NONEX™ Trenching Demonstration
Henderson, Nevada
August 28, 2006

Background

This report summarizes vibration monitoring of three trench blasts using NONEX™ to develop and extend a 6 ft deep trench. The test site was located south of Henderson, Nevada, in the foothills of the McCullough Mountain Range. The Range is characterized by volcanic deposits of andesite, basalt flows, and dacite while the test site appeared to comprise blocky, weathered dacite units.

The trench blasting and excavation tests took place August 28, 2006. The purpose of the tests was to demonstrate and evaluate the application of NONEX™ as a blasting product to fragment a trench 6 ft deep and 6 ft wide in igneous rock as part of an evaluation program being conducted by Aimone-Martin Associates, LLC under contract with CH2M HILL. The evaluation included ground vibration measurements and excavation of the fragmented rock. Aimone-Martin Associates, LLC provided seismographs used to monitor the attenuation of ground vibrations and airblast. Mr. Tom Hale designed the blasts and excavated the trenches. Sanders Construction, Inc. provided the drill rig. The NONEX™ product was supplied by Sean Weaver, of Nonex, LLC.

Test Blasts

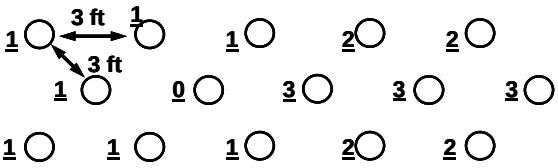
Table 1 gives a summary of the three test shots, hole spacings, and total charge loading. All holes were initiated on one delay. Powder factors used for each blast are also provided. During drilling, random holes were monitored for penetration rate and the results are given in Table 2. Schematics of the three blasts are given in Figure 1. Test blasts 1 and 3 were designed as opening cuts and Test 2 was a trench extension of Test 1. Figure 2 shows the drilling and excavating equipment. Typical hole patterns and loading of the NONEX™ product are shown in Figure 3.

Table 1 Summary of NONEX™ test blasts

Trial Blast	Number of Holes	Total Charge	Average Depth	Spacing	Burden	Power Factor		
		(g)	(ft)	(ft)	(ft)	(g/ft^3)	(g/yd^3)	(lb/yd^3)
1	15	14400	6.7	3	3	15.9	429.9	0.95
2	36	43200	7	3	2	28.6	771.4	1.70
3	15	26400	6.5	3	2	45.1	1218.5	2.69

Table 2 Summary of drill hole penetration rates

Test	Average hole depth	Rate of Penetration	
		Average	Range (no. holes)
	(ft)	(ft/sec)	(ft/sec)
1	6.2	2.24	2.02 – 2.4 (3)
2	6.82	1.90	1.37 – 2.28 (7)
3	6.5	1.94	1.67 – 2.25 (6)



SHOT 1 – OPENING CUT

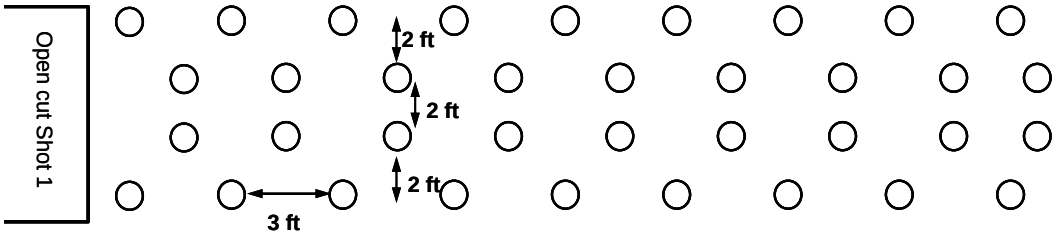
(600 g) (24 sticks) = 14,400 g = 31.75 lbs

(3ft)(3ft)(6.67 ft deep)(15 holes)/27 = 33.3 yd³

0.95 lb/yd³ = 15.9 g/ft³

N

(a)



SHOT 2 – Trench with a free face to East, shot 1

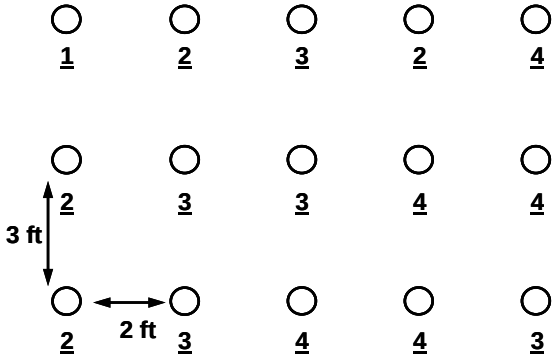
(600 g) (72 sticks) = 43200g = 95.26 lbs

(3ft)(2ft)(7.0 ft deep)(36 holes)/27 = 56 yd³

1.70 lb/yd³ = 28.6 g/ft³

N

(b)



SHOT 3 – Opening Cut

(600 g) (44 sticks) = 26400 g = 58.21 lbs

(3ft)(2ft)(6.5 ft deep)(15 holes)/27 = 21.7 yd³

2.69 lb/yd³ = 45.1 g/ft³

N

(c)

Figure 1 Test blast hole layouts and powder factors

(a) (b)

Figure 2 Drill rig (a) and backhoe (b), used to excavate trenches

(a) (b)

Figure 3 Typical hole pattern layout (a) and loading NONEX™ product (b)

Seismograph Monitoring

Seismographs were placed in linear arrays shown in photograph in Figure 4, coupled to the rock with distances to the closest holes ranging from 5 to 120 ft. Very close-in measurements were used to characterize the vibrations generated by the product. Seismographs were set to trigger at

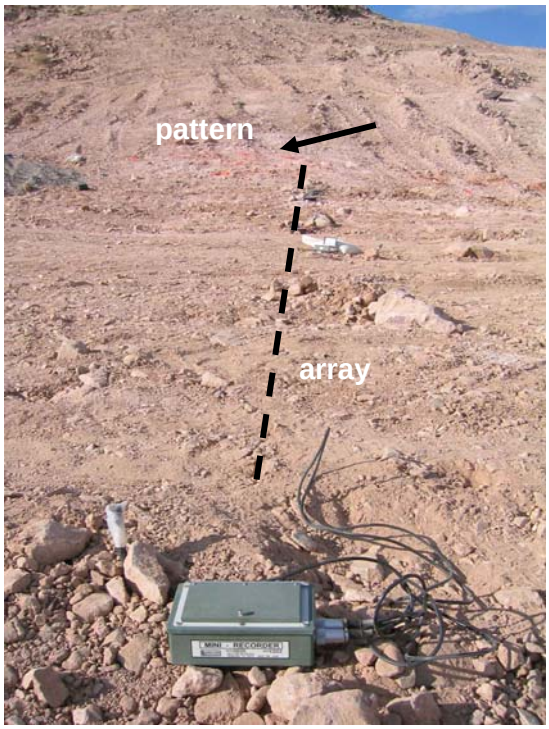


Figure 4 Linear array of seismographs placed to the north

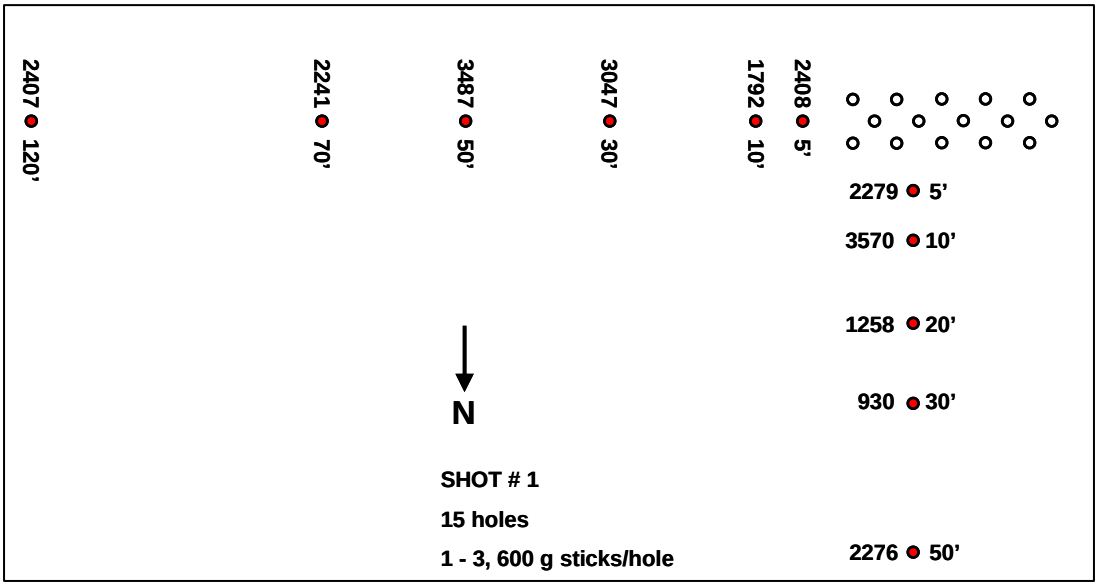
0.02 to 0.08 ips ground vibration and 125 db airblast. A record length of 6 seconds and a sample rate of 1024 were employed. Figure 5 shows the arrays of seismograph in relation to each test blast. The seismograph serial numbers are shown along with the distance from the closest hole. Test 1 employed two arrays with one to the north and one to the east. One array to the south and one to the north were used during Test 2. For Test 3, only one array to the south was used.

Table 3 summarizes the data collected during the monitoring. Seismograph records are found in the Appendix.

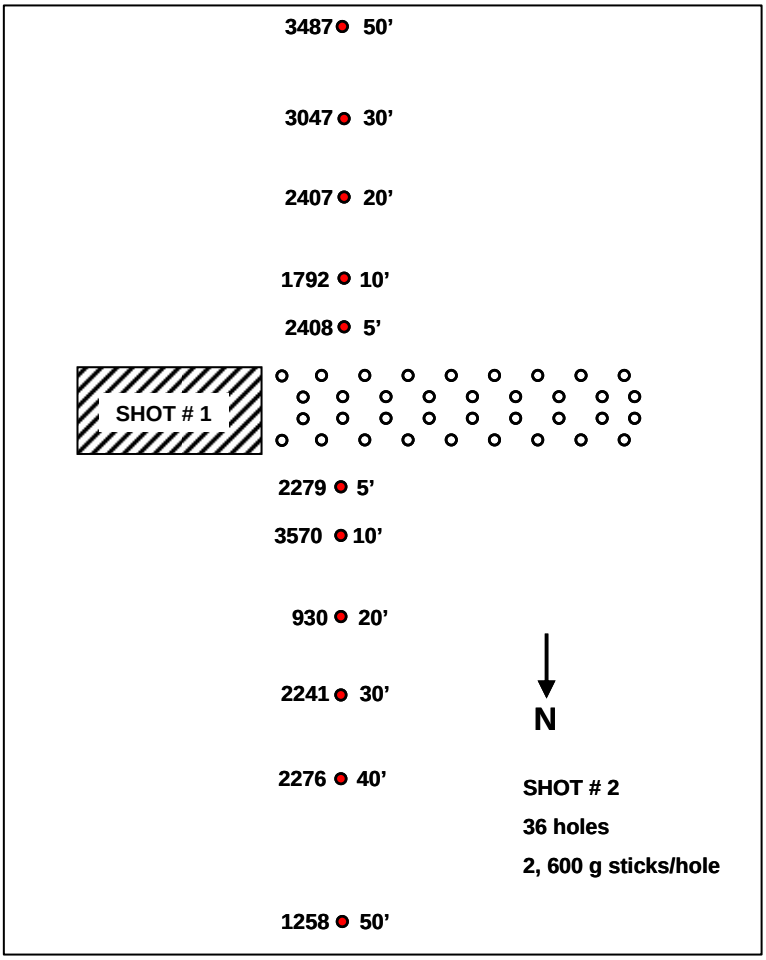
Ground Vibration Attenuation

A plot of peak ground velocity versus scaled distance, found in Figure 6, shows the attenuation of the ground motion for the NONEX™ demonstration compared with regular explosive attenuation study previously conducted in Henderson by Aimone-Martin Associates, LLC (http://www.cityofhenderson.com, City Departments, Building & Fire Safety, Blasting Information, Blasting Studies and Reports). The purpose of the Henderson study was to establish baseline decay of ground vibrations from typical construction development blasts that included utility trenching, mass excavation, and road development. In addition, large-scale gross differences in geology were assessed by placing seismographs in different compass directions to study if varying ground motion intensity levels occurred in geologically preferential directions. It was concluded that there were no statistically significant difference in attenuation or decay of ground motions in three directions toward surrounding residential communities.

The Henderson study included ANFO as the main explosive in 4-inch to 6-inch diameter blastholes. Seismographs were placed both close-in (40 ft from a typical blast) and far-field (up to 6000 ft away).

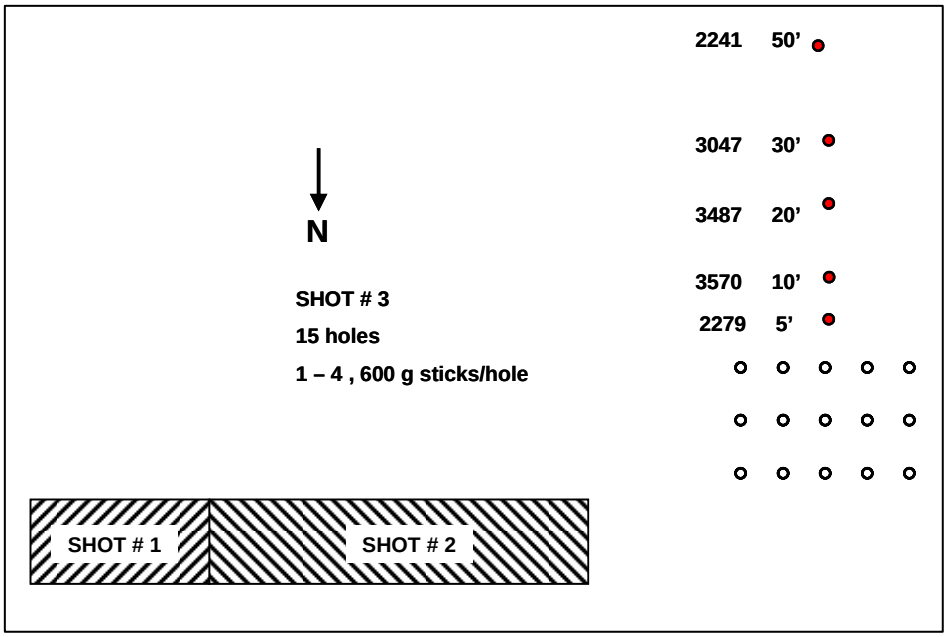


(a)



(b)

Figure 5 Seismograph arrays relative to test hole patterns



(c)

Figure 5 (cont.) Seismograph arrays relative to test hole patterns

Table 3 Summary of data Collected

Shot Date	Shot Time	Unit	Orientation	Distance From Shot (in)	Charge Weight/ Delay (lb)	Scaled Distance ($ft/lb^{1/2}$)	Scaled Distance ($ft/lb^{1/3}$)	Peak Particle Velocity (in/sec)	Peak Frequency (Hz)	FFT Frequency (Hz)	Airblast (psi)
08/28/06	8:46 AM	2408	parallel	5	31.75	0.89	1.58	3.28			
		1792		10	31.75	1.77	3.16	2.20	85.0	57.00	128
		3047		30	31.75	5.32	9.49	0.65	64.0	58.00	112
		3487		50	31.75	8.87	15.81	0.17	64.0	57.50	112
		2241		70	31.75	12.42	22.13	0.06	36.5	30.00	106
		2407		120	31.75	21.30	37.94	nd			
		2279	north line	5	31.75	0.89	1.58	2.48	24.3	18.00	129
		3570	perpendicular	10	31.75	1.77	3.16	1.28	25.6	18.50	124
		1258		20	31.75	3.55	6.32	0.66	36.5	22.00	118
		930		30	31.75	5.32	9.49	0.44	34.1	32.50	118
		2276		50	31.75	8.87	15.81	0.25	26.9	23.50	112
08/28/06	12:24	2408	south line	5	95.24	0.51	1.10	4.80			
		1792	perpendicular	10	95.24	1.02	2.19	3.04	46.5	29.00	135
		2407		20	95.24	2.05	4.39	nd			
		3047		30	95.24	3.07	6.58	0.98	46.5	15.00	128
		3487		50	95.24	5.12	10.97	0.39	39.3	15.00	123
		2279	north line	5	95.24	0.51	1.10	10.56	28.3	14.00	136
		3570	perpendicular	10	95.24	1.02	2.19	7.04	28.3	13.00	134
		930		20	95.24	2.05	4.39	1.36	28.3	38.00	127
		2241		30	95.24	3.07	6.58	1.00	34.1	37.00	126
		2276		40	95.24	4.10	8.77	0.84	32.0	28.00	126
		1258		60	95.24	6.15	13.16	0.57	39.3	38.30	120
08/28/06	3:06	2279	south line	5	58.20	0.66	1.29	14.08	12.1	5.00	148
		3570	perpendicular	10	58.20	1.31	2.58	8.00	30.1	24.00	150
		3487		20	58.20	2.62	5.17	1.60	102.0	14.00	148
		3047		30	58.20	3.93	7.75	0.88	30.1	28.00	143
		2241		50	58.20	6.55	12.92	0.47	30.1	30.00	138

