Surface-Wave FTAN dispersion and P-wave attenuation tomography of Yucca Flat, Nevada

SAND2016-7741PE

By Liam Toney and Charles Hoots

U.S. DEPARTMENT OF ENERGY

Sandia National Laboratories

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SURFACE-WAVE TOMOGRAPHY OF YUCCA FLAT, NEVADA

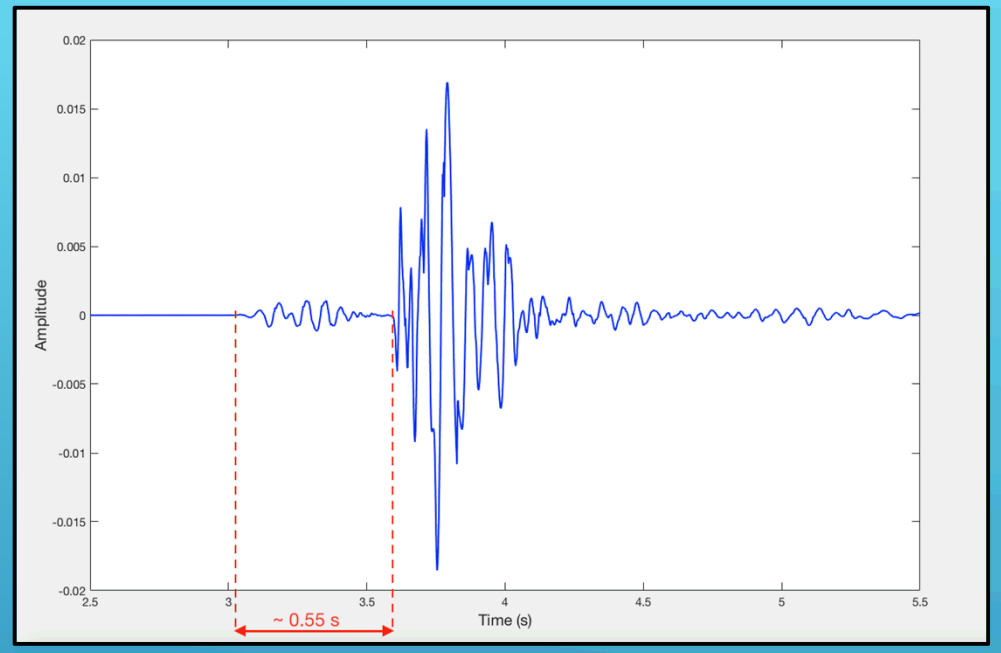
Liam Toney

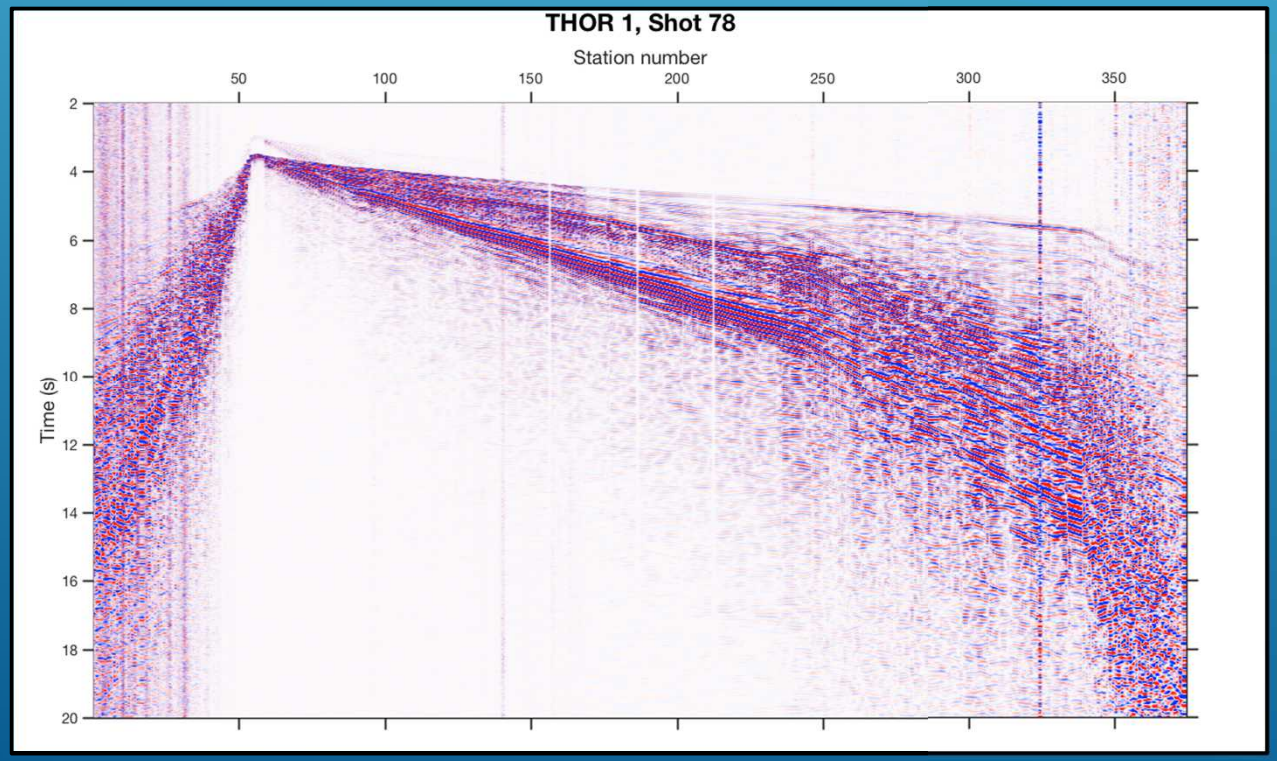
INTERNSHIP PROGRAM
NEXT GENERATION
IRIS
SINCE 1998

