Tony Creek Dual Microseismic Experiment (ToC2ME)

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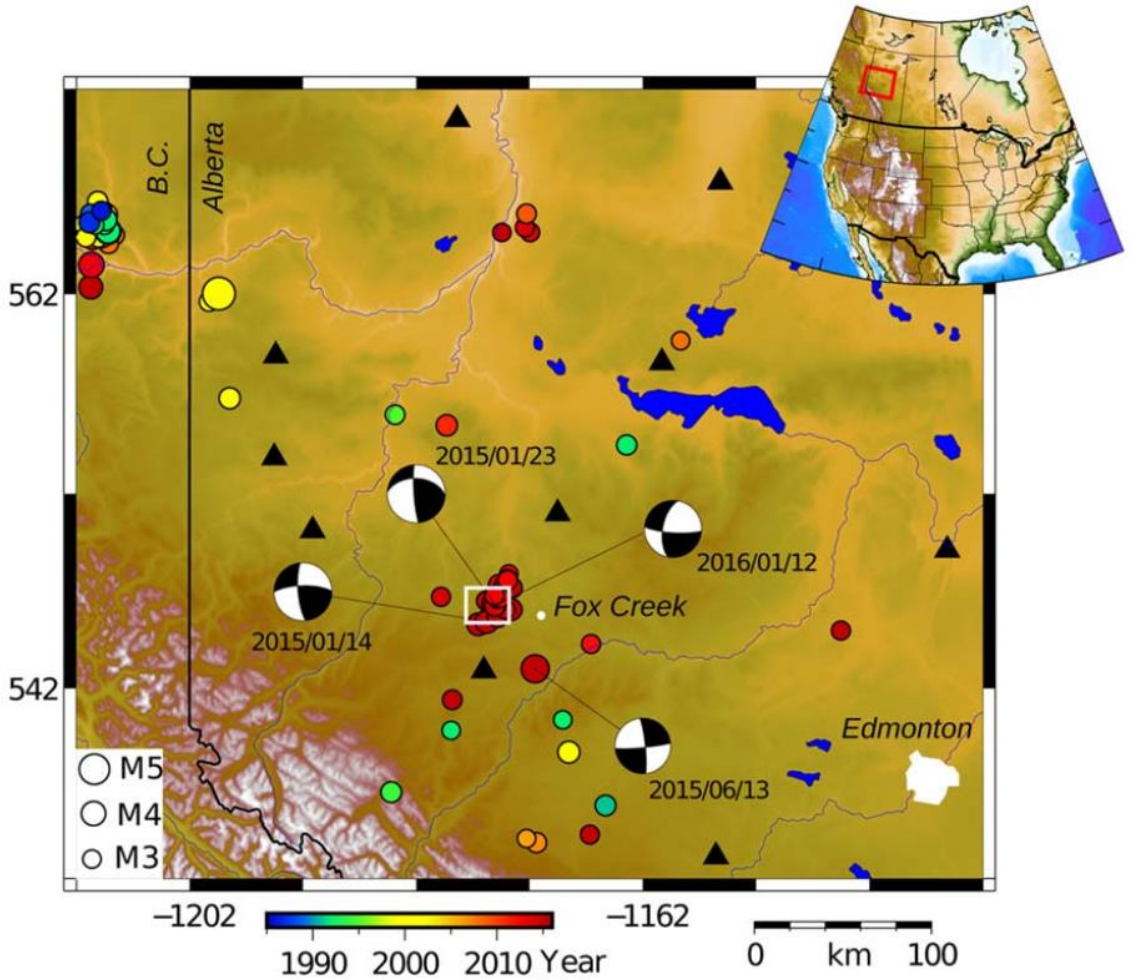
Outline

- Background
- Field experiment
- Data
- Preliminary results
- Future work

Background

- **Induced seismicity** in Alberta
- Caused mainly by hydraulic fracturing
- In the Fox Creek area, the target is the Duvernay, approximately 3.5 km deep
- Earthquakes as large as ML 4.6 have been triggered



Bao & Eaton, 2016

Background: Monitoring

Monitoring falls into two categories:

1. Microseismic monitoring

- **M** < 0
- Many *nearby* stations (dx: 50 – 500 m)
- Surface or downhole monitoring
- 15 Hz geophones

2. Induced seismicity monitoring

- **M** > 0
- Many *sparse* stations (dx: 2 km – 100 km)
- Dominantly surface monitoring
- Broadband seismometers
  (f ≤ 0.01 Hz)

Field Experiment

Field site:

