

FINAL REPORT

Bat Monitoring, Fort Leonard Wood, Missouri: Sound and Seismic Effects

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INTRODUCTION

The U.S. Army Maneuver Support Center of Excellence and U.S. Army Garrison Fort Leonard Wood (Installation) has prepared a Biological Assessment (BA) to evaluate effects of the construction and operation of a Mine Clearing Line Charge (MICLIC) range on threatened and endangered species at the Installation. A pilot monitoring plan will describe the process in which field data are to be gathered and timelines in which field data are processed and/or reported. The data collected during this pilot monitoring survey will be used to validate the noise and seismic estimations, as described in the BA, for MICLIC detonations and ensure that thresholds of sound and vibration have not been surpassed. If field data results surpass thresholds, the USFWS will be consulted and appropriate coordination will be conducted.

Dr. Kevin Mickus, geophysicist and Distinguished Professor in the Department of Geography, Geology, and Planning at Missouri State University (MSU), was the lead scientist on the pilot monitoring survey to assess the noise and sound effects during MICLIC testing. He was assisted in the field by Paul Wilkerson, an undergraduate student in geology. The seismic and sound data were collected at King Cave which is the closest of the seven caves to the MICLIC Range (Figures 1 and 2).

METHODS

Instrumentation

The InstanTel Blastmate III-Micromate model was used to record both seismic and sound data. Seismic levels were recorded in inches per second (ips) and sound was recorded in pounds per square inch (psi). The deployed system had a three component seismic sensor to record vertical tangential and radial components of the source signal and a linear microphone to record the air blast. The equipment was housed in a metal cylinder that was connected to a 12-volt battery which was charged by a solar panel. The seismic sensor was bolted to the roof of cave. We rented the equipment from Matheson Mining Consultants, Denver, CO, who also independently confirmed MSU's interpretations of the data records. The equipment is routinely used to monitor mining blasts and blasts at construction sites.

Sound

Sound levels were monitored by MSU using a sound meter to record the sound levels and the time (events) at which they occurred. Two sound meters were deployed on a battery system attached to a solar panel for long-term monitoring. The sound meters were placed at the entrance to King Cave in the morning of October 8, 2018. Data were recorded until the morning of October 25, 2018. For reference the Federal limit is 133 dBL. The data recorded by the Blastmate is in psi; however, these numbers can be converted to decibels (dBL) using $dBL = 20 \log(P/P_0)$ where P is pressure in psi and the reference pressure P_0 is 2.9×10^{-9} .

Seismic

Seismic activity was monitored by MSU using two seismic monitoring systems, which recorded seismic levels and the time (events) at which they occurred. The seismometers were deployed on external battery systems with a solar panel so recording can occur for multiple weeks at a time. The seismic monitors were placed at the entrance to King Cave in the morning of October 8, 2018. Data were recorded until the morning of October 25, 2018. One seismometer was attached to the roof of King Cave at its entrance (Figures 3 and 4) and a second seismometer was attached to bedrock on the floor of the cave at its entrance. The second seismometer (attached to the cave floor) failed after 5 days of recording as the solar panel failed to work. The other seismometer recorded data the entire time it was deployed including the date of the blast on October 22, 2018.

For both the sound and seismic recording, the stations were installed on October 8, 2018, one site visit to check on the batteries and collect data occurred on October 15, 2018 and the stations were removed on October 25, 2018.

Figure 5 shows the output of the machine once an event occurs. The trigger level for a seismic event was set 0.01 in/sec. The seismic sensor records three components, vertical and two horizontals (transverse and longitudinal).

RESULTS

Seismic and Sound Data

During the recording of the data, several events were identified on the seismic records. Three of these events were caused by disturbances by project team members from our or another group during the touching or picking up of the geophones and vocal correspondence near the instruments while at the site. We will not show the records of these events. The other events evaluated were as follows:

Event 1 (Figure 5): a sound event occurred on 10/8 with a peak dBL level of 119.5 dBL. There was no seismic event associated with this sound event;

Event 2 (Figure 5): a series of sound events (maybe somebody at the site) occurred on 10/10 with a peak dBL level of 117.4 dBL. There were no seismic events associated with this event;

Event 3 (Figure 5): a series of sound events occurred on 10/10 with a peak dBL level of 116.3 dBL. There were no seismic events associated with this event;

