



Much Needed Broadband Recording for Hydraulic Fracturing

Aibing Li

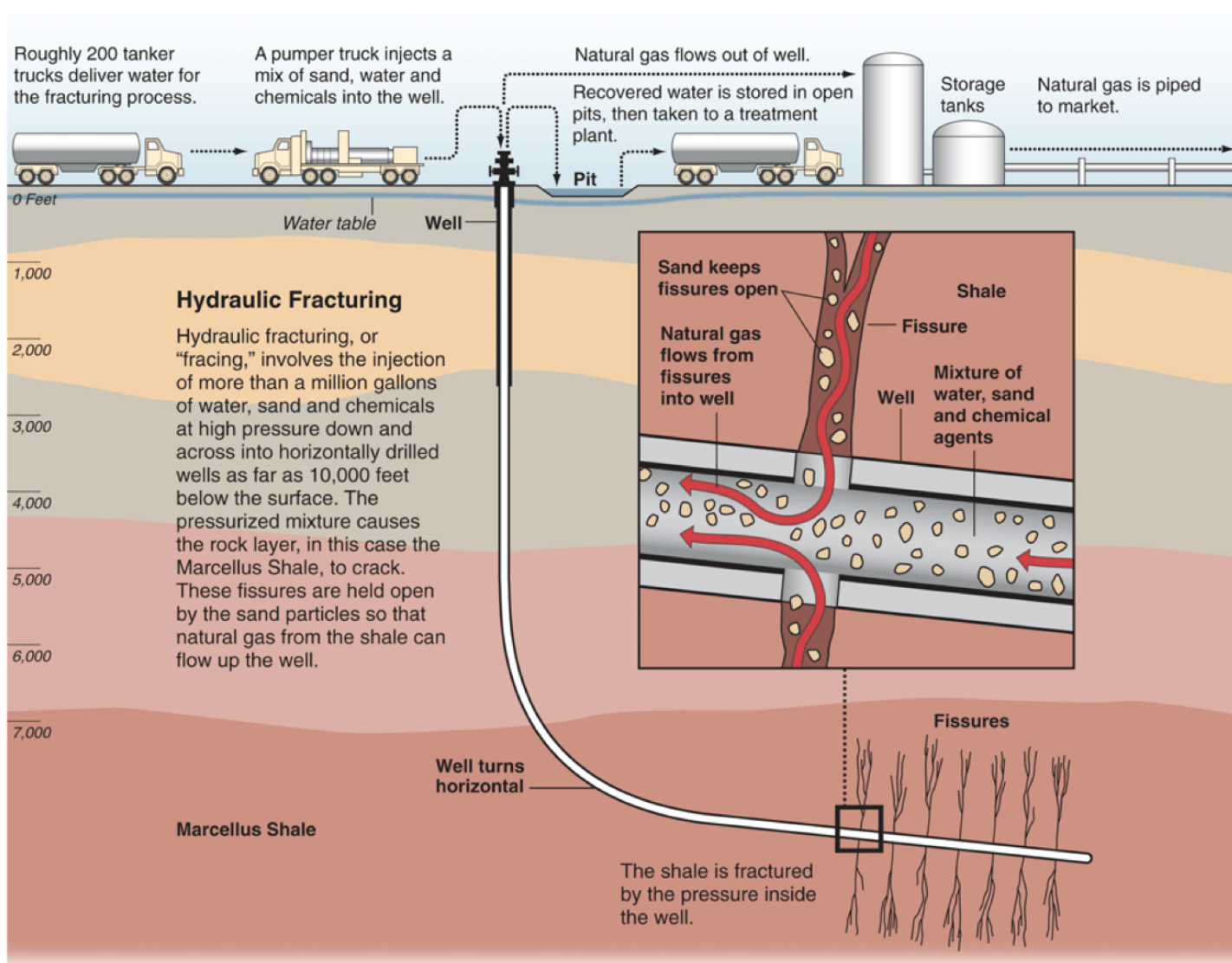
Hongru Hu

Ricardo Zavala

GSH/IRIS Workshop , June 3, 2014, Houston

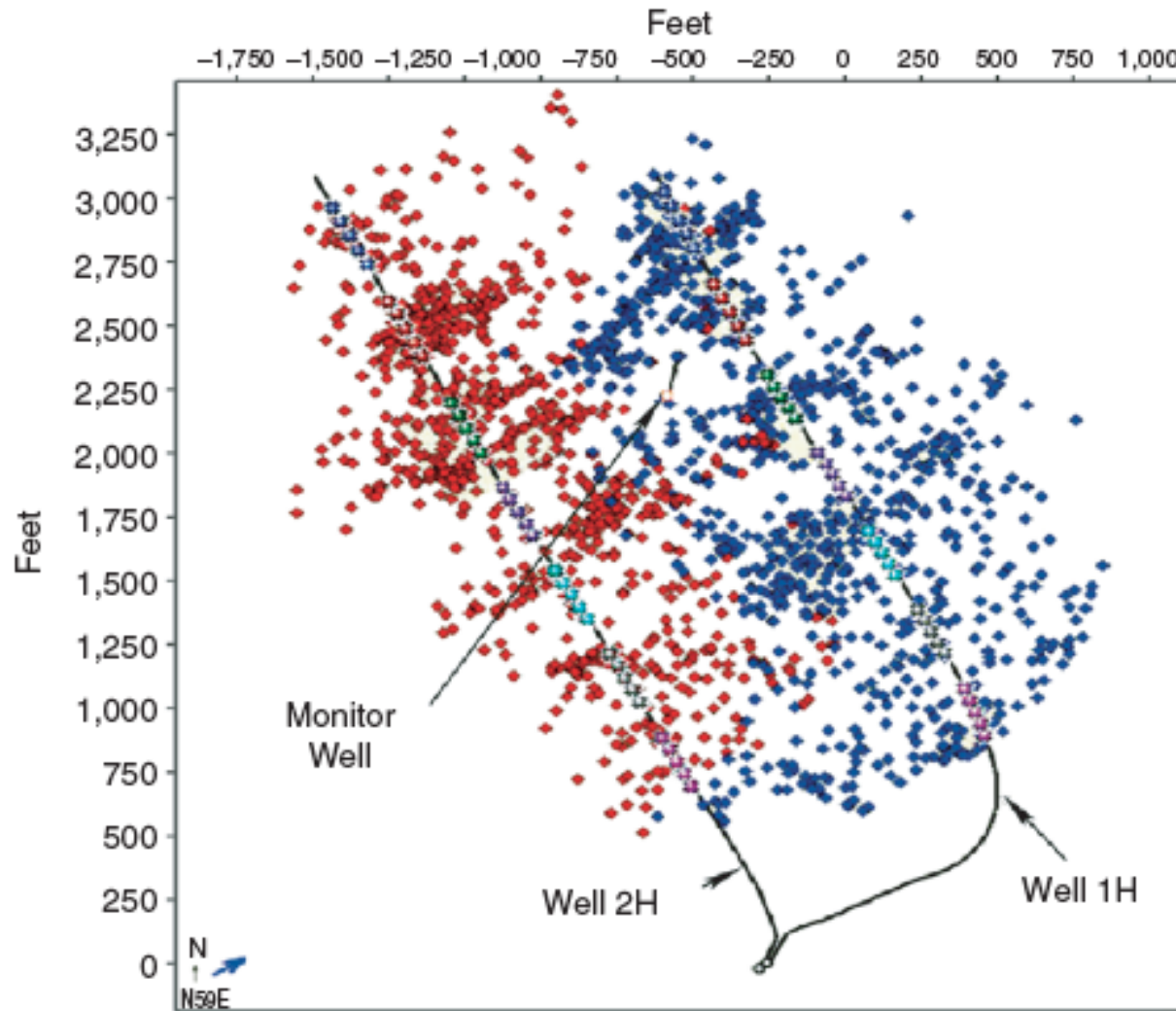
Hydraulic Fracturing

Injecting a million gallons of water, sand, and chemical mixture



(Granberg, 2010)

Typical properties of microseismicity



Magnitude:
-3 to -1

Frequency:
50-200 Hz

Source; shear
mechanism

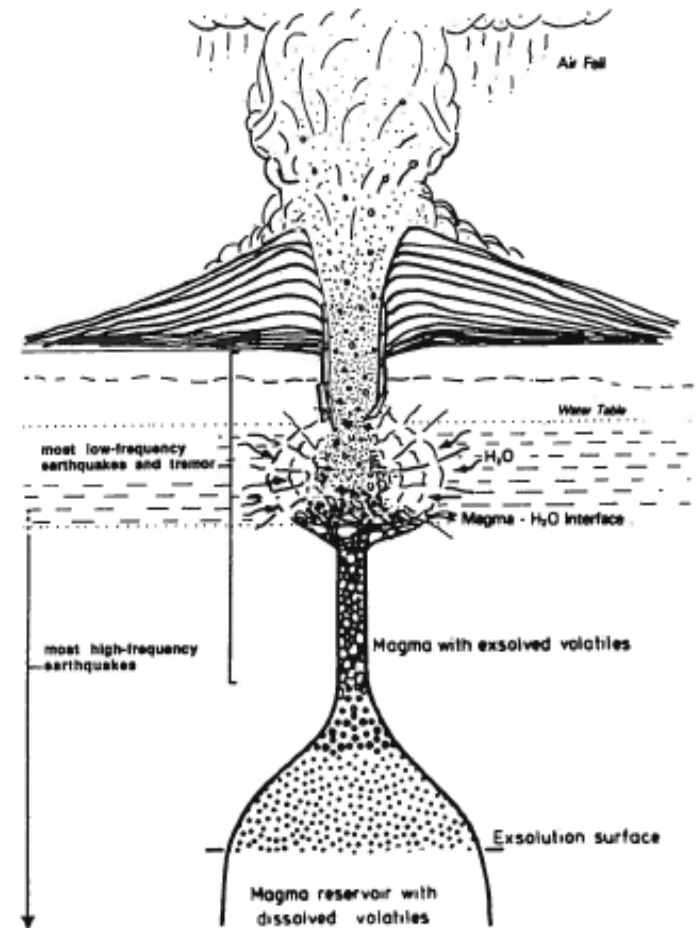
(Mayerhofer et al., 2011, Maxwell, 2011)