Figure 6 Peak Ground Velocity versus Scaled Distance attenuation line

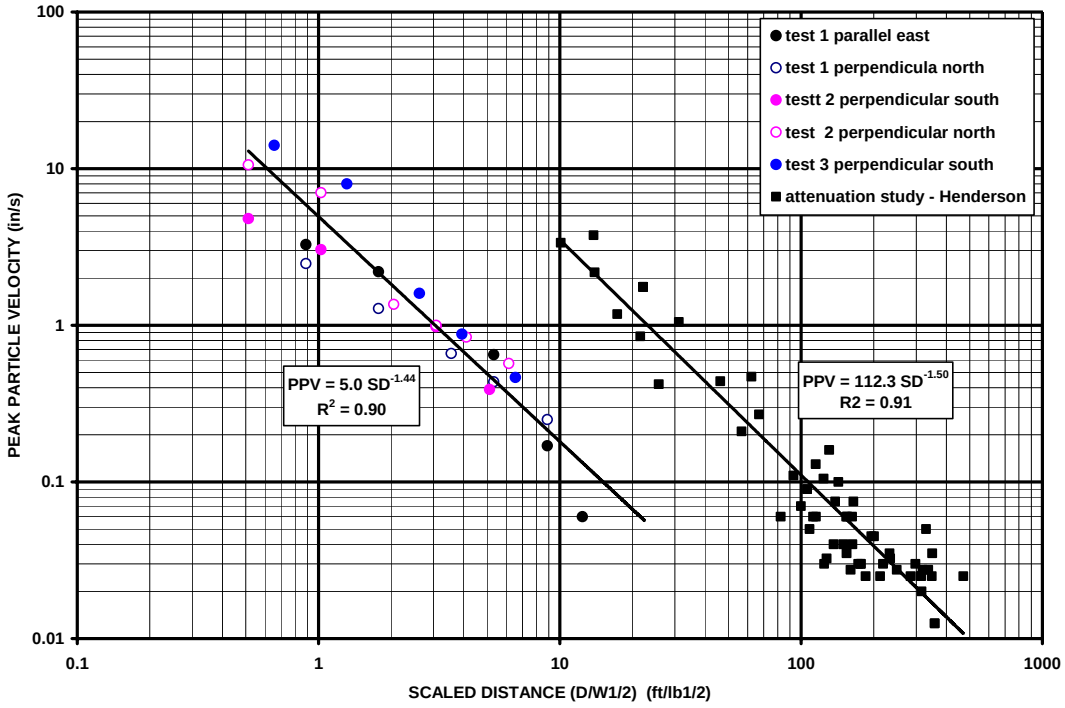


Figure 6 Ground vibration attenuation plot of NONEX™ test shots in comparison with attenuation using ANFO established during a previous study (Aimone-Martin, 2005)

The best-fit power curve equations (50-percentile) plotted on a log-log graph are as follows:

$PPV = 5.0\ SD^{-1.44}$ NONEX™

$PPV = 112.3\ SD^{-1.5}$ ANFO (attenuation Study – Henderson)

The values of -1.44 and -1.50 for the two studies are considered to be very close. The site slope parameters reflect site geology (both rock type and rock structures). These numbers, in close agreement, demonstrate the geology is very similar in both studies.

The y-intercept (at scaled distance = 1) indicates the amount of energy placed in the ground close-in to the blast. The values of 5.0 and 112.3 for respective studies indicate the energy out-put levels of the two products transferred to the ground and not used in the rock fracturing process (NONEX™ and ANFO, respectively). This energy forms the basis for off-site ground vibrations that travel away from the blast site and may be potentially disturbing to structure owners.

Extending the NONEX™ best-fit line forward, the predicted ground vibration level of 0.01 ips is estimated for a scaled distance value of approximately 80 ft/lb ^{½}. This intensity of ground vibration is considered to be "barely perceptible" to persons residing inside building.

Ground Motion Frequencies

A cursory review of predominant frequency components of the time histories in the Appendix demonstrates that Test 1 appeared to be completely contained during detonation generated 30 to 40 Hz frequencies along the north line and around 60 Hz along the east line. Close-

in (5 – 10 ft), 12 to 14 Hz frequencies predominated in the north line and are likely to represent "ground roll" or displacement of the ground surface. Test 2 generated frequencies beyond 20 ft between 30 and 40 Hz with the south line and north lines exhibiting some 12 to 14 Hz close-in values. Test 3 with a high powder factor generated flying rock. The large ground displacement resulted frequencies of 5 to 10 Hz close-in, 13 to 14 Hz at 20 ft, and 28 to 30 Hz beyond 30 ft. The lower overall frequencies measured during Test 3 were influenced by the ground surface heave.

Airblast Attenuation

Airblast intensities for each test blast are given in Figure 7 as a function of cube-root scaled distance. Very close-in data were not used as these airblast levels were not fully developed as a function of distance. The variation in attenuation slopes for the Test 1 NONEX™ shot resulted from the high wind conditions early in the day of the tests. For comparison the attenuation of airblast for the a well-characterized shot during the Henderson attenuation study using ANFO is also included. Airblast for the Henderson study was correlated with the elevation of the blasts relative to the lower elevation at which seismographs were placed. The NONEX™ test shots were essentially blasted at the same elevation as the seismograph placement.

The decay rate of blast energy in the air is expected to follow the same trend for all shots. The range of slope from -0.076 to 0.094 is normal and expected. Ambient air conditions (other than wind speed and direction) play a very small role influencing the attenuation of wave speed in air.

The y-intercept at cube-root scaled distance of unity (1.0) indicates the amount of energy expelled into the air at the blast site. These intercepts are highly controlled by site geology and the quality of the rock blasted (e.g. weathering, fractures) as well as confinement, distribution of change, and stemming quality and quantity. These intercept factors are plotted in Figure 8 against powder factor to illustrate that increasing powder factors increase the amount of wasted energy into the air as expected. Such analysis is extremely preliminary as there are many other factors that contributed to airblast during Tests 2 and 3 that are evidenced in videos taken during the blasts. Further, more data is required to establish any trends. Nonetheless, the airblast generated close-in to the NONEX™ tests shots generated overall lower y-intercepts compared with the ANFO shots recorded during the attenuation study of the City of Henderson.

Wave Speed

During tests, one linear array of seismographs was connected in series to obtain the speed of surface wave passing along the ground surface. This wave speed is not associated with either the P-wave (compression) or S-wave (shear) body wave traditionally obtained during reflection or refraction seismic surveys. Typical blasting-type seismographs do not possess the resolution required to measure body waves. Our experience in using blasting seismographs to characterize surface rock formations has allowed us to form general conclusions regarding the relative measure of weathering of rock in which we perform blasting studies. Field wave speed measurements are indicative of the degree of near-surface fracturing, or within several feet of the surface. Generally, field measurements should be supported with lab measurements of tensile strength and P- and S-wave speed using intact specimens.

The array use for wave speed measurements was the east line employed during Test 1 (seismographs at 5, 10, 30 and 50 ft). A plot of distance (or position of each seismograph) versus arrival time is given in Figure 9 for the radial component. This component provides the most reliable field data. The slope of the best-fit line indicates the surface wave speed and is computed to be approximately 3360 ft/sec.

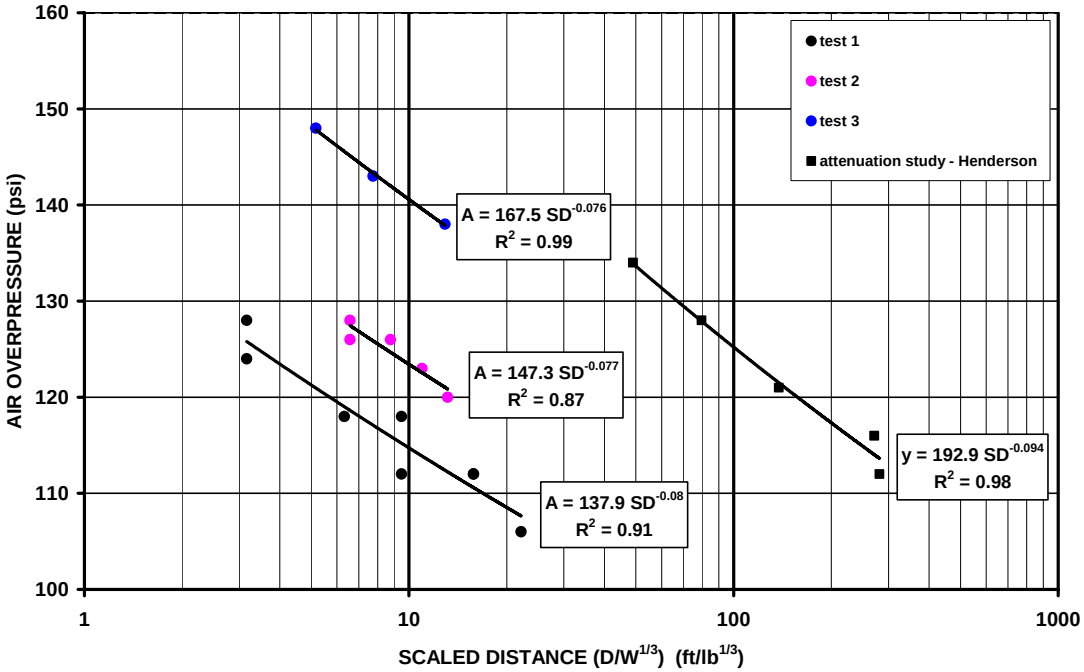


Figure 7 Airblast versus cube-root scaled distance for test shots compared with attenuation study data

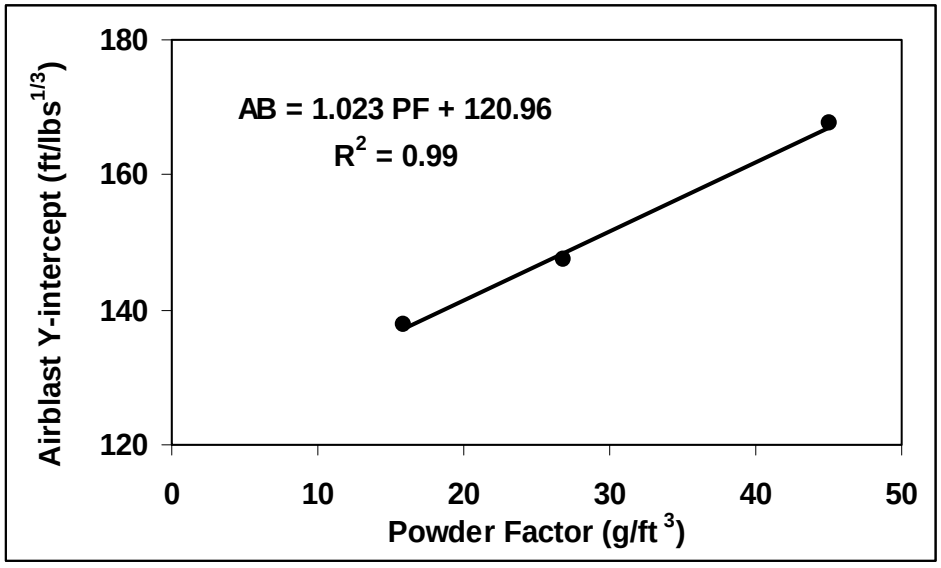


Figure 8 Airblast y-intercept as a function of power factor

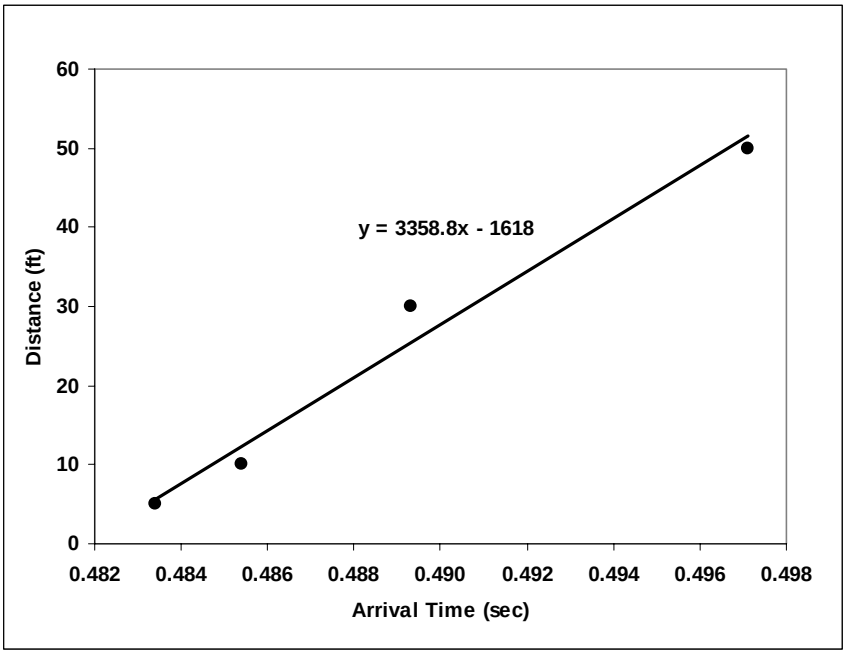


Figure 9 Distance versus arrival time for surface wave speed calculations, Test 1

Trench Excavations

Each trench shot was excavated to observe the final limits of the blasted trench. Photographs of the three test trenches are given in Figures 10 through 12. The walls of Test 1 and 2 trenches were washed the previous day to enable the observations of natural fractures along the trench south walls.

Figure 13 shows approximate trench dimensions relative to original drill hole layouts for Test 1 and 2. The average trench depth for Test 2 and the deepest depths noted for Tests 1 and 3 are given in Table 4. Powder factors of each blast are included.

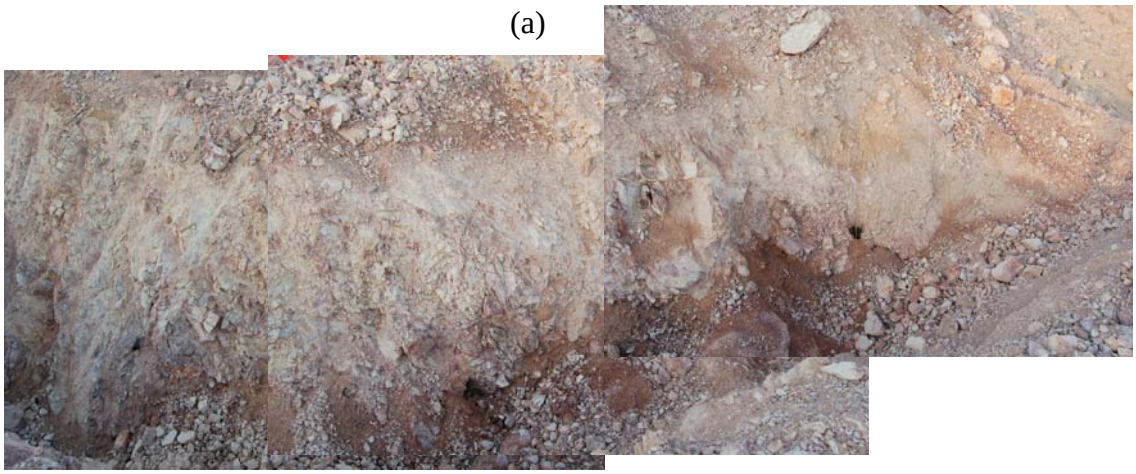
The opening shot with the highest power factor (Test 3) generated the deepest trench relative to the drilled hole depths. Test 2 resulted in some high ground along the trench bottom.

