TRANSPARENT EARTH

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SDSMT

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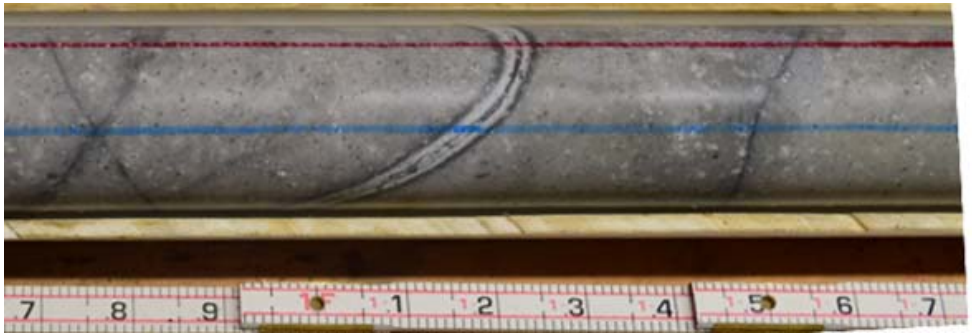
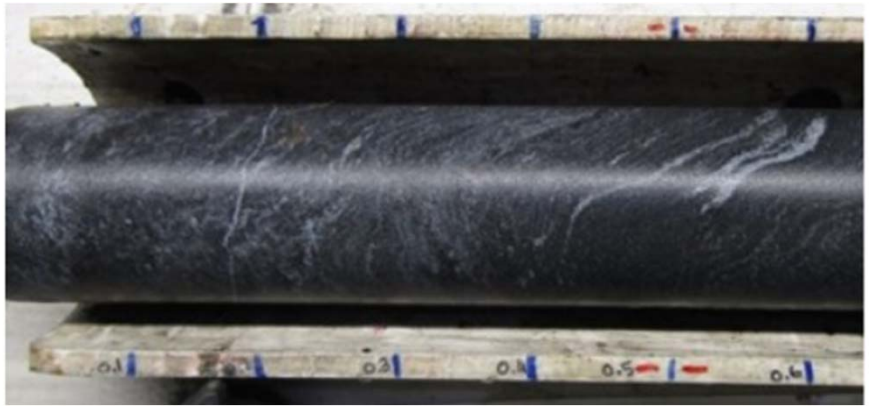
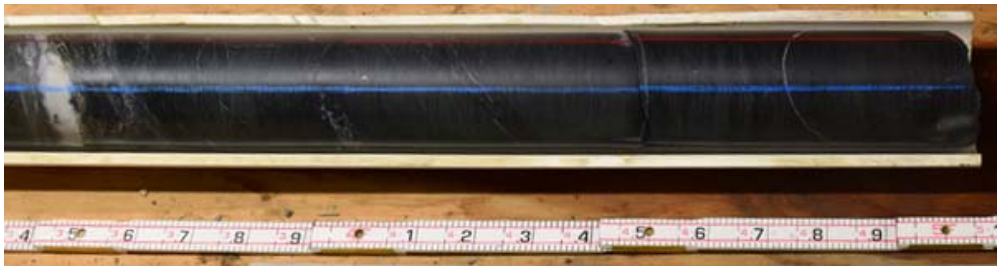
A History of Geophysical Investigations

- Began in 2010
- Initial funding by NSF Geoengineering
- Continued presence at SURF since that time
- Tends to concentrate on geophysical investigation of physical properties of the SURF underground
- Although projects have wide ranges, only two will be showcased today
  - Seismic tomographic study near the Big X next to the Yates Shaft on the 4850 Level
  - High-resolution seismic tomography associated with hydraulic fracturing (data from kISMET project)







Rock Types

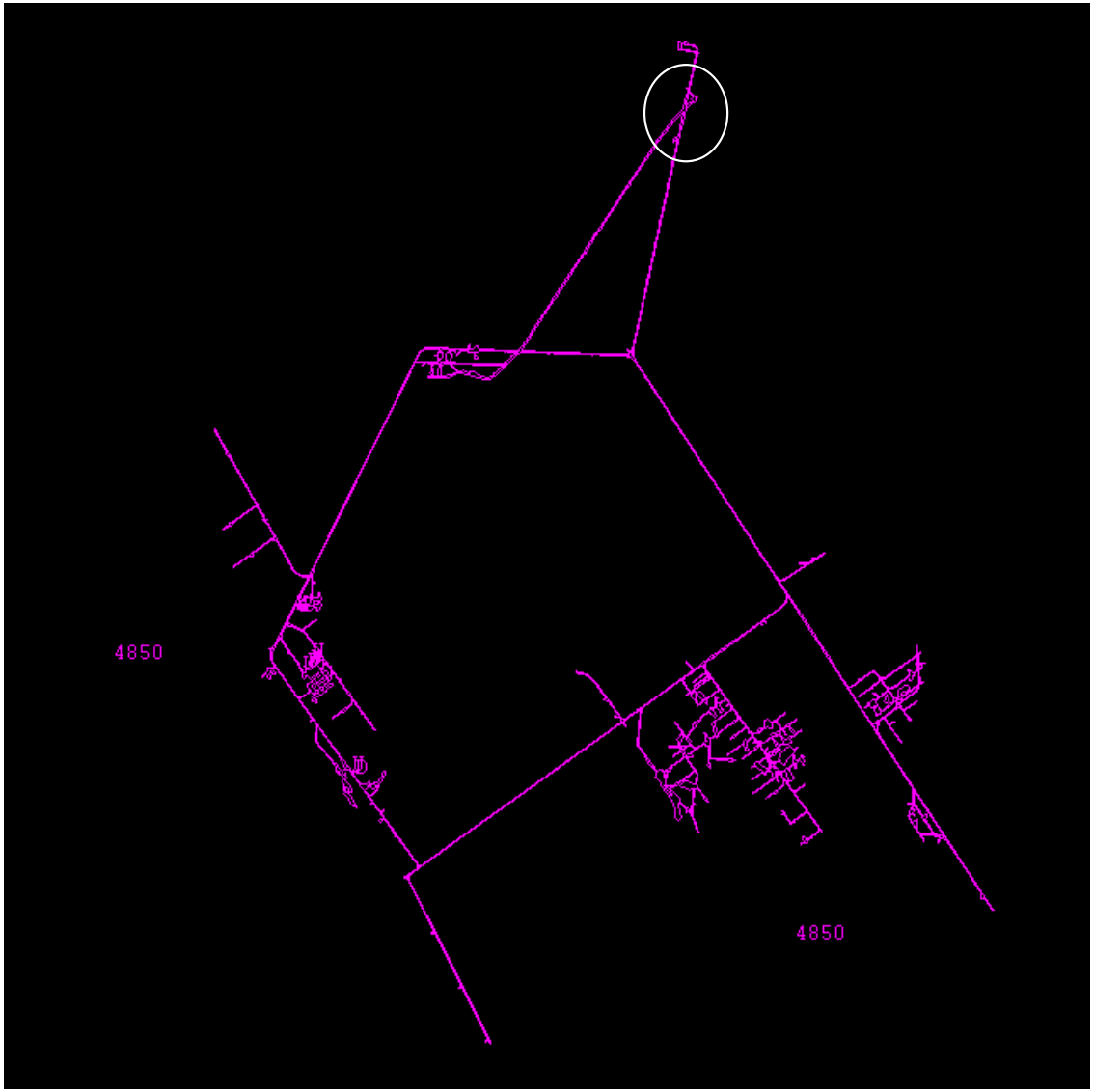
Rhyolite – intrusive igneous rock ~55 my

