T2.3 - P1

A New Experimental Field Study of the Effects of Explosive Detonation Products on Seismic Radiation

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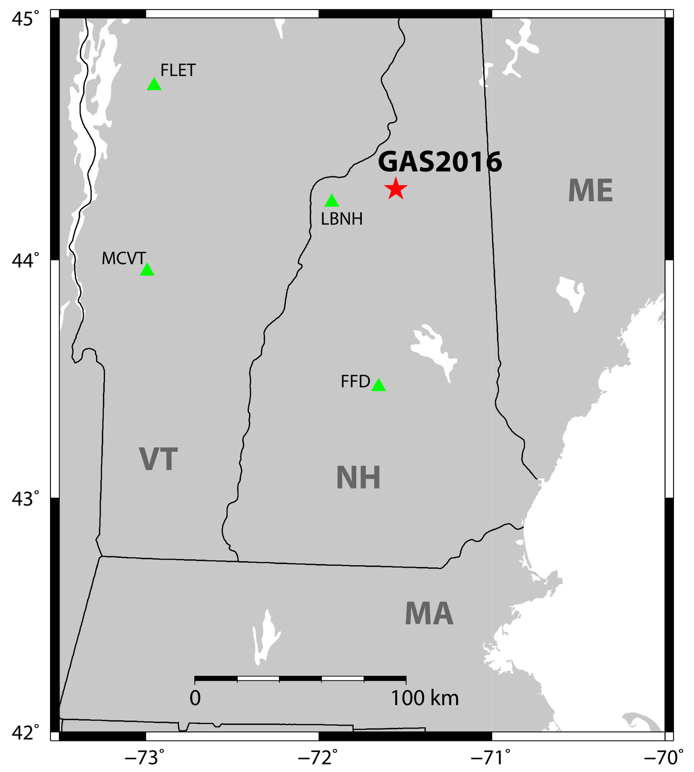
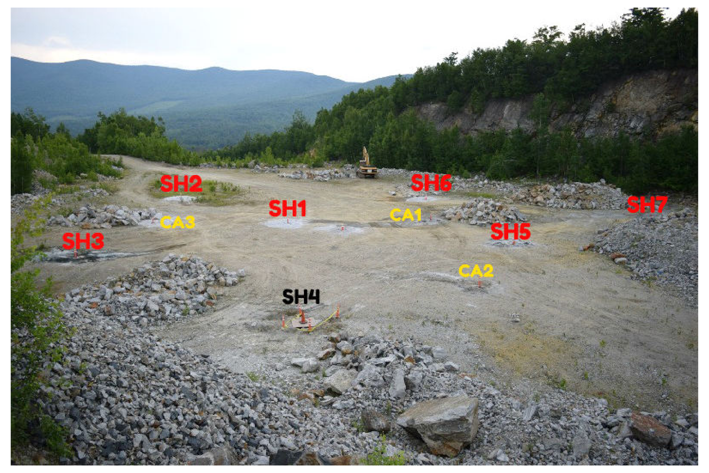
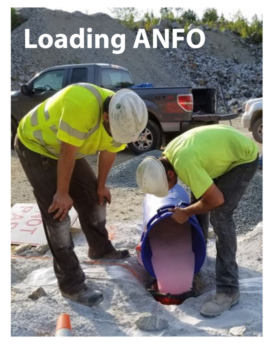
Abstract

Understanding explosion source processes is of great importance for seismic event characterization and explosive yield estimate. Weston Geophysical conducted a series of chemical explosions using various explosives with different properties in order to investigate their effect on seismic signatures. Previous experimental data (NEDE, e.g. Martin et al, 2012) suggest that low-frequency P-wave amplitudes are affected by the explosive velocity of detonation (VOD) and by the thermodynamic characteristics of gaseous explosive products (Stroujkova, 2015). The new experiment (GAS2016) conducted in New Hampshire in 2016 was designed to isolate the effects of the amount of the explosive gases by using aluminized and non-aluminized explosive pairs. Our new results confirm NEDE findings and indicate that seismic amplitudes and source signatures are affected not only by the explosive yield and VOD, but also by the volume of gaseous products and by the presence of fluids in the emplacement medium.

1. The Experiment Overview







GAS2016 experiment was conducted in a granite quarry in NH in August, 2016. Six single-shot explosions and three calibration shots were conducted during the experiment. The following explosives were used to conduct the shots:

1. TNT
2. Tritonal (TNT/Al 80/20)
3. ANFO
4. Aluminized ANFO (ANFO/Al 80/20).
5. COMP B boosters (to initiate the charges and for the calibration shots).