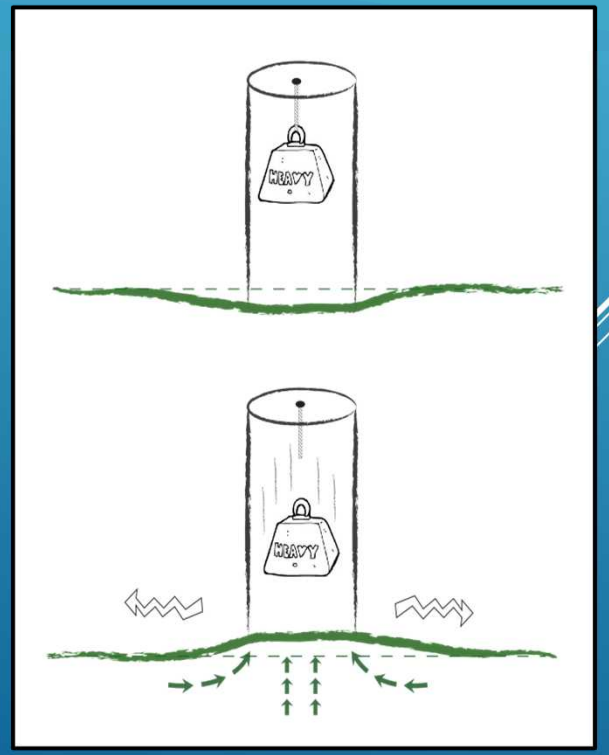
THE SEISMIC HAMMER™

DATA PROPERTIES

- Large SNR (32 strikes per location)
- Surface rebound effect is measurable

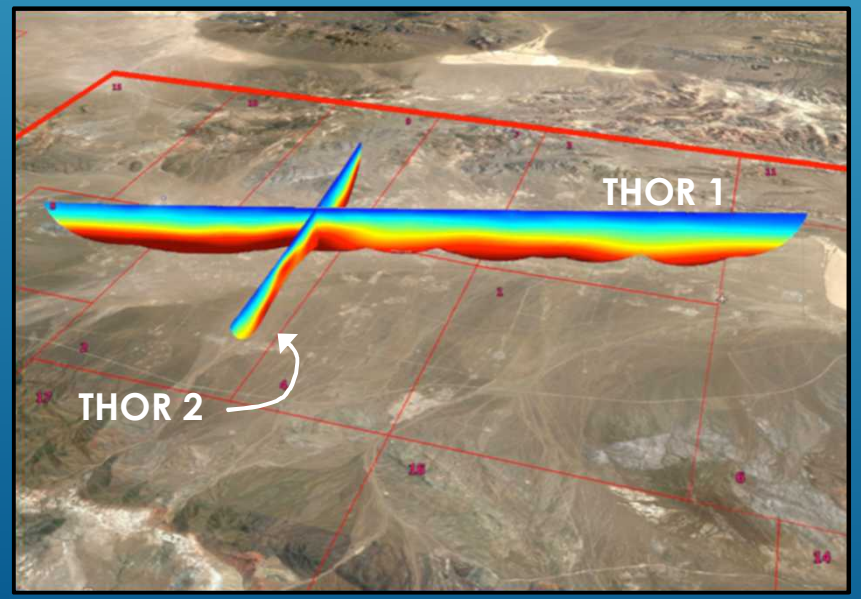