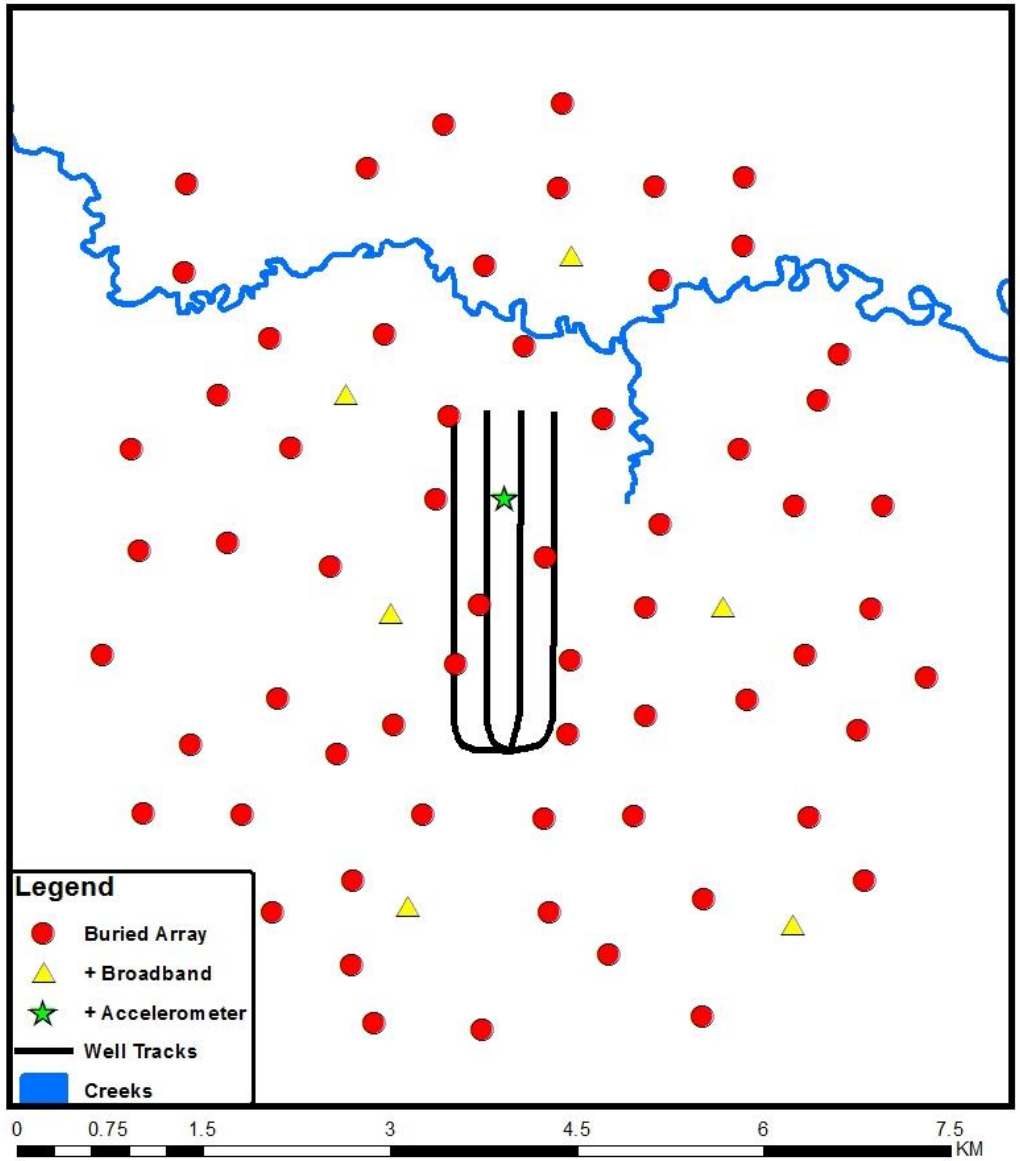
- West of Fox Creek
- 56 km^2 area
- 4 wells – 2.5 km each

Equipment:

- 69-station shallow borehole array
- 6 broadband seismometers
- 1 accelerometer
- (+ a few surface 3C geophones)

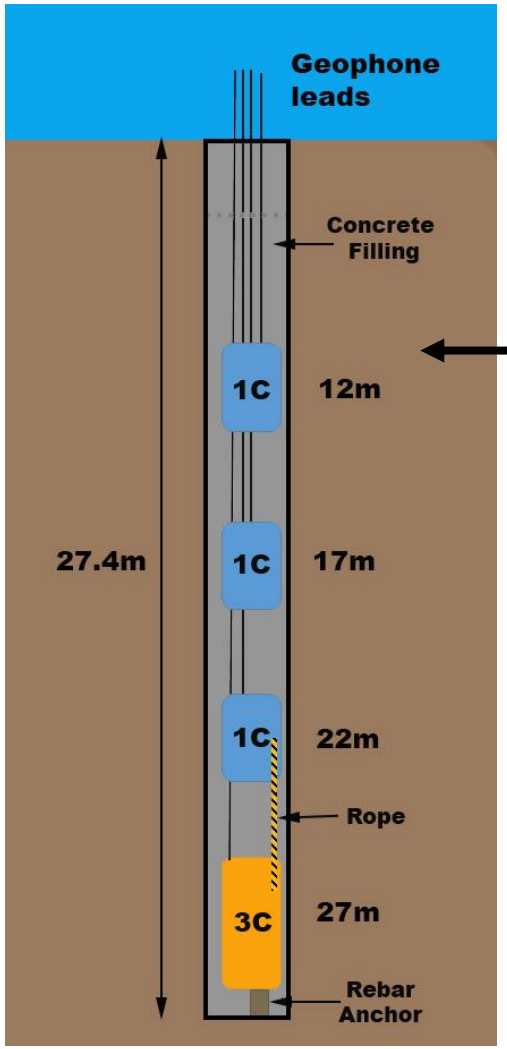
Timeline:

- Mid-October to early December 2016

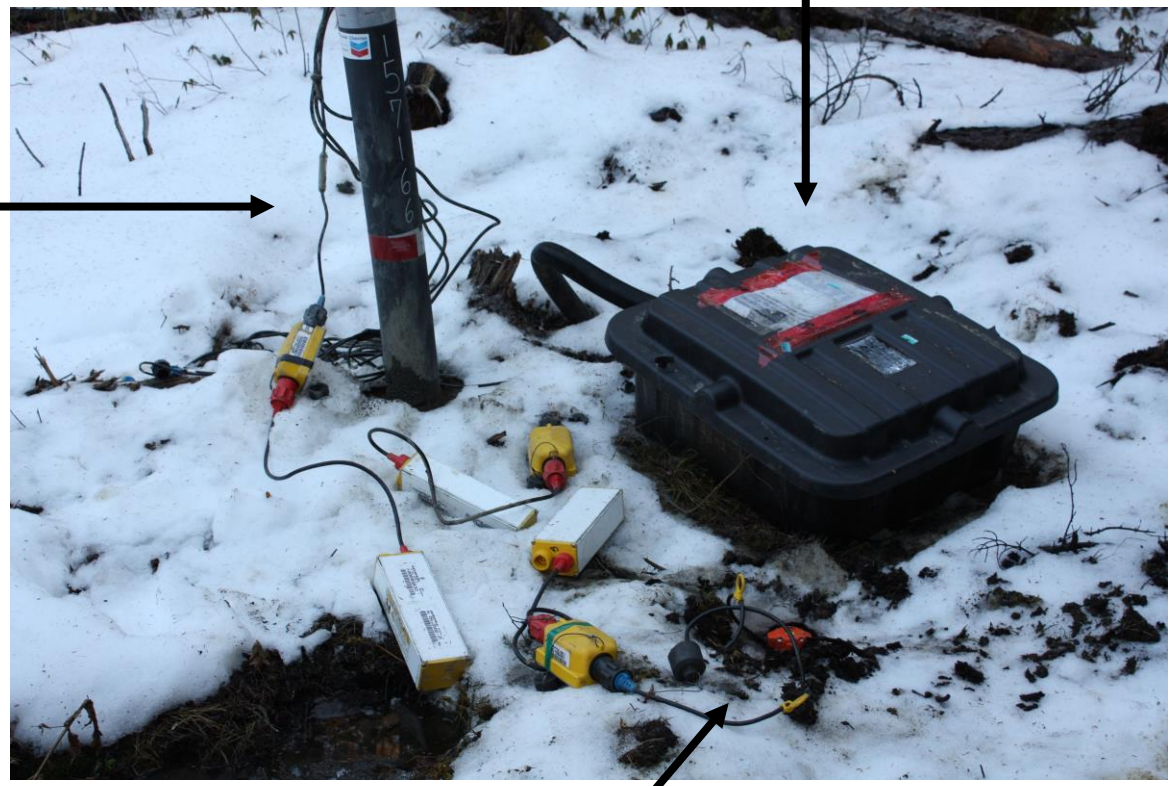


Field Experiment

Shallow borehole array



Broadband seismometer



Surface 3C geophone

Data

- We have:
  - 50 days of continuous data from the shallow borehole array (.sg2)
  - 65 days of continuous data from the broadband/accelerometer

