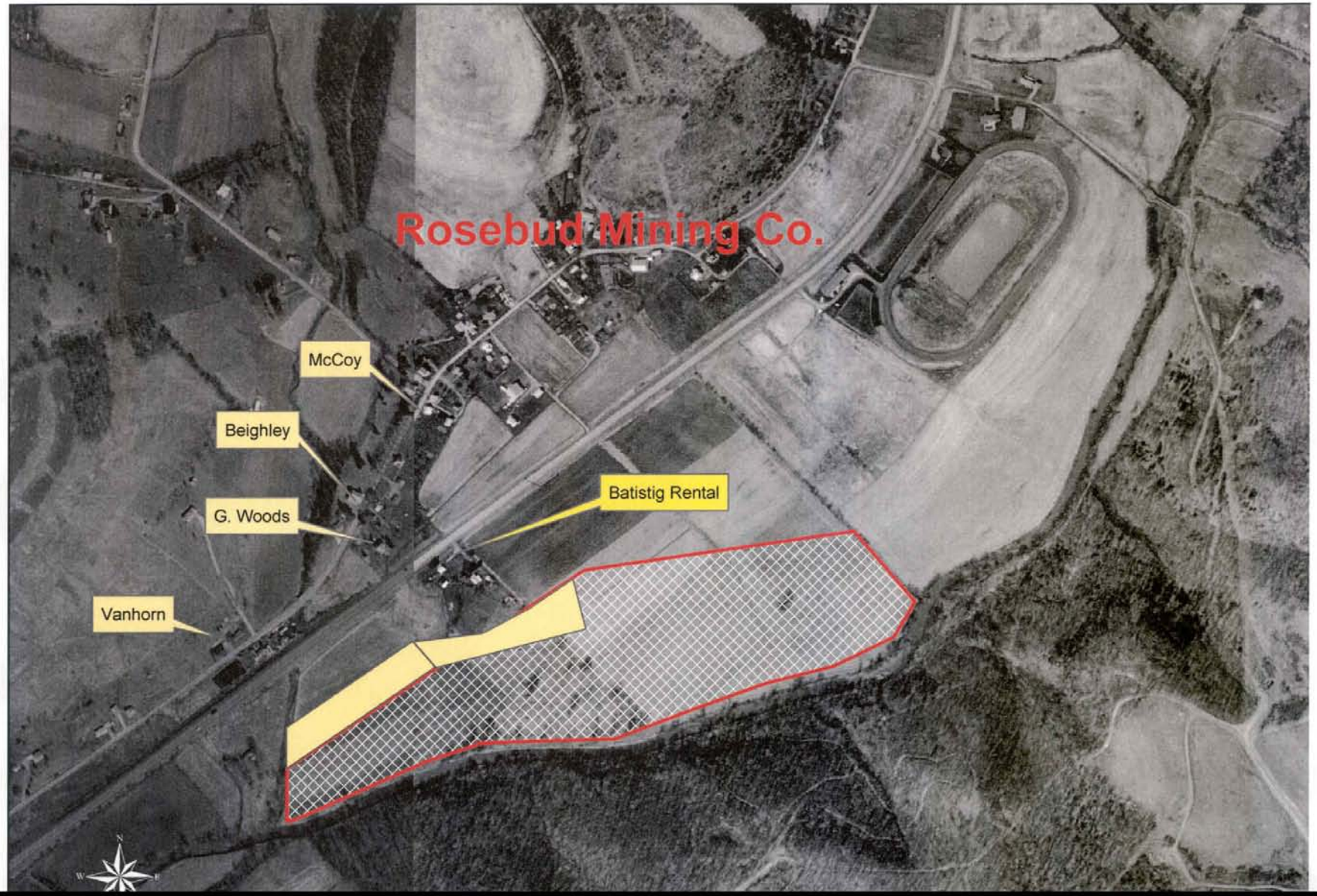
Electronic Detonator Case Study

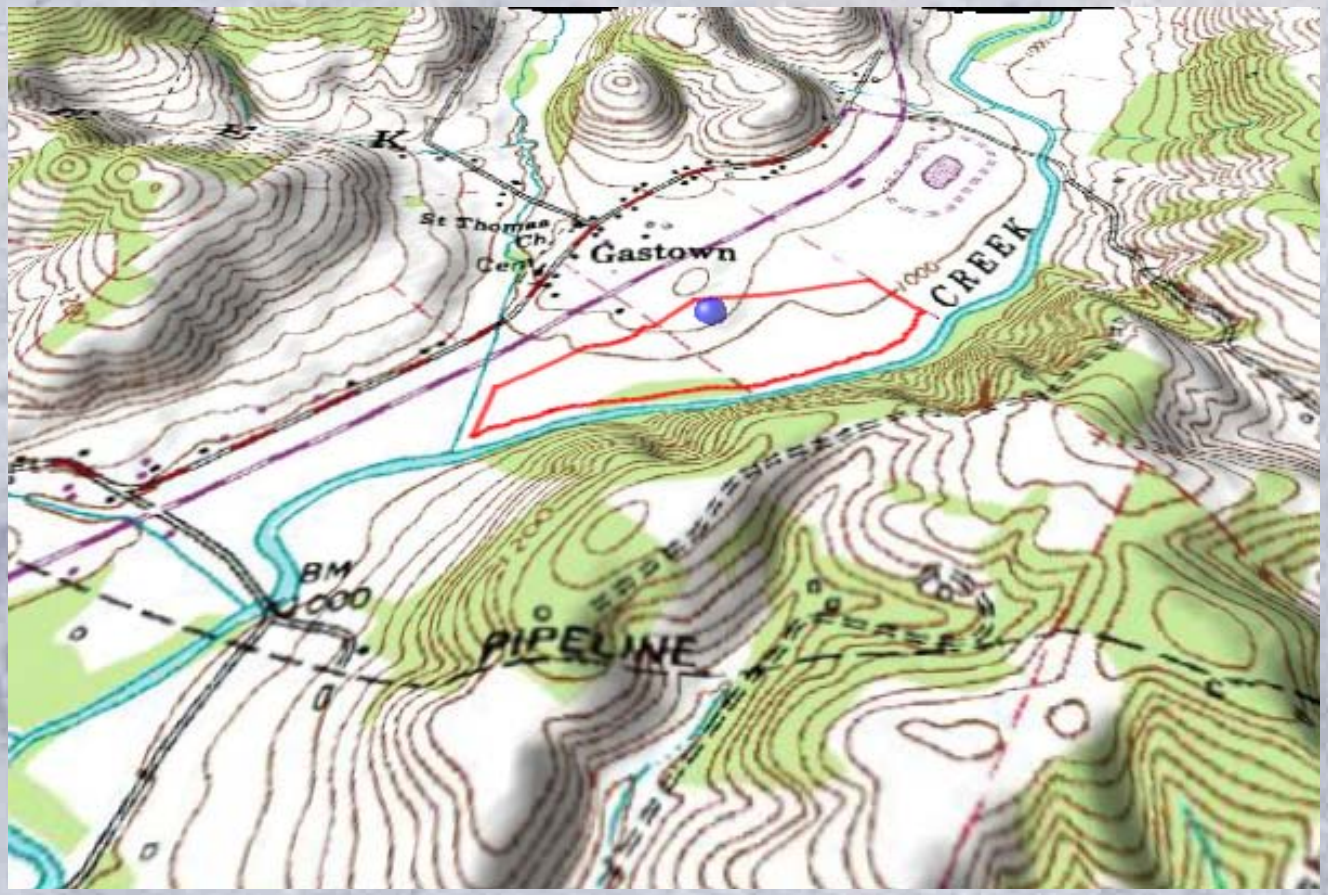
An Early (2001,02) Electronic Detonator Success Story



1,500 3,000

0 750

The Geography



Mining site located in a relatively flat, relatively broad stream valley.

The Geology

- Water
- Soft Shale
- Thick soils
- Clay Seams
- Low frequency vibrations dominate.

- Local residents have their homes built on this material.

Overburden

- Depths 45’ to 80’
- Sandstone seams 6’ to 25’
- Shale on top of the coal seam
- Shale the first 8 to 15’ of drill holes

The Mine Site/mining Method

- Block stripping
- Open faces limited or non-existent
- Limited options for PPV reduction

Decking was the 1st Choice

- The mining operator decided to initially attempt to resolve the problem by decking.
- A blast consisted of 28 holes.
- The Holes were loaded with 2 decks per hole and a maximum of 261 pounds per deck.
- The PPV was 1.04 inches/second @ 13 Hz.

Decking

- Due to decking the shot duration was 800 ms.
- Long duration blast vibration coupled with low dominant frequencies spawned numerous homeowner complaints (26 blast complaints one year)..
- The PA DEP immediately responded by halting the blasting until an alternative plan could be established that would ensure 1.0 in/sec PPV or the Z-Curve.

What to do next?