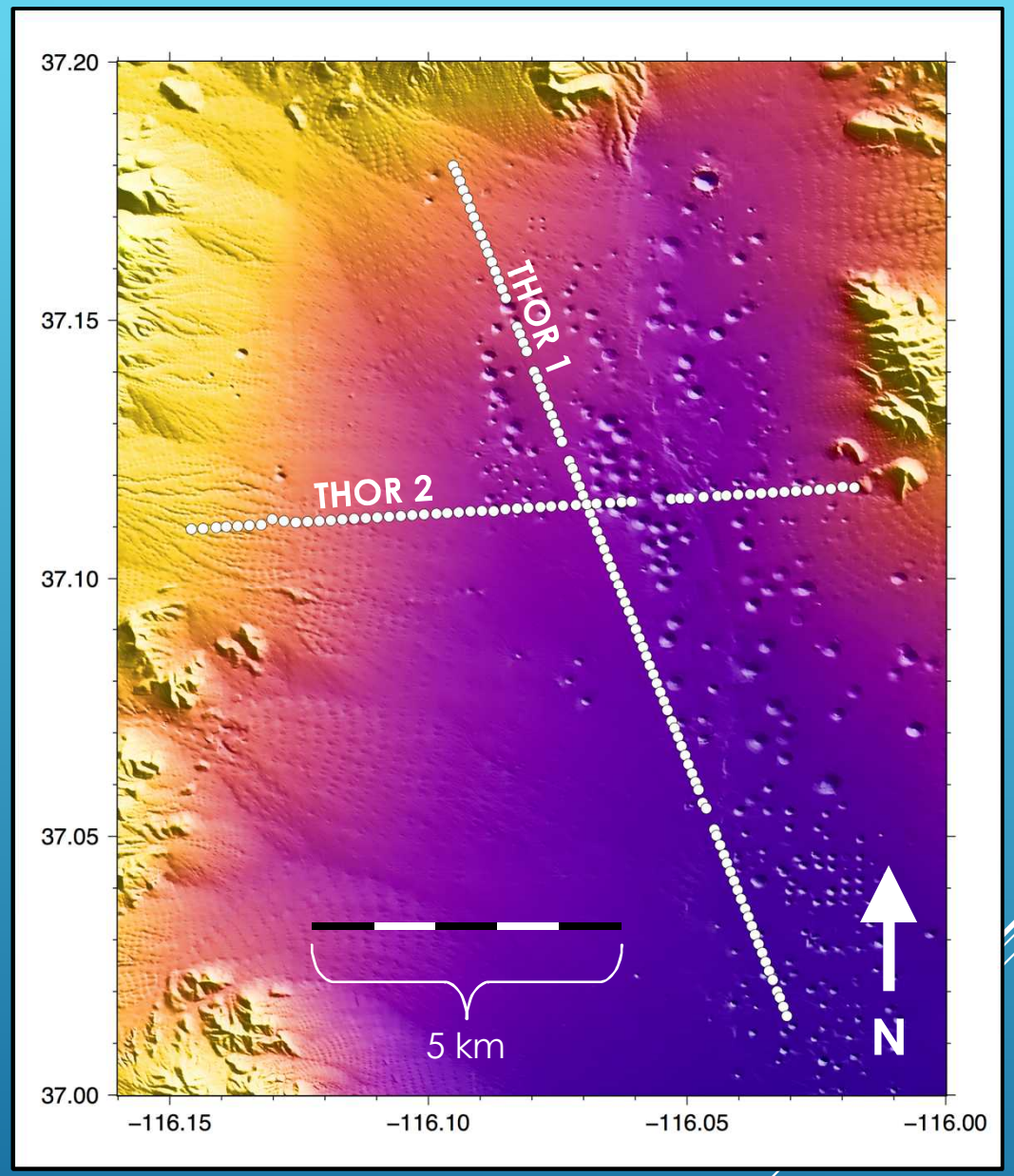




SURVEY LOCATION

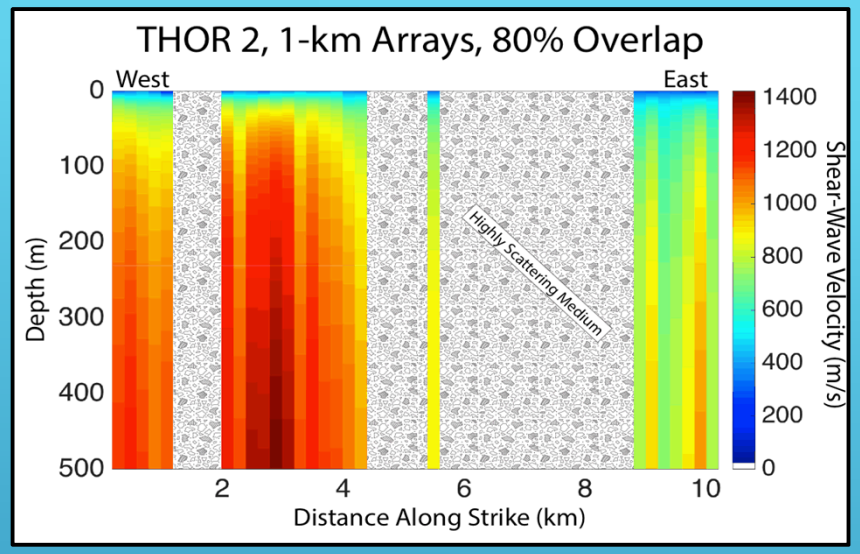
- 900 detonations between 1951 & 1992
- Next series of shots occurs at intersection