Table 4 Approximate trench depth

Test	Average hole depth	Average trench depth	Powder Factor	
	(ft)	(ft)	(g/ft^3)	(lbs/yd^3)
1	6.2	5.5	15.9	0.95
2	6.82	5.1	26.8	1.70
3	6.5	8	45.1	2.69

Figure 10 Excavated trench, Test 1, east wall (south wall to right)

(a)



(b)

Figure 11 Excavated trench, shot 2, facing west (a) and trench south wall (b)

(a) (b)

Figure 12 Excavated trench shot 3, facing west (a) and facing south (b)

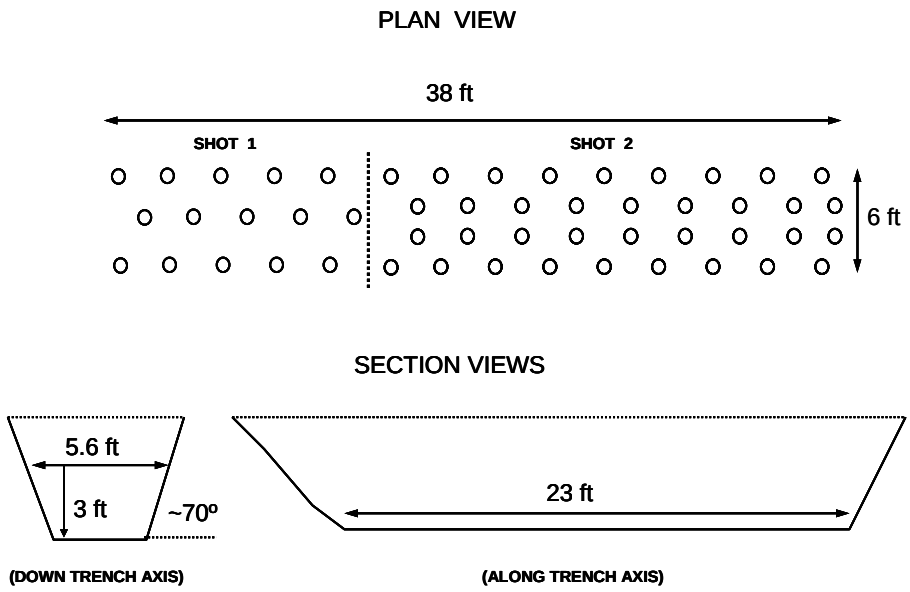


Figure 13 Trench Test shots 1 and 2: original plan view of blast holes (above) and approximate post-shot trench dimensions (below)

Particle Size Distributions

Particle size distributions were analyzed for fragmented rock placed in piles for Tests 1 and 3. Trench Test 2 was not analyzed based on time constraints that did not allow the placement of fragmented rock in one location.

Digital photographs, shown in Figure 14, were taken in the field and analyzed using Split-Desktop® image processing program. The software employs an edge detection algorithm to delineate individual particles. However, the process requires manual editing to correct for hidden

(a) (b)

Figure 14 Blasted rock piles for Test 1 (a) and Test 3 (b)

particles and the large number of fines that cannot be detected on photographs. Once the delineation of particles is performed, a binary image is created and used for calculation of the particle size distribution given as percentage of particle size passing through a U.S. standard sieve sizes. The percentage of fine material present in an image was estimated using Rosin-Rammler size distribution.

The resulting particle size distributions for Tests 1 and 3 are shown in Figure 15. Particle sizes for Test 3 (designed a high powder factor) are shown to be larger that those for Test 1 (designed with a lower powder factor). The size difference is due to the gas energy that was not used in the fragmentation process but rather for extensive vertical rock surface displacement and resulting flyrock generated in Test 3. Clearly, high powder factors, although successful in excavating rock, are not efficient in the fragmentation progress and tend to create high airblast along with flyrock.

Recommendations

It is recommended that field testing of NONEX™ continue in different rock types with various rock mass characteristics (e.g. fracturing and weathering properties) and determine the limitation in product application. A suite of characterization studies are encouraged to develop power factor relations with rock properties for different excavation applications.

References

Aimone-Martin, C.T., Blasting Attenuation Study, Crystal Ridge, MacDonald Ranch and MacDonald Highlands, for the City of Henderson, May 2005.

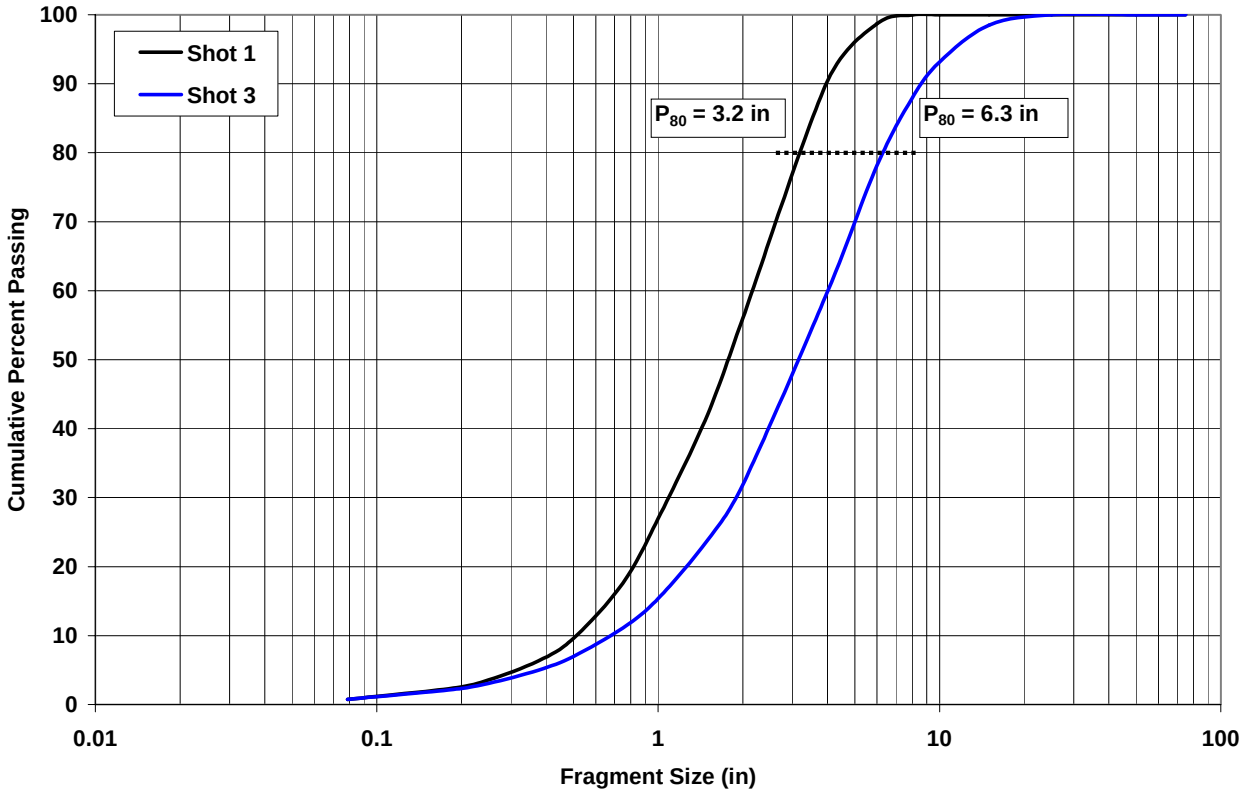


Figure 15 Particle size distributions for Tests 1 and 3 fragments

APPENDIX

NONEX
Trenching Demonstration
Henderson, Nevada
Shot 1 - 15.9 g/cf
10 ft
parallel array

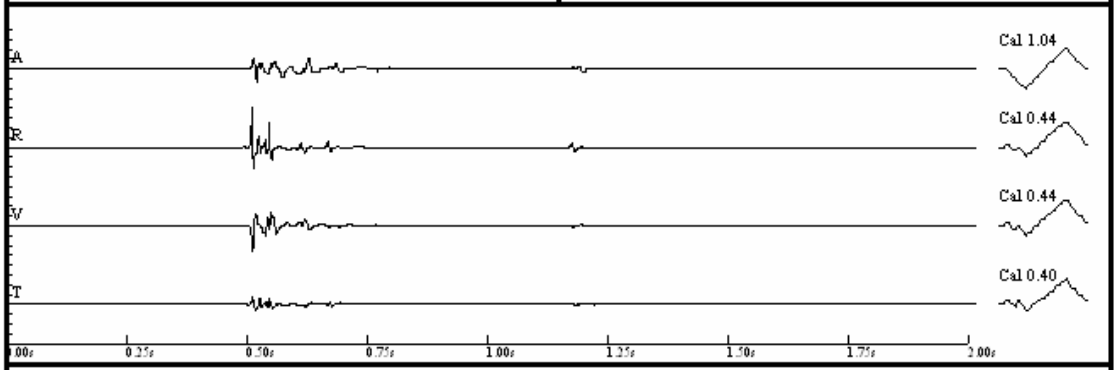
File Name: 01792019.DTB
Number: 019
Date: 9/6/2006
Time: 08:46
Serial Number: 1792
Seismic Trigger: 0.0800 in/s 2.0320 mm/s
Acoustic Trigger: 125 dB
Sample Rate: 1024
Record Duration: 6.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 1x
Battery: 6.4

Amplitudes and Frequencies

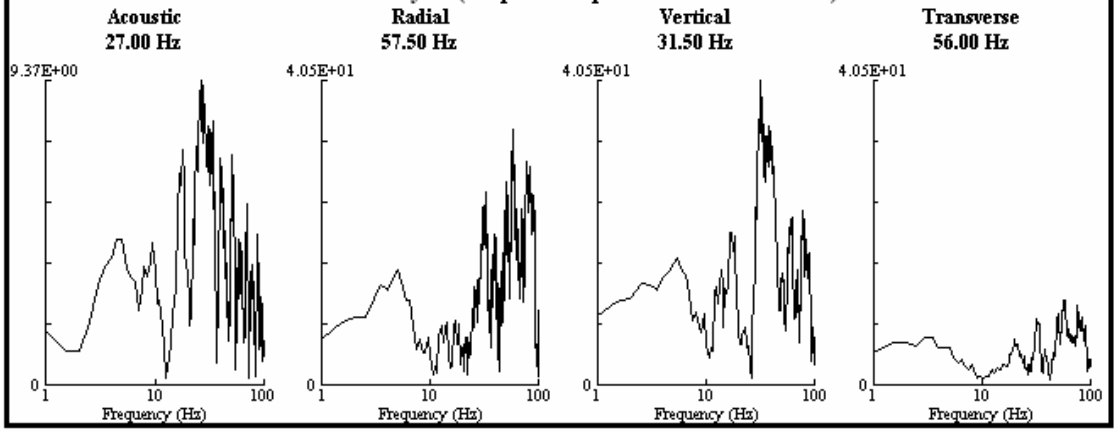
Acoustic: 128 dB @ 170.6 Hz
(0.52Mb 0.0075psi 0.0520kPa)
Radial: **2.20in/s 55.88mm/s @ 85.3Hz**
Vertical: 1.44in/s 36.576mm/s @ 56.8Hz
Transverse: 0.44in/s 11.176mm/s @ 85.3Hz

Graph Information

Duration: 0.000s To: 2.000s
Acoustic Scale:
130dB 0.63Mb (0.158Mb/div)
Seismic Scale:
2.20in/s (0.550in/s/div) 55.88mm/s (13.970mm/s/div)
Time Line Intervals at: 0.25 s



Fourier Analysis (Amplitude Spectrum - Box Window)



NONEX
Trenching Demonstration
Henderson, Nevada
Shot 1 - 15.9 g/cf
30 ft
parallel array

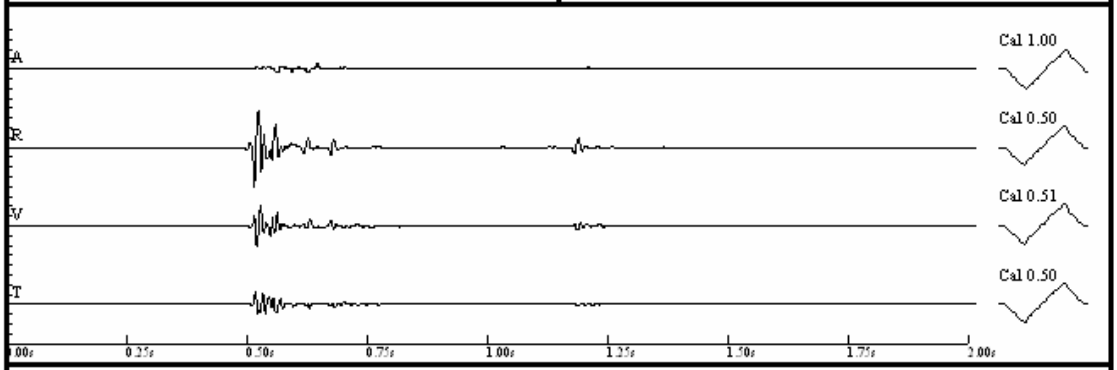
File Name: 03047032.DTB
Number: 032
Date: 9/6/2006
Time: 08:44
Serial Number: 3047
Seismic Trigger: 0.0300 in/s 0.7620 mm/s
Acoustic Trigger: 123 dB
Sample Rate: 1024
Record Duration: 6.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 2x
Battery: 6.5

Amplitudes and Frequencies

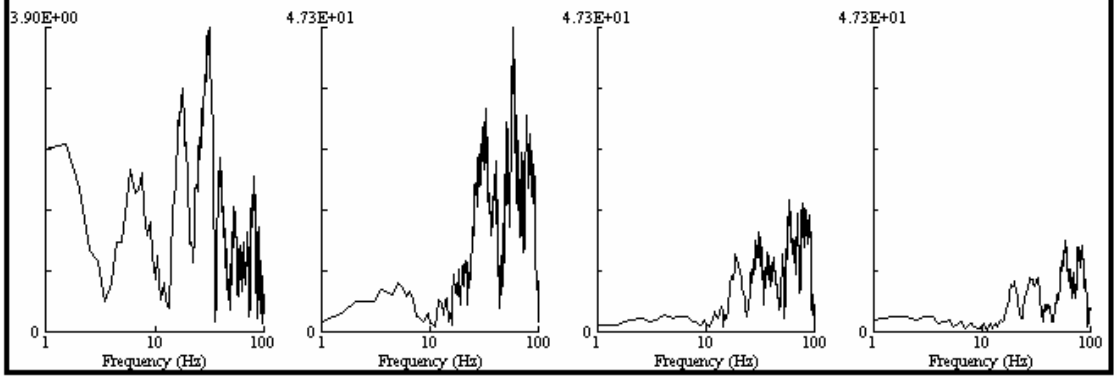
Acoustic: 112 dB @ 0.0 Hz
(0.08Mb 0.0012psi 0.0080kPa)
Radial: **0.65in/s 16.51mm/s @ 64.0Hz**
Vertical: 0.34in/s 8.636mm/s @ 73.1Hz
Transverse: 0.21in/s 5.334mm/s @ 102.4Hz

Graph Information

Duration: 0.000s To: 2.000s
Acoustic Scale:
130dB 0.63Mb (0.158Mb/div)
Seismic Scale:
0.65in/s (0.163in/s/div) 16.51mm/s (4.128mm/s/div)
Time Line Intervals at: 0.25 s



Fourier Analysis (Amplitude Spectrum - Box Window)



NONEX
Trenching Demonstration
Henderson, Nevada
Shot 1 - 15.9 g/cf
50 ft
parallel array

File Name: 03487026.DTB
Number: 026
Date: 9/6/2006
Time: 08:45
Serial Number: 3487
Seismic Trigger: 0.0200 in/s 0.5080 mm/s
Acoustic Trigger: 123 dB
Sample Rate: 1024
Record Duration: 6.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 2x
Battery: 6.3

Amplitudes and Frequencies

Acoustic: 112 dB @ 0.0 Hz
(0.08Mb 0.0012psi 0.0080kPa)