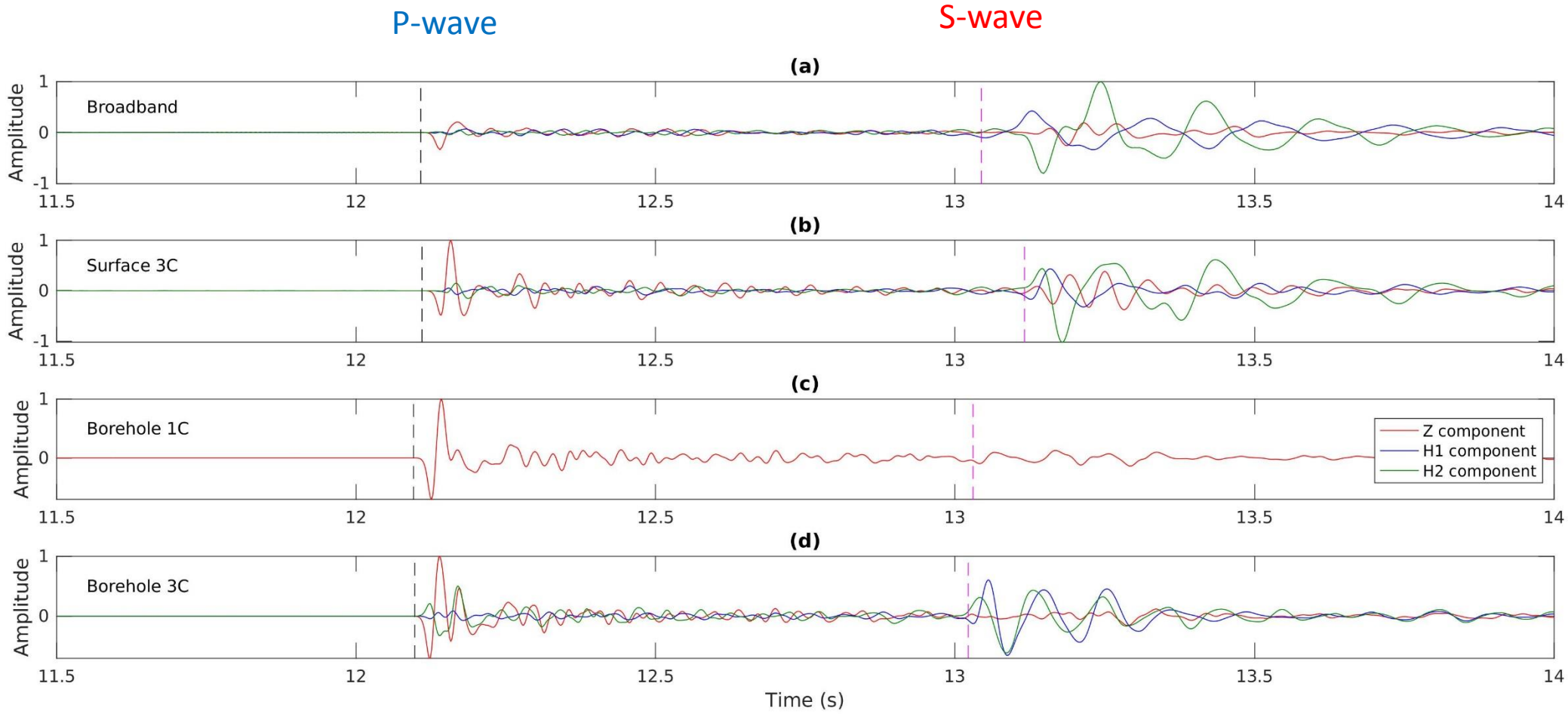
- In total: 4TB of data

- Recorded 9 events above ML 3.0 – a record for this region

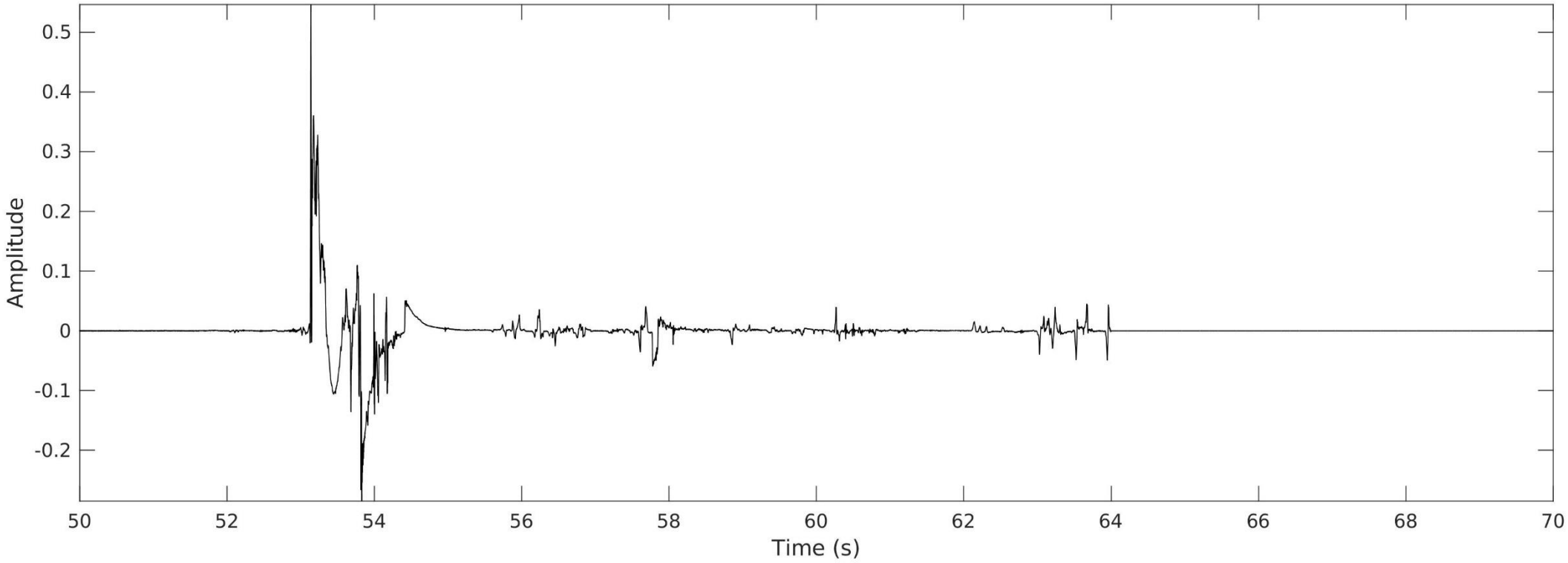
Preliminary Results: Microseismic Events