Upper Poorman Formation – metasedimentary rock; carbonate mica phyllite

Yates Unit of the Poorman Formation – amphibolite; metamorphosed basalt

~2 by

1. Pillar study near
“Big X”



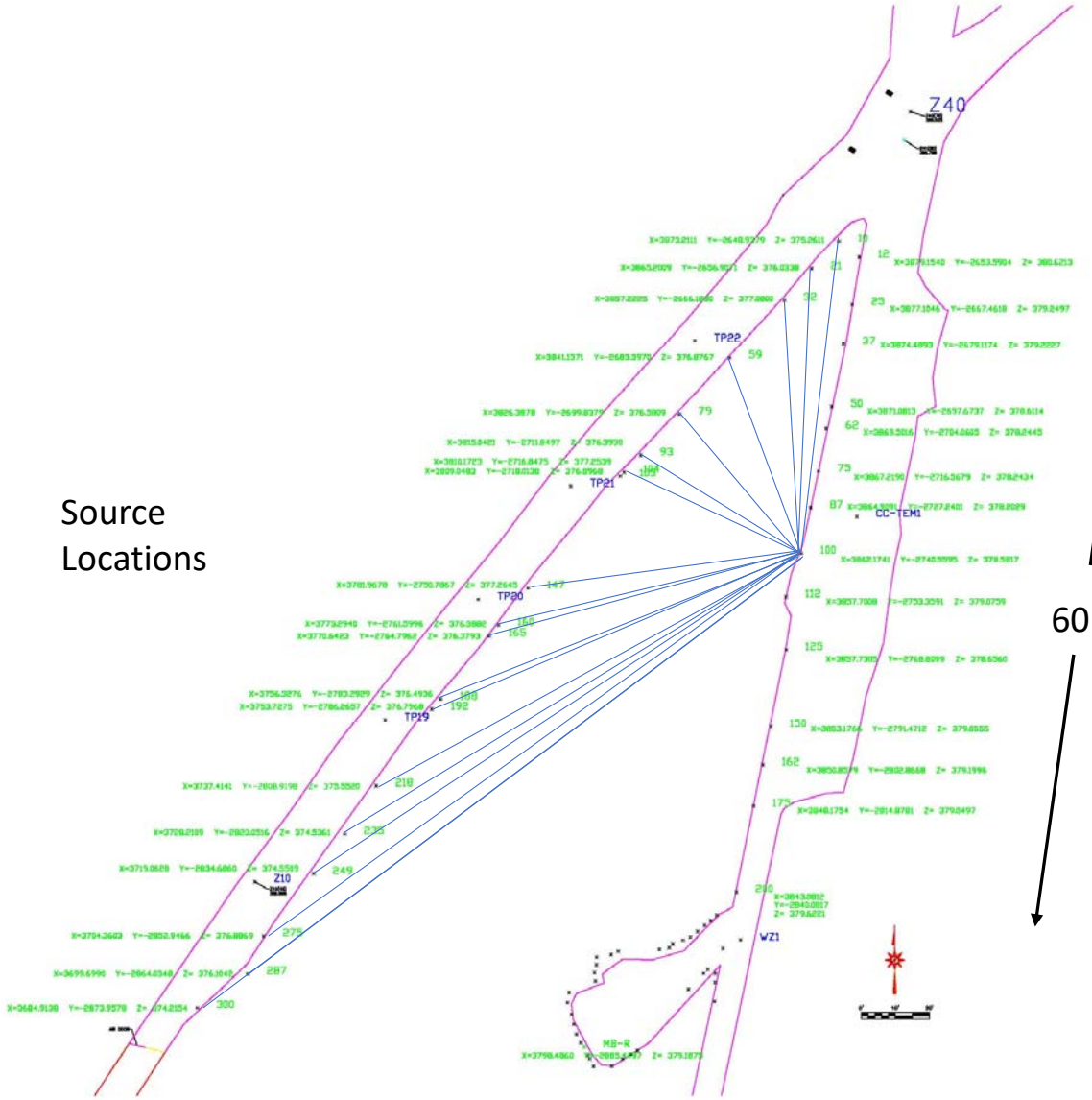
Purpose of the Study:

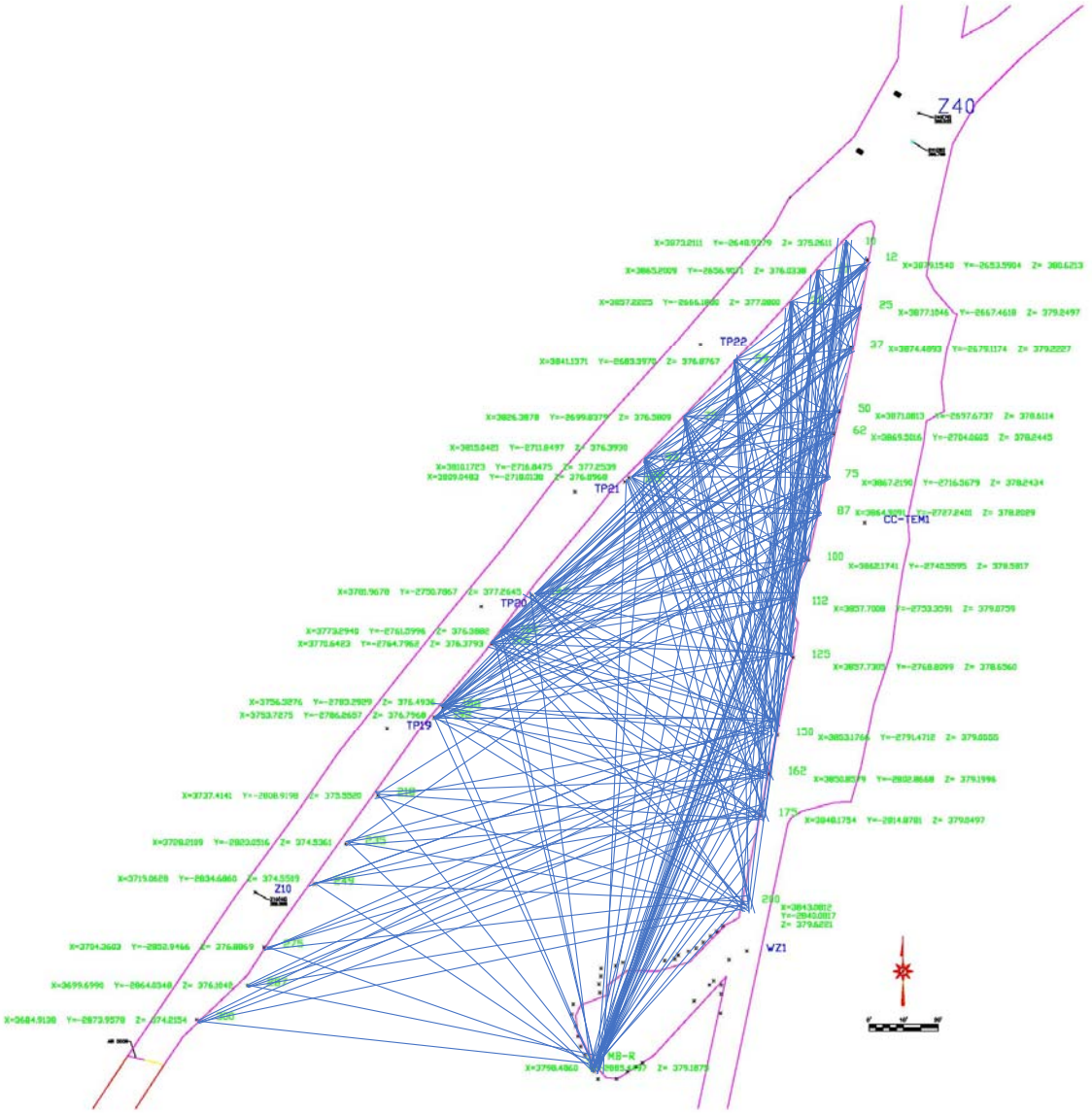
1. Determine deformation characteristics in the pillar of rock between the West Drift and Exhaust Drift near the Yates Shaft

2. Determine if seismic tomography can delineate the rhyolite intrusions

3. Identify discontinuities, e.g. faults and/or major fractures, that may affect performance of the pillar

4. Determine seismic velocities to use in interpretation of data from existing seismic arrays


Source Locations
60 m
Receiver Locations
Z40
TP22
TP21
CC-TEM1
TP20
TP19
Z10
WZ1
MB-R