All blastholes were stemmed with crushed stone after the charges were loaded. Two of the shots (SH3 and SH7) were loaded into water-filled boreholes. before stemming

Why do we use aluminized explosives?

Adding aluminum to conventional explosives results in exothermic reactions producing additional heat due to aluminum oxidation:

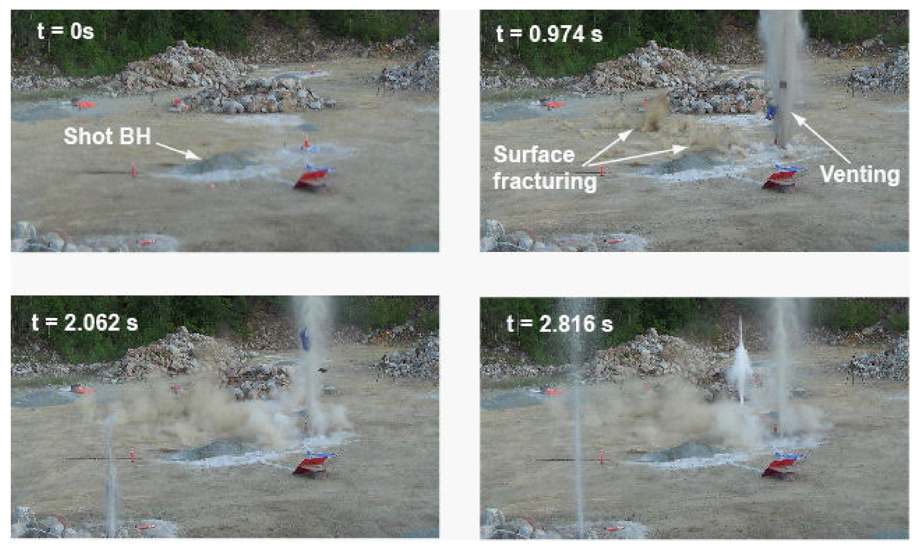
$2Al + 1.5O_2 = Al_2O_3$ $\Delta H = -1590$ kJ/mol
$2Al + 3CO = 3C + Al_2O_3$ $\Delta H = -1251$ kJ/mol
$2Al + 3H_2O = 3H_2 + Al_2O_3$ $\Delta H = -866$ kJ/mol

Thus, adding aluminum powder to the explosive mixture increases the amount of heat (energy) released during the detonation, accompanied by the reduction in the amount of the detonation products.
In addition, the temperature of detonation is significantly higher for the aluminized explosives (~5000 °C)

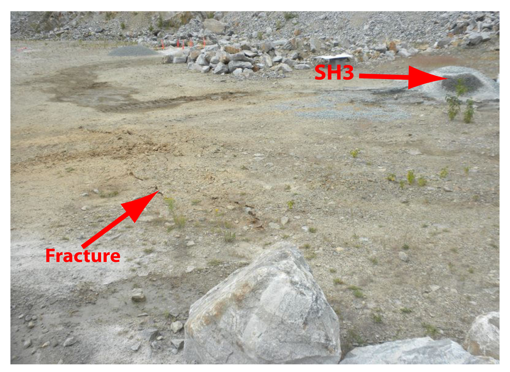
Explosions

Shot	Centroid depth, m	Charge length, m	TNTe yield, kg	Explosive type	Shot hole
SH1	12.3	1.26	63.2	TNT	Drained
SH2	12.4	1.18	96.2	Tritonal	Drained
SH3	12.0	1.26	63.2	TNT	Water-filled
SH5	11.6	2.10	63.1	ANFO	Drained
SH6	11.6	2.10	94.1	ANFO/Al 80/20	Drained
SH7	10.4	4.27	60.9	ANFO	Water-filled, fracture zone

