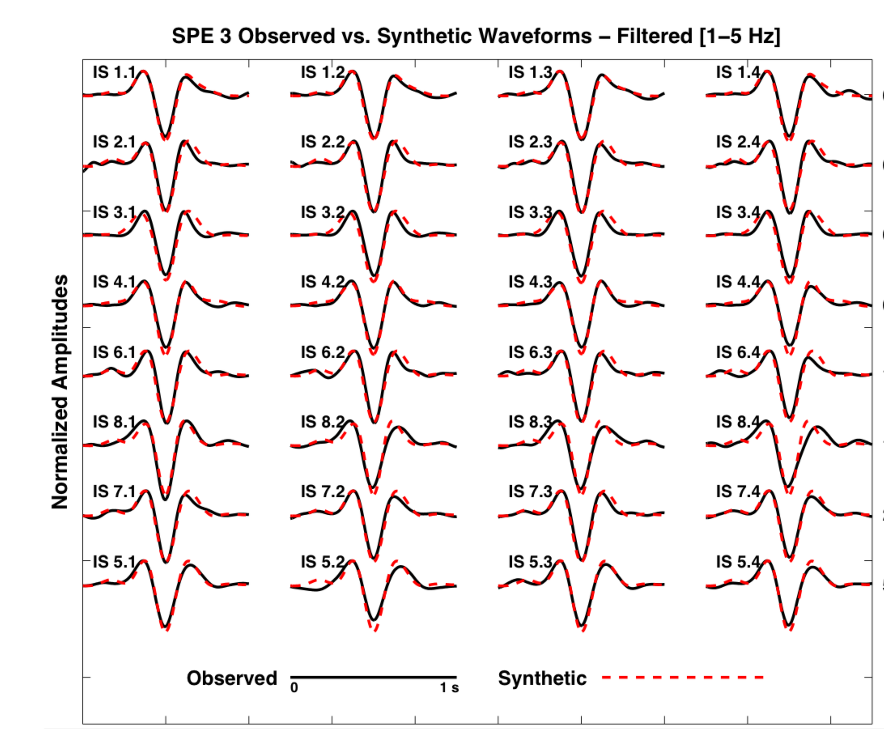

Figure 5: Forward modeling of SPE-3 signals using near-source surface accelerometers and the Rayleigh integral method.

Boundary Element Model

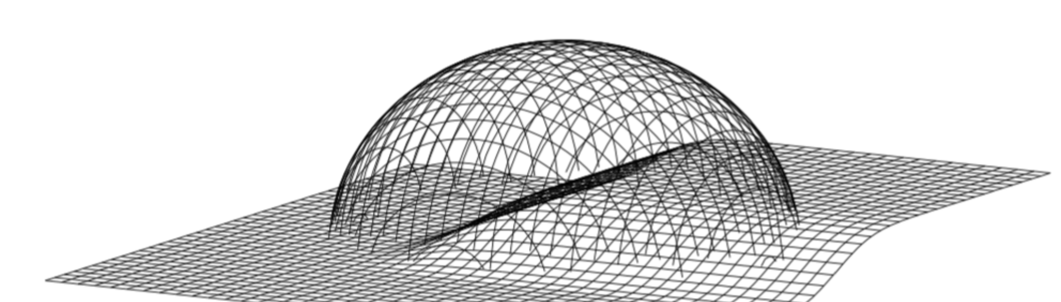

Figure 6: Schematic of the boundary element model for calculating an infrasound source function from a buried explosion.

Summary

The purpose of this project is to investigate explosive depth, yield, and rock damage effects on acoustic signals. Figures 2 and 3 illustrate the relationship between explosion parameters and infrasound signals. Source inversion (Figure 4) and modeling using near-epicenter ground motions (Figures 5 and 6) elucidate the physical mechanisms behind this relationship.