Z40
TP22
TP21
CC-TEM1
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Z10
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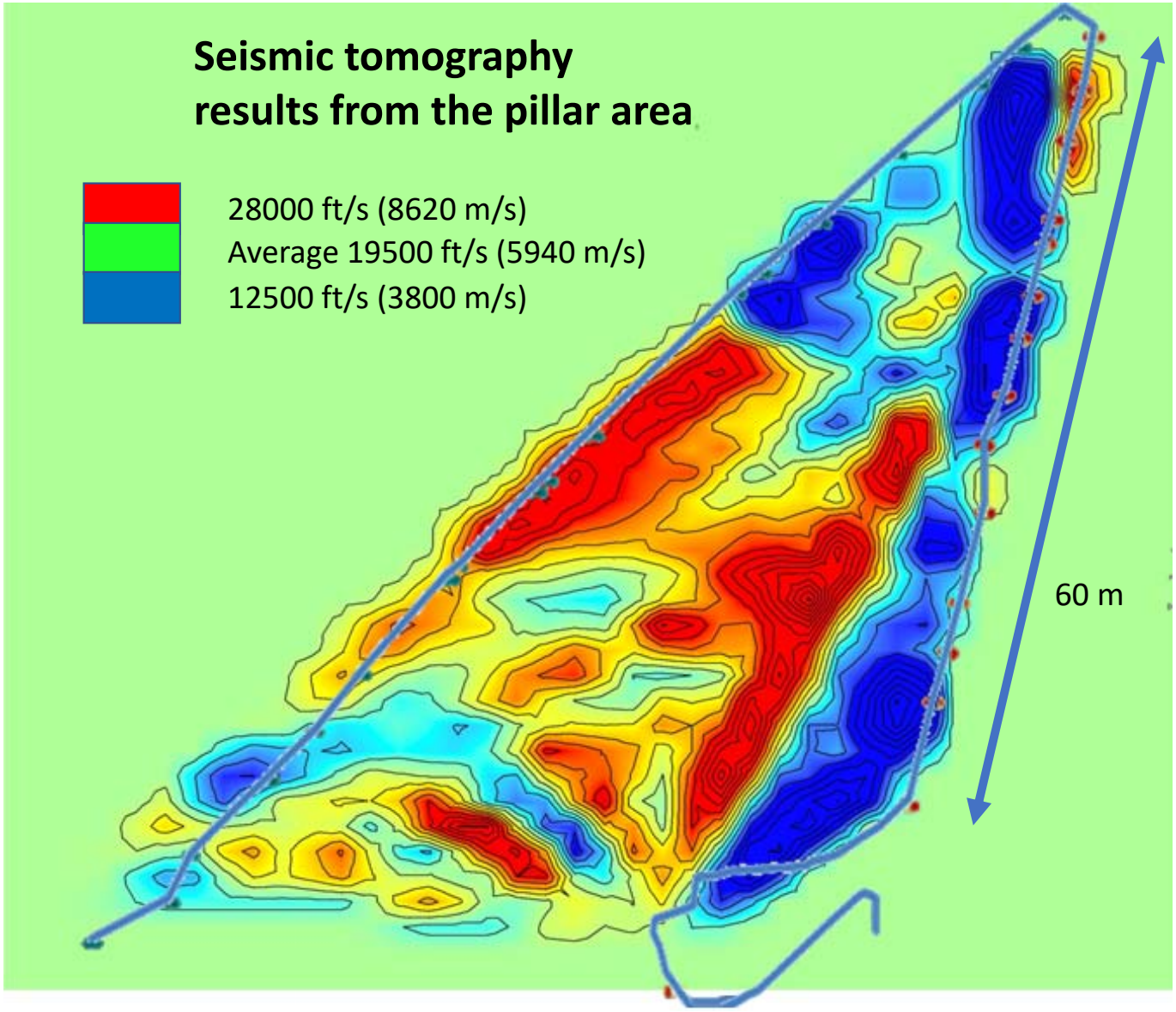
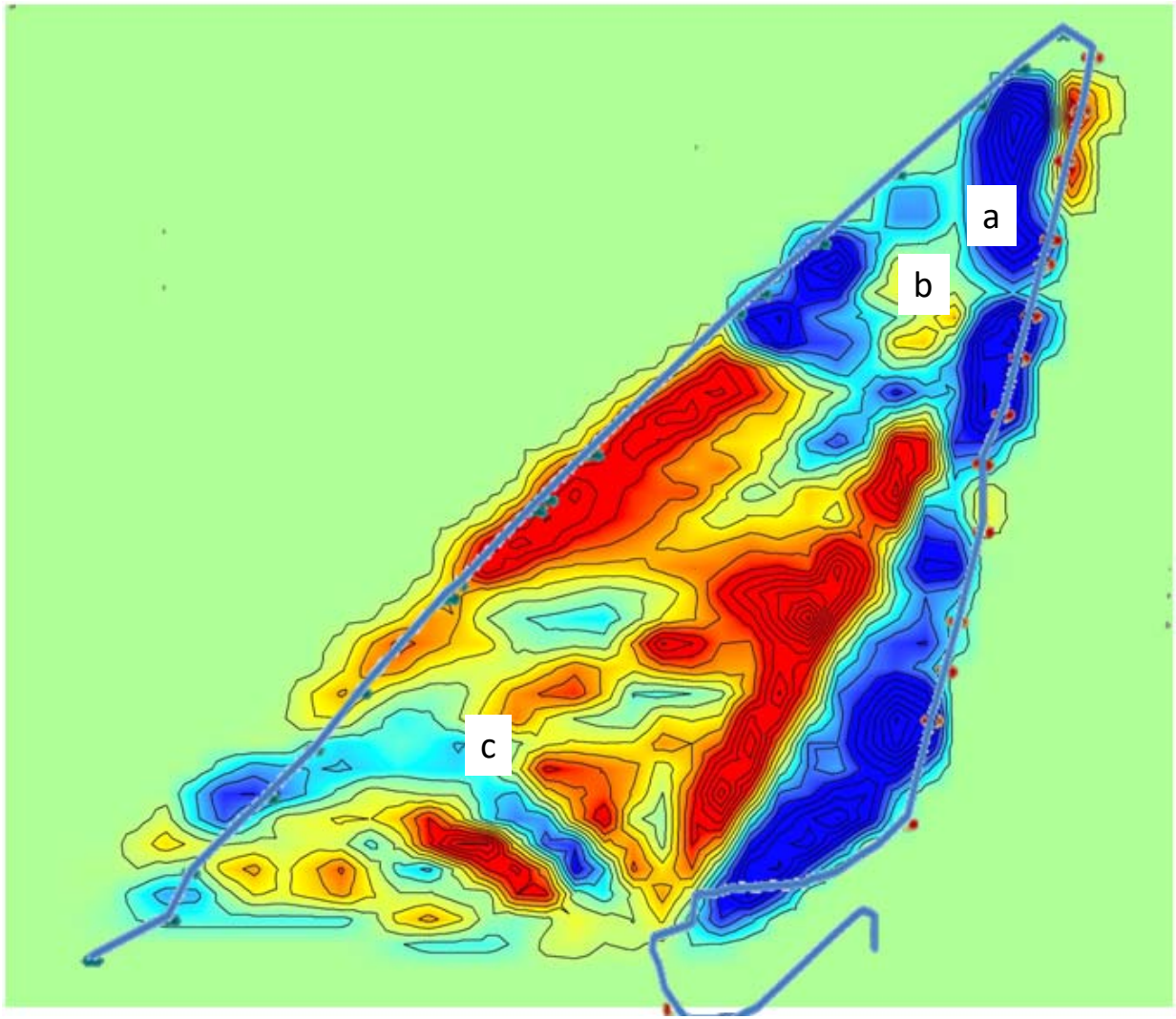
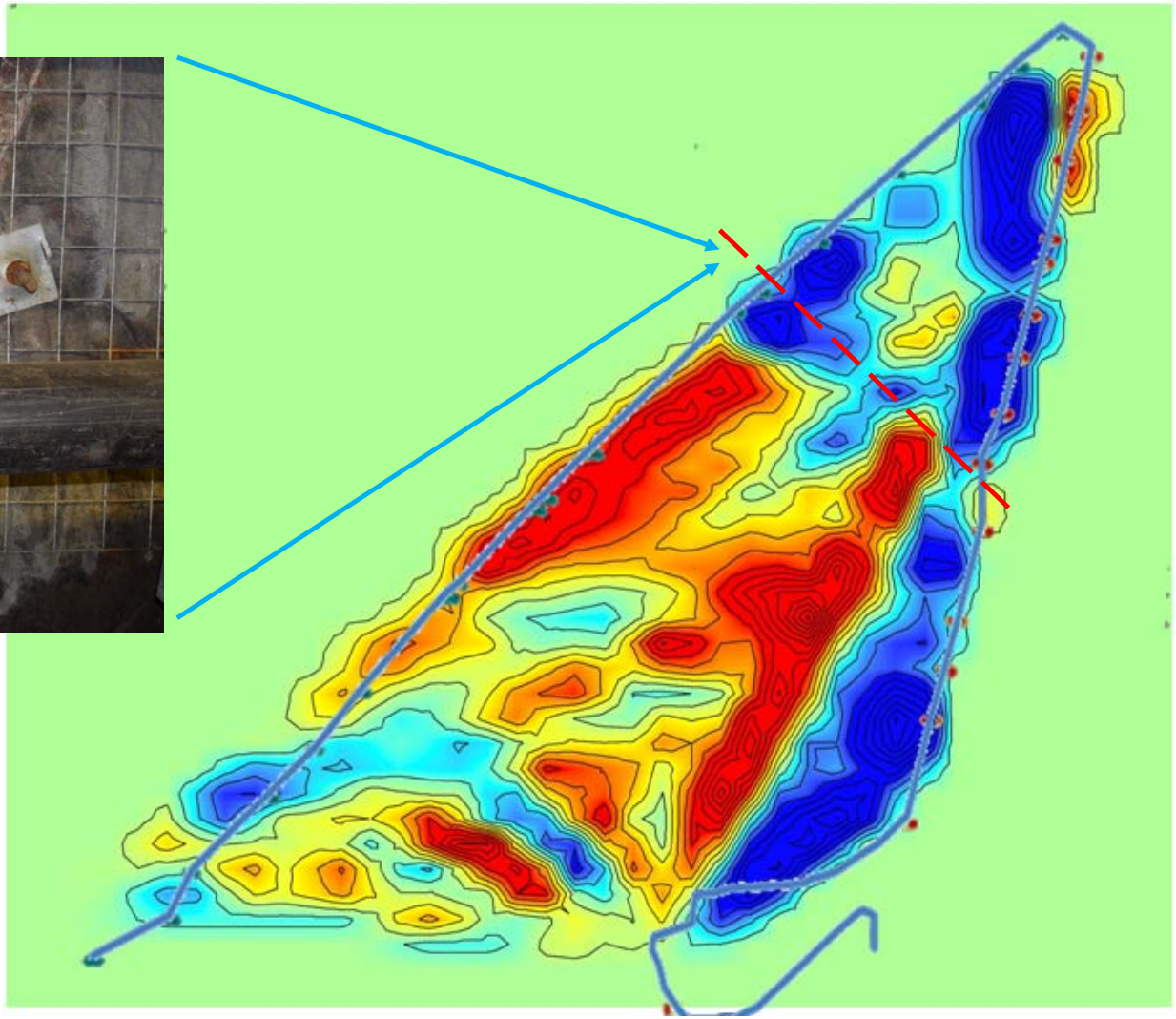
MB-R