- Example Mw 1.6 event:

Phase shifts between broadband and geophones



Preliminary Results: “Unidentified waveform”

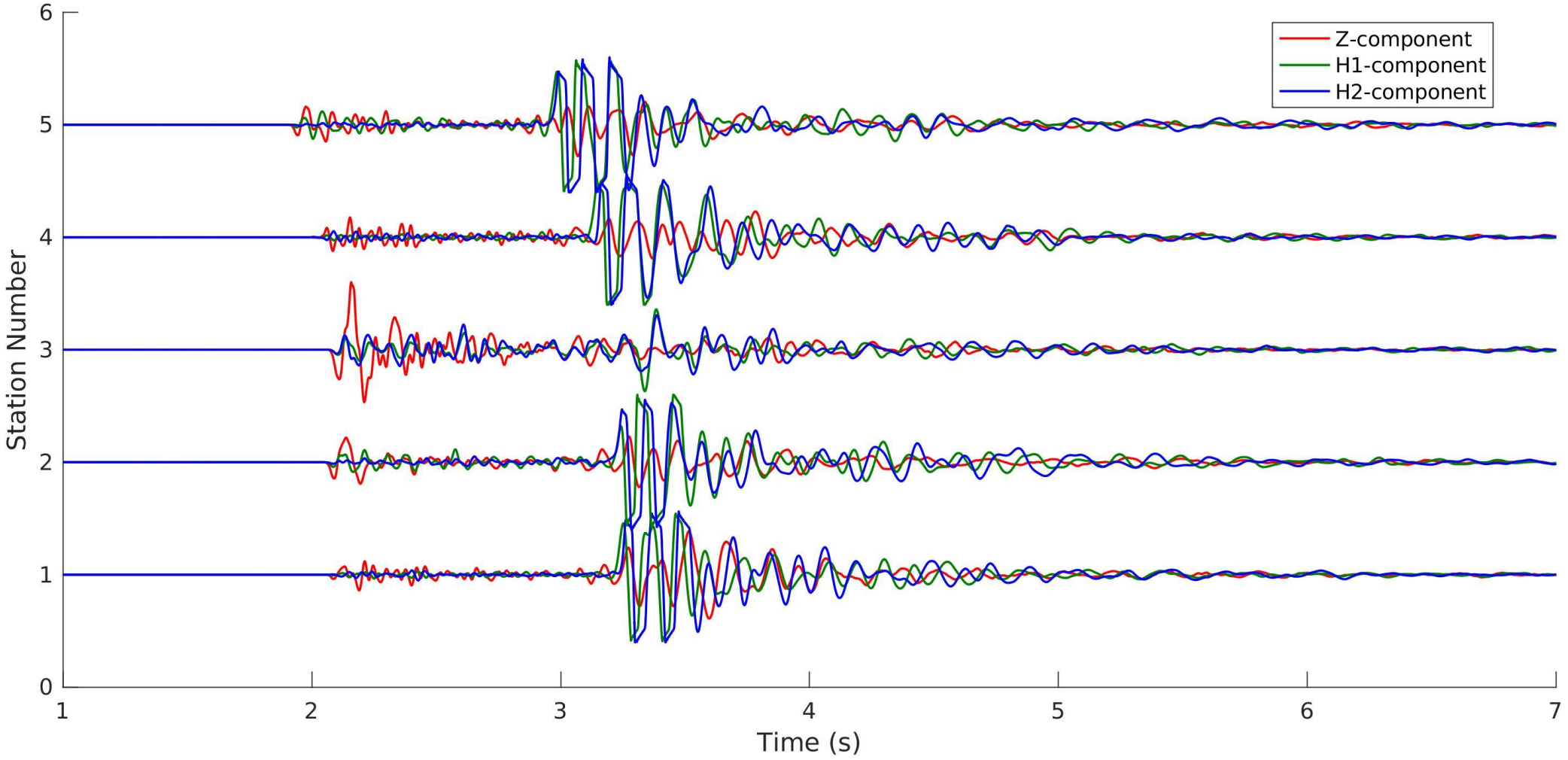


Preliminary Results: “Unidentified waveform”