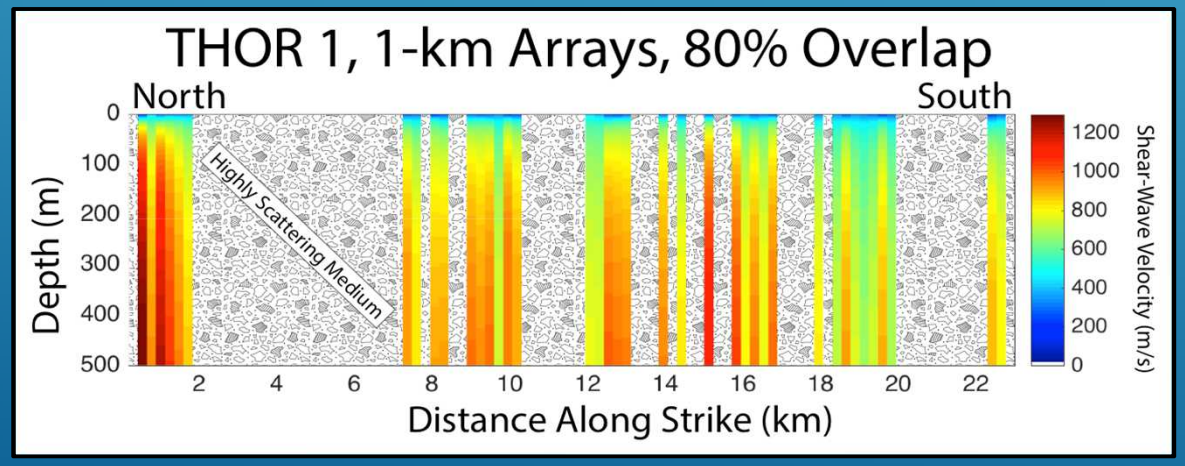


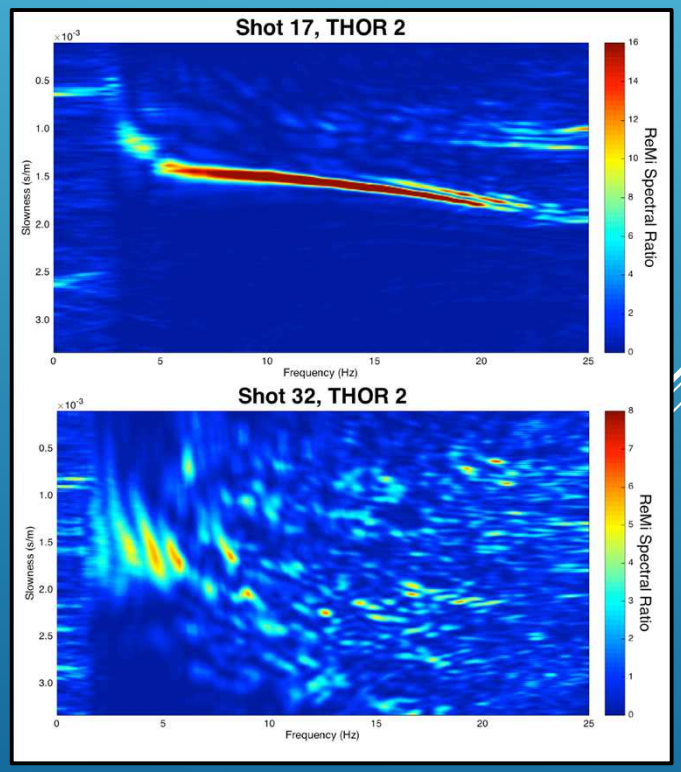


S-WAVE MODEL (PHASE VELOCITY)