Event 4 (Figure 5): a series of sound events occurred on 10/10 with a peak dBL level of 107.3 dBL. There were no seismic events associated with this event;

Event 5 (Figures 5 and 6): a seismic event occurred on 10/12 with a peak particle velocity of 0.232 in/s on the transverse component. There was no sound event associated with this event:

Event 6 (Figure 6): a seismic event occurred on 10/14 with a peak particle velocity of 0.020 in/s on the vertical component. There was no sound event associated with this event:

Event 7 (Figure 6): a sound event occurred on 10/15 with a peak dBL level of 137.4 dBL. There was no seismic events associated with this event. The source of this sound event is unknown, but was above the federal limit of 133 dBL:

Event 8 (Figure 7): a sound event occurred on 10/16 with a peak dBL level of 139.8 dBL. There was no seismic events associated with this event. The source of this sound event is unknown, but was above the federal limit of 133 dBL: and

Event 9 (Figure 7): a sound event occurred on 10/22 with a peak dBL level of 120.3 dBL. There was no seismic events associated with this event. This event was associated with the MICLIC blast and was below the federal level of 133 dBL and the 126 dBL threshold identified in the BA.

DISCUSSION AND CONCLUSIONS

Seismic and sound data were collected for over a two week period at King Cave (Figures 1 and 2) using an Instantel Blastmate seismic recorder and linear microphone. The data (Figures 5-7) show several seismic and sound events, but during the MICLIC blast on 10/22 there were no seismic events (larger than the trigger level of 0.01 in/s), thus the MICLIC blast was well below the 0.20 in/s threshold identified in the BA. However, a sound event associated with the air blast was recorded with a peak sound level of 120.3 dBL which is about 13 dBL (or 10%) below the federal level of 133 dBL as well as 6 dBL (or 5%) below the threshold of 126 dBL identified in the BA. Two events did occur at levels slightly above the Federal level (137 and 140 dBL), but these are of unknown source and not associated with the blast.