Seismic tomography
results from the pillar area
28000 ft/s (8620 m/s)
Average 19500 ft/s (5940 m/s)
12500 ft/s (3800 m/s)
60 m



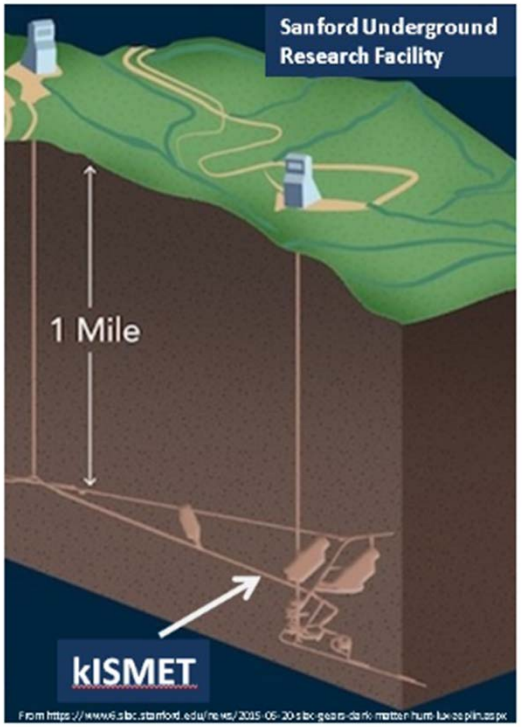
P wave velocities



P wave velocities

2. High-resolution seismic tomography

– imaging hydraulic fractures



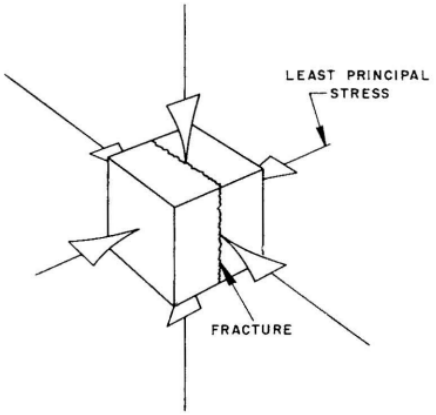
50 m

Oldenburg, et al. 2017

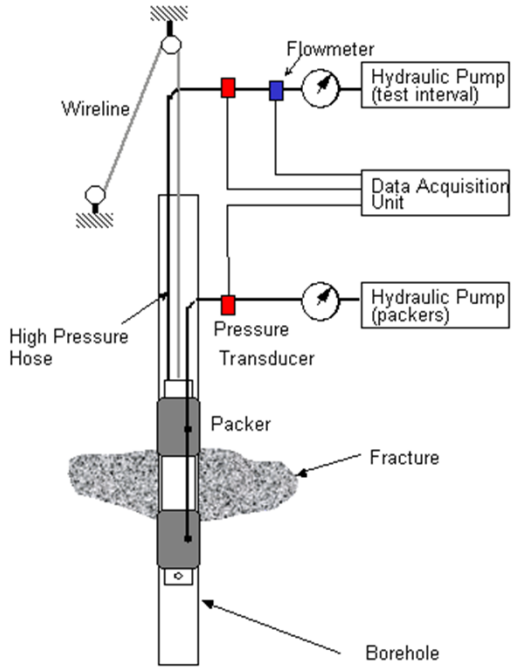
Hydraulic Fracturing

Process

- Pump water at high pressure down a borehole and into the target rock
- Increase the deviatoric stresses in the rock to promote rock fracturing



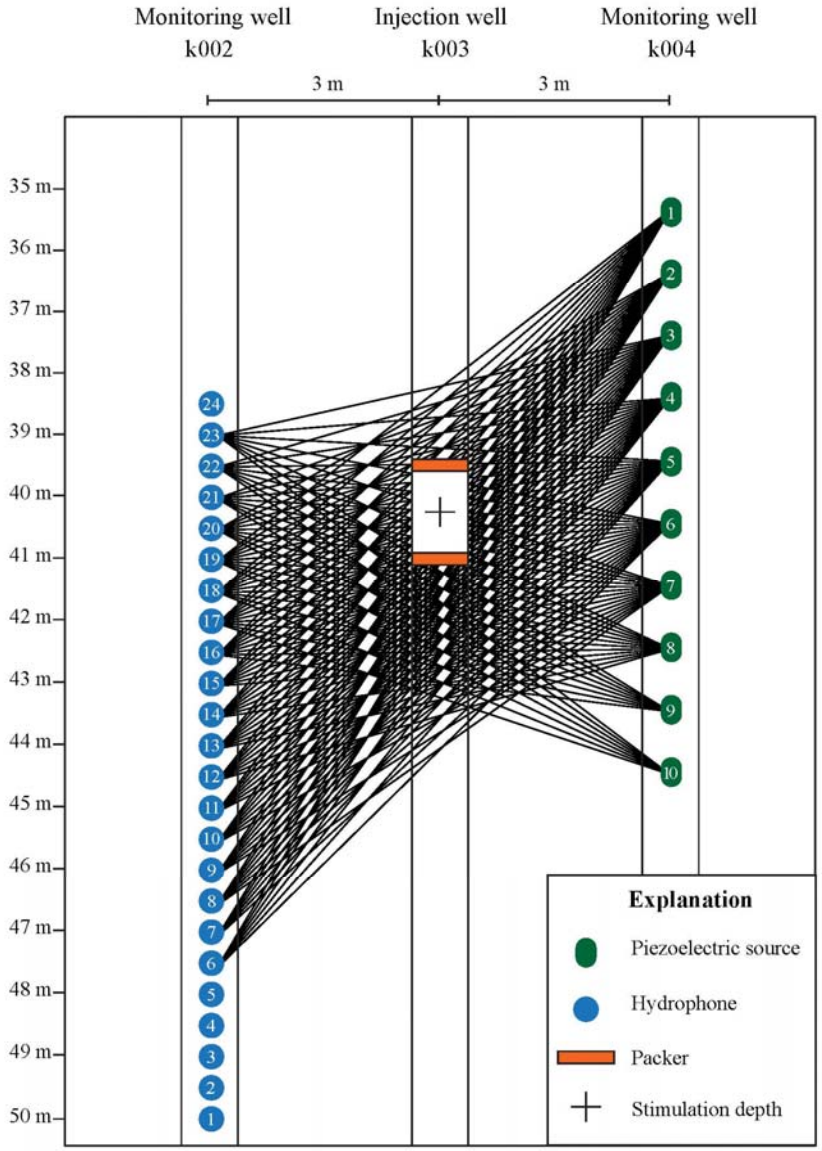
Hubbert and Willis (1972)



Haimson and Lee (1984)