Questions

- What are the effects of water in ground deformation during hydraulic fracturing?
- Can the water effects be observed and identified?

Volcanic Earthquakes

- High-frequency earthquakes (5-15 Hz)
 - Caused by shear slip on faults
 - Clear P and S wave
- Low-frequency (1-5 Hz)
 - Caused by pressure change during the transport of unsteady fluid (magma, ground water)
 - Lack of S wave
- Volcanic tremor (long duration of shaking)



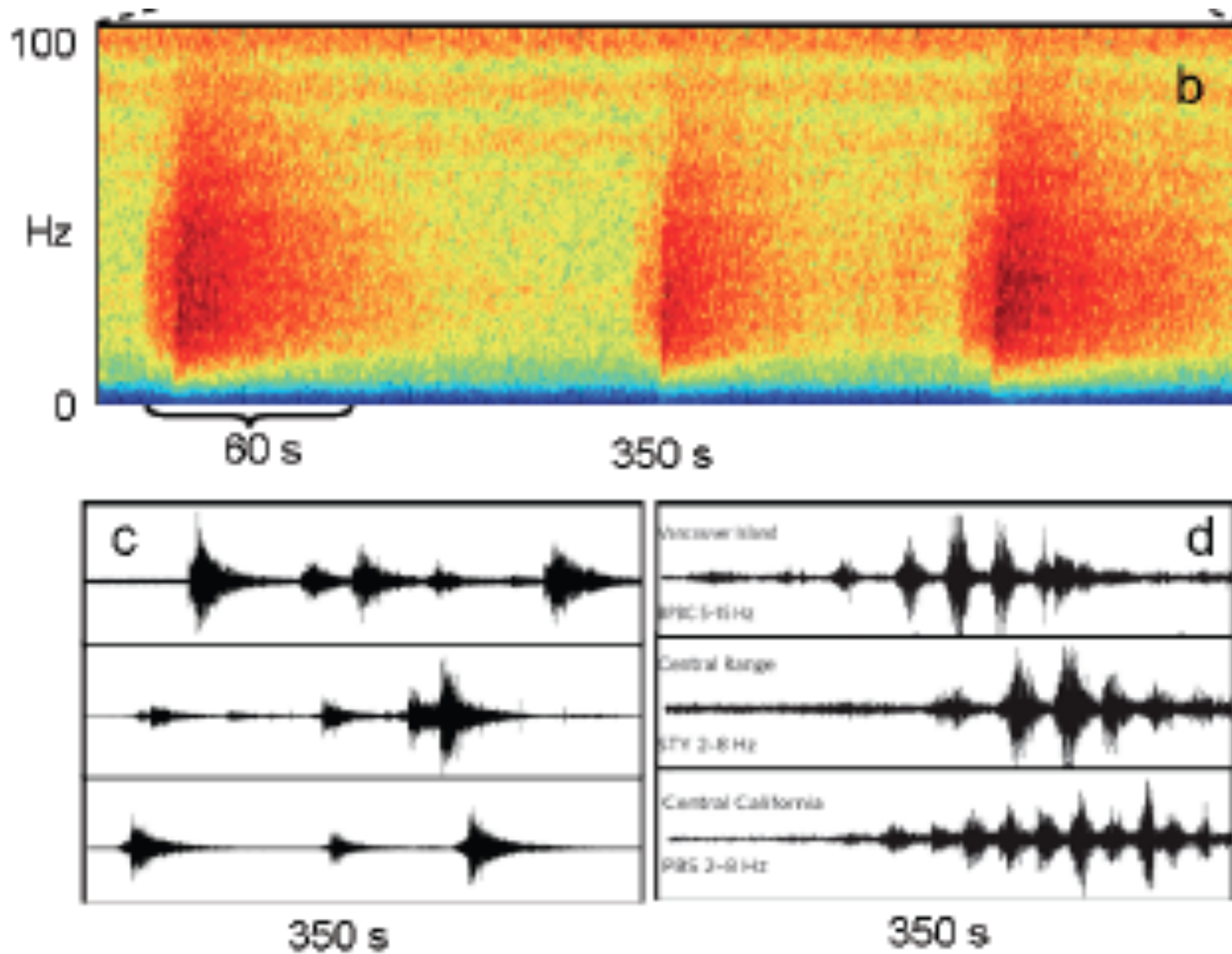
(McNutt, 1996)