SH1: venting and the development of the surface fractures



SH5: surface fracturing

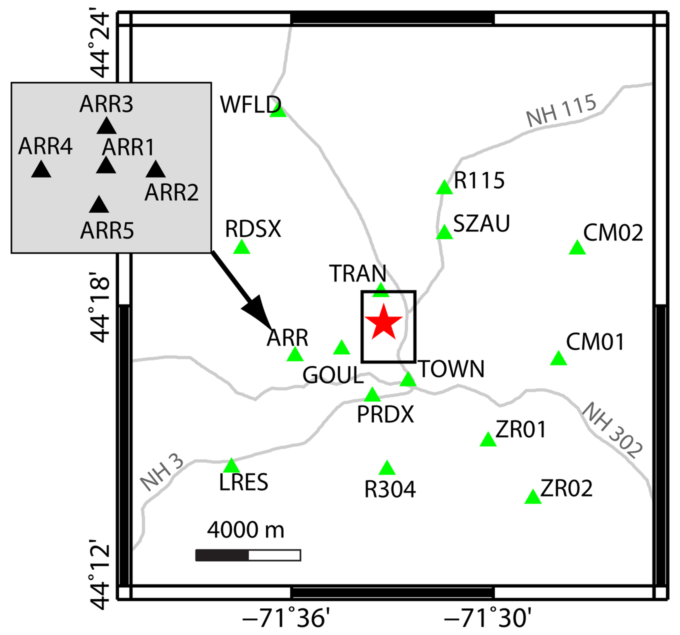


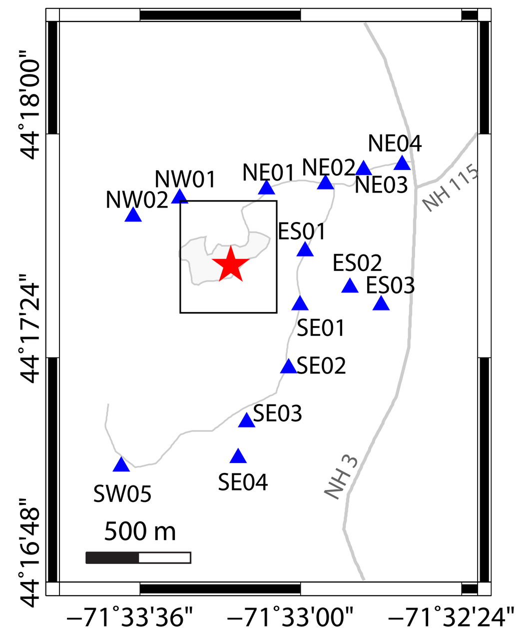
Drilling back into the shot boreholes

Five out of six shot boreholes were cleaned after the explosions. Evidence of melt was found in the rock fragments. The largest amount of solidified melt was found for the Tritonal shot (SH2).

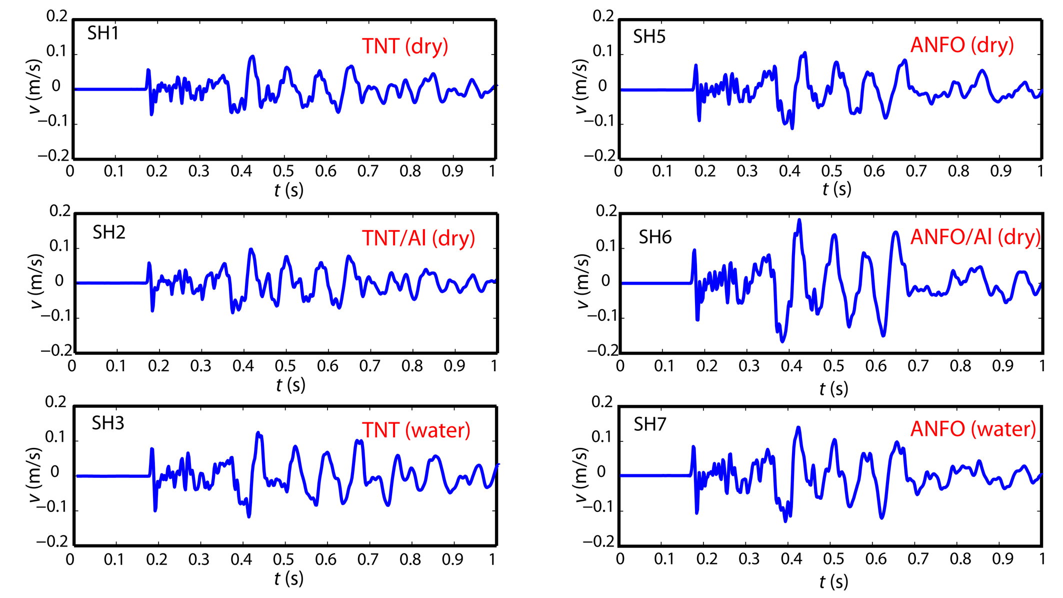
2. Seismic Data

To monitor the explosions WGC deployed 45 seismic instruments from near field to local distances (1.5 m to 9.4 km). Five Endevco and five TerraTech accelerometers were installed in close proximity to the explosions. All of the near-source accelerometers located within 200 m from the explosion were grouted. 35 short-period seismometers were fielded beyond 300 m.
All of these instruments recorded 3C of motion using Reftek 130 (RT130) data loggers.

