

HAL Project Report

Jessie Bonner and Mark Leidig
Weston Geophysical Corp.

jes_bonner@westongeo.com, mleidig@westongeo.com

Objective

The objective of the experiment was to acquire a new and unique dataset of seismic amplitude measurements from explosions in hard rock (e.g., granitic rock). The test bed used for the experiment (Figure 1) was an aggregate quarry, which blasts rock and then use a series of crushers to reduce the rock to sizes required for road construction, asphalt, or landscaping uses.



Figure 1. Photo of the quarry test site with approximate locations of shots.

Seismic Stations

Figure 2 shows the locations of the seismic stations relative to the test site. The 1 Hz Sercel L-4C 3D seismometers were placed on a paving stone, oriented to true north, leveled, and covered with a plastic bucket. The buckets were secured with plastic stakes that were hammered into the ground. Data for all stations were recorded at 250 sps on a Reftek RT130 DAS, supplied by PASSCAL. More recording parameters can be found in Table 1. The DAS was placed in a plastic tub and the GPS clock was attached to the outside of the tub lid. The external GPS clocks acquired UTC time.

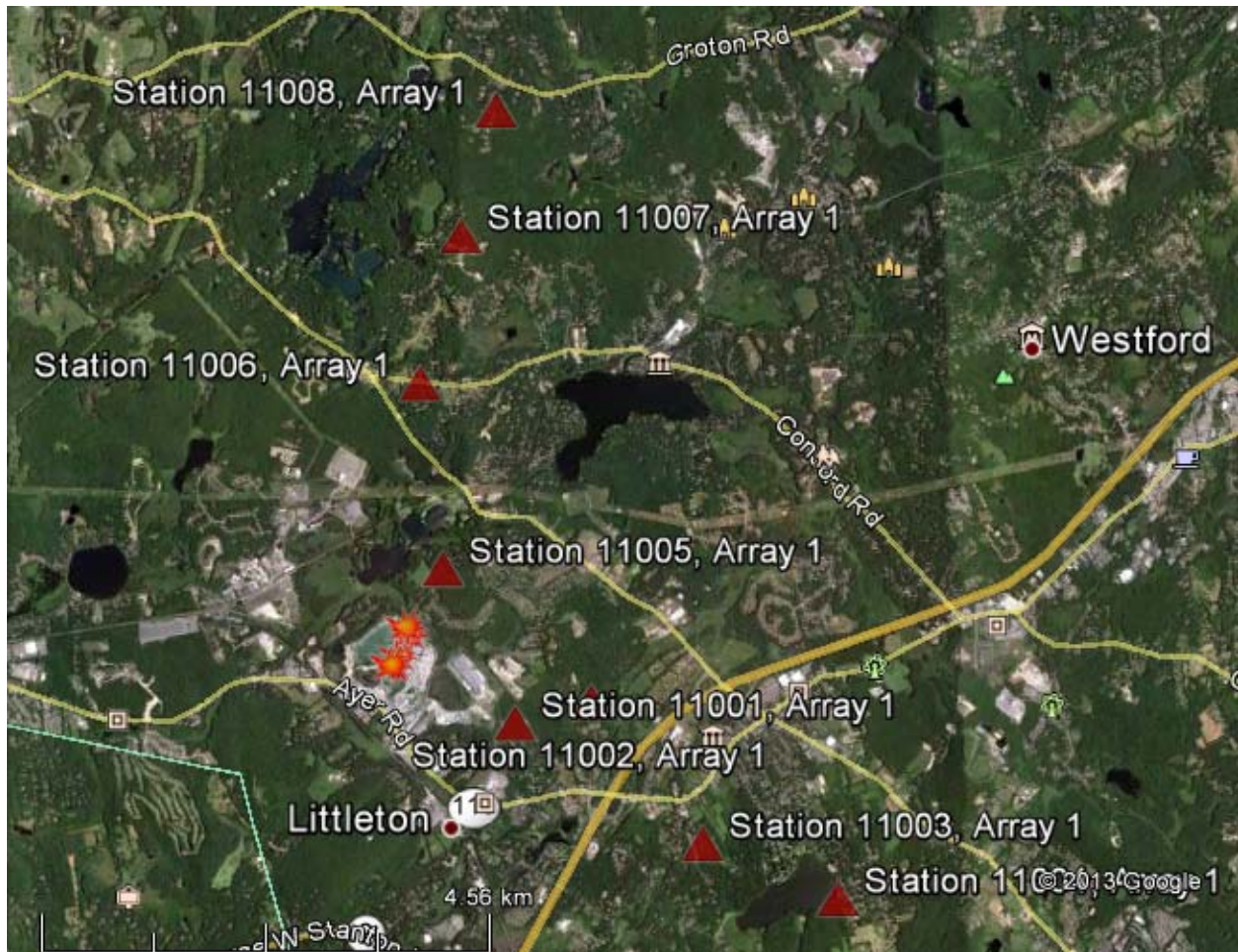


Figure 2. Map of seismic stations (red triangles) and shot locations (orange flames). (Google Earth Background).

Table 1. Seismic Sensors.

Station	Latitude, WGS84	Longitude, WGS84	Elevation (m)	Sensor	DAS	Sample Rate (SPS)
1	42.54585	-71.50459	103	1 Hz L-4C 3D	RT130	250
2	42.5475	-71.49505	90	1 Hz L-4C 3D	RT130	250
3	42.53421	-71.48174	92	1 Hz L-4C 3D	RT130	250
4	42.52874	-71.46513	100	1 Hz L-4C 3D	RT130	250
5	42.56024	-71.51288	114	1 Hz L-4C 3D	RT130	250
6	42.57732	-71.51486	116	1 Hz L-4C 3D	RT130	250
7	42.59069	-71.50907	108	1 Hz L-4C 3D	RT130	250
8	42.60207	-71.50414	142	1 Hz L-4C 3D	RT130	250

Explosions

Weston Geophysical Corp. (WGC) contracted a local explosives company to design a series of small explosions. The design objectives for the shots included:

- At least four single-fired explosions in granite