Non-volcanic LFEs and Tremors

- Found in Japan, Cascadia, and other subductions zones, and the San Andreas Fault.
- Shear slip on existing faults
- Associated with high fluid pressure

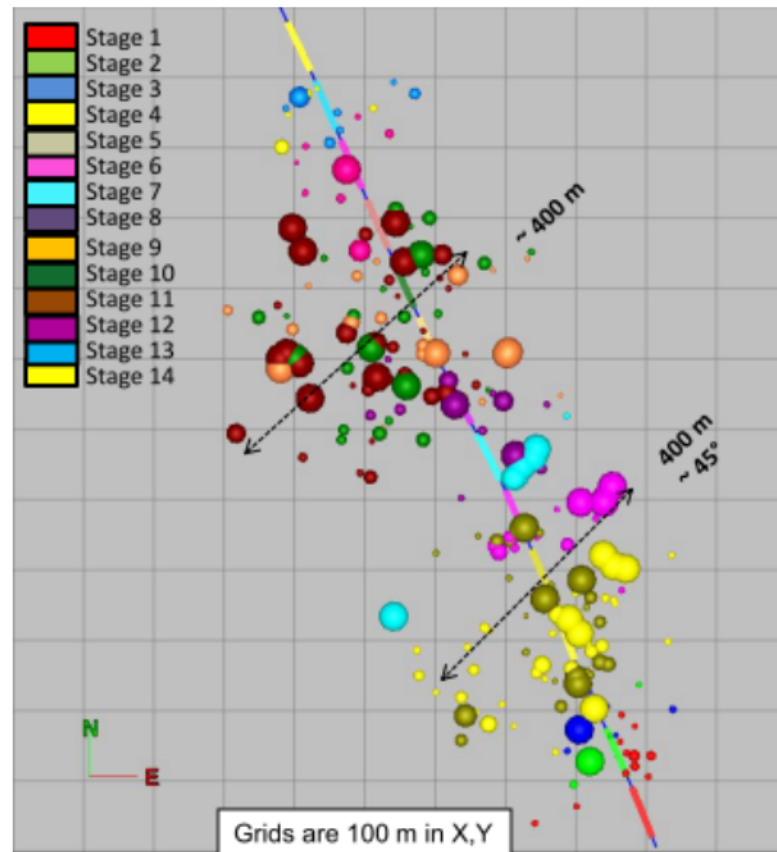
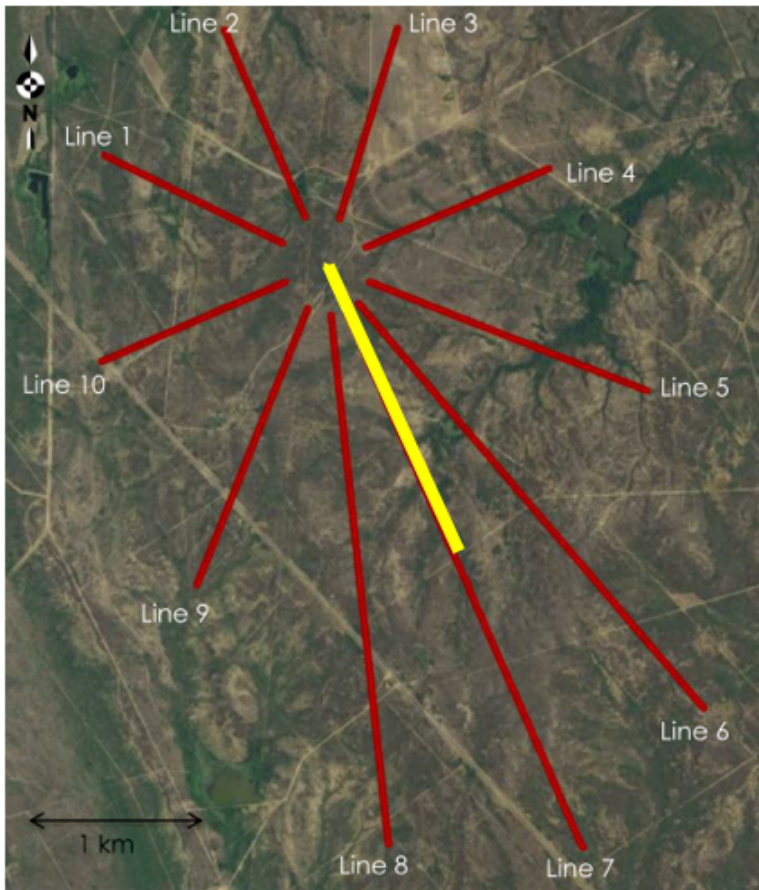
(Becken et al., 2011; Ide et al., 2007; Shelly et al., 2007, Shelly, 2010)

Long Period and Long Duration Events in the Barnett Shale, TX



(Das and Zoback, 2012)