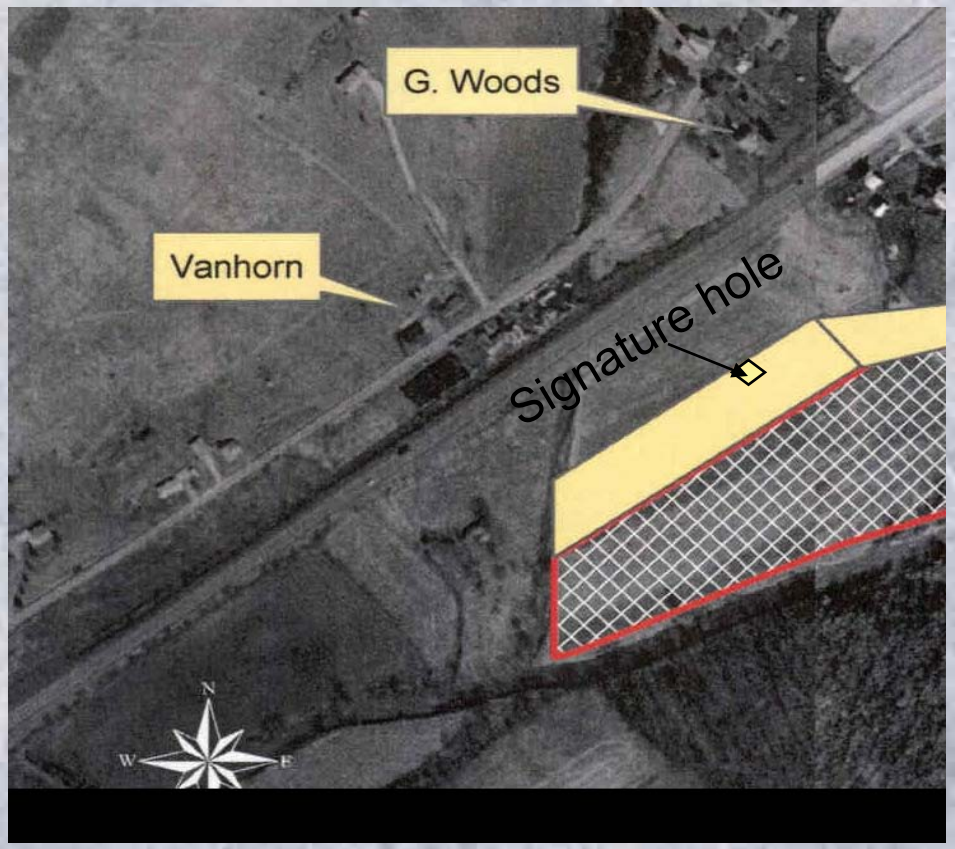
- The blasting contractor, his consultant, and the permittee's engineers met with the DEP to discuss electronic detonators and the methodology of the signature hole technique
- The proposal was a single signature hole loaded with the maximum amount of explosives the blasting contractor thought they might want to use per blast hole.