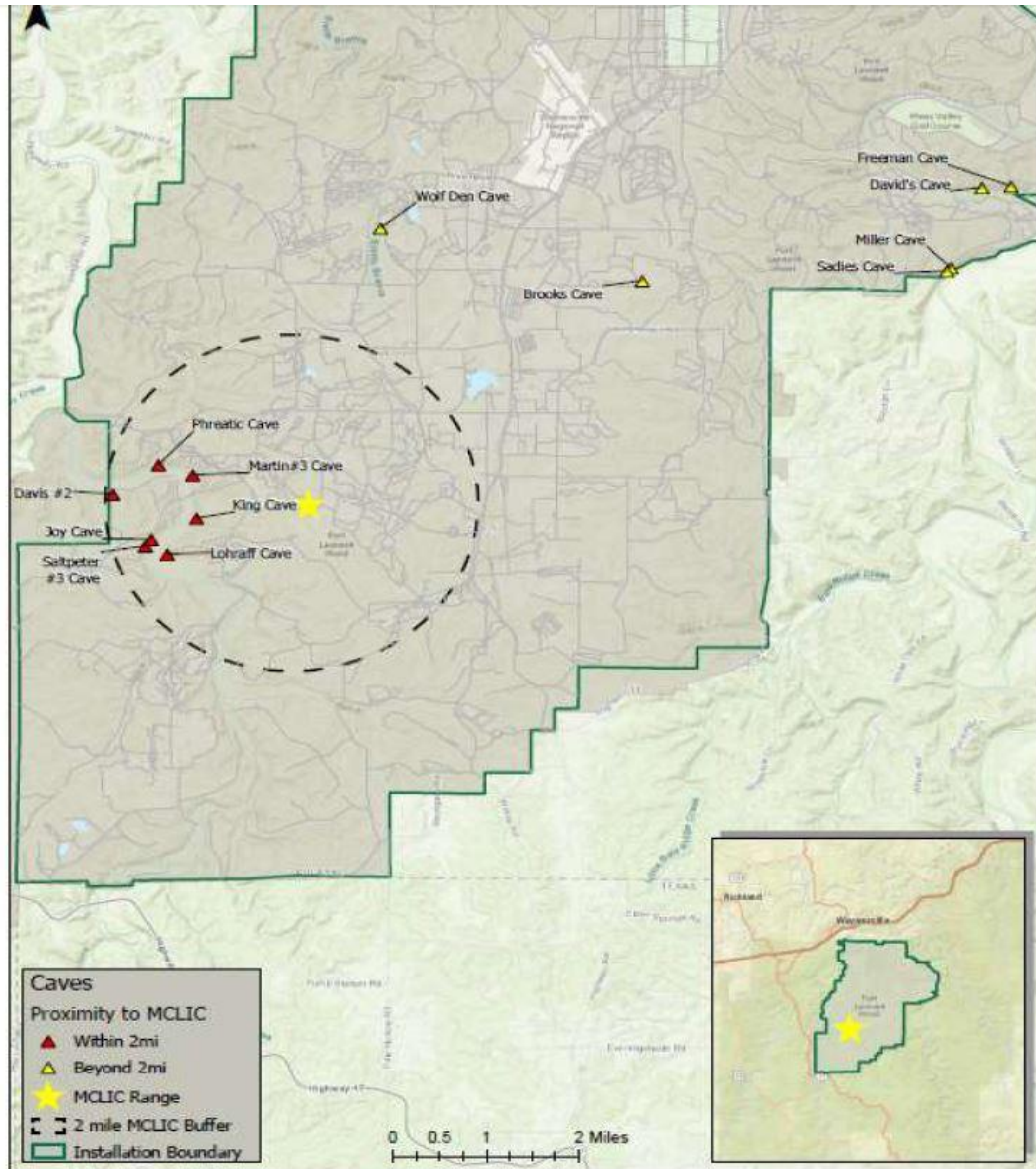


Figure 1. Location of caves associated with MCLIC Range.

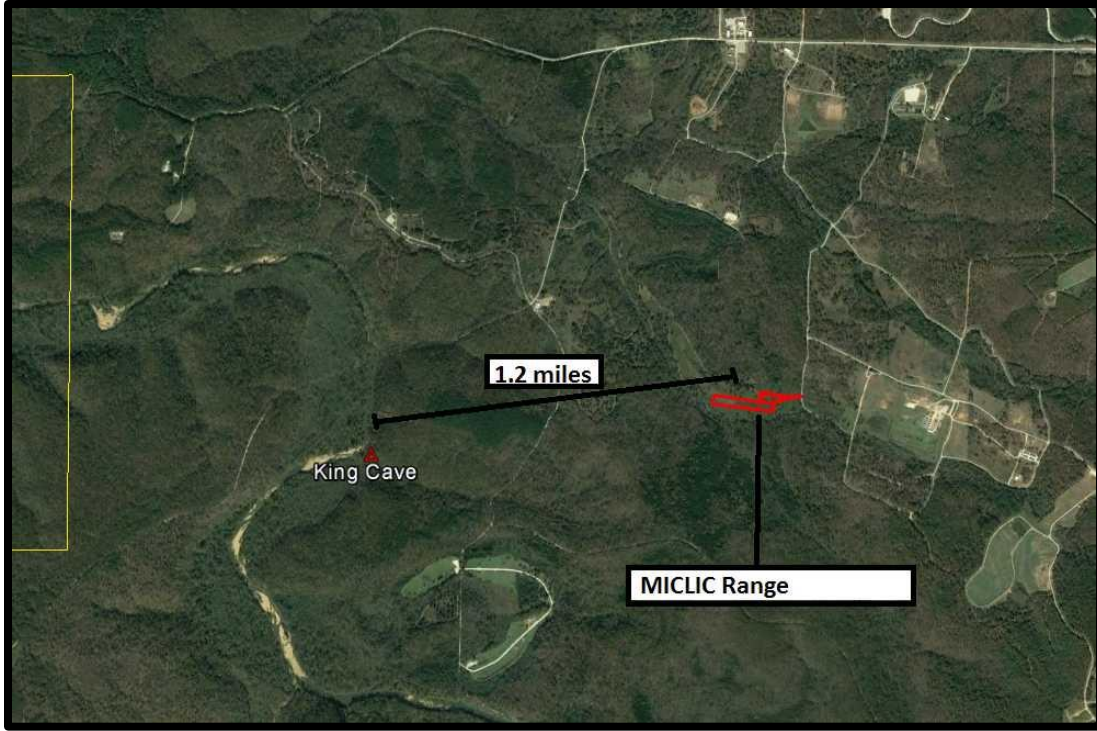


Figure 2. Location of King Cave in relation to the MICLIC Range.