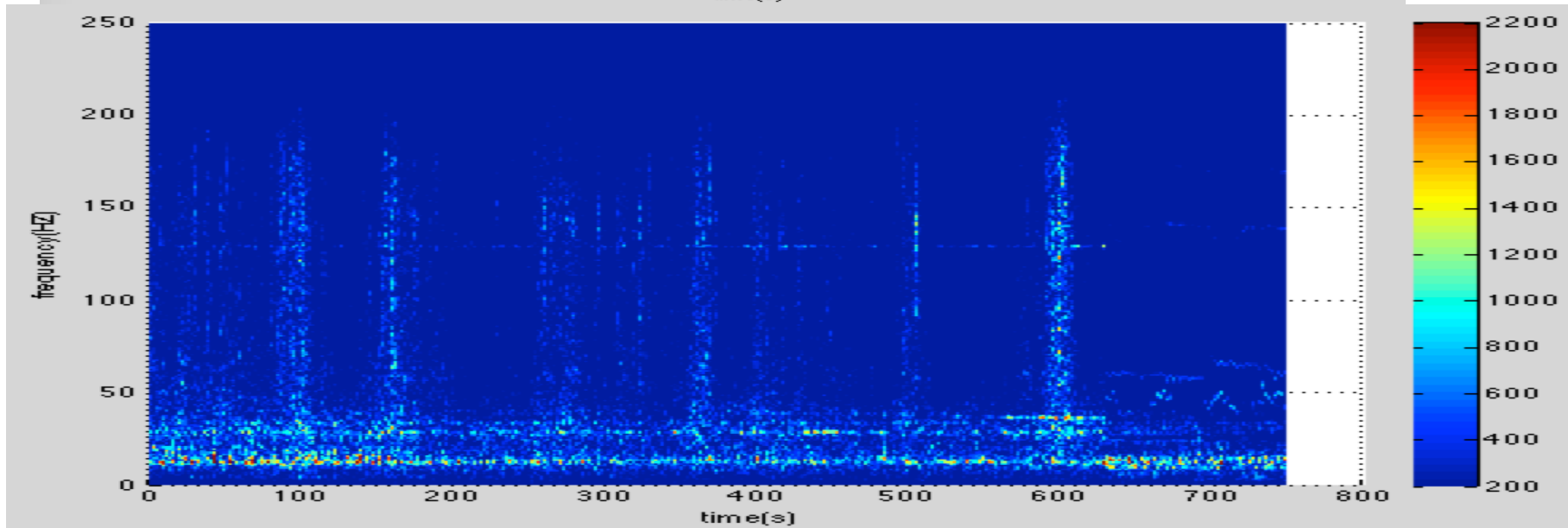
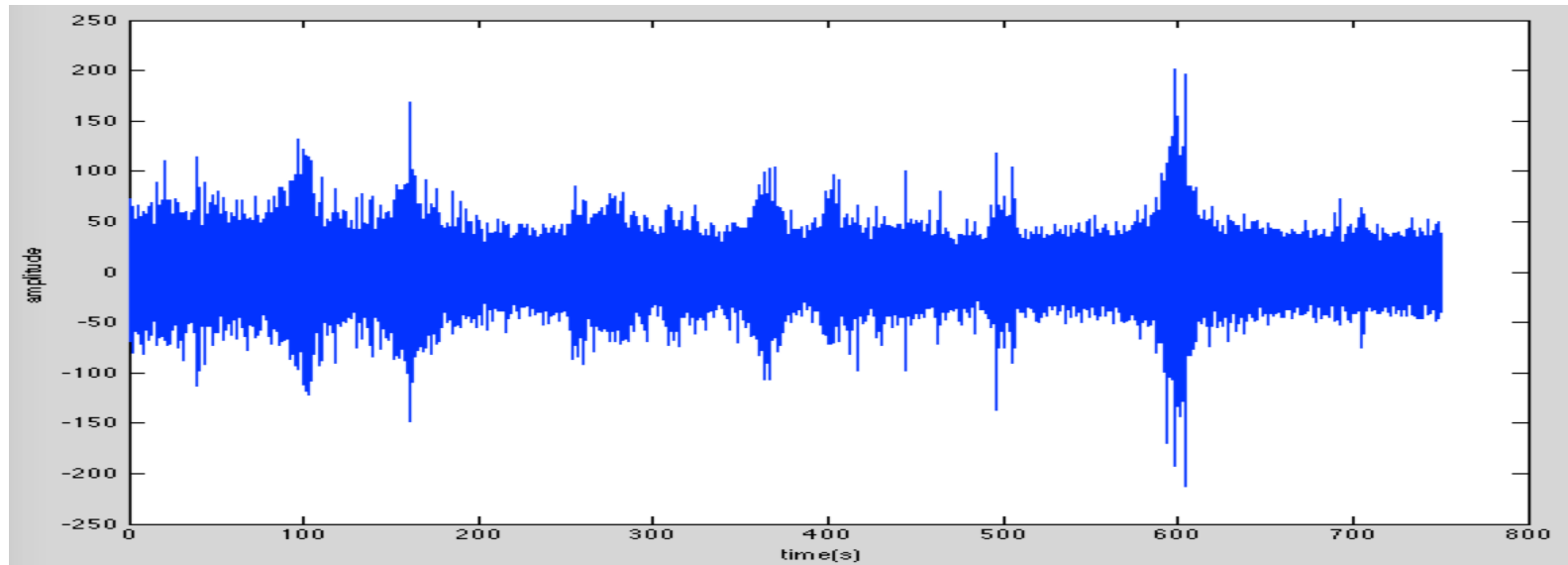
Hydraulic Fracturing in the Eagle Ford Shale in NE Mexico