⇒ Moose attack on station

Preliminary Results: Clipped Event

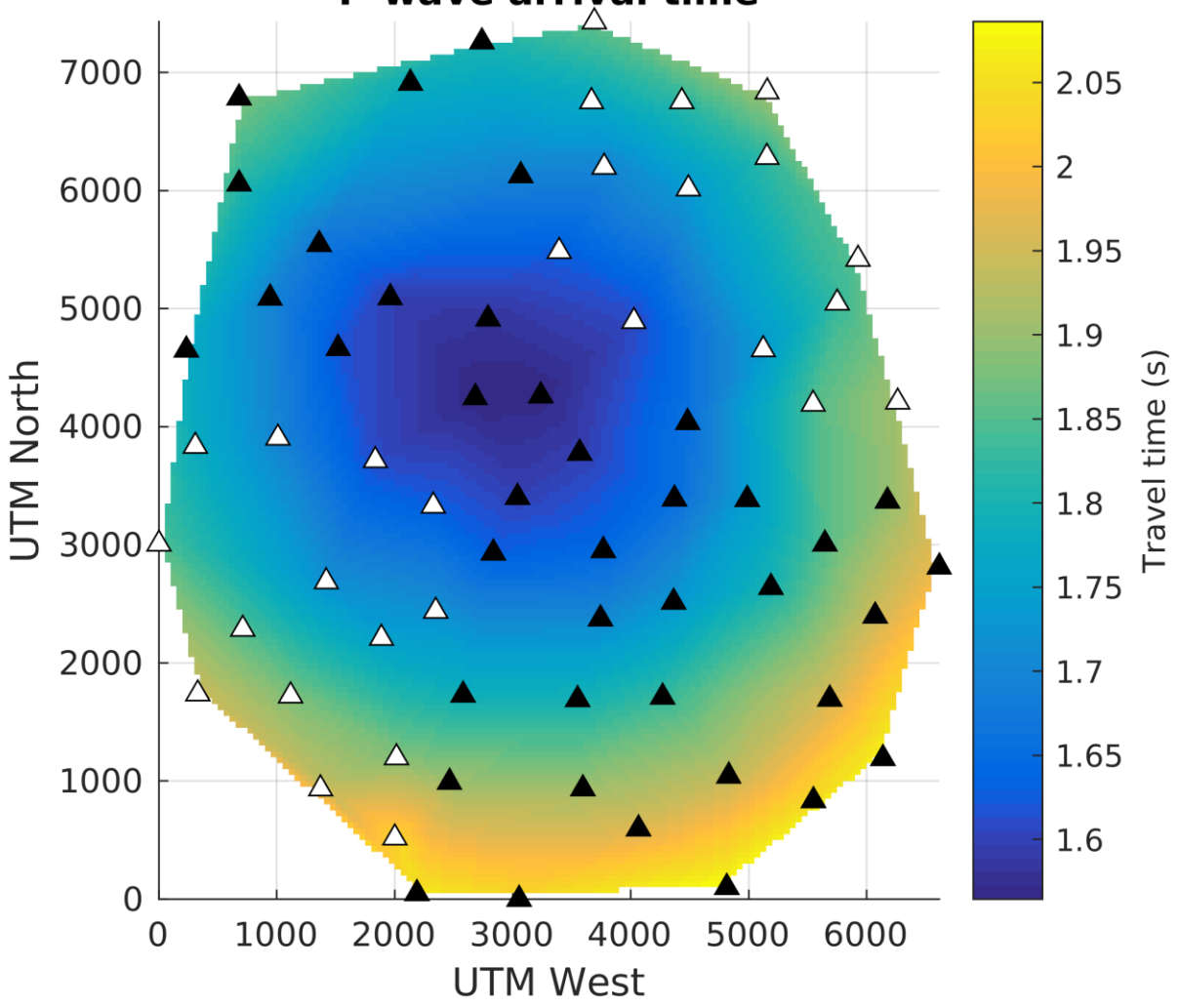
- Mw 3.6

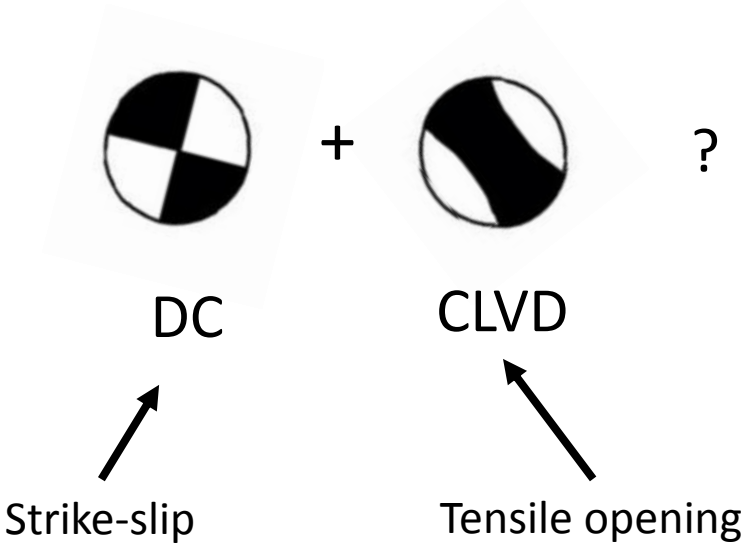


Preliminary Results: “Focal Mechanism”