Figure 3. Seismic recorders at King Cave. The seismic sensor is attached to the top of the cave while the round containers contain the data recorders/batteries and solar panels. The sound meters were attached to the round containers.



Figure 4. The data recorders (blue boxes) inside while the round containers. The sound meters were placed inside the round tube coming out of the containers (upper portion of the bottom container).



Event Report

Start
Finish
Number of Intervals/Interval
Sample Rate
Operator/Setup File Name

October 12, 2018 20:44:35
 October 15, 2018 09:21:09
 242.44/900 sec
 1024 sps
 Operator/MO-State_rental_Mic.mmb

Serial Number
Model Number
Battery Level
Unit Calibration
Unit File Name
USB Sensor Support

UM11902
 Micromate ISEE 10.89
 3.8 volts
 April 25, 2018 by InstanTel
 UM11902_20181012204435.IDFH
 Disabled

Notes
Location
Client
Company
General Notes
Extended Notes Not text to be displayed.

Post Event Notes No text to be displayed.

Geophone	Tran	Vert	Long
Peak Particle Velocity	0.037 in/s	0.034 in/s	0.009 in/s
Zero Crossing Frequency	<1 Hz	<1 Hz	N/A
Date	Oct 13, 2018	Oct 13, 2018	Oct 12, 2018
Time	00:14:35	00:14:35	20:59:35
Sensor Check	✓ Passed	✓ Passed	✓ Passed
Frequency	7.5 Hz	6.7 Hz	7.5 Hz
Overswing Ratio	3.5	5.0	3.3

Peak Vector Sum 0.037 in/s at October 13, 2018 00:14:35

ISEE Linear Microphone
 Peak Sound Pressure Level
 Date
 Time
 Zero Crossing Frequency
 Sensor Check
 Frequency
 Test Amplitude

0.021553 psi
 Oct 15, 2018
 03:44:35
 22.3 Hz
 ✓ Passed
 19.7 Hz
 1493 mv

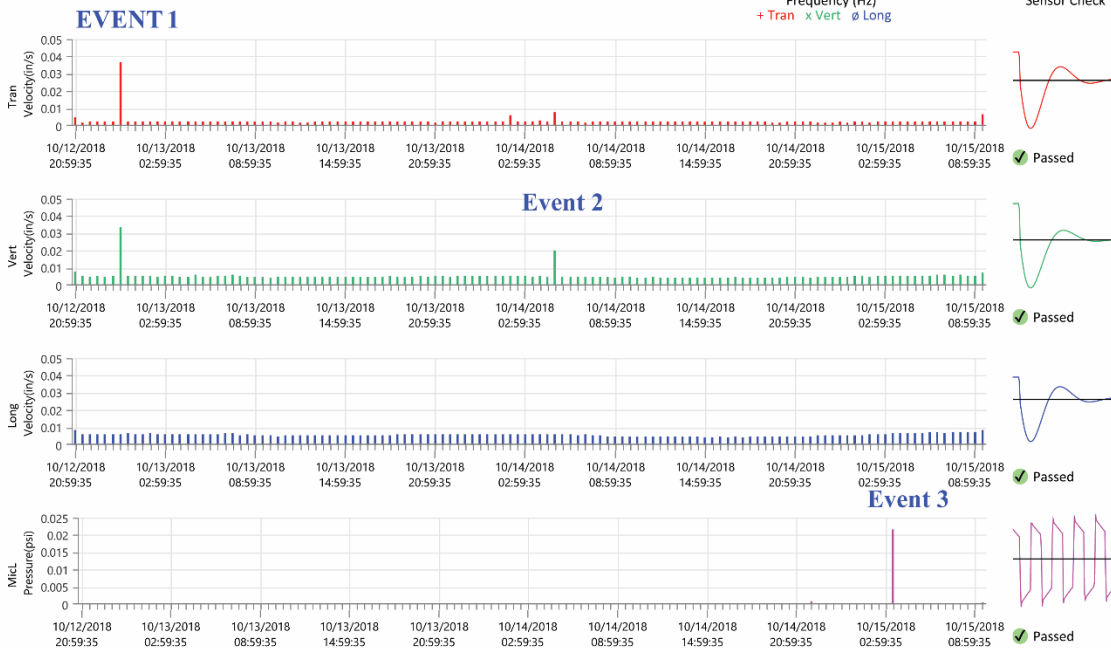
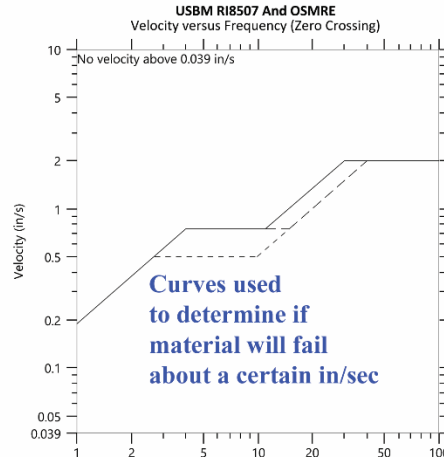