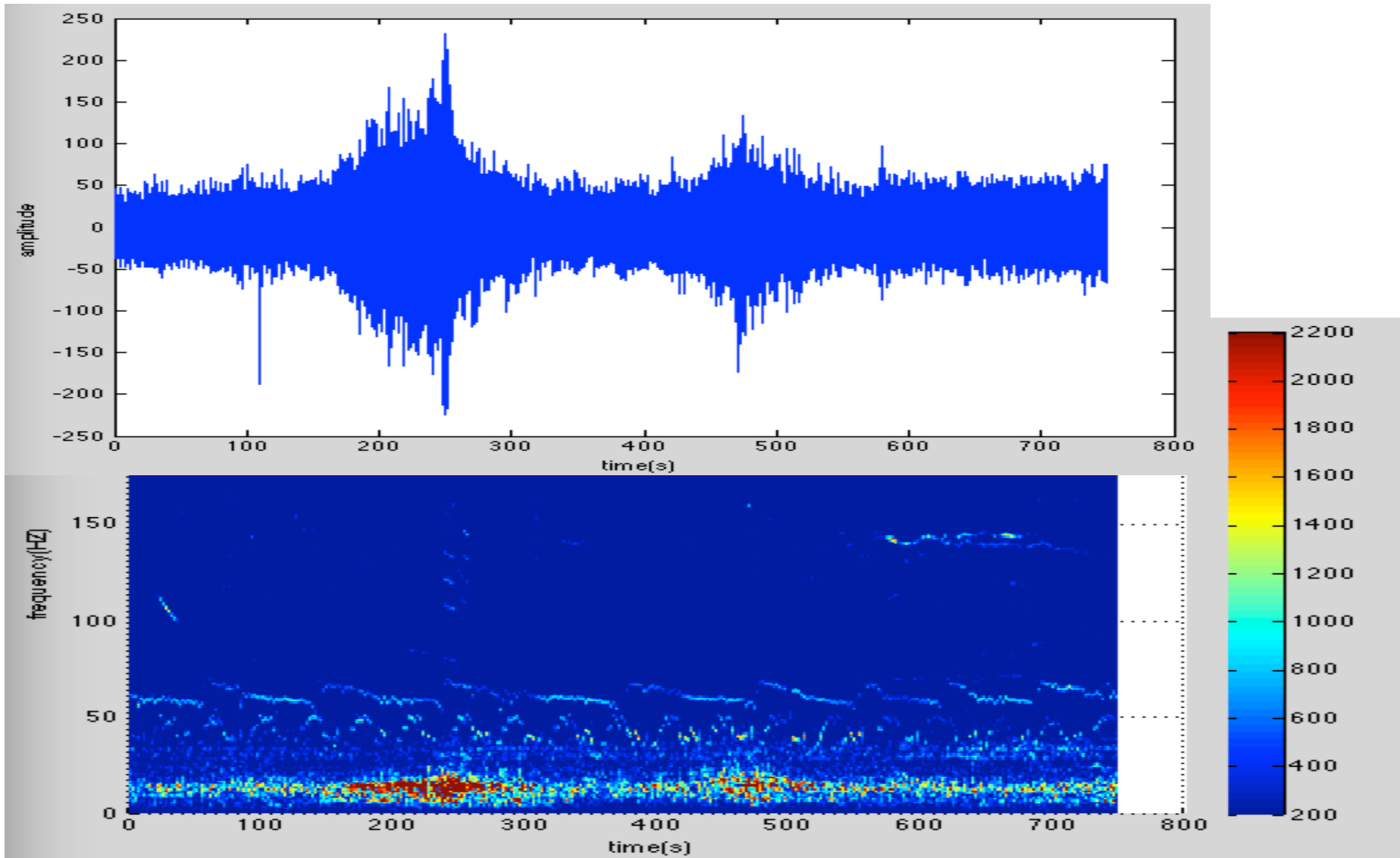
Map of receivers (1008) and the well

Map of microseismic events at 14 stages

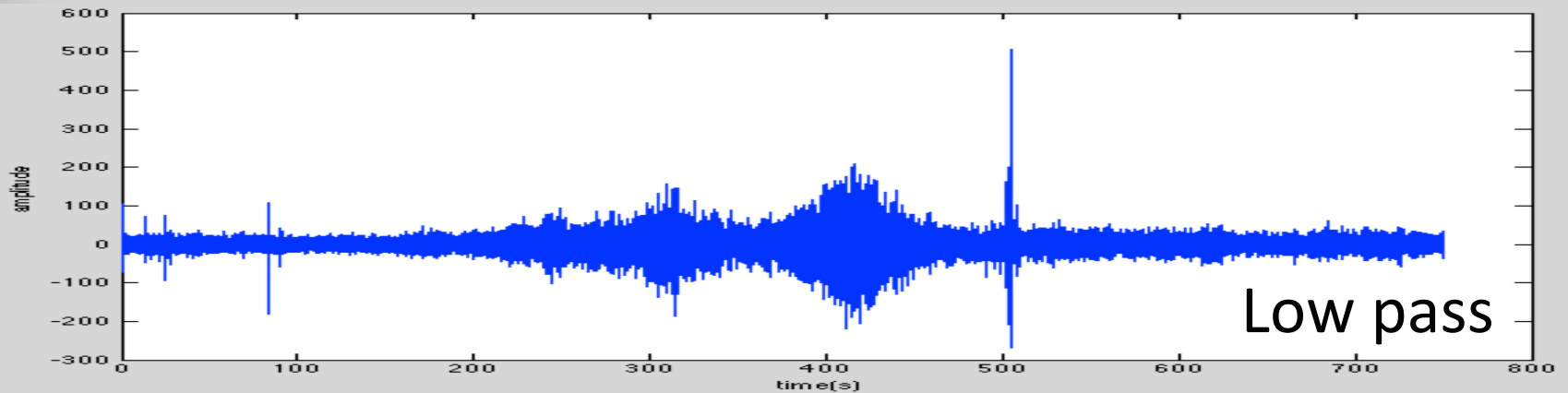
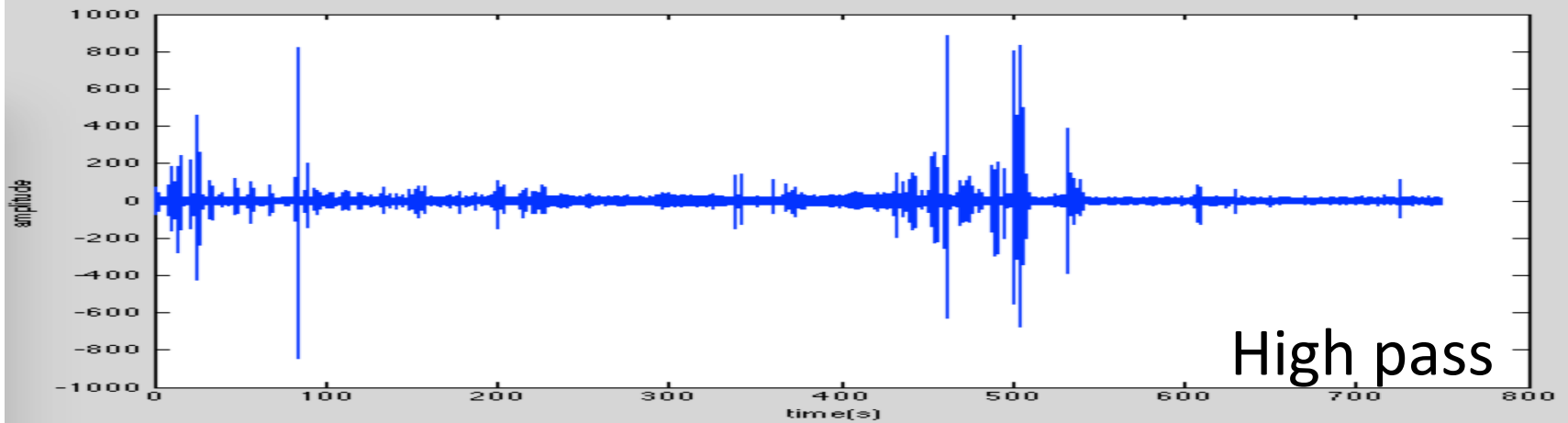
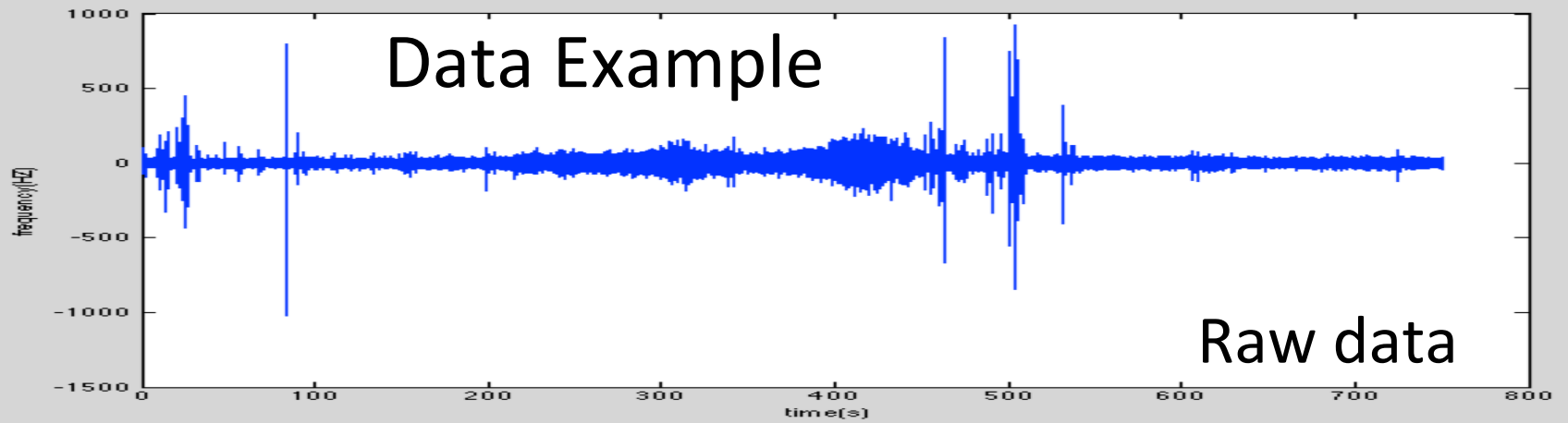
Geophone Record and frequency-time plot (1)