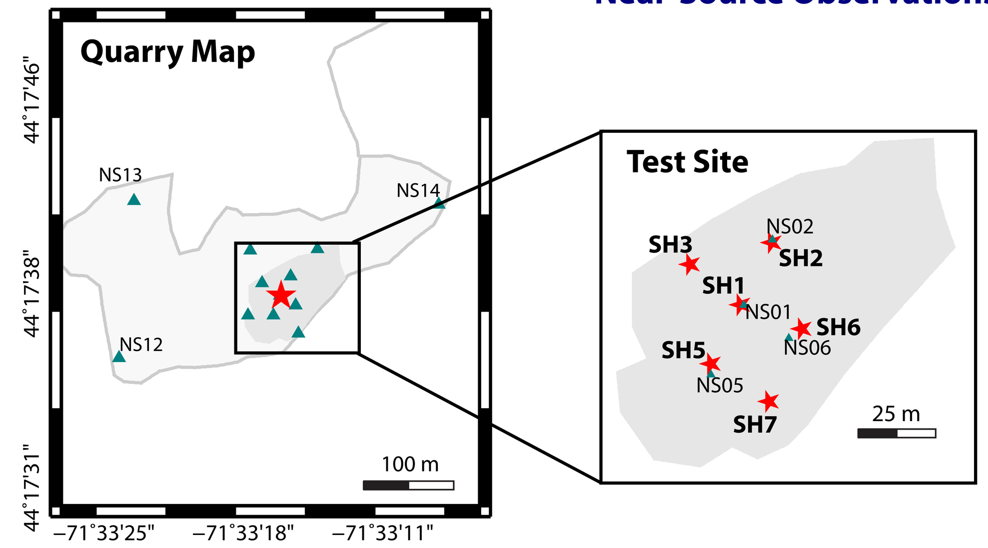


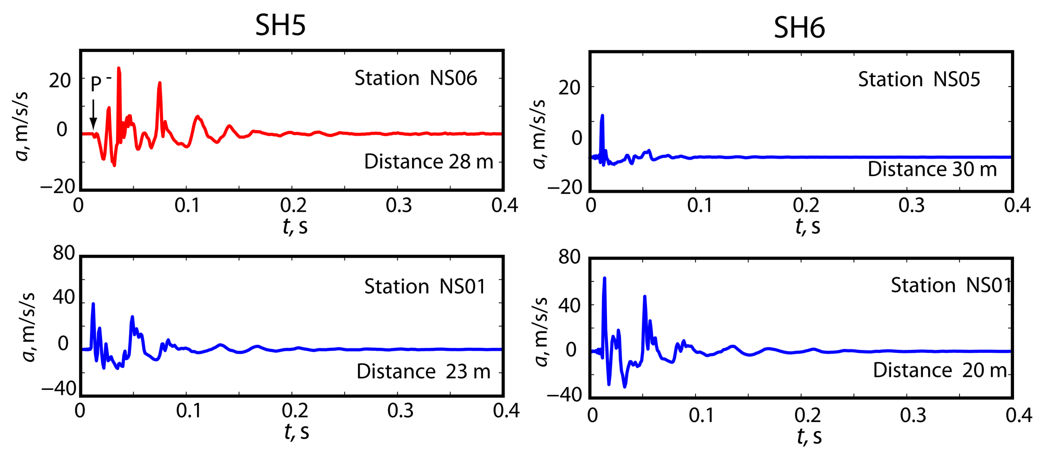


Station ES02 (~600 m from the sources)