Figure 5. Output from the InstanTel Blastmate seismic and sound recorder: October 12 to 15, 2018. The bottom graphs show seismic events on the vertical (vert), transverse (Tran) and longitudinal (Long) components in in/s, and the sound events from the linear microphone (MicL) in psi. Three significant events are marked on the graphs.



Event Report

Start
Finish
Number of Intervals/Interval
Sample Rate
Operator/Setup File Name

October 8, 2018 12:02:56
October 12, 2018 20:42:27
418.63/900 sec
1024 sps
Operator/MO-State_rental_Mic.mmb

Serial Number
Model Number
Battery Level
Unit Calibration
Event File Name
USB Sensor Support

UM11902
Micromate ISEE 10.89
3.8 volts
April 25, 2018 by InstanTel
UM11902_20181008120256.IDFH
Disabled

Notes
Location
Client
Company
General Notes
Extended Notes Not text to be displayed.

Post Event Notes No text to be displayed.

Geophone	Tran	Vert	Long
Peak Particle Velocity	0.006 in/s	0.232 in/s	0.009 in/s
Zero Crossing Frequency	<1 Hz	<1 Hz	N/A
Date	Oct 8, 2018	Oct 12, 2018	Oct 8, 2018
Time	16:47:56	20:42:27	16:32:56
Sensor Check	Passed	Passed	Passed
Frequency	7.3 Hz	7.3 Hz	7.5 Hz
Overswing Ratio	3.3	3.7	3.2

Peak Vector Sum 0.232 in/s at October 12, 2018 20:47:56

ISEE Linear Microphone	
Peak Sound Pressure Level	0.002631 psi
Date	Oct 8, 2018
Time	19:17:56
Zero Crossing Frequency	24.4 Hz
Sensor Check	Passed
Frequency	19.7 Hz
Test Amplitude	1292 mv

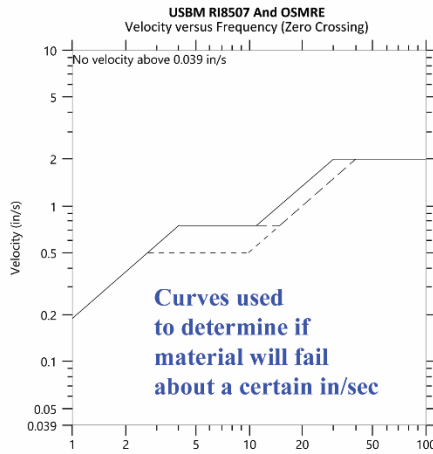


Figure 6. Output from the InstanTel Blastmate seismic and sound recorder: October 8 to 12, 2018. The bottom graphs show seismic events on the vertical (vert), transverse (Tran) and longitudinal (Long) components in in/s, and the sound events from the linear microphone (MicL) in psi. Three significant events are marked on the graphs.



Event Report

Start
Finish
Number of Intervals/Interval
Sample Rate
Operator/Setup File Name

October 15, 2018 09:30:23
October 24, 2018 08:51:27
861.40/900 sec
1024 sps
Operator/MO-State_rental_Mic.mmb

Serial Number
Model Number
Battery Level
Unit Calibration
Event File Name
USB Sensor Support

UM11902
Micromate ISEE 10.89
3.8 volts
April 25, 2018 by InstanTel
UM11902_20181015093023.IDFH
Disabled

Notes
Location
Client
Company
General Notes
Extended Notes Not text to be displayed.

Post Event Notes No text to be displayed.