A Couple Local Residences

Figure 1 - Wood residence

Figure 2 - Van Horne residence

Signature Hole

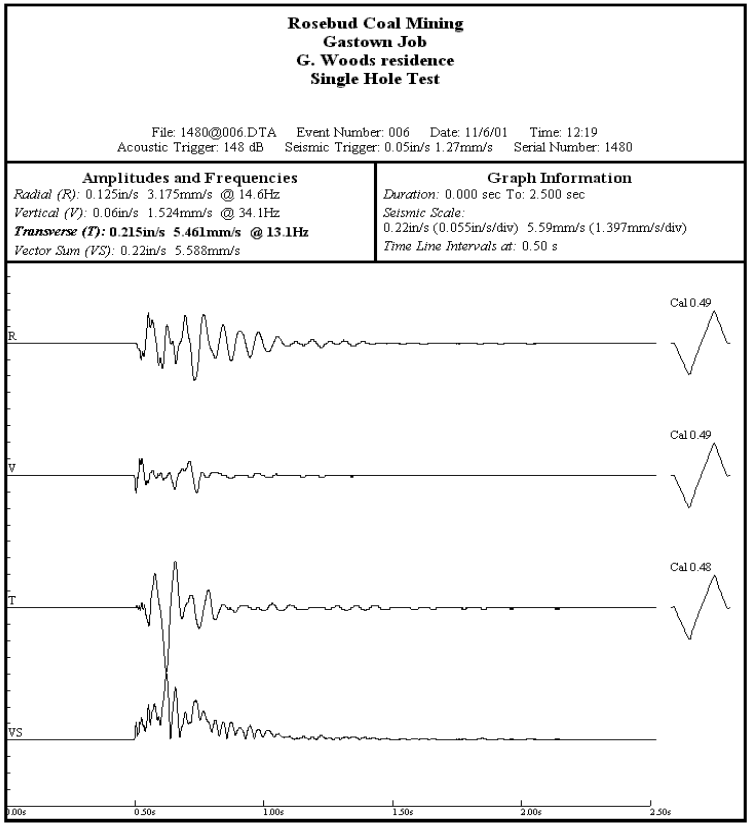


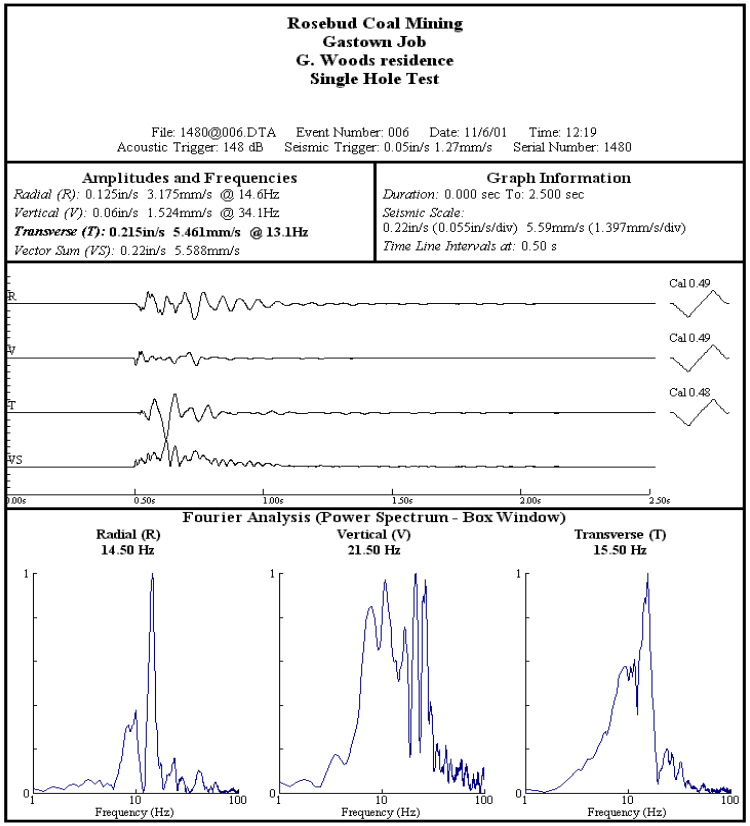
The Signature Hole

- Shot Nov. 6, 2001
- Wood residence 720 feet (219.5 m).
- Van Horne residence 830 feet (253 m).
- 521 lbs shot
- PPV at Wood 0.21 @13Hz
- First analysis concentrated on the Wood location
- Scaled Distance of 44.5

Signature Hole Analysis

- **Notice the dominant energy Frequencies 10 to 14 Hz**





Signature Hole Results

- The horizontal components of the vibration wave have the most effect on above ground structures response to the vibration.
- The delay intervals of 22ms between adjacent holes in a row and 89ms between row's was chosen, but results in 2 holes being detonated within the 8 millisecond criteria

The New Blast Design

- PA DEP needed to be informed that over 3 times the LBS per delay as the last decked blast are to be detonated.
- PA DEP's Response: Do not exceed 1.0 PPV. You can do anything you think will work.

Site Vibration Limit Background

- The PA vibration limit changed to the Z-curve July 2001.
- This site was under a permit issued before 7/2001 and had a grandfathered ground vibration limit of 1.0 in/sec.
- Due to the geology common to western PA the vibration limit change to the Z-curve was was widely maligned and misunderstood.

Electronic Production Blasting #1

- Nov. 13, 2001
- Best scenario 2 rows of up to 10 holes per row with each blast.
- First shot 16 holes, blast consisted of 2 rows of 8 holes with 832 pounds (378kg) of explosives firing within 8 ms.
- PPV of this blast was 0.35 inches/second @ 19.6 Hz.

Electronic Production Blasting #1

- The blast duration was reduced by 557 ms from 800 ms to 243 ms.
- Scaled Distance of 20.8
- The frequencies have moved to a more acceptable range.