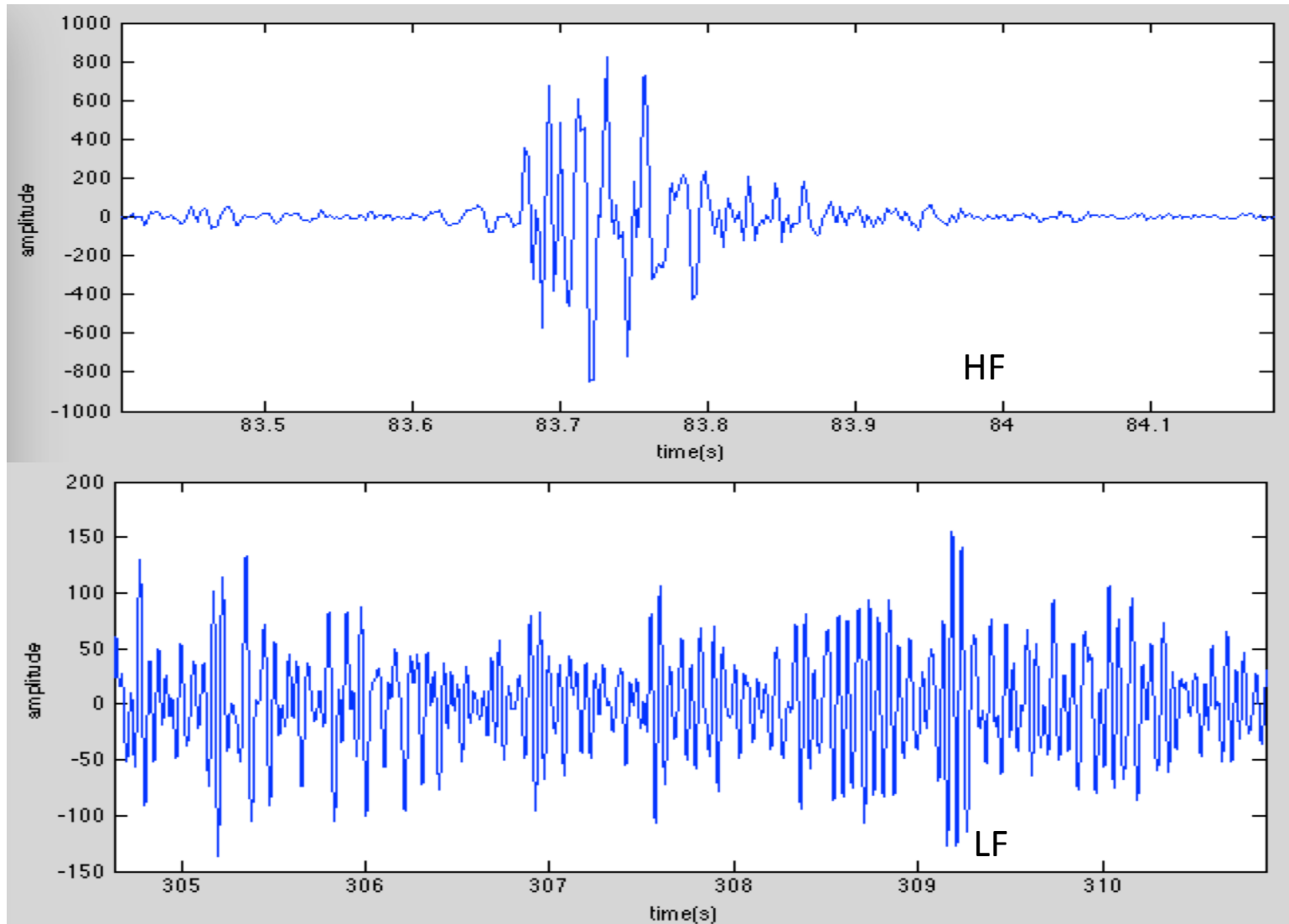
Geophone Record and frequency-time plot (2)