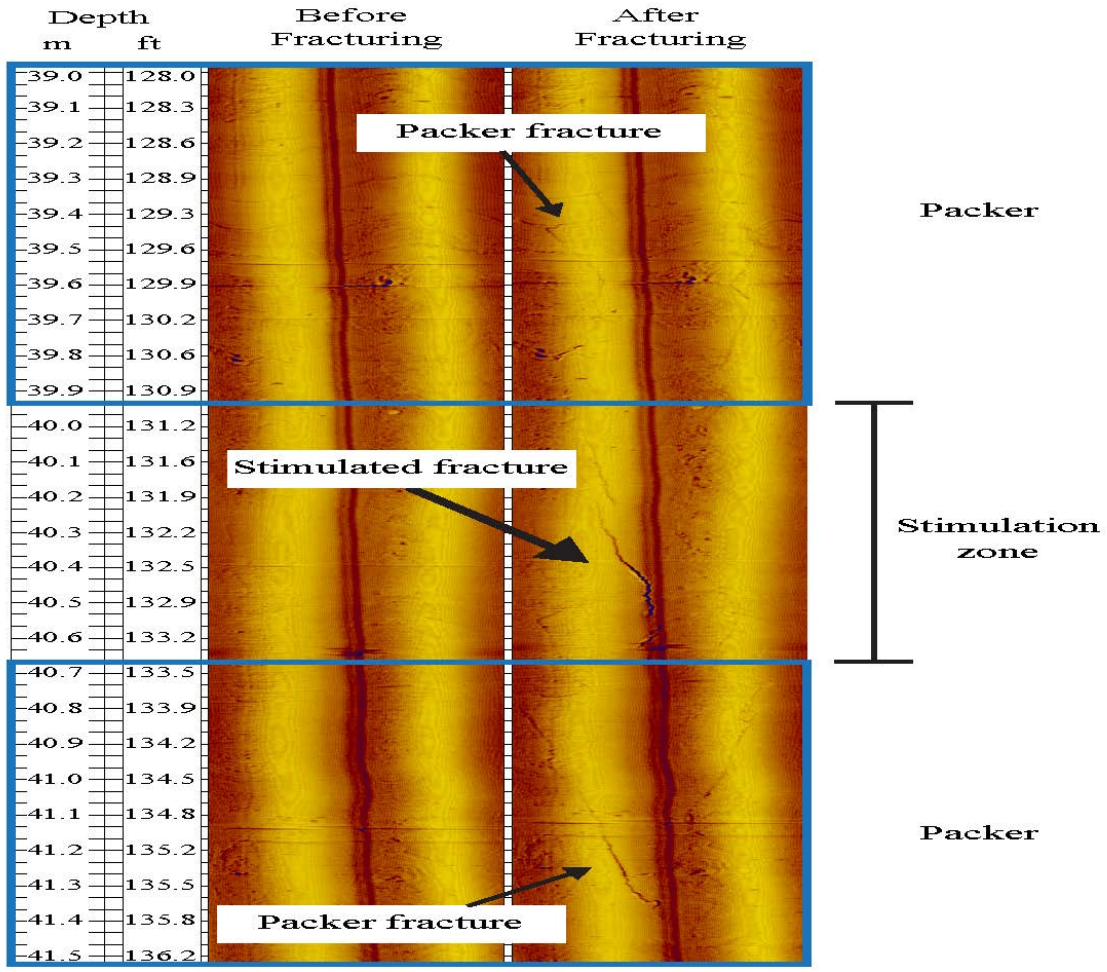
Continuous Active-Source Seismic Monitoring (CASSM)

(Tom Daley, LBL)