November 13, 2001, Seismogram

Rosebud Mining
Gastown Job
Glenna Mae Wood residence
Production Blast

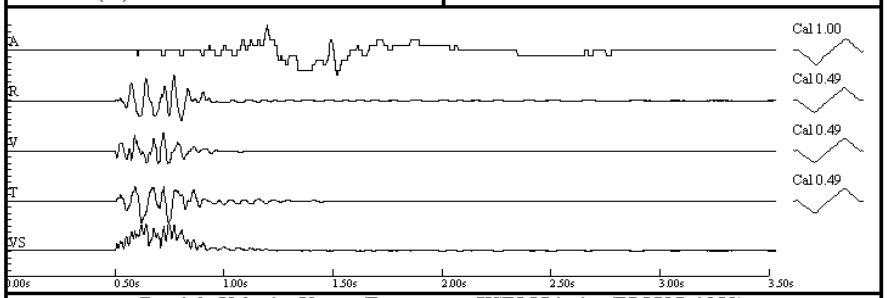
File: WOOD@246.DTA Event Number: 246 Date: 11/13/01 Time: 16:12
Acoustic Trigger: 120 dB Seismic Trigger: 0.05in/s 1.27mm/s Serial Number: 1478

Amplitudes and Frequencies

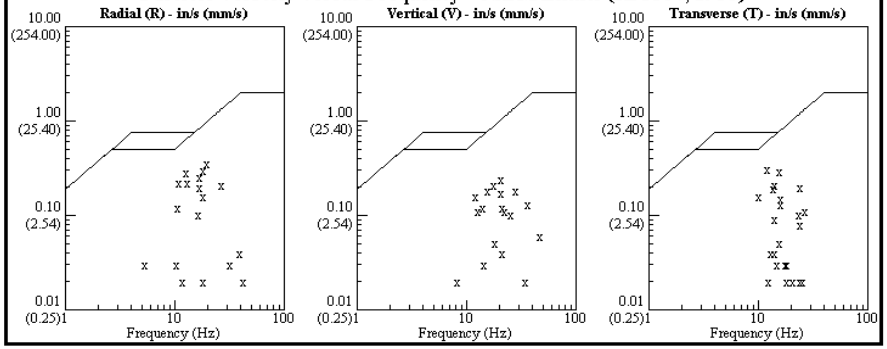
Acoustic (A): 120 dB @ 8.8 Hz
(0.20Mb 0.0029psi 0.0200kPa)
***Radial (R):* 0.35in/s 8.89mm/s @ 19.6Hz**
Vertical (V): 0.24in/s 6.096mm/s @ 20.4Hz
Transverse (T): 0.31in/s 7.874mm/s @ 12.1Hz
Vector Sum (VS): 0.395in/s 10.033mm/s

Graph Information

Duration: 0.000 sec To: 3.500 sec
Acoustic Scale:
120dB 0.20Mb (0.050Mb/div)
Seismic Scale:
0.35in/s (0.088in/s/div) 8.89mm/s (2.223mm/s/div)
Time Line Intervals at: 0.50 s



Particle Velocity Versus Frequency - USBM Limits (RI 8507, 1980)



Electronic Production Blasting #2

- Dec. 5, 2001
- 30 holes, maximum 1160 lbs per delay.
- Scaled Distance of 16.1
- PPV 0.76 @ Hz 21.3
- Mrs. Wood (who was not too happy about the previous blasting w/pyrotechnic caps) said to the blasting contractor manager, “that shot was very good, you can blast like that any time young man.”

December 5, 2001, Seismogram

Rosebud Mining
Gastown Job
Glenna Mae Wood residence
Production Blast

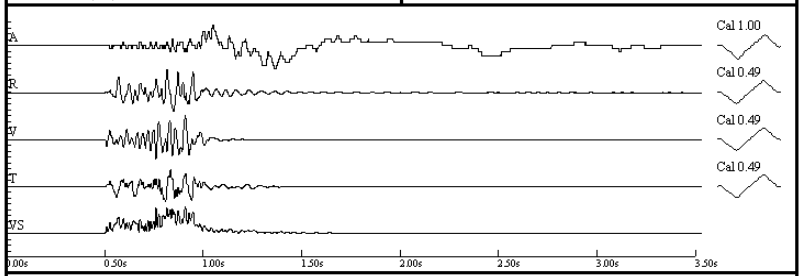
File: 12_10285.DTA Event Number: 285 Date: 12/5/01 Time: 11:30
Acoustic Trigger: 120 dB Seismic Trigger: 0.05in/s 1.27mm/s Serial Number: 1478

Amplitudes and Frequencies

Acoustic (A): 123 dB @ 1.9 Hz
(0.28Mb 0.0041psi 0.0280kPa)
Radial (R): 0.72in/s 18.288mm/s @ 25.6Hz
***Vertical (V):* 0.76in/s 19.304mm/s @ 21.3Hz**
Transverse (T): 0.55in/s 13.97mm/s @ 16.0Hz
Vector Sum (VS): 0.87in/s 22.098mm/s