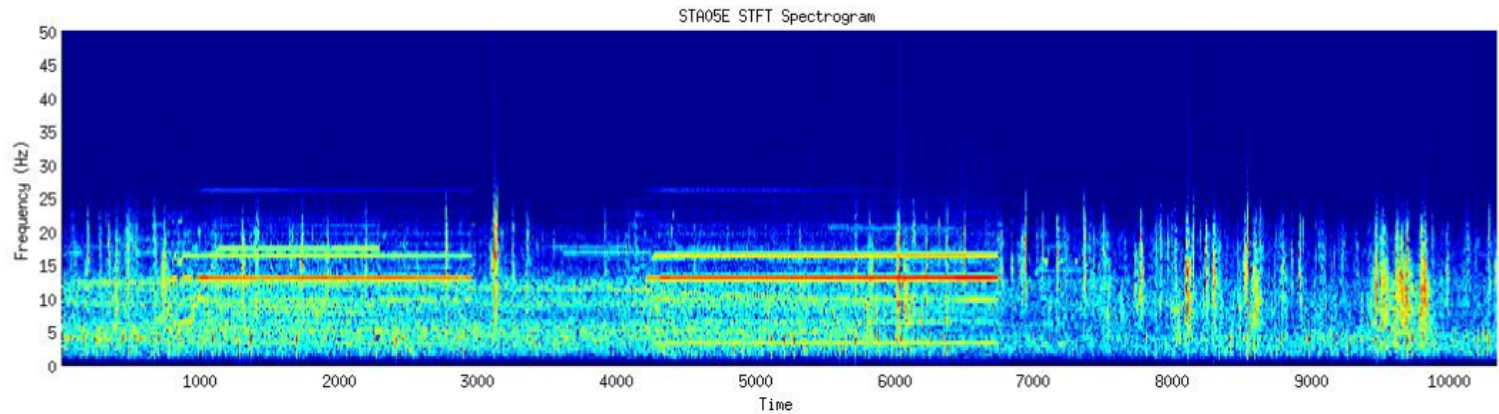
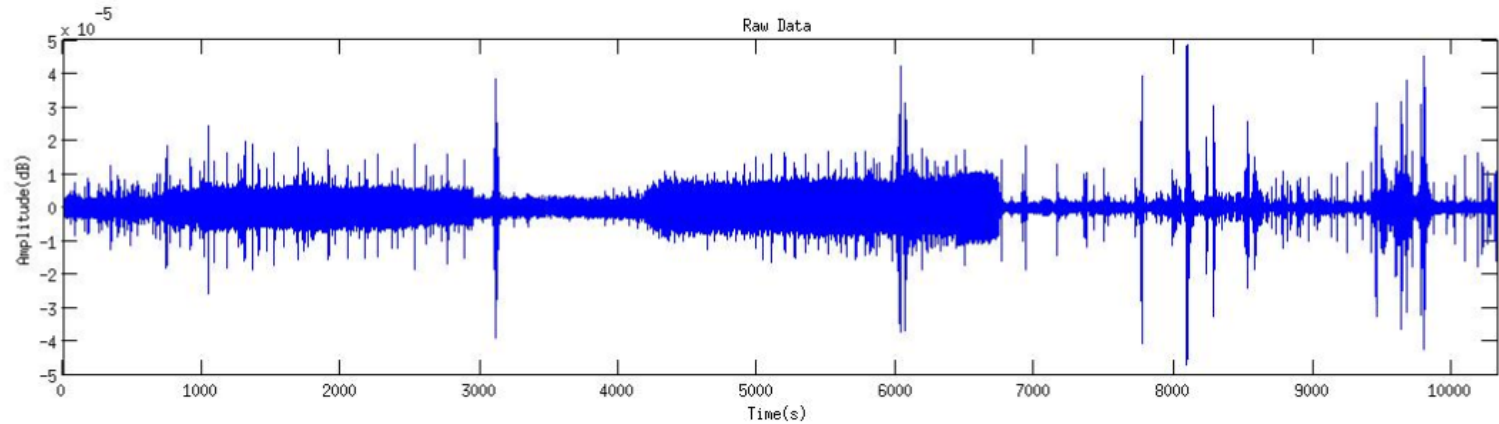
Data Example



Seismograms for HF and LF events



Broadband records and time-frequency plot for a hydraulic fracturing experiment in the Sichuan basin