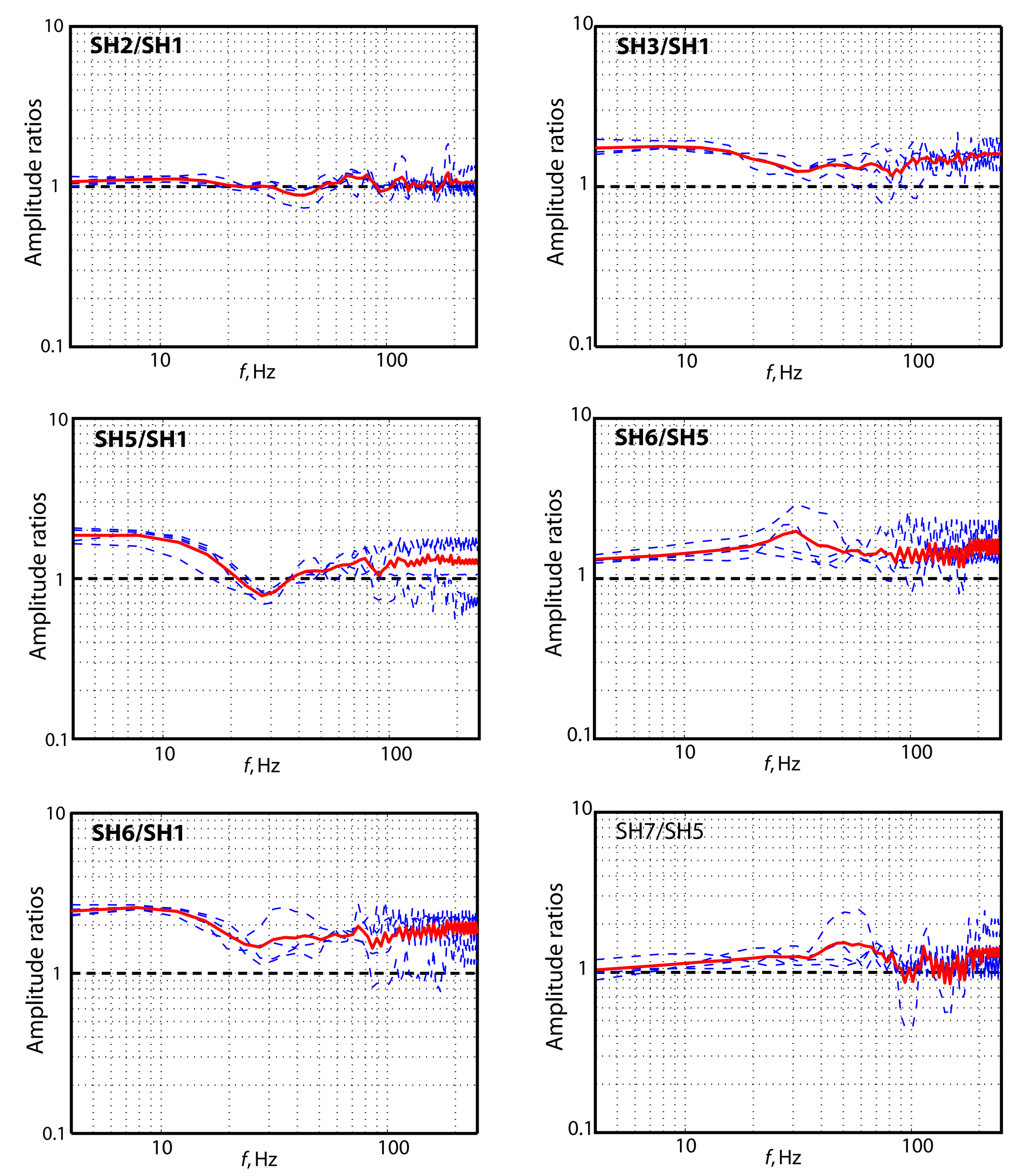


Near-Source Observations





Spectral Ratios for the Local Stations (1.2 - 9.4 km)



3. Conclusions

The active source explosion experiment (GAS2016) was conducted in New Hampshire in August, 2016. The purpose of the experiment was to study the seismic signatures of the explosion sources produced with different explosive types. WGC collected seismic data from 45 stations between 1.5 m and 10 km from the sources.

P-wave amplitude ratios between the shots do not always agree with the yield ratios. The amplitudes from the TNT and Tritonal shots were very similar, even though the Tritonal charge had larger yield by a factor of 1.53. The presence of water in the shot borehole increases the amplitudes by a factor of ~1.5 for the TNT.

Shot 1 / Shot 2	Amplitude ratio	Heat (yield) ratio
Tritonal / TNT (dry)	1	1.53
TNT(water) / TNT(dry)	1.55	1
ANFO(dry) / TNT(dry)	1.3	1
(ANFO/Al) / ANFO (dry)	1.46	1.5
ANFO(water) / ANFO (dry)	1.25	0.97

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