Graph Information

Duration: 0.000 sec To: 3.500 sec
Acoustic Scale:
123dB 0.28Mb (0.070Mb/div)
Seismic Scale:
0.76in/s (0.190in/s/div) 19.30mm/s (4.826mm/s/div)
Time Line Intervals at: 0.50 s



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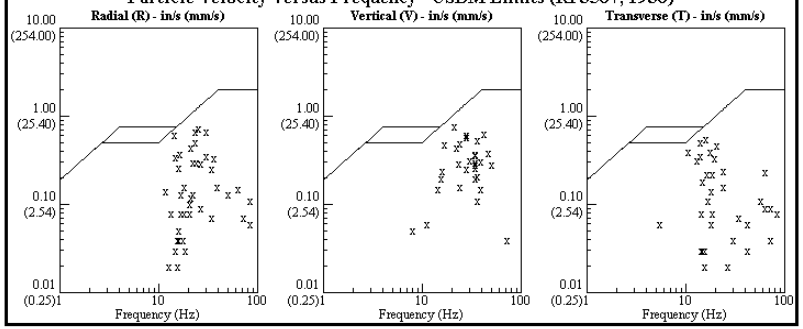


Signature Hole #2

- Jan. 3, 2002
- As the mining progressed the filter or geology between the blast location and the recording locations changed resulting the vibration signals being conditioned differently.
- The characteristics of the vibration recordings indicated that a second signature hole study should be conducted.

Signature Hole #2

- 342 lbs (155kg) in a single hole.
- 550 feet (168m) to the Wood residence.
- PPV 0.43 (10.9mm/s) @ 12.3 Hz
- The analysis again determined the optimum timing sequence.
- Optimum timing was now 33 ms hole to hole, with 76 ms between rows

Jan. 18, 2002 Blast

- The timing configuration of the blast resulted in 2 holes being fired within the 8 ms.
- Max. lbs per delay 530 (241kg), SD of 22.2
- PPV 1.0 (25.4 mm/s)@ 26.9 Hz
- Max allowable PPV (Under Z-Curve) at 26.9 Hz is 1.34ips
- The remaining blasts resulted in peak particle velocity levels at higher frequencies that provided maximum allowable PPV limits greater that the flat 1.0 inch per second in the original mining permit

Rosebud Mining
Gastown Job
Glenna Mae Woods residence
Production Blast

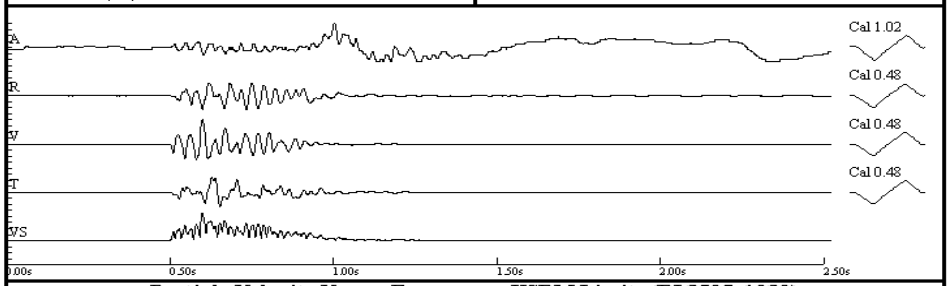
File: 1_18@004.DTA Event Number: 004 Date: 1/18/02 Time: 10:33
Acoustic Trigger: 125 dB Seismic Trigger: 0.05in/s 1.27mm/s Serial Number: 1175

Amplitudes and Frequencies

Acoustic (A): 124 dB @ 4.2 Hz
(0.32Mb 0.0046psi 0.0320kPa)
Radial (R): 0.58in/s 14.732mm/s @ 30.1Hz
***Vertical (V):* 1.00in/s 25.40mm/s @ 26.9Hz**
Transverse (T): 0.61in/s 15.494mm/s @ 16.5Hz
Vector Sum (VS): 1.15in/s 29.21mm/s

Graph Information

Duration: 0.000 sec To: 2.500 sec
Acoustic Scale:
124dB 0.32Mb (0.080Mb/div)
Seismic Scale:
1.00in/s (0.250in/s/div) 25.40mm/s (6.350mm/s/div)
Time Line Intervals at: 0.50 s