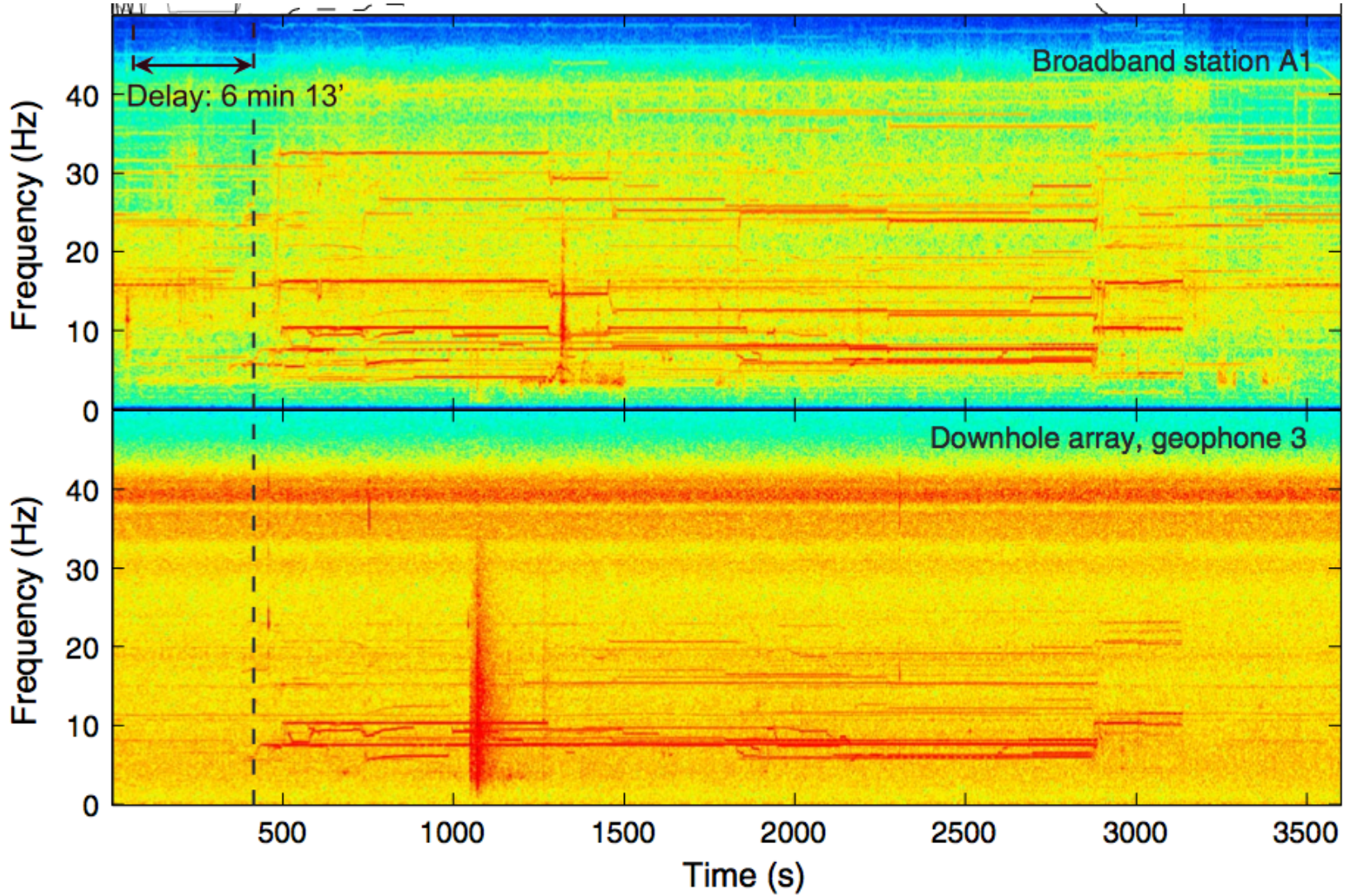


Resonance Frequency: 14, 18, and 28 Hz.

LFE: 3-4 Hz

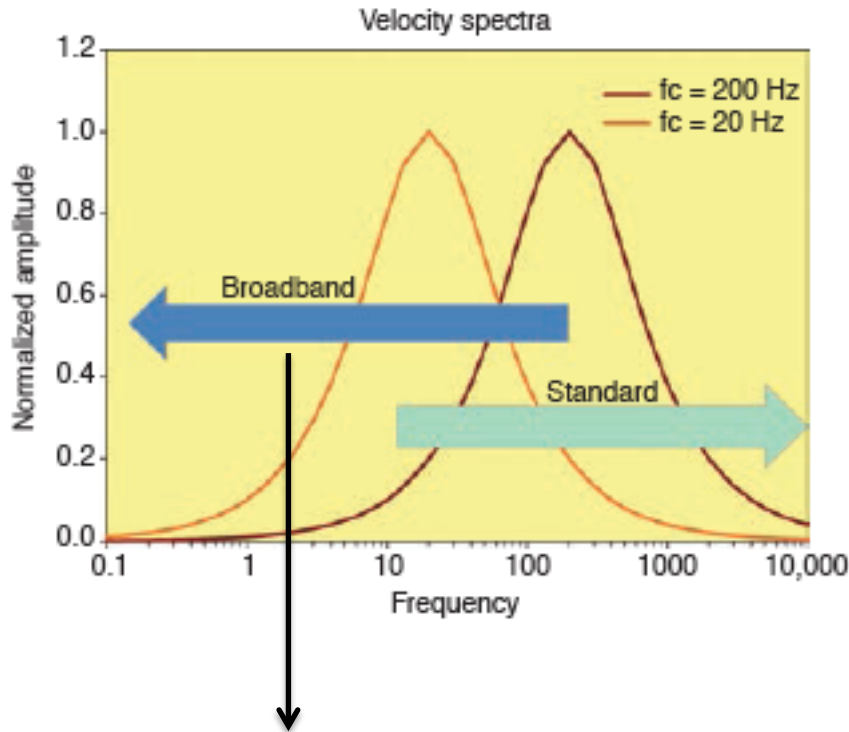
(Yu and Zhang, 2013)

Comparison of time-frequency plots from a broadband station and a geophone



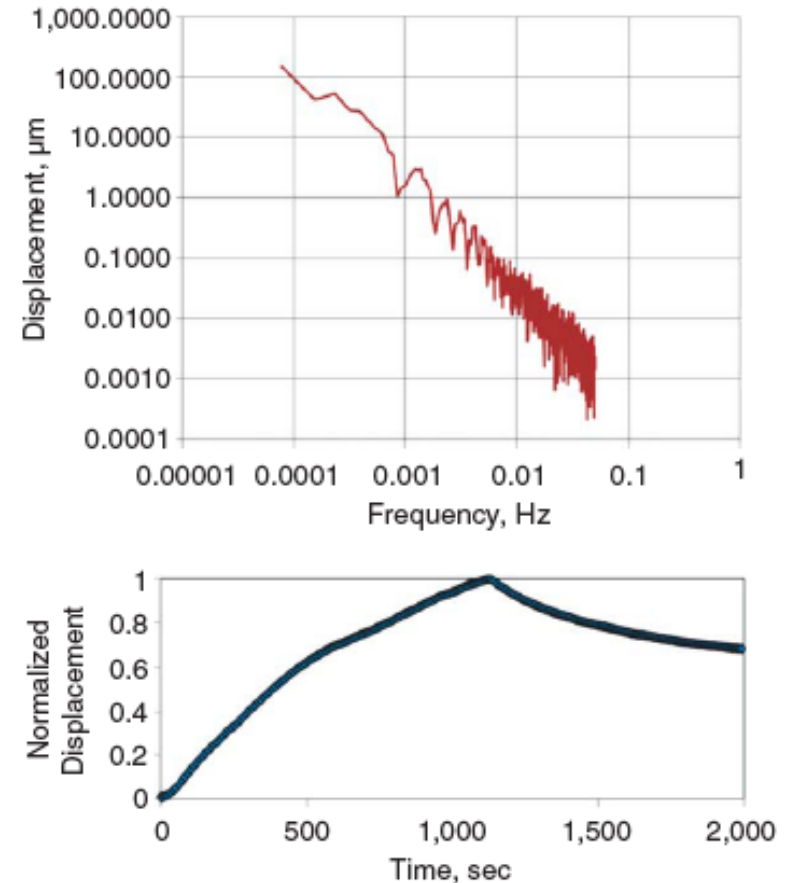
(Tary et al, 2014)

Dominant frequencies for geophone, broadband sensor, and tiltmeter



Not well acquired and studied

(Maxwell, 2014)



(Warpinski et al., 2013)

Summary

- Low-frequency events exist during the hydraulic fracturing treatment.
- Typical geophones do not have good responses for the interested LFEs.
- Broadband data acquisition is needed to study the LFEs.
- Detail studies need be conducted to understand the mechanisms of LFEs and their role in forming the fracture network.

Acknowledgement

- Thanks PEMEX-CONACYT-SENER for supporting Ricardo Zavala.
- Thanks PEMEX E&P for allowing us to use the data in Hongru's and Ricardo's thesis researches and in this presentation.