- At least two shots to have smaller length/diameter aspect ratios in multiple boreholes
- For multiple borehole shots, ensure no delays between blast initiation
- Ensure partial confinement to produce seismic and pressure signals
- Include face shots for less confinement
- Include shots with heave or partial cratering
- Use an explosive that has been well characterized (e.g., known TNT equivalent)
- Consider a range of yields and sDOBs that:
 - Ensure safe vibration and overpressure levels at nearby houses
 - Produce minimal flyrock

The blasting company designed and detonated a delay-fired production blast and four single-fired test shots to meet most of the required objectives. Tables 2 and 3 provide detailed information of the shots.



Figure 3. Map of explosions in quarry. (Google Earth Background).

Table 2. Blast size and origin information

Shot #	Yield (kg)	Location	Latitude	Longitude	Elev (m)	Date	Time (UTC)
1	9,245 Production	First Hole	42.55498	-71.51782	51	9/7/2011	18:38:16.346
		Beg Last Row	42.55495	-71.51774	51		
		End Last Row	42.55525	-71.51744	51		
		End First Row	42.55530	-71.51752	52		
2	182.4	Single BH	42.55574	-71.51802	52	9/7/2011	19:00:13.640
3	357.5	BH 1	42.55305	-71.51898	49	9/8/2011	15:07:17.876
		BH 2	42.55302	-71.51899	49		
4	59.9	BH 1	42.55218	-71.51960	51	9/8/2011	15:31:03.436
		BH 2	42.55219	-71.51964	51		
		BH 3	42.55217	-71.51965	51		
		BH 4	42.55216	-71.51963	52		
5	98	BH 1	42.55221	-71.52006	50	9/8/2011	15:58:53.194
		BH 2	42.55223	-71.52005	50		
		BH 3	42.55224	-71.52007	50		
		BH 4	42.55222	-71.52009	50		

Table 3. Blast design

Source	Weight (lbs)	# Holes	Hole Diameter (cm)	Centroid Depth (m)	Hole Depth (m)	Stemming (m)	Burden (m)	Notes
1	20337	48	13.97	Varied	15.24	Varied	3.9624	Free-Face
2	402	1	15.24	11.1252	16.1544	6.096	3.9624	Free-Face
3	788	2	15.24	9.15924	14.6304	3.68808	3.9624	Free-Face
4	132	4	15.24	4.45008	4.8768	4.02336	-	Buried, retarc
5	216	4	15.24	5.22732	6.096	4.35864	-	Buried, retarc

Waveforms

Figure 4 shows an example of the vertical component waveforms from Shot 2.