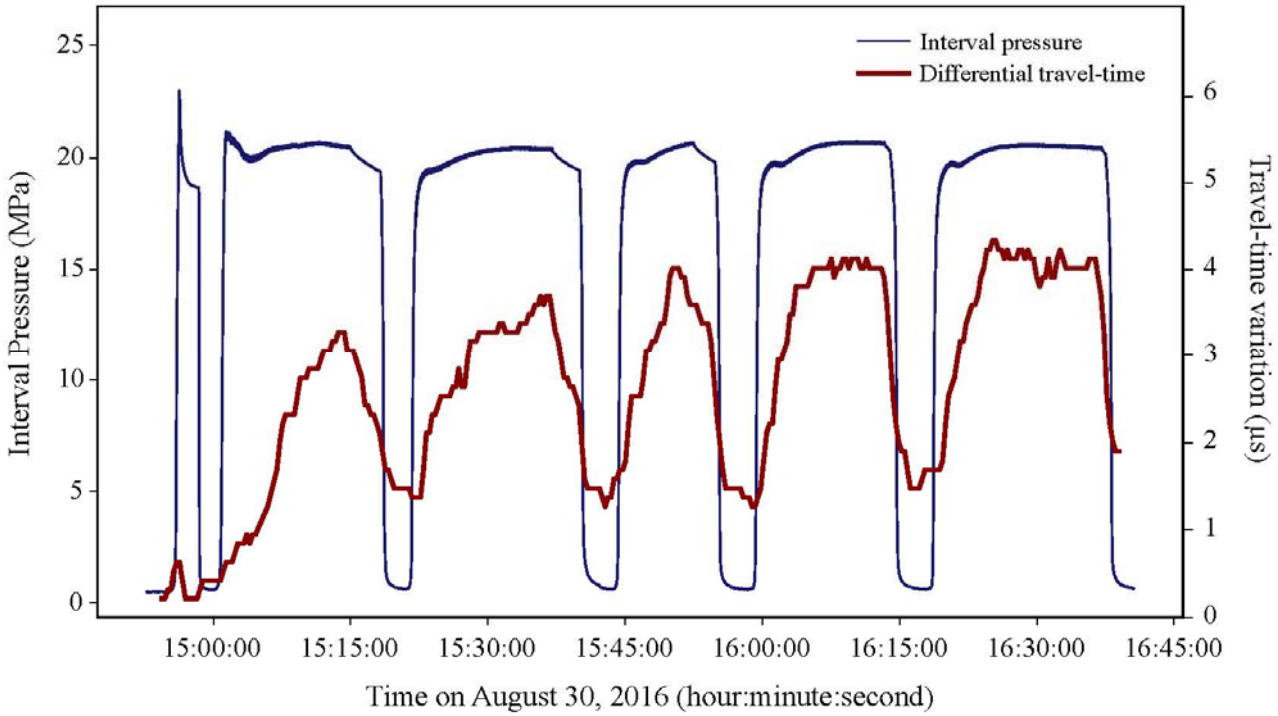


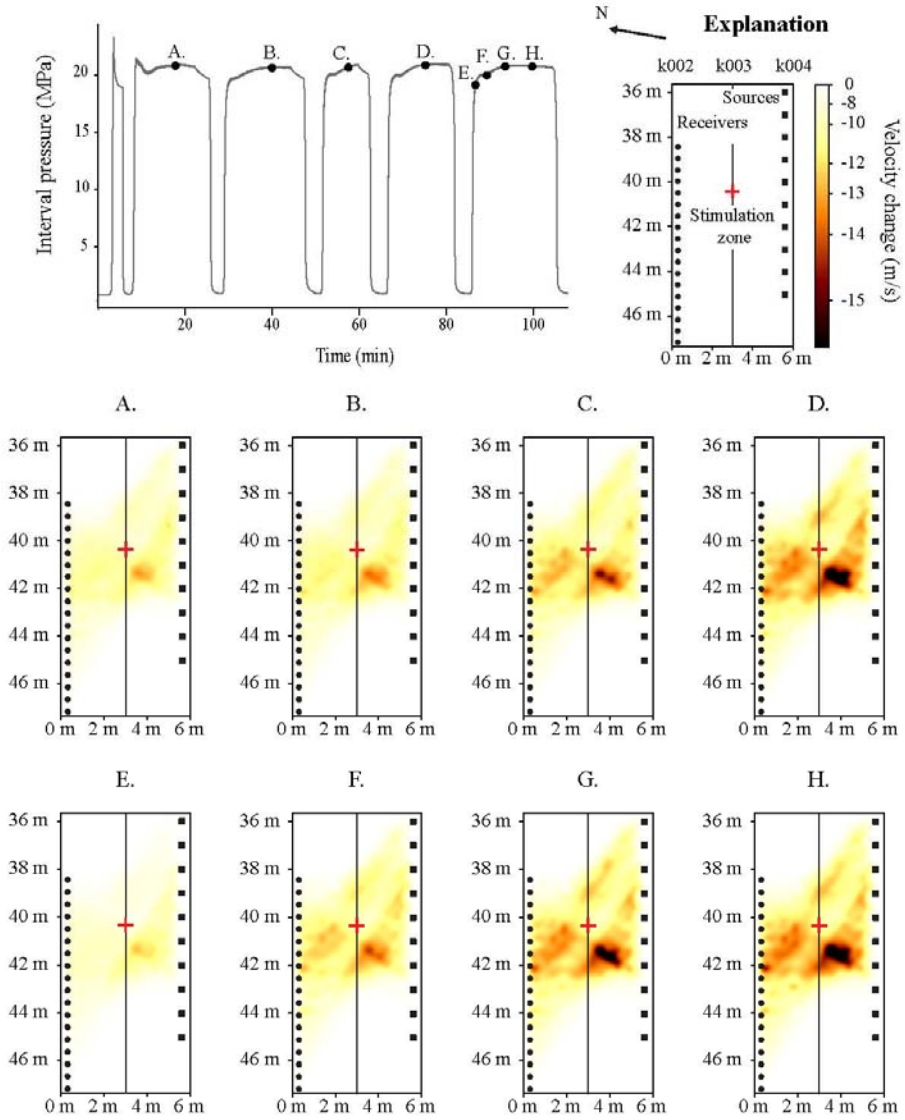
Medler, 2019

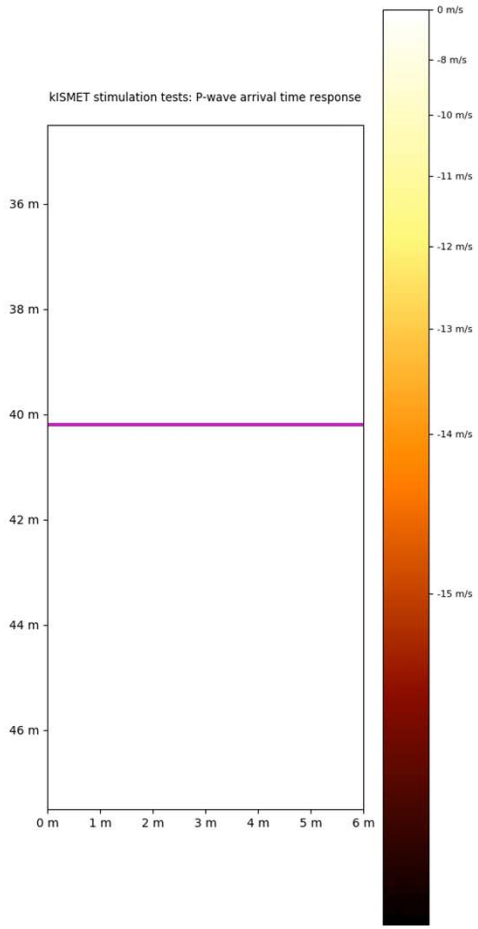
Acoustic televiewer



Oldenburg, et al. 2017


Interval pressure
Differential travel-time
Interval Pressure (MPa)
Travel-time variation (μs)
0
5
10
15
20
25
0
1
2
3
4
5
6
15:00:00
15:15:00
15:30:00
15:45:00
16:00:00
16:15:00
16:30:00
16:45:00
Time on August 30, 2016 (hour:minute:second)


Interval pressure (MPa)
Time (min)
A.
B.
C.
D.
E.
F.
G.
H.
N
Explanation
k002
k003
k004
Sources
Receivers
Stimulation zone
Velocity change (m/s)
0 m 2 m 4 m 6 m
36 m
38 m
40 m
42 m
44 m
46 m


kISMET stimulation tests: P-wave arrival time response
36 m
38 m
40 m
42 m
44 m
46 m
0 m
1 m
2 m
3 m
4 m
5 m
6 m
0 m/s
-8 m/s
-10 m/s
-11 m/s
-12 m/s
-13 m/s
-14 m/s
-15 m/s

Observations

1. CASSM successfully detected the hydraulic fracturing
2. Fracture geometry imaged:
   - Total length = 5 m
   - Aperture = 0.55 mm
3. Fracturing-related processes included:
   - Transition from fracture growth to fracture stabilization
   - Extent of the permanent damage could be estimated