- Phase-velocity ReMi used
- Lots of scattering = spatially incomplete

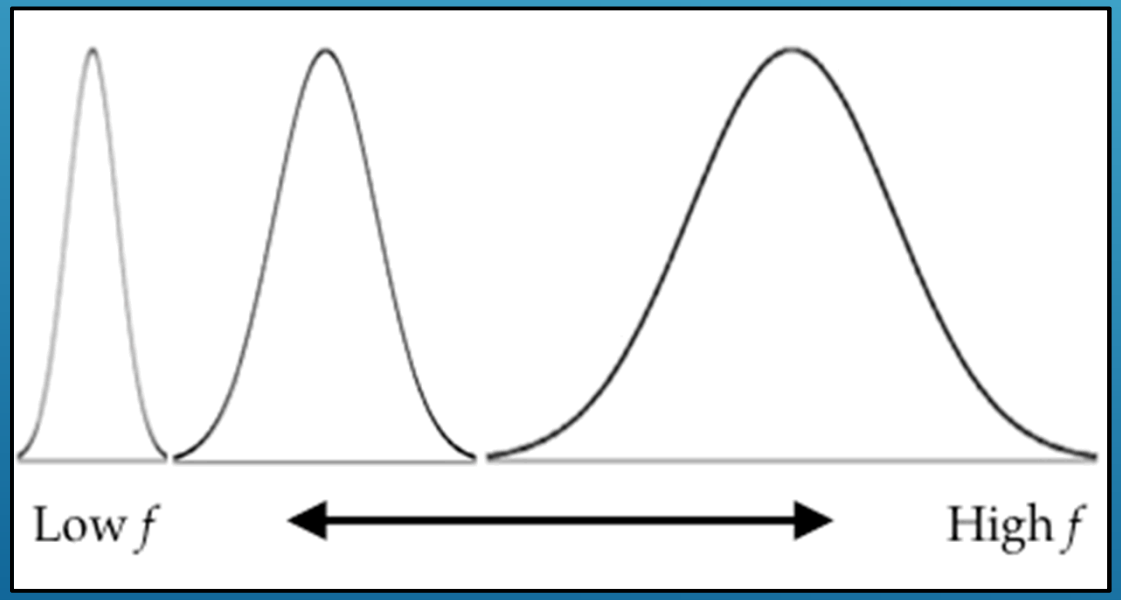