Radial: 0.13in/s 3.302mm/s @ 46.5Hz

Vertical: **0.175in/s 4.445mm/s @ 64.0Hz**

Transverse: 0.05in/s 1.27mm/s @ 56.8Hz

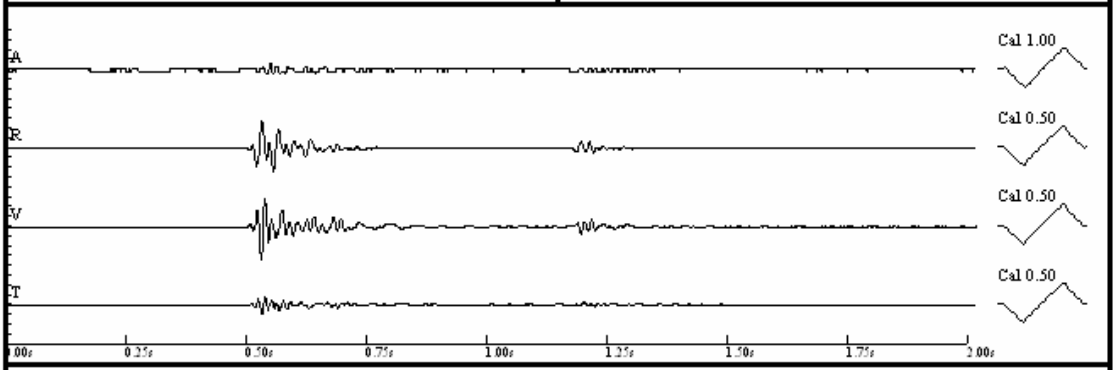
Graph Information

Duration: 0.000s To: 2.000s

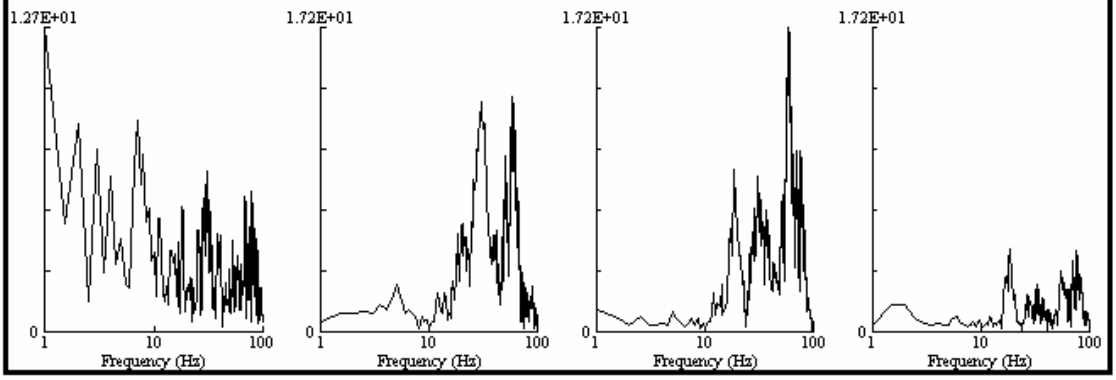
Acoustic Scale:
130dB 0.63Mb (0.158Mb/div)

Seismic Scale:
0.20in/s (0.050in/s/div) 5.08mm/s (1.270mm/s/div)

Time Line Intervals at: 0.25 s



Fourier Analysis (Amplitude Spectrum - Box Window)



NONEX
Trenching Demonstration
Henderson, Nevada
Shot 1 - 15.9 g/cf
70 ft
parallel array

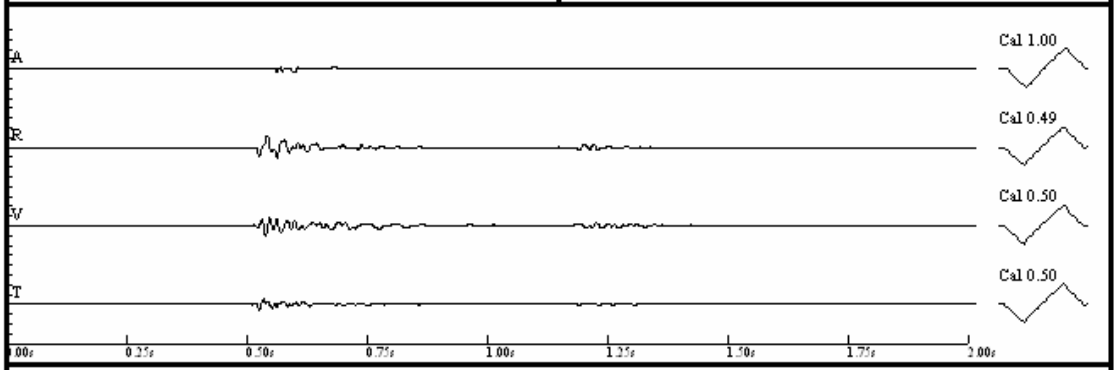
File Name: 02241008.DTB
Number: 008
Date: 9/6/2006
Time: 08:44
Serial Number: 2241
Seismic Trigger: 0.0300 in/s 0.7620 mm/s
Acoustic Trigger: 125 dB
Sample Rate: 1024
Record Duration: 6.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 2x
Battery: 6.6

Amplitudes and Frequencies

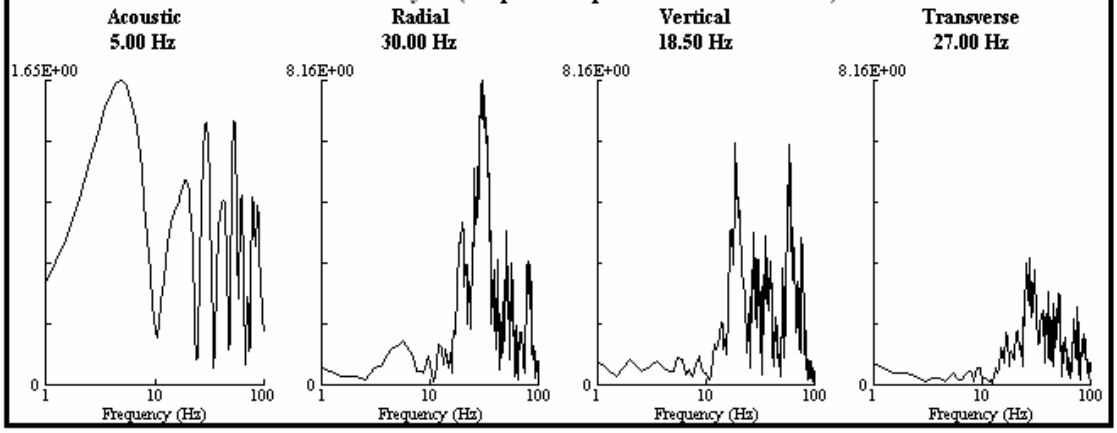
Acoustic: 106 dB @ 0.0 Hz
(0.04Mb 0.0006psi 0.0040kPa)
Radial: **0.06in/s 1.524mm/s @ 36.5Hz**
Vertical: 0.055in/s 1.397mm/s @ 56.8Hz
Transverse: 0.03in/s 0.762mm/s @ 64.0Hz

Graph Information

Duration: 0.000s To: 2.000s
Acoustic Scale:
130dB 0.63Mb (0.158Mb/div)
Seismic Scale:
0.20in/s (0.050in/s/div) 5.08mm/s (1.270mm/s/div)
Time Line Intervals at: 0.25 s



Fourier Analysis (Amplitude Spectrum - Box Window)



NONEX
Trenching Demonstration
Henderson, Nevada
Shot 1 - 15.9 g/cf
5 ft
perpendicular array

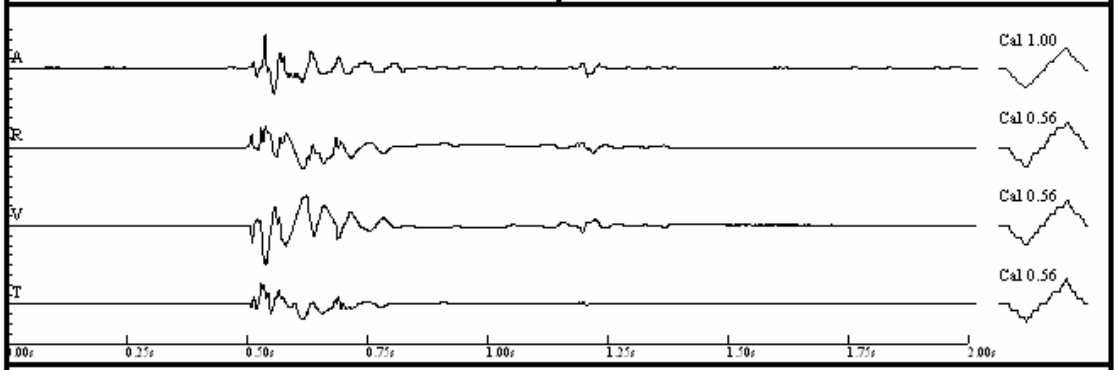
File Name: 02279001.DTB
Number: 001
Date: 9/6/2006
Time: 08:45
Serial Number: 2279
Seismic Trigger: 0.0800 in/s 2.0320 mm/s
Acoustic Trigger: 132 dB
Sample Rate: 1024
Record Duration: 6.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 1x
Battery: 6.5

Amplitudes and Frequencies

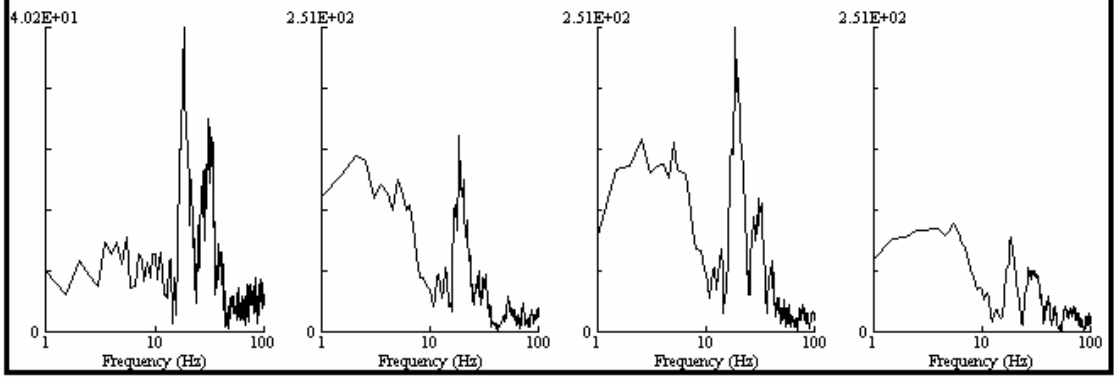
Acoustic: 129 dB @ 51.2 Hz
(0.56Mb 0.0081psi 0.0560kPa)
Radial: 1.36in/s 34.544mm/s @ 18.9Hz
Vertical: **2.48in/s 62.992mm/s @ 24.3Hz**
Transverse: 1.28in/s 32.512mm/s @ 22.2Hz

Graph Information

Duration: 0.000s To: 2.000s
Acoustic Scale:
130dB 0.63Mb (0.158Mb/div)
Seismic Scale:
2.48in/s (0.620in/s/div) 62.99mm/s (15.748mm/s/div)
Time Line Intervals at: 0.25 s



Fourier Analysis (Amplitude Spectrum - Box Window)



NONEX
Trenching Demonstration
Henderson, Nevada
Shot 1 - 15.9 g/cf
10 ft
perpendicular array

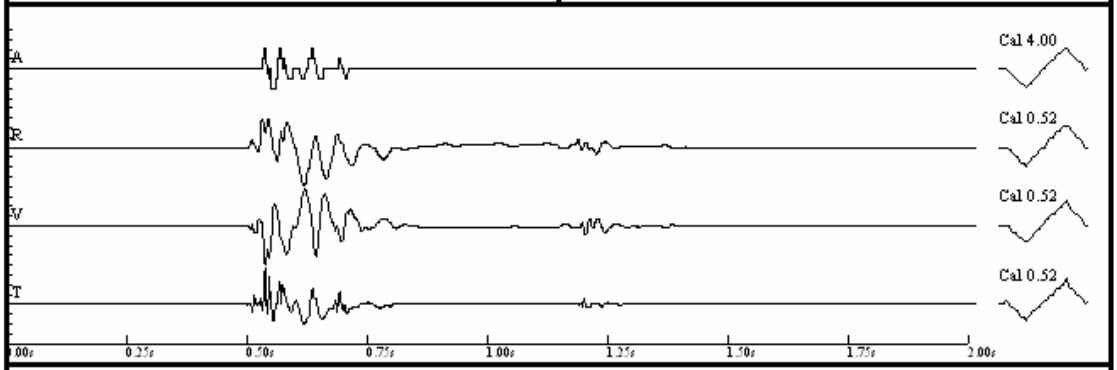
File Name: 03570004.DTB
Number: 004
Date: 9/6/2006
Time: 11:46
Serial Number: 3570
Seismic Trigger: 0.0800 in/s 2.0320 mm/s
Acoustic Trigger: 130 dB
Sample Rate: 1024
Record Duration: 6.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 1x
Battery: 6.2

Amplitudes and Frequencies

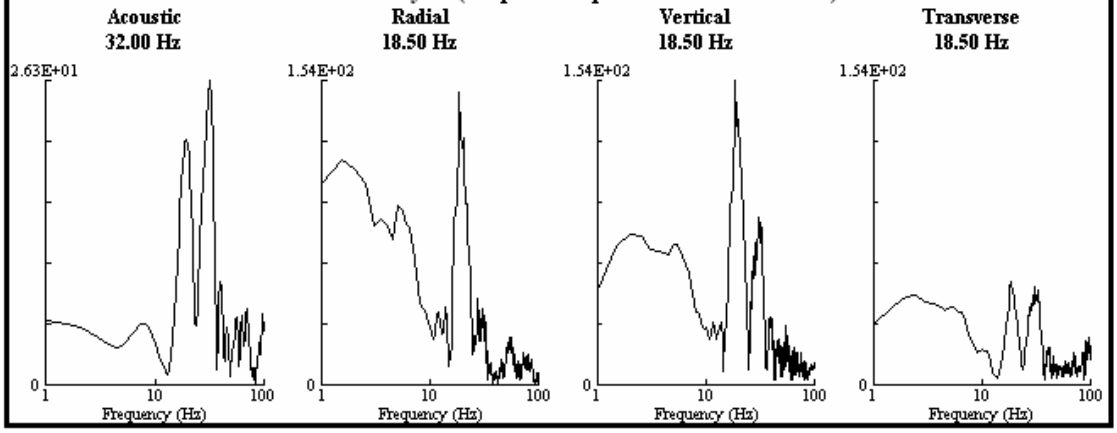
Acoustic: 124 dB @ 0.0 Hz
(0.32Mb 0.0046psi 0.0320kPa)
Radial: 1.24in/s 31.496mm/s @ 14.6Hz
Vertical: **1.28in/s 32.512mm/s @ 25.6Hz**
Transverse: 1.16in/s 29.464mm/s @ 64.0Hz

Graph Information

Duration: 0.000s To: 2.000s
Acoustic Scale:
130dB 0.63Mb (0.158Mb/div)
Seismic Scale:
1.28in/s (0.320in/s/div) 32.51mm/s (8.128mm/s/div)
Time Line Intervals at: 0.25 s



Fourier Analysis (Amplitude Spectrum - Box Window)



NONEX
Trenching Demonstration
Henderson, Nevada
Shot 1 - 15.9 g/cf
20 ft
perpendicular array

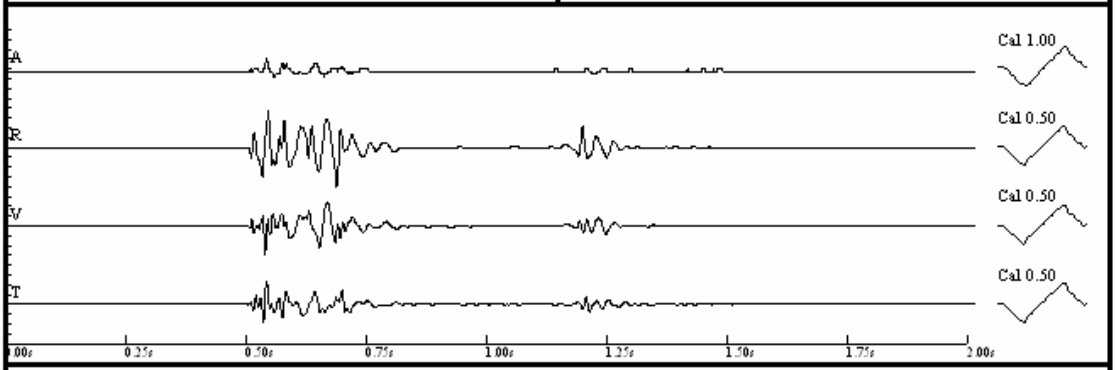
File Name: 01258003.DTB
Number: 003
Date: 9/6/2006
Time: 08:45
Serial Number: 1258
Seismic Trigger: 0.0200 in/s 0.5080 mm/s
Acoustic Trigger: 132 dB
Sample Rate: 1024
Record Duration: 6.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 2x
Battery: 6.5