Mw 3.6

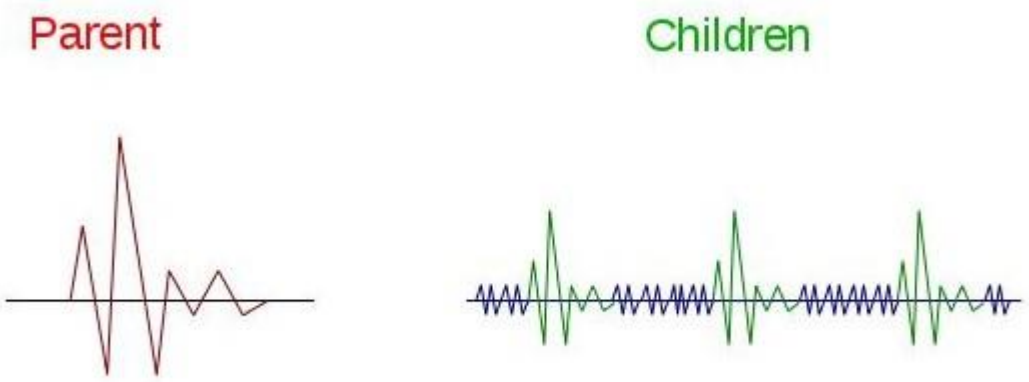
Black = compression
White = dilation



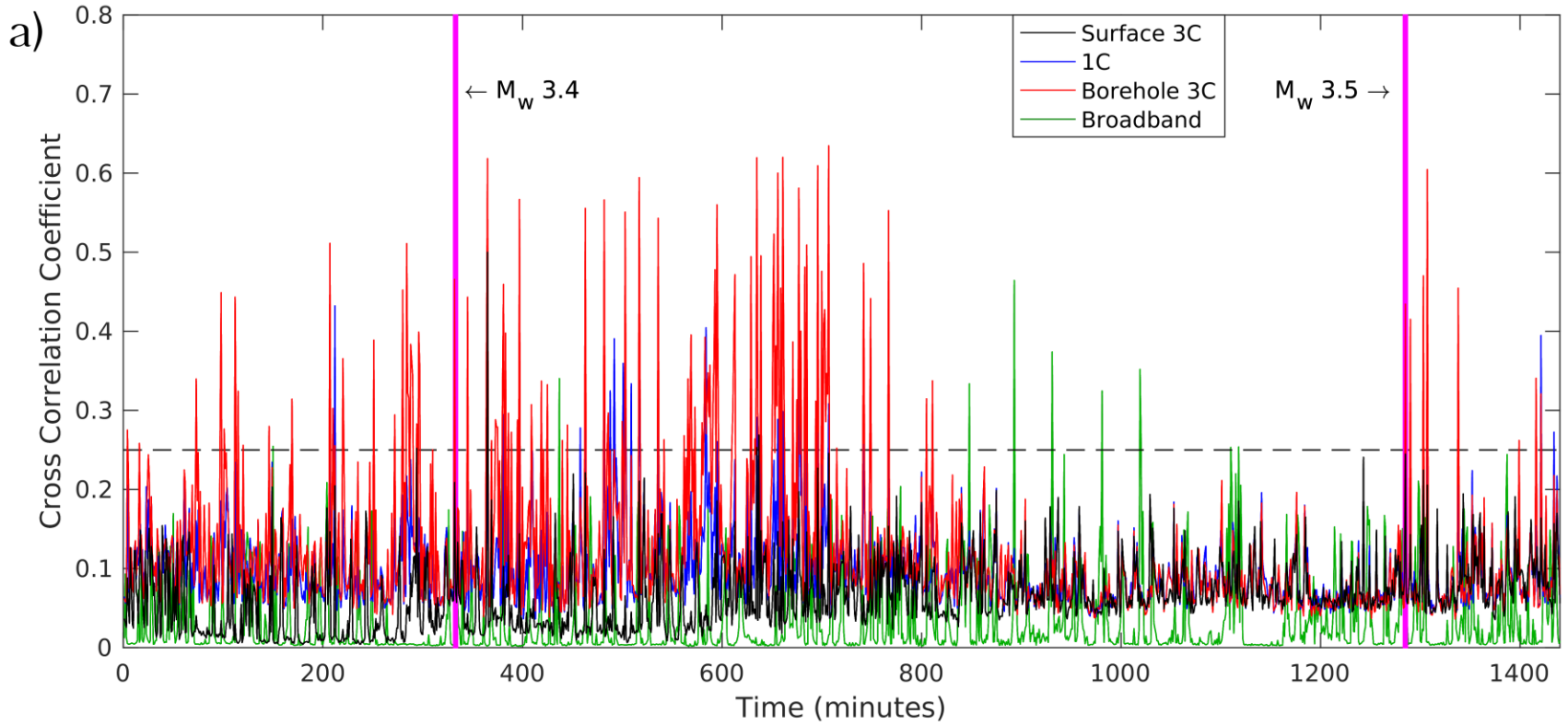


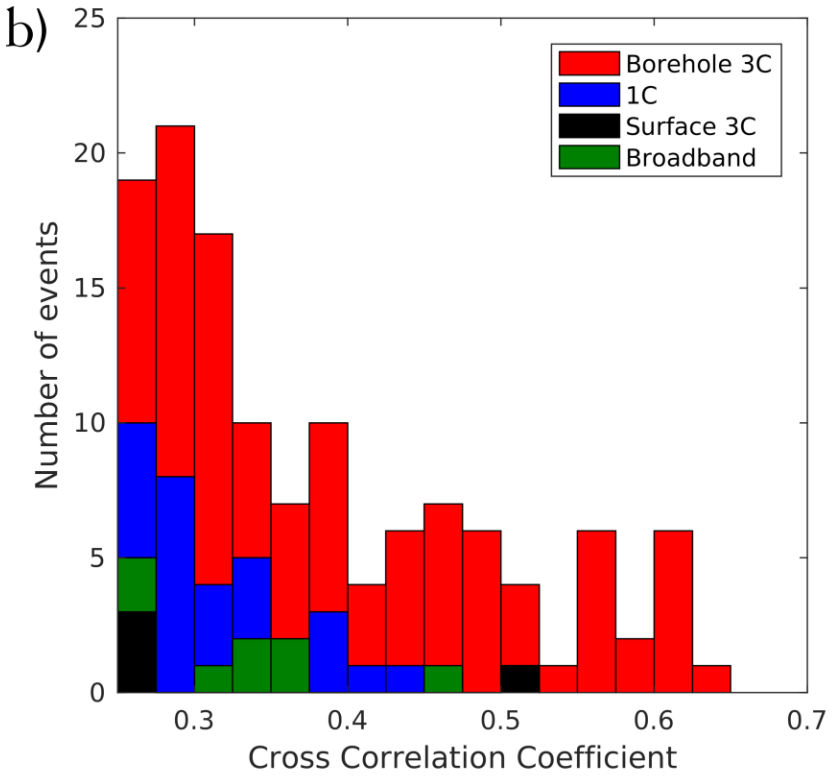
Preliminary Results: Cross Correlation i.e. MFA

- **MFA** = Matched Filtering Analysis
  - MFA is a template-based approach of detecting microseismic events in raw data using the waveforms of select template events and **cross correlation**.
- Some terminology:
  - '*Parent*' – original template ; '*child*' – event found using parent



Preliminary Results: Cross Correlation





⇒Verdict: The borehole 3C is the best for event detection during noisy periods, but the broadband does better in quieter conditions

Future work

- Microseismic processing (locations, magnitudes etc.)

- Developing an approach using Full Waveform Inversion (FWI) to simultaneously converge upon source parameters and a velocity model.
  - ➢ Joint work between the MIC and the CREWES.

- Geomodelling
  - ➢ Combining well log data and 3C/3D seismic data to build a geomodel for the area.

+ other exciting, unexpected directions!

Conclusions

- The Tony Creek Dual Microseismic Experiment (ToC2ME) was presented
- Induced seismicity **and** microseismic monitoring systems
- Preliminary results show this is a rich and very interesting dataset
- A lot of future work!

Acknowledgements

We would like to thank:

- Terra Sine and Nanometrics for their tremendous help with the field work
- The anonymous companies for letting us monitor their hydraulic fracturing treatment
- The sponsors of the Microseismic Industry Consortium
- Natural Sciences and Engineering Research Council of Canada (NSERC)

Thank you!
Questions/comments?