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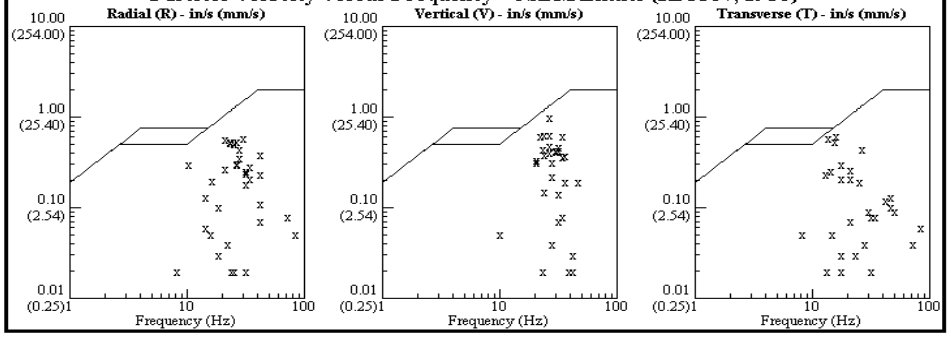


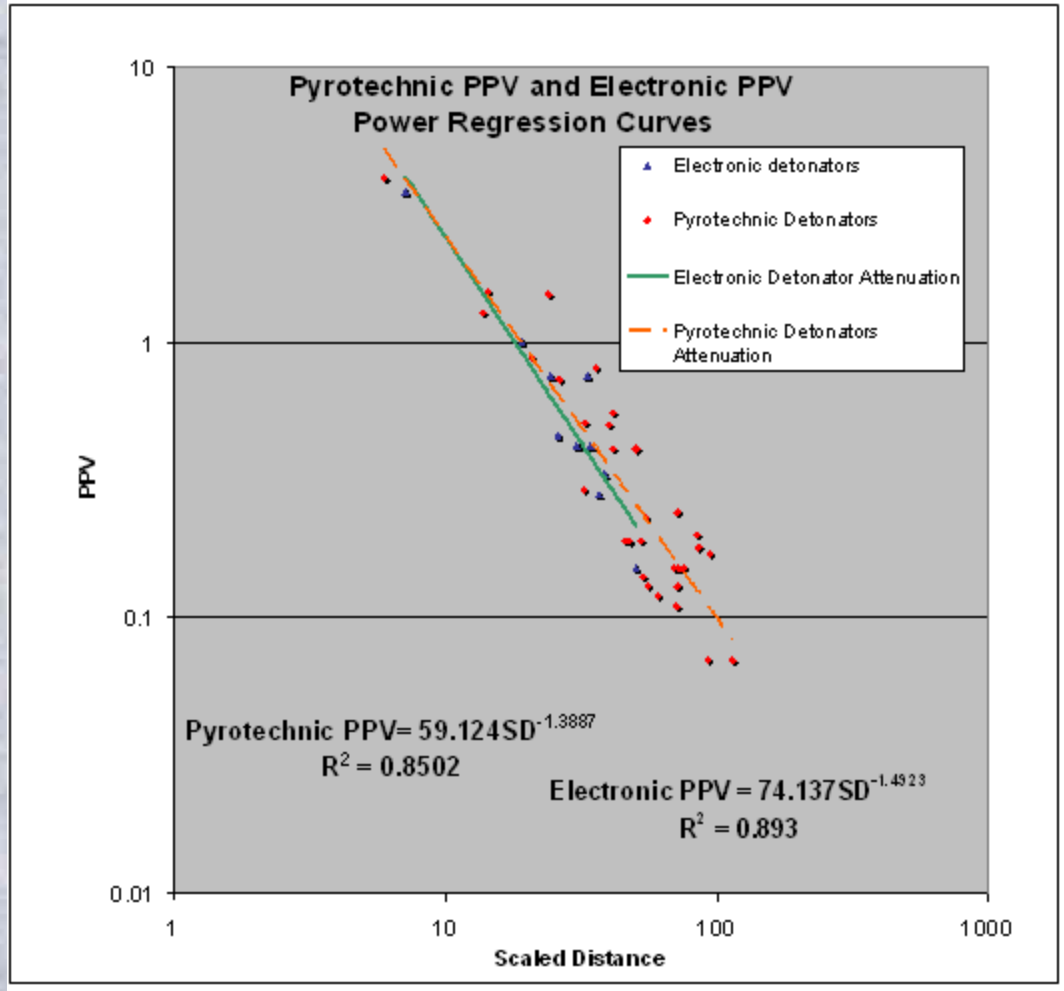
PA DEP Site Regression Study

- The DEP conducted their own seismic monitoring and analysis studies.
- These studies were compared to help the operator design blasts that didn't exceed the regulatory limit and to gain a better understanding of electronic detonators and their effect on blast vibrations.
- DEP had monitored the ground vibrations in several locations adjacent to the mine site.