Amplitudes and Frequencies

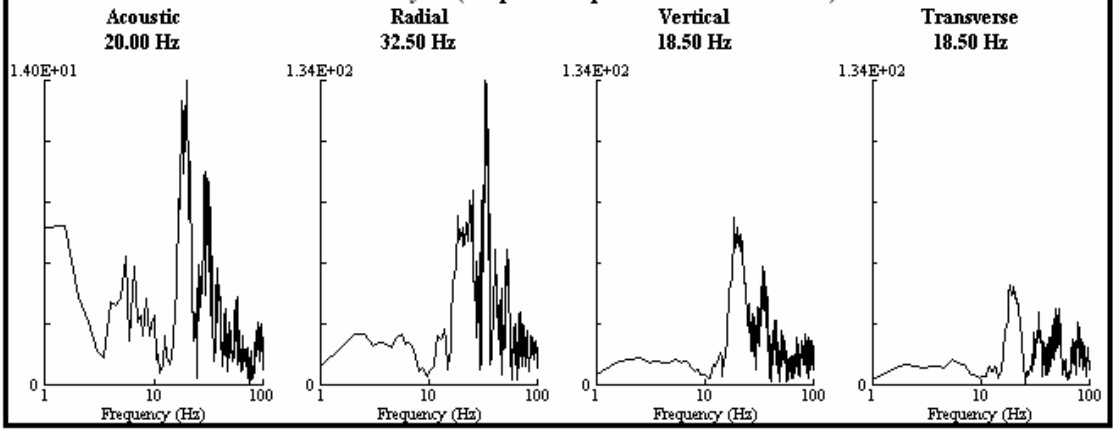
Acoustic: 118 dB @ 73.1 Hz
(0.16Mb 0.0023psi 0.0160kPa)
Radial: **0.66in/s 16.764mm/s @ 36.5Hz**
Vertical: 0.495in/s 12.573mm/s @ 64.0Hz
Transverse: 0.37in/s 9.398mm/s @ 56.8Hz

Graph Information

Duration: 0.000s To: 2.000s
Acoustic Scale:
130dB 0.63Mb (0.158Mb/div)
Seismic Scale:
0.66in/s (0.165in/s/div) 16.76mm/s (4.191mm/s/div)
Time Line Intervals at: 0.25 s



Fourier Analysis (Amplitude Spectrum - Box Window)



NONEX
Trenching Demonstration
Henderson, Nevada
Shot 1 - 15.9 g/cf
30 ft
perpendicular array

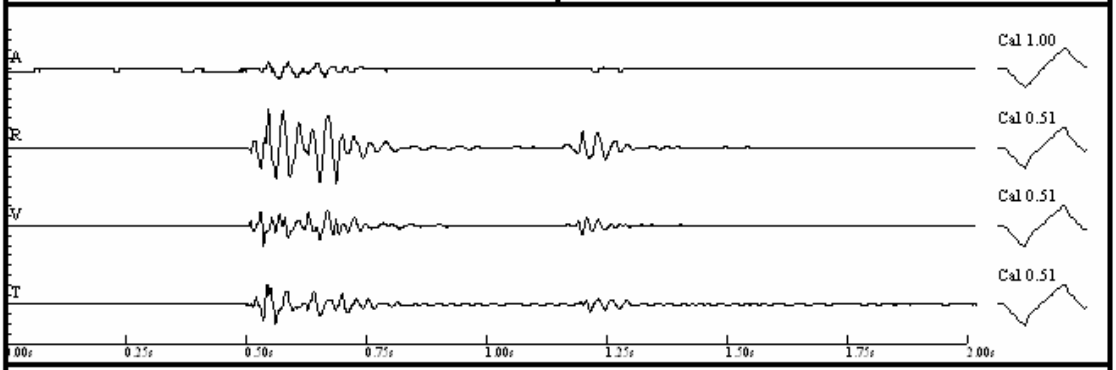
File Name: 00930017.DTB
Number: 017
Date: 9/6/2006
Time: 08:45
Serial Number: 930
Seismic Trigger: 0.0200 in/s 0.5080 mm/s
Acoustic Trigger: 131 dB
Sample Rate: 1024
Record Duration: 6.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 2x
Battery: 6.4

Amplitudes and Frequencies

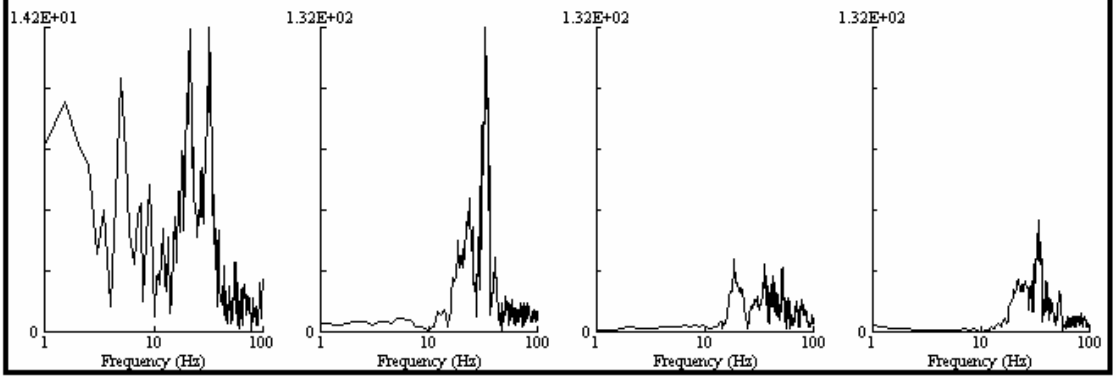
Acoustic: 118 dB @ 30.1 Hz
(0.16Mb 0.0023psi 0.0160kPa)
Radial: **0.435in/s 11.049mm/s @ 34.1Hz**
Vertical: 0.22in/s 5.588mm/s @ 30.1Hz
Transverse: 0.215in/s 5.461mm/s @ 32.0Hz

Graph Information

Duration: 0.000s To: 2.000s
Acoustic Scale:
130dB 0.63Mb (0.158Mb/div)
Seismic Scale:
0.44in/s (0.110in/s/div) 11.18mm/s (2.794mm/s/div)
Time Line Intervals at: 0.25 s



Fourier Analysis (Amplitude Spectrum - Box Window)



NONEX
Trenching Demonstration
Henderson, Nevada
Shot 1 - 15.9 g/cf
50 ft
perpendicular array

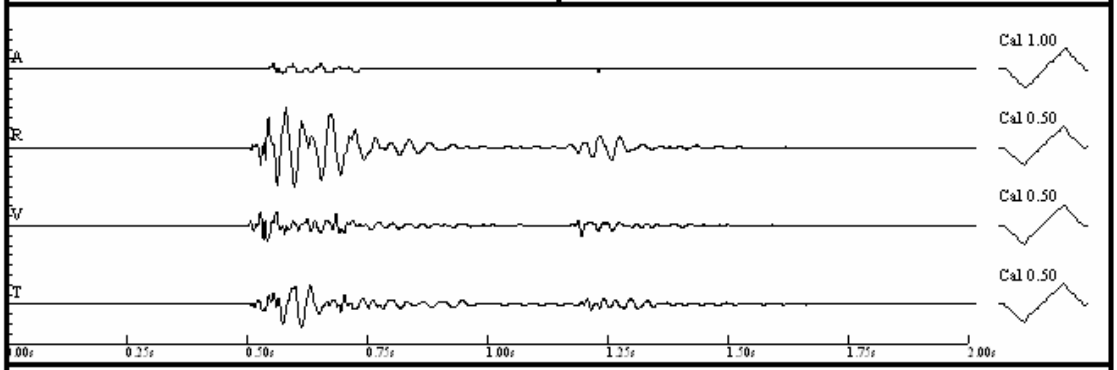
File Name: 02276002.DTB
Number: 002
Date: 9/6/2006
Time: 08:45
Serial Number: 2276
Seismic Trigger: 0.0200 in/s 0.5080 mm/s
Acoustic Trigger: 131 dB
Sample Rate: 1024
Record Duration: 6.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 2x
Battery: 6.5

Amplitudes and Frequencies

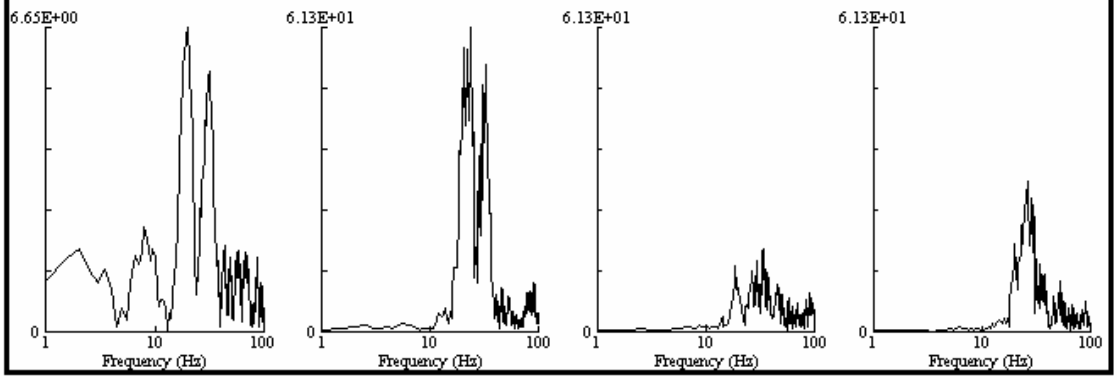
Acoustic: 112 dB @ 0.0 Hz
(0.08Mb 0.0012psi 0.0080kPa)
Radial: **0.25in/s 6.35mm/s @ 26.9Hz**
Vertical: 0.10in/s 2.54mm/s @ 46.5Hz
Transverse: 0.145in/s 3.683mm/s @ 28.4Hz

Graph Information

Duration: 0.000s To: 2.000s
Acoustic Scale:
130dB 0.63Mb (0.158Mb/div)
Seismic Scale:
0.25in/s (0.063in/s/div) 6.35mm/s (1.588mm/s/div)
Time Line Intervals at: 0.25 s



Fourier Analysis (Amplitude Spectrum - Box Window)



NONEX
Trenching Demonstration
Henderson, Nevada
Shot 2 - 28.6 g/cf
5 ft
north array - perpendicular

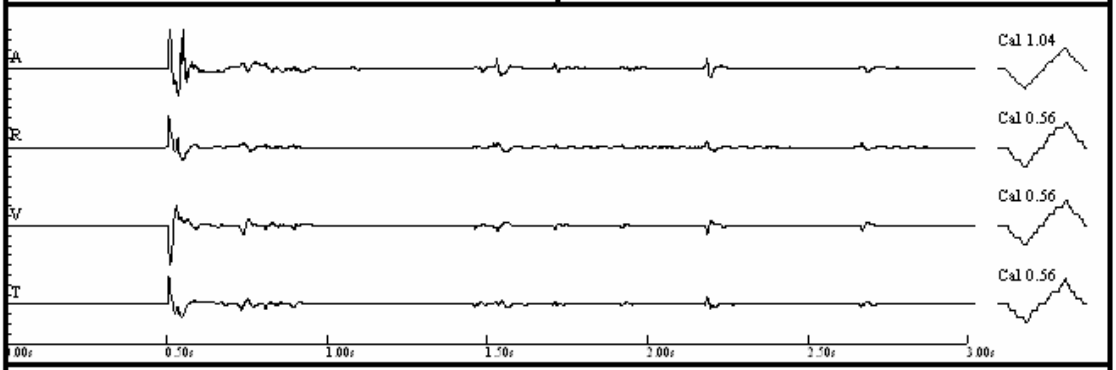
File Name: 02279002.DTB
Number: 002
Date: 9/6/2006
Time: 12:23
Serial Number: 2279
Seismic Trigger: 0.0800 in/s 2.0320 mm/s
Acoustic Trigger: 132 dB
Sample Rate: 1024
Record Duration: 6.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 1x
Battery: 6.5

Amplitudes and Frequencies

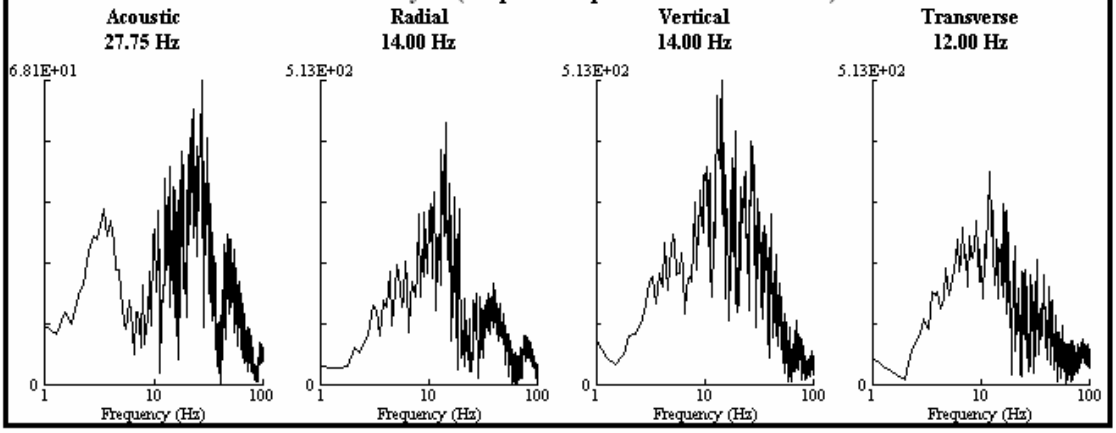
Acoustic: 136 dB @ 34.1 Hz
(1.32Mb 0.0191psi 0.1320kPa)
Radial: 8.24in/s 209.296mm/s @ 28.4Hz
Vertical: **10.56in/s 268.224mm/s @ 28.4Hz**
Transverse: 7.36in/s 186.944mm/s @ 34.1Hz

Graph Information

Duration: 0.000s To: 3.000s
Acoustic Scale:
136dB 1.26Mb (0.315Mb/div)
Seismic Scale:
10.50in/s (2.625in/s/div) 266.70mm/s (66.675mm/s/div)
Time Line Intervals at: 0.50 s



Fourier Analysis (Amplitude Spectrum - Box Window)



NONEX
Trenching Demonstration
Henderson, Nevada
Shot 2 - 28.6 g/cf
10 ft
north array - perpendicular

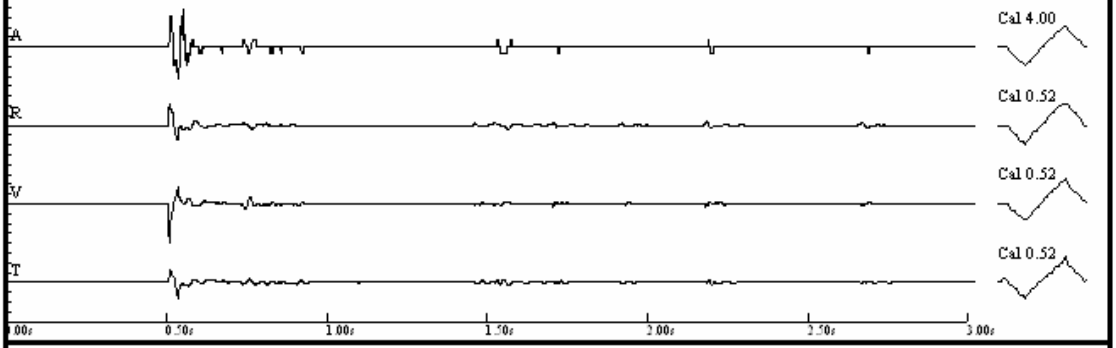
File Name: 03570007.DTB
Number: 007
Date: 9/6/2006
Time: 12:25
Serial Number: 3570
Seismic Trigger: 0.0800 in/s 2.0320 mm/s
Acoustic Trigger: 130 dB
Sample Rate: 1024
Record Duration: 6.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 1x
Battery: 6.2

Amplitudes and Frequencies

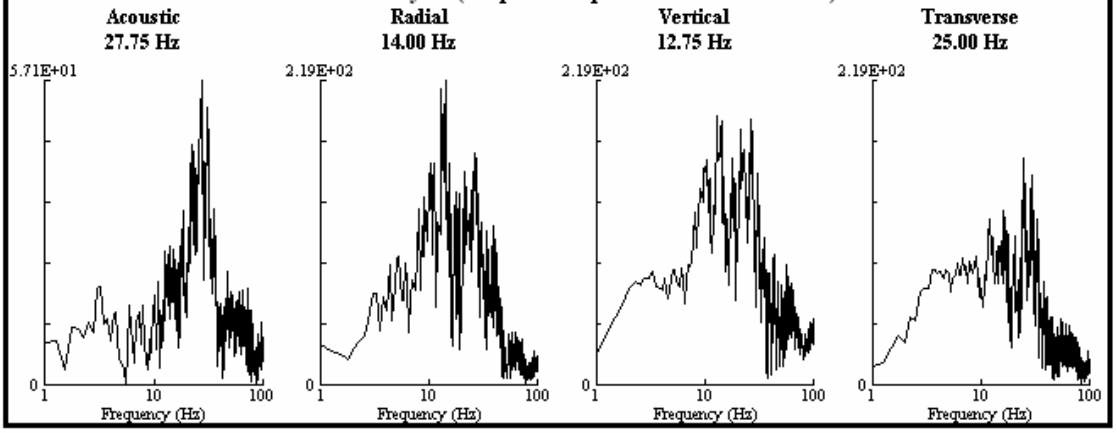
Acoustic: 134 dB @ 34.1 Hz
(0.96Mb 0.0139psi 0.0960kPa)
Radial: 3.68in/s 93.472mm/s @ 26.9Hz
Vertical: **7.04in/s 178.816mm/s @ 28.4Hz**
Transverse: 3.00in/s 76.20mm/s @ 9.8Hz

Graph Information

Duration: 0.000s To: 3.000s
Acoustic Scale:
134dB 1.00Mb (0.251Mb/div)
Seismic Scale:
7.04in/s (1.760in/s/div) 178.82mm/s (44.704mm/s/div)
Time Line Intervals at: 0.50 s



Fourier Analysis (Amplitude Spectrum - Box Window)



NONEX
Trenching Demonstration
Henderson, Nevada
Shot 2 - 28.6 g/cf
20 ft
north array - perpendicular

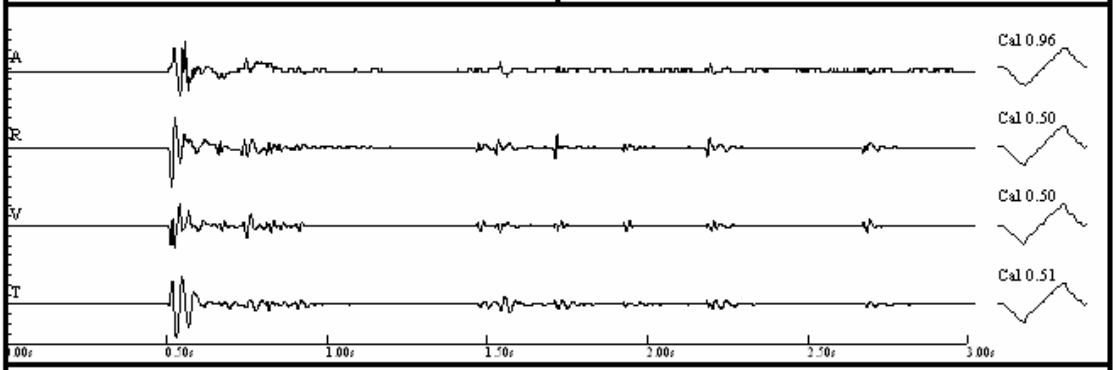
File Name: 00930019.DTB
Number: 019
Date: 9/6/2006
Time: 12:24
Serial Number: 930
Seismic Trigger: 0.0300 in/s 0.7620 mm/s
Acoustic Trigger: 131 dB
Sample Rate: 1024
Record Duration: 6.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 2x
Battery: 6.4

Amplitudes and Frequencies

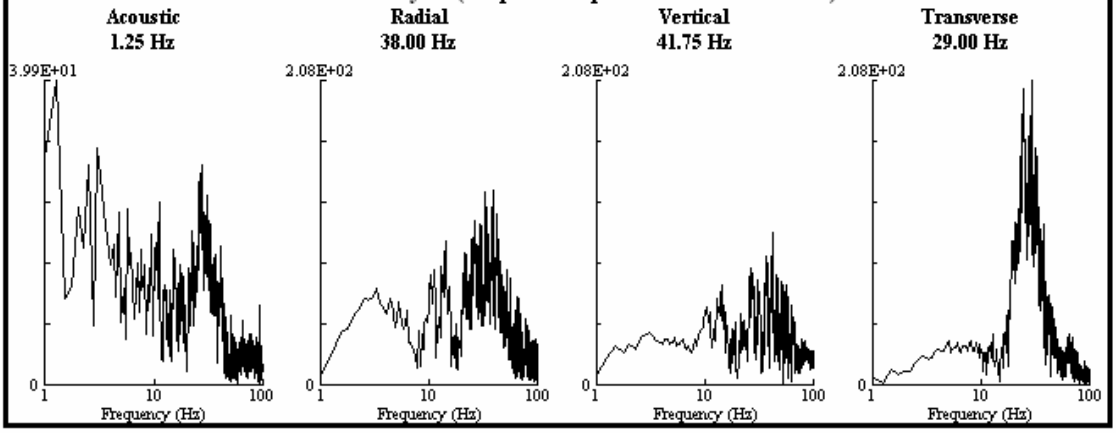
Acoustic: 127 dB @ 128.0 Hz
(0.44Mb 0.0064psi 0.0440kPa)
Radial: **1.36in/s 34.544mm/s @ 28.4Hz**
Vertical: 0.75in/s 19.05mm/s @ 39.3Hz
Transverse: 1.17in/s 29.718mm/s @ 28.4Hz

Graph Information

Duration: 0.000s To: 3.000s
Acoustic Scale:
130dB 0.63Mb (0.158Mb/div)
Seismic Scale:
1.36in/s (0.340in/s/div) 34.54mm/s (8.636mm/s/div)
Time Line Intervals at: 0.50 s



Fourier Analysis (Amplitude Spectrum - Box Window)



NONEX
Trenching Demonstration
Henderson, Nevada
Shot 2 - 28.6 g/cf
30 ft
north array - perpendicular

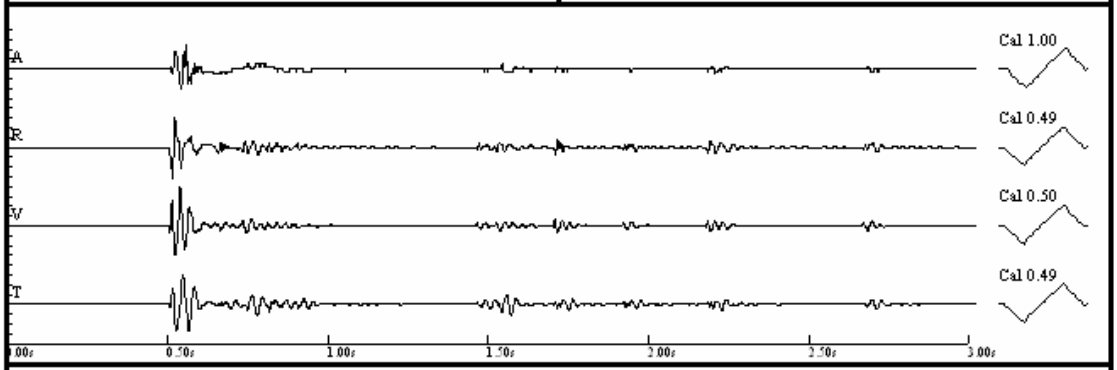
File Name: 02241010.DTB
Number: 010
Date: 9/6/2006
Time: 12:23
Serial Number: 2241
Seismic Trigger: 0.0300 in/s 0.7620 mm/s
Acoustic Trigger: 125 dB
Sample Rate: 1024
Record Duration: 6.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 2x
Battery: 6.6

Amplitudes and Frequencies

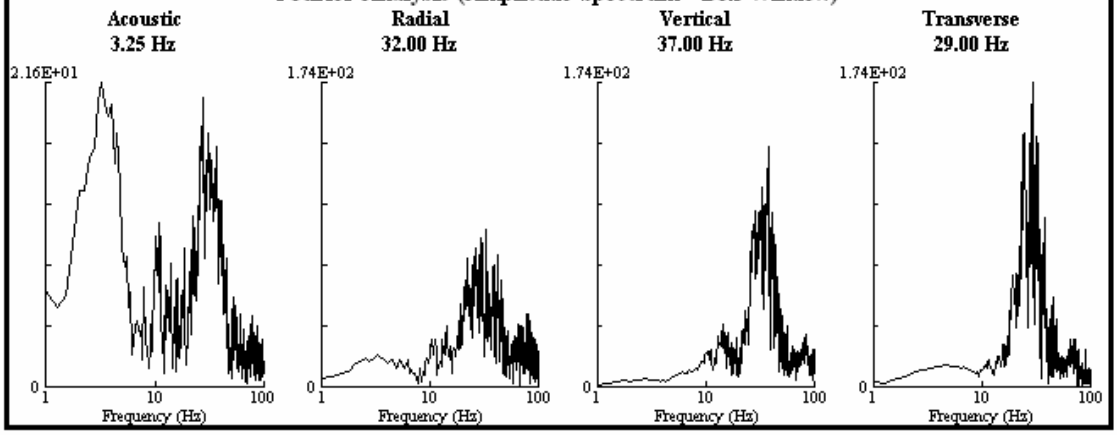
Acoustic: 126 dB @ 56.8 Hz
(0.40Mb 0.0058psi 0.0400kPa)
Radial: 0.80in/s 20.32mm/s @ 30.1Hz
Vertical: **1.00in/s 25.40mm/s @ 34.1Hz**
Transverse: 0.76in/s 19.304mm/s @ 28.4Hz

Graph Information

Duration: 0.000s To: 3.000s
Acoustic Scale:
130dB 0.63Mb (0.158Mb/div)
Seismic Scale:
1.00in/s (0.250in/s/div) 25.40mm/s (6.350mm/s/div)
Time Line Intervals at: 0.50 s



Fourier Analysis (Amplitude Spectrum - Box Window)



NONEX
Trenching Demonstration
Henderson, Nevada
Shot 2 - 28.6 g/cf
40 ft
north array - perpendicular

File Name: 02276004.DTB
Number: 004
Date: 9/6/2006
Time: 12:25
Serial Number: 2276
Seismic Trigger: 0.0300 in/s 0.7620 mm/s
Acoustic Trigger: 131 dB
Sample Rate: 1024
Record Duration: 6.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 2x
Battery: 6.6

Amplitudes and Frequencies

Acoustic: 126 dB @ 34.1 Hz
(0.40Mb 0.0058psi 0.0400kPa)

Radial: 0.355in/s 9.017mm/s @ 26.9Hz

Vertical: **0.84in/s 21.336mm/s @ 32.0Hz**

Transverse: 0.405in/s 10.287mm/s @ 26.9Hz

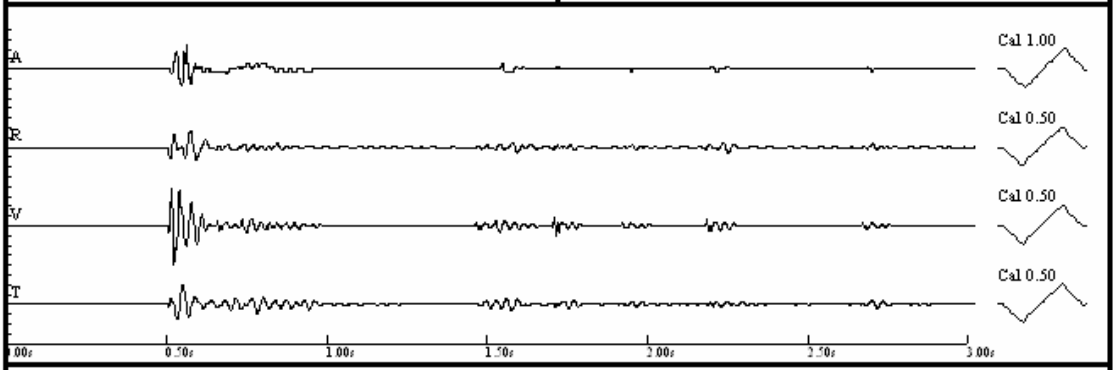
Graph Information

Duration: 0.000s To: 3.000s

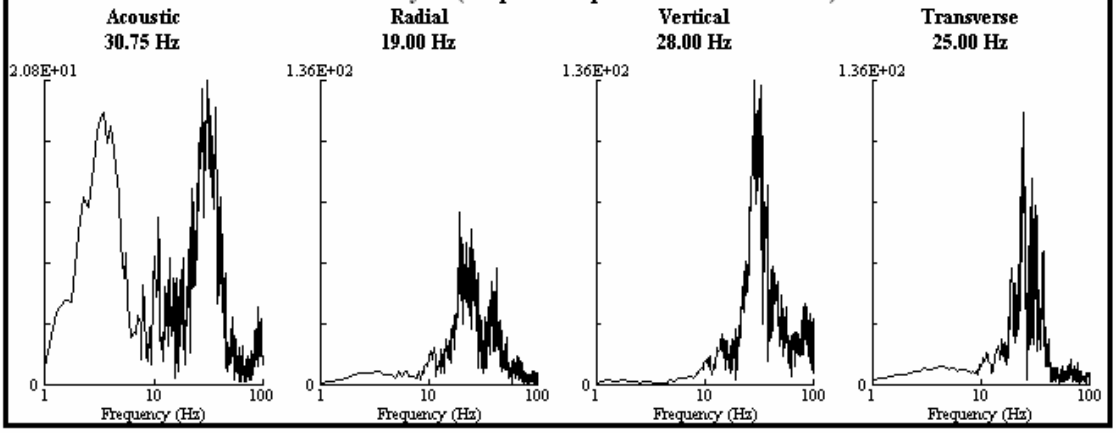
Acoustic Scale:
130dB 0.63Mb (0.158Mb/div)

Seismic Scale:
0.84in/s (0.210in/s/div) 21.34mm/s (5.334mm/s/div)

Time Line Intervals at: 0.50 s



Fourier Analysis (Amplitude Spectrum - Box Window)



NONEX
Trenching Demonstration
Henderson, Nevada
Shot 2 - 28.6 g/cf
50 ft
north array - perpendicular

File Name: 01258006.DTB
Number: 006
Date: 9/6/2006
Time: 12:25
Serial Number: 1258
Seismic Trigger: 0.0200 in/s 0.5080 mm/s
Acoustic Trigger: 132 dB
Sample Rate: 1024
Record Duration: 6.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 2x
Battery: 6.5

Amplitudes and Frequencies

Acoustic: 120 dB @ 128.0 Hz
(0.20Mb 0.0029psi 0.0200kPa)

Radial: 0.225in/s 5.715mm/s @ 22.2Hz

Vertical: **0.57in/s 14.478mm/s @ 39.3Hz**

Transverse: 0.155in/s 3.937mm/s @ 28.4Hz

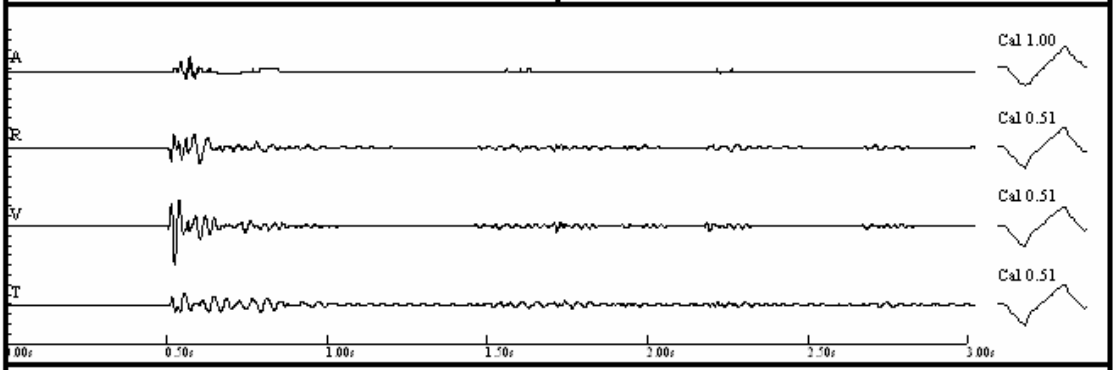
Graph Information

Duration: 0.000s To: 3.000s

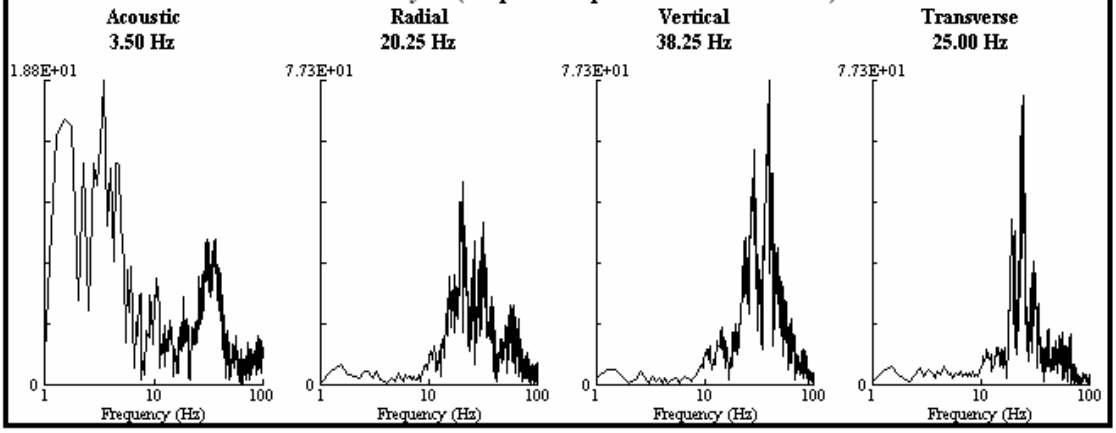
Acoustic Scale:
130dB 0.63Mb (0.158Mb/div)

Seismic Scale:
0.57in/s (0.143in/s/div) 14.48mm/s (3.620mm/s/div)

Time Line Intervals at: 0.50 s



Fourier Analysis (Amplitude Spectrum - Box Window)



NONEX
Trenching Demonstration
Henderson, Nevada
Shot 2 - 28.6 g/cf
10 ft
south array - perpendicular

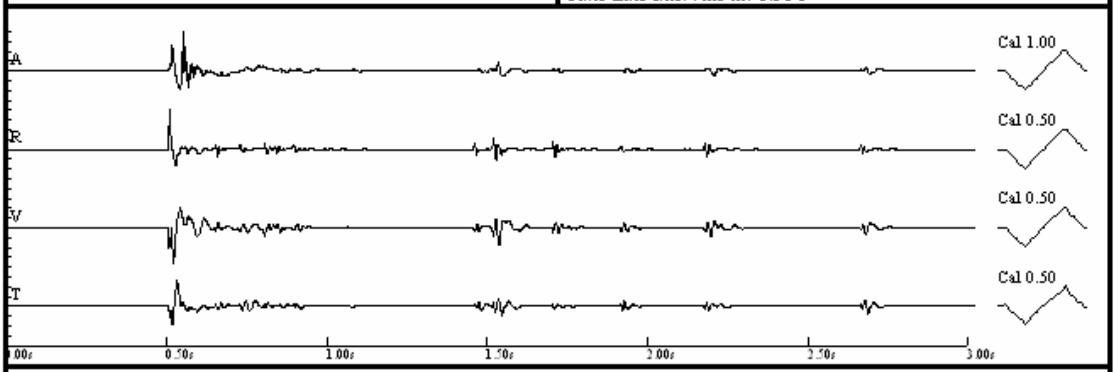
File Name: 01792031.DTB
Number: 031
Date: 9/6/2006
Time: 12:25
Serial Number: 1792
Seismic Trigger: 0.0400 in/s 1.0160 mm/s
Acoustic Trigger: 130 dB
Sample Rate: 1024
Record Duration: 6.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 1x
Battery: 6.4

Amplitudes and Frequencies

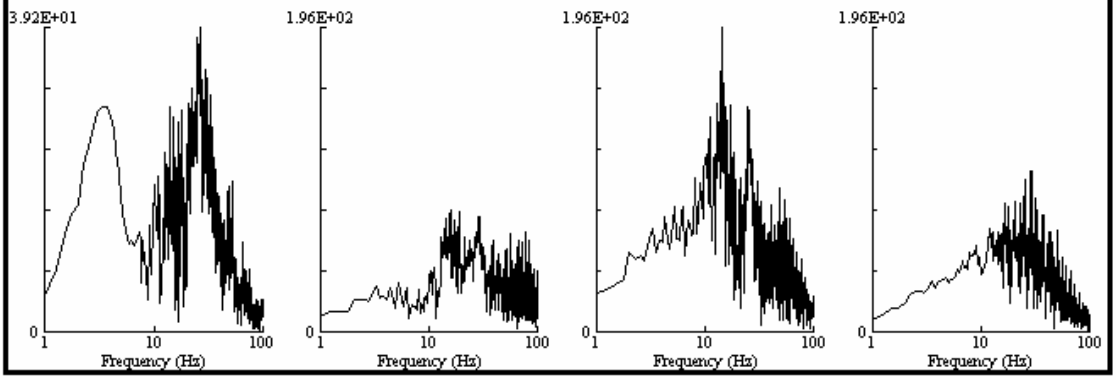
Acoustic: 135 dB @ 73.1 Hz
(1.12Mb 0.0162psi 0.1120kPa)
Radial: **3.04in/s 77.216mm/s @ 46.5Hz**
Vertical: 2.72in/s 69.088mm/s @ 32.0Hz
Transverse: 2.02in/s 51.308mm/s @ 19.6Hz

Graph Information

Duration: 0.000s To: 3.000s
Acoustic Scale:
135dB 1.12Mb (0.281Mb/div)
Seismic Scale:
3.04in/s (0.760in/s/div) 77.22mm/s (19.304mm/s/div)
Time Line Intervals at: 0.50 s



Fourier Analysis (Amplitude Spectrum - Box Window)



NONEX
Trenching Demonstration
Henderson, Nevada
Shot 2 - 28.6 g/cf
30 ft
south array - perpendicular

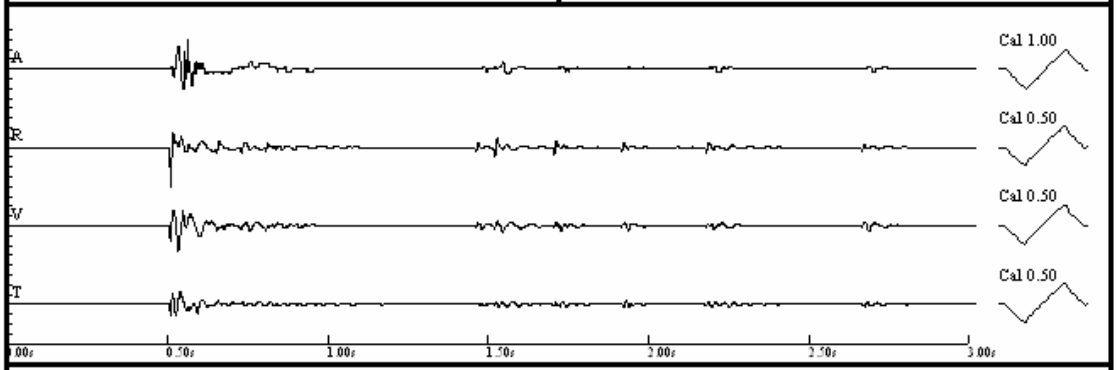
File Name: 03047035.DTB
Number: 035
Date: 9/6/2006
Time: 12:24
Serial Number: 3047
Seismic Trigger: 0.0300 in/s 0.7620 mm/s
Acoustic Trigger: 128 dB
Sample Rate: 1024
Record Duration: 6.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 2x
Battery: 6.5

Amplitudes and Frequencies

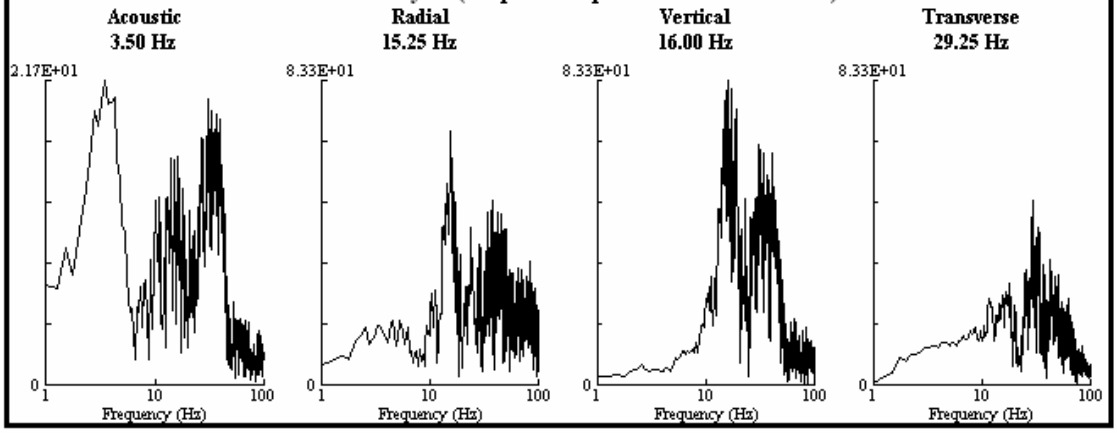
Acoustic: 128 dB @ 128.0 Hz
(0.48Mb 0.0070psi 0.0480kPa)
Radial: **0.98in/s 24.892mm/s @ 46.5Hz**
Vertical: 0.62in/s 15.748mm/s @ 32.0Hz
Transverse: 0.315in/s 8.001mm/s @ 24.3Hz

Graph Information

Duration: 0.000s To: 3.000s
Acoustic Scale:
130dB 0.63Mb (0.158Mb/div)
Seismic Scale:
0.98in/s (0.245in/s/div) 24.89mm/s (6.223mm/s/div)
Time Line Intervals at: 0.50 s



Fourier Analysis (Amplitude Spectrum - Box Window)



NONEX
Trenching Demonstration
Henderson, Nevada
Shot 2 - 28.6 g/cf
50 ft
south array - perpendicular

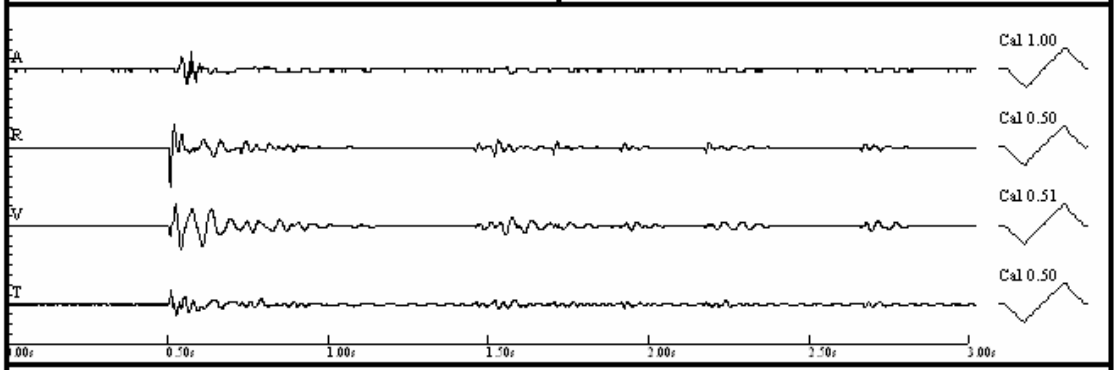
File Name: 03487030.DTB
Number: 030
Date: 9/6/2006
Time: 12:24
Serial Number: 3487
Seismic Trigger: 0.0300 in/s 0.7620 mm/s
Acoustic Trigger: 128 dB
Sample Rate: 1024
Record Duration: 6.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 2x
Battery: 6.4

Amplitudes and Frequencies

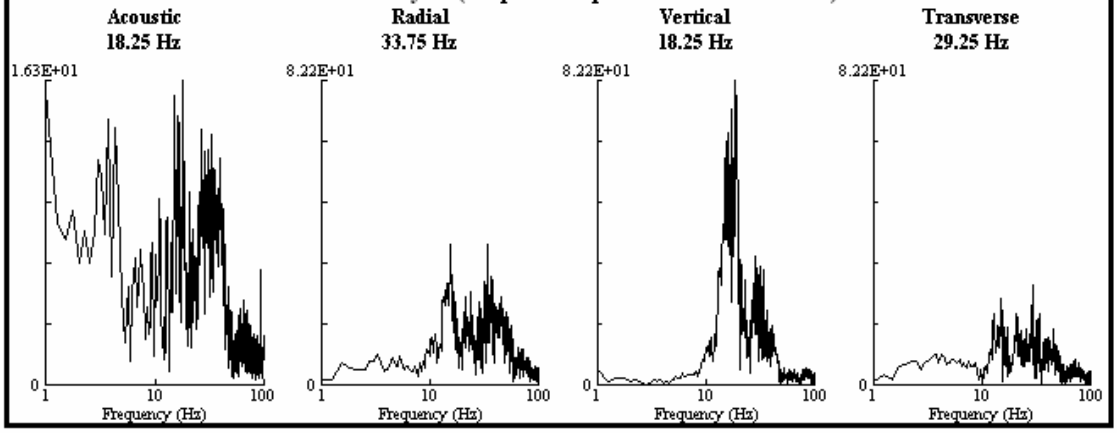
Acoustic: 123 dB @ 128.0 Hz
(0.28Mb 0.0041psi 0.0280kPa)
Radial: **0.39in/s 9.906mm/s @ 39.3Hz**
Vertical: 0.24in/s 6.096mm/s @ 20.4Hz
Transverse: 0.14in/s 3.556mm/s @ 46.5Hz

Graph Information

Duration: 0.000s To: 3.000s
Acoustic Scale:
130dB 0.63Mb (0.158Mb/div)
Seismic Scale:
0.39in/s (0.098in/s/div) 9.91mm/s (2.477mm/s/div)
Time Line Intervals at: 0.50 s



Fourier Analysis (Amplitude Spectrum - Box Window)



NONEX
Trenching Demonstration
Henderson, Nevada
Shot 3 - 45.1 g/cf
5 ft
south array - perpendicular

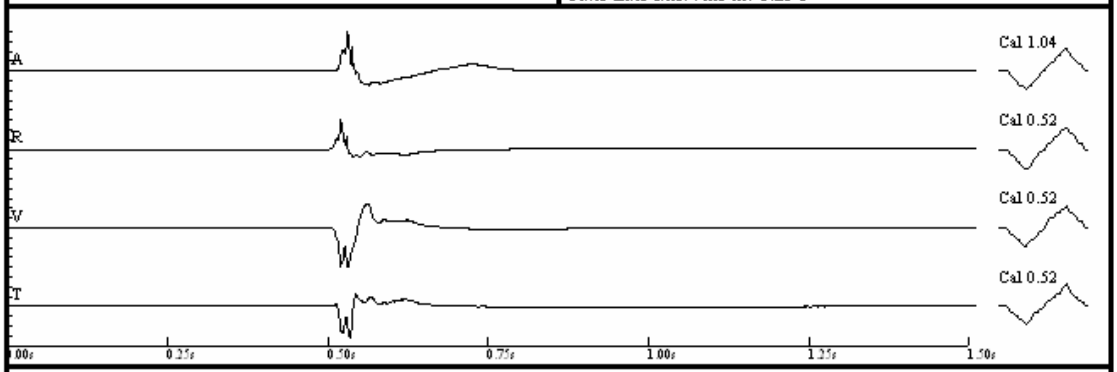
File Name: 02279005.DTB
Number: 005
Date: 9/6/2006
Time: 15:05
Serial Number: 2279
Seismic Trigger: 0.0800 in/s 2.0320 mm/s
Acoustic Trigger: 132 dB
Sample Rate: 1024
Record Duration: 6.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 1x
Battery: 6.5

Amplitudes and Frequencies

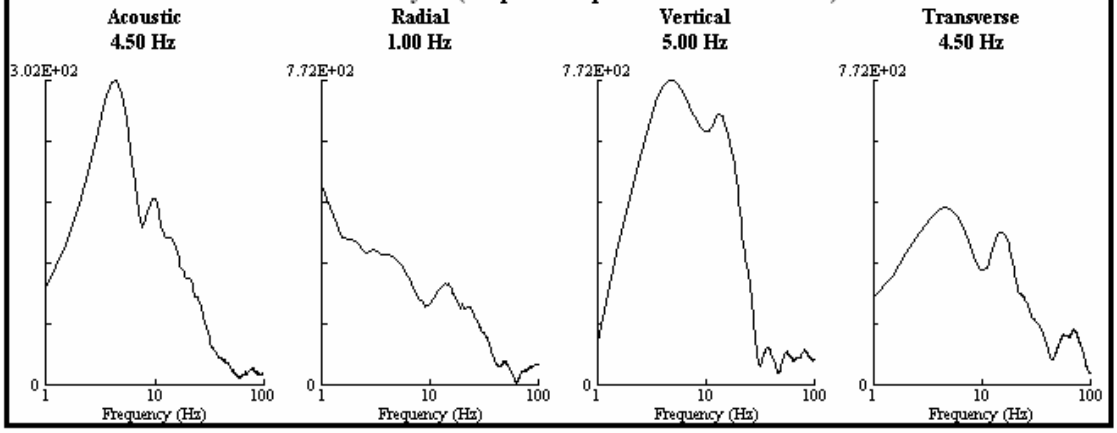
Acoustic: 148 dB @ 3.2 Hz
(4.96Mb 0.0719psi 0.4959kPa)
Radial: 10.56in/s 268.224mm/s @ 18.2Hz
Vertical: **14.08in/s 357.632mm/s @ 12.1Hz**
Transverse: 11.36in/s 288.544mm/s @ 20.4Hz

Graph Information

Duration: 0.000s To: 1.500s
Acoustic Scale:
148dB 5.02Mb (1.256Mb/div)
Seismic Scale:
14.00in/s (3.500in/s/div) 355.60mm/s (88.900mm/s/div)
Time Line Intervals at: 0.25 s



Fourier Analysis (Amplitude Spectrum - Box Window)



NONEX
Trenching Demonstration
Henderson, Nevada
Shot 3 - 45.1 g/cf
10 ft
south array - perpendicular

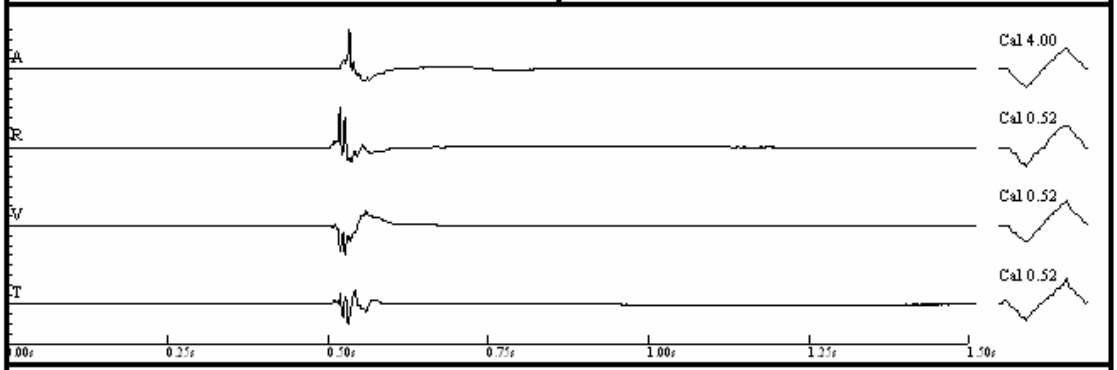
File Name: 03570009.DTB
Number: 009
Date: 9/6/2006
Time: 15:07
Serial Number: 3570
Seismic Trigger: 0.0800 in/s 2.0320 mm/s
Acoustic Trigger: 130 dB
Sample Rate: 1024
Record Duration: 6.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 1x
Battery: 6.2

Amplitudes and Frequencies

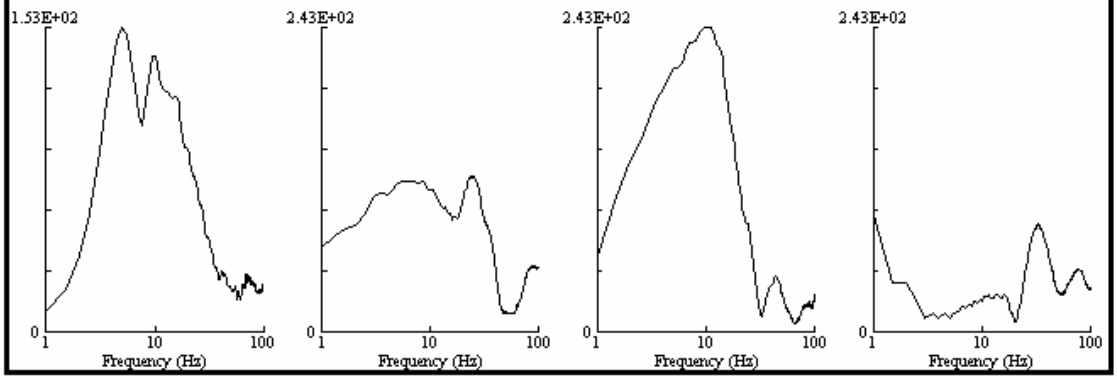
Acoustic: 150 dB @ 28.4 Hz
(6.56Mb 0.0951psi 0.6559kPa)
Radial: **8.00in/s 203.20mm/s @ 30.1Hz**
Vertical: 5.76in/s 146.304mm/s @ 15.0Hz
Transverse: 3.92in/s 99.568mm/s @ 64.0Hz

Graph Information

Duration: 0.000s To: 1.500s
Acoustic Scale:
150dB 6.32Mb (1.581Mb/div)
Seismic Scale:
8.00in/s (2.000in/s/div) 203.20mm/s (50.800mm/s/div)
Time Line Intervals at: 0.25 s



Fourier Analysis (Amplitude Spectrum - Box Window)



NONEX
Trenching Demonstration
Henderson, Nevada
Shot 3 - 45.1 g/cf
20 ft
south array - perpendicular

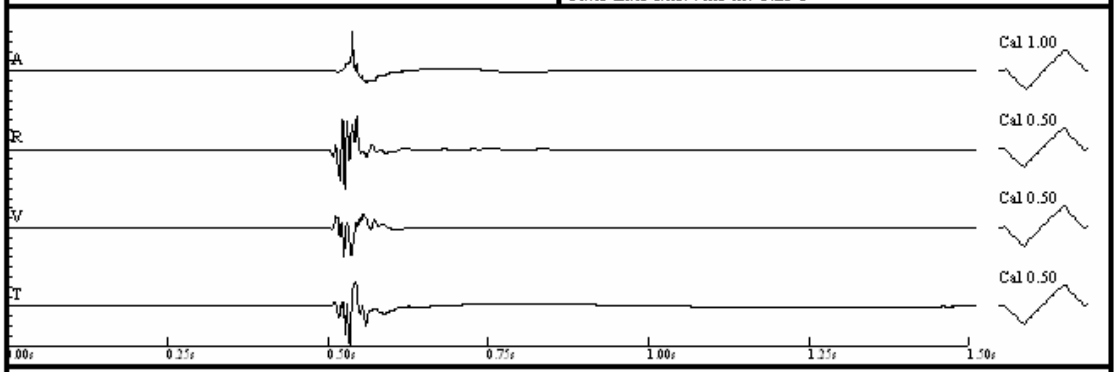
File Name: 03487032.DTB
Number: 032
Date: 9/6/2006
Time: 15:06
Serial Number: 3487
Seismic Trigger: 0.0300 in/s 0.7620 mm/s
Acoustic Trigger: 128 dB
Sample Rate: 1024
Record Duration: 6.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 2x
Battery: 6.4

Amplitudes and Frequencies

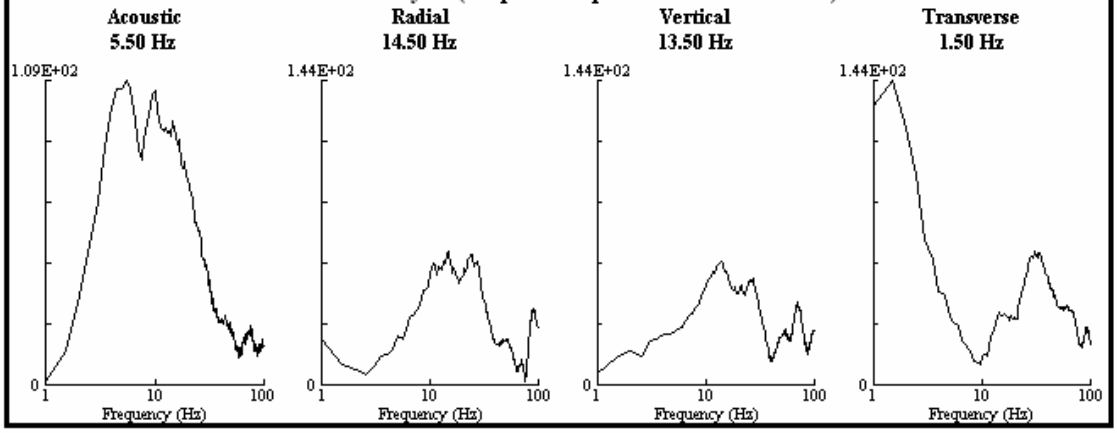
Acoustic: 148 dB @ 20.4 Hz
(4.96Mb 0.0719psi 0.4959kPa)
Radial: **1.60in/s 40.64mm/s @ 102.4Hz**
Vertical: 1.20in/s 30.48mm/s @ 85.3Hz
Transverse: 1.56in/s 39.624mm/s @ 85.3Hz

Graph Information

Duration: 0.000s To: 1.500s
Acoustic Scale:
148dB 5.02Mb (1.256Mb/div)
Seismic Scale:
1.60in/s (0.400in/s/div) 40.64mm/s (10.160mm/s/div)
Time Line Intervals at: 0.25 s



Fourier Analysis (Amplitude Spectrum - Box Window)



NONEX
Trenching Demonstration
Henderson, Nevada
Shot 3 - 45.1 g/cf
30 ft
south array - perpendicular

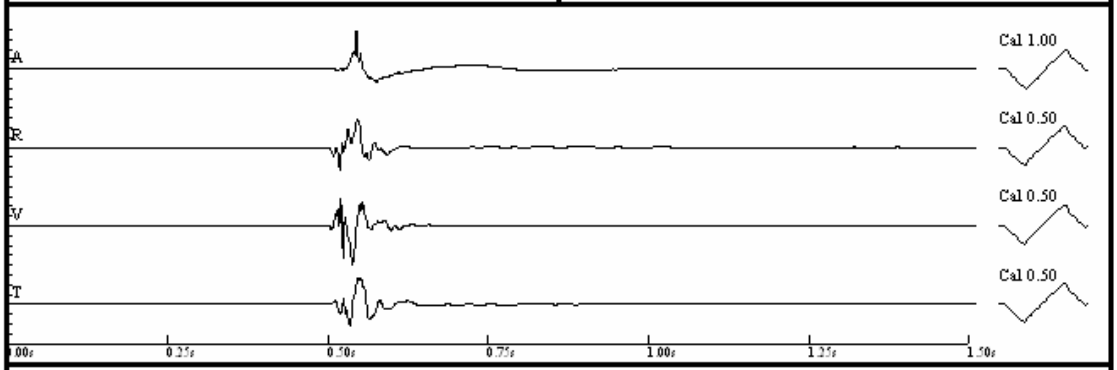
File Name: 03047037.DTB
Number: 037
Date: 9/6/2006
Time: 15:06
Serial Number: 3047
Seismic Trigger: 0.0300 in/s 0.7620 mm/s
Acoustic Trigger: 128 dB
Sample Rate: 1024
Record Duration: 6.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 2x
Battery: 6.5

Amplitudes and Frequencies

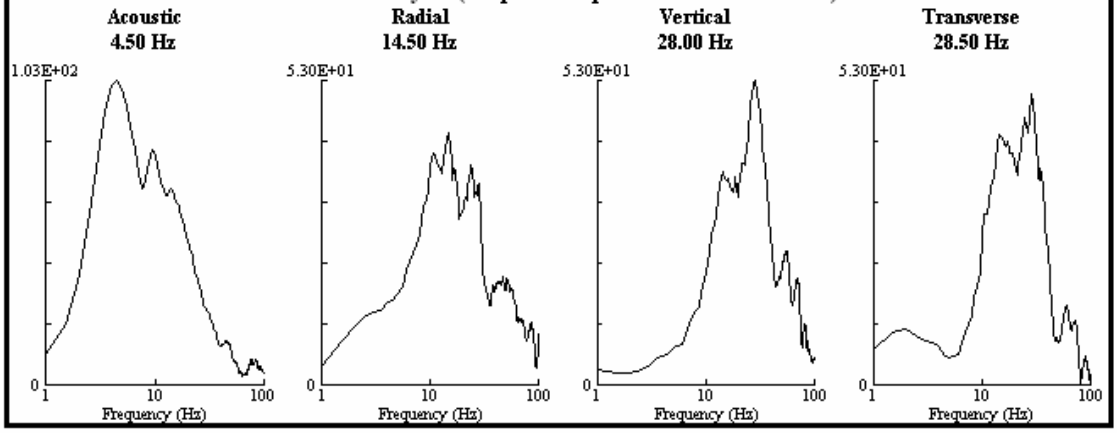
Acoustic: 143 dB @ 18.9 Hz
(2.76Mb 0.0400psi 0.2759kPa)
Radial: 0.62in/s 15.748mm/s @ 19.6Hz
Vertical: **0.88in/s 22.352mm/s @ 30.1Hz**
Transverse: 0.60in/s 15.24mm/s @ 23.2Hz

Graph Information

Duration: 0.000s To: 1.500s
Acoustic Scale:
143dB 2.83Mb (0.706Mb/div)
Seismic Scale:
0.88in/s (0.220in/s/div) 22.35mm/s (5.588mm/s/div)
Time Line Intervals at: 0.25 s



Fourier Analysis (Amplitude Spectrum - Box Window)



NONEX
Trenching Demonstration
Henderson, Nevada
Shot 3 - 45.1 g/cf
50 ft
south array - perpendicular

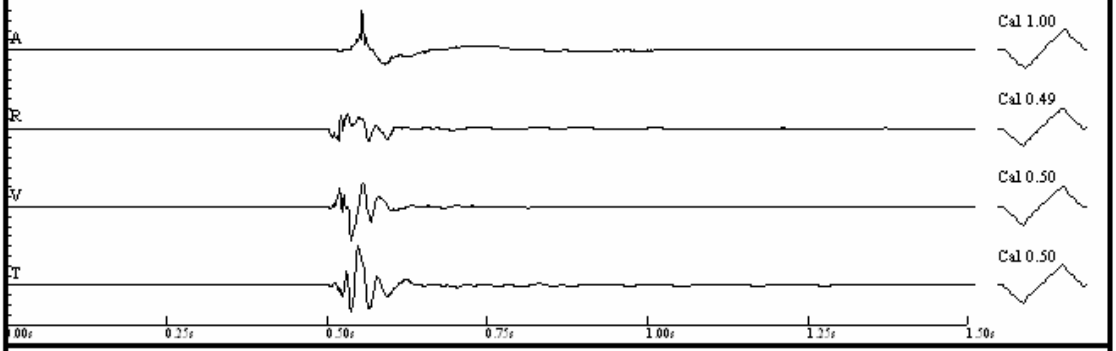
File Name: 02241015.DTB
Number: 015
Date: 9/6/2006
Time: 15:04
Serial Number: 2241
Seismic Trigger: 0.0300 in/s 0.7620 mm/s
Acoustic Trigger: 125 dB
Sample Rate: 1024
Record Duration: 6.0 Seconds
Pre-Trigger: 0.50 Seconds
Sensor Gain: 2x
Battery: 6.6

Amplitudes and Frequencies

Acoustic: 138 dB @ 14.6 Hz
(1.56Mb 0.0226psi 0.1560kPa)
Radial: 0.165in/s 4.191mm/s @ 14.6Hz
Vertical: 0.405in/s 10.287mm/s @ 30.1Hz
Transverse: **0.465in/s 11.811mm/s @ 30.1Hz**

Graph Information

Duration: 0.000s To: 1.500s
Acoustic Scale:
138dB 1.59Mb (0.397Mb/div)
Seismic Scale:
0.47in/s (0.118in/s/div) 11.94mm/s (2.985mm/s/div)
Time Line Intervals at: 0.25 s



Fourier Analysis (Amplitude Spectrum - Box Window)