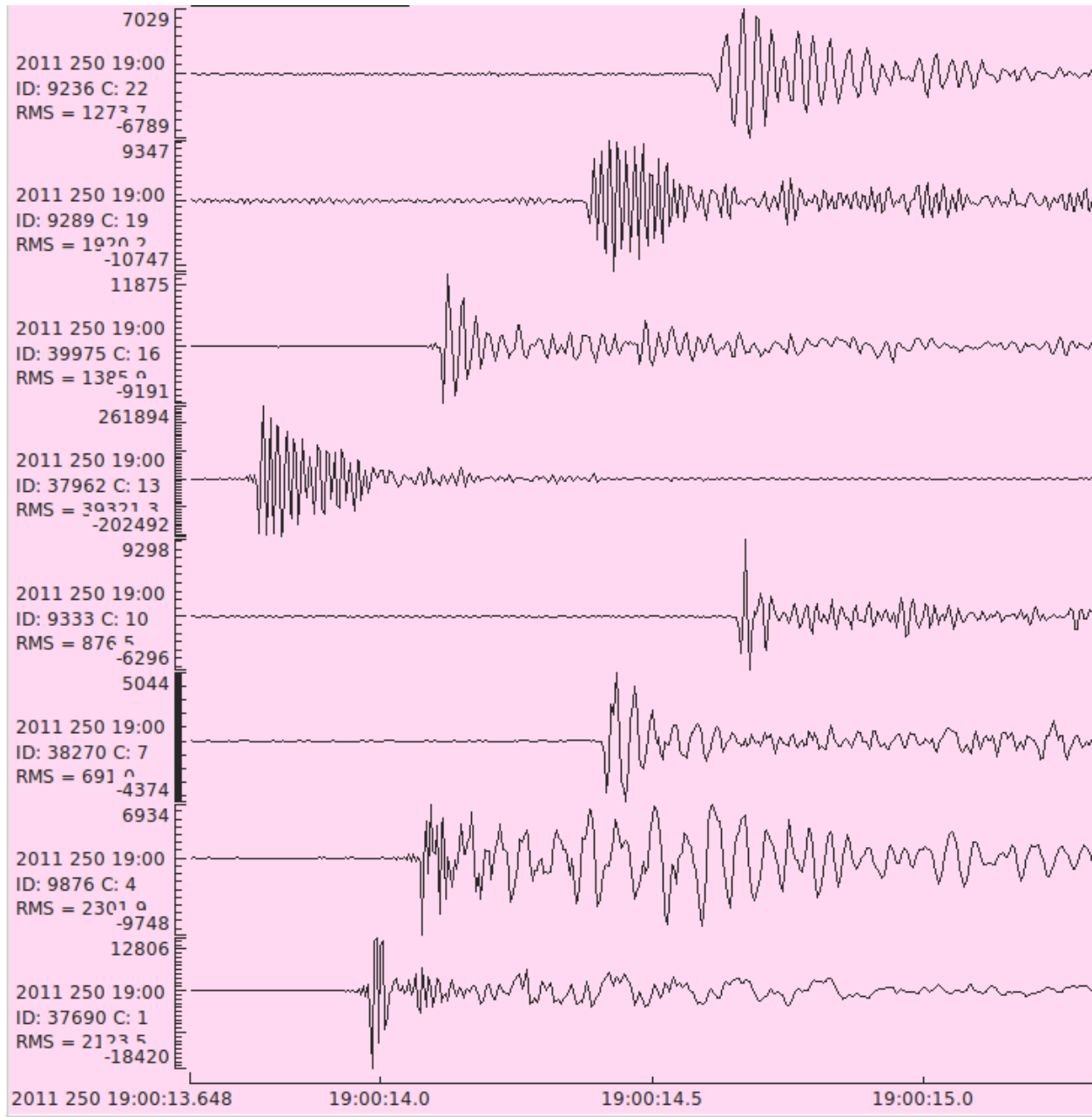


Figure 4. Vertical component waveforms for Shot 2.

ACKNOWLEDGMENTS

We thank Noel Barstow and PASSCAL for continued support, including loaning us several RT130s for the deployment.