Geophone	Tran	Vert	Long
Peak Particle Velocity	0.734 in/s	1.706 in/s	0.751 in/s
Zero Crossing Frequency	85.3 Hz	2.6 Hz	85.3 Hz
Date	Oct 24, 2018	Oct 24, 2018	Oct 24, 2018
Time	08:51:27	08:51:27	08:51:27
Sensor Check	✓ Passed	✓ Passed	✓ Passed
Frequency	7.3 Hz	7.3 Hz	7.3 Hz
Overswing Ratio	3.5	3.8	3.3
Peak Vector Sum	1.821 in/s at October 24, 2018 09:00:23		

ISEE Linear Microphone	
Peak Sound Pressure Level	0.027514 psi
Date	Oct 16, 2018
Time	09:45:23
Zero Crossing Frequency	10.4 Hz
Sensor Check	✓ Passed
Frequency	19.7 Hz
Test Amplitude	1562 mv

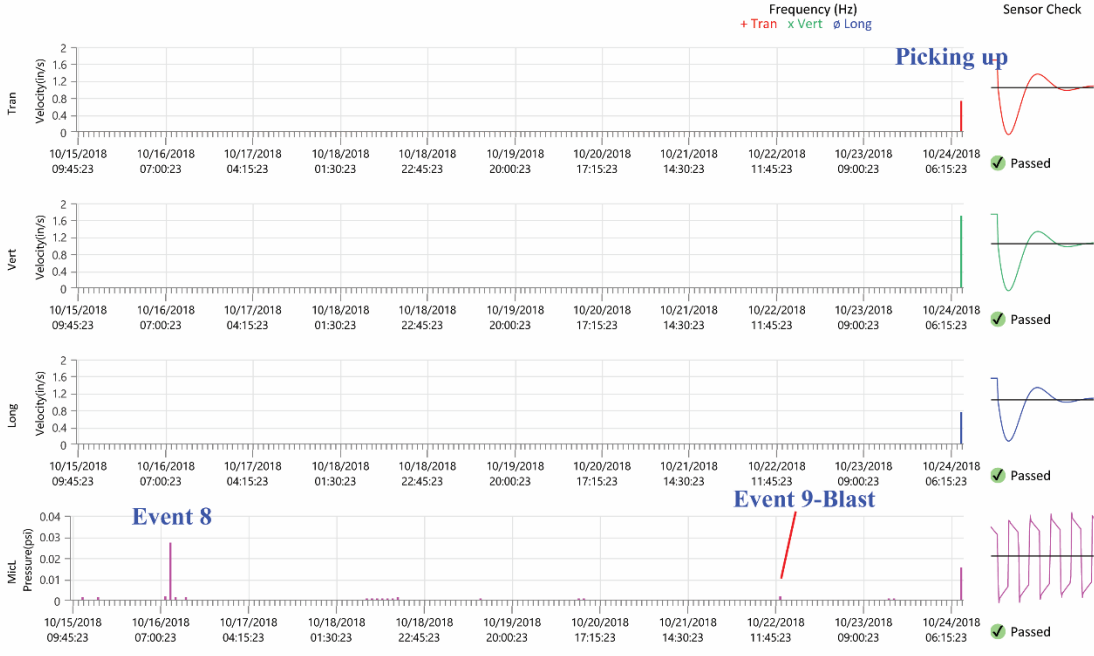
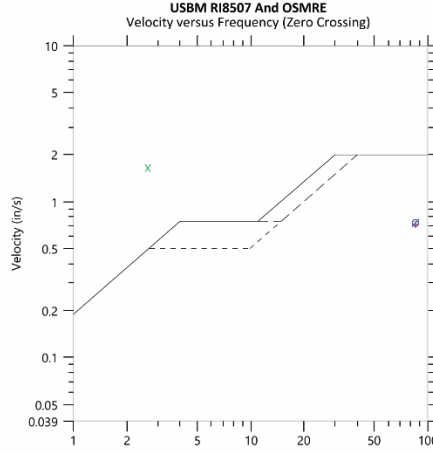


Figure 7. Output from the InstanTel Blastmate seismic and sound recorder: October 15 to 24, 2018. The bottom graphs show seismic events on the vertical (vert), transverse (Tran) and longitudinal (Long) components in in/s, and the sound events from the linear microphone (MicL) in psi. Three significant events are marked on the graphs.