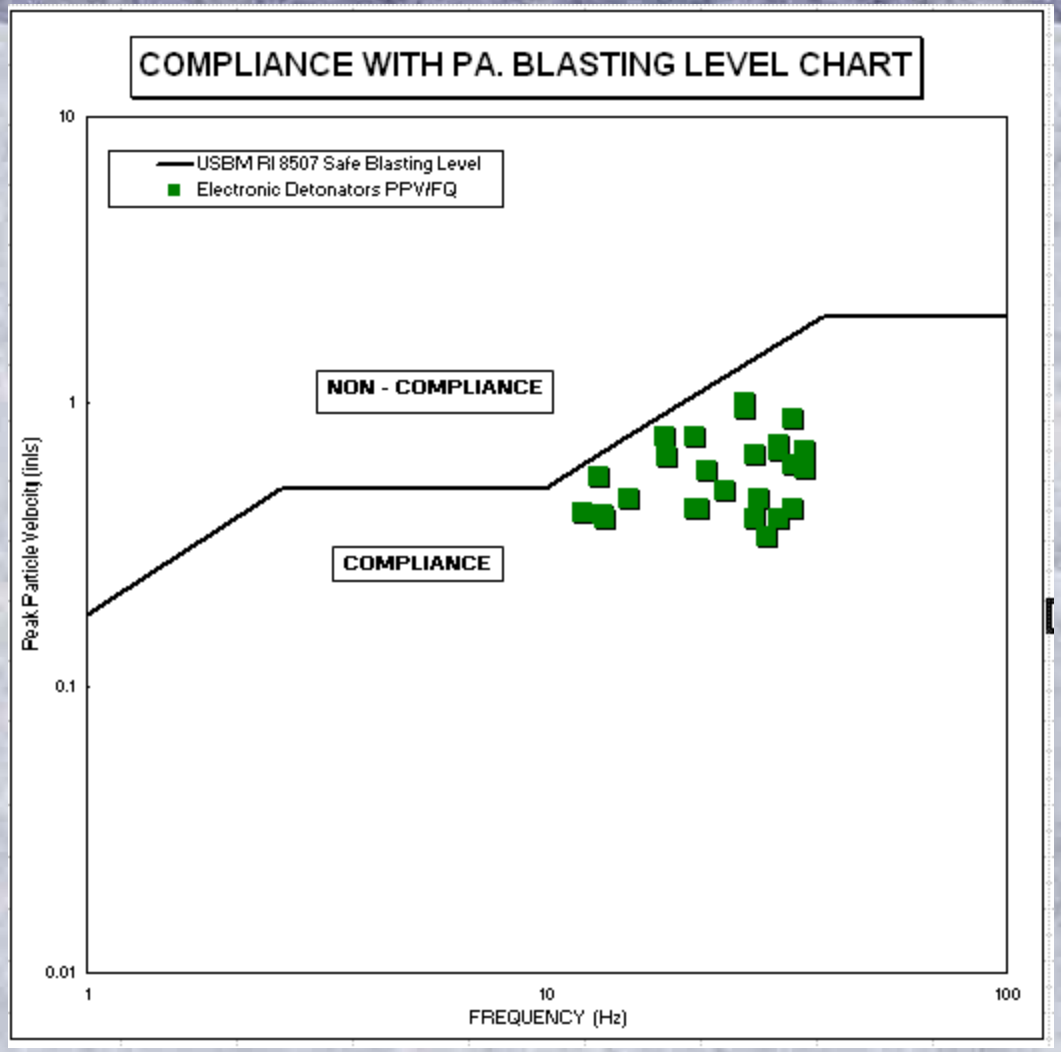
Pyrotechnic/Electronic Attenuation

- Data from 3 blasts using pyrotechnic detonators in April and May of 2001 and data from 5 blasts in April and May of 2002 were collected using electronic detonators.

Site Regression Characteristics



Electronic Detonators PPV/FQ vs. Z-curve



ELECTRONIC DETONATORS

- The permittee and the contract miner were able to keep operating as compliance levels were met.
- The contract miner mined coal at normal production rates.
- Local residents were able to cope with the blasting.
- PA DEP experienced a reduction in complaints.
- The blasting contractor learned of the advantages of using electronic detonators.

A Cooperative Effort

- DEP Inspector (on left) and Rosebud manager (on right)
- The proposal for and the acceptance of electronic detonator use to control ground vibrations were widely viewed as a cooperative effort.
- Cooperative efforts are good for both regulators and industry.

WIDER REACHING RESULTS

- Some western PA mine operators and blasting contractors became able to mine/blast close to houses and stay under the new vibration limits.
- A new method to reduce complaints was established.
- Electronic detonators are widely used in western PA (as well as throughout the state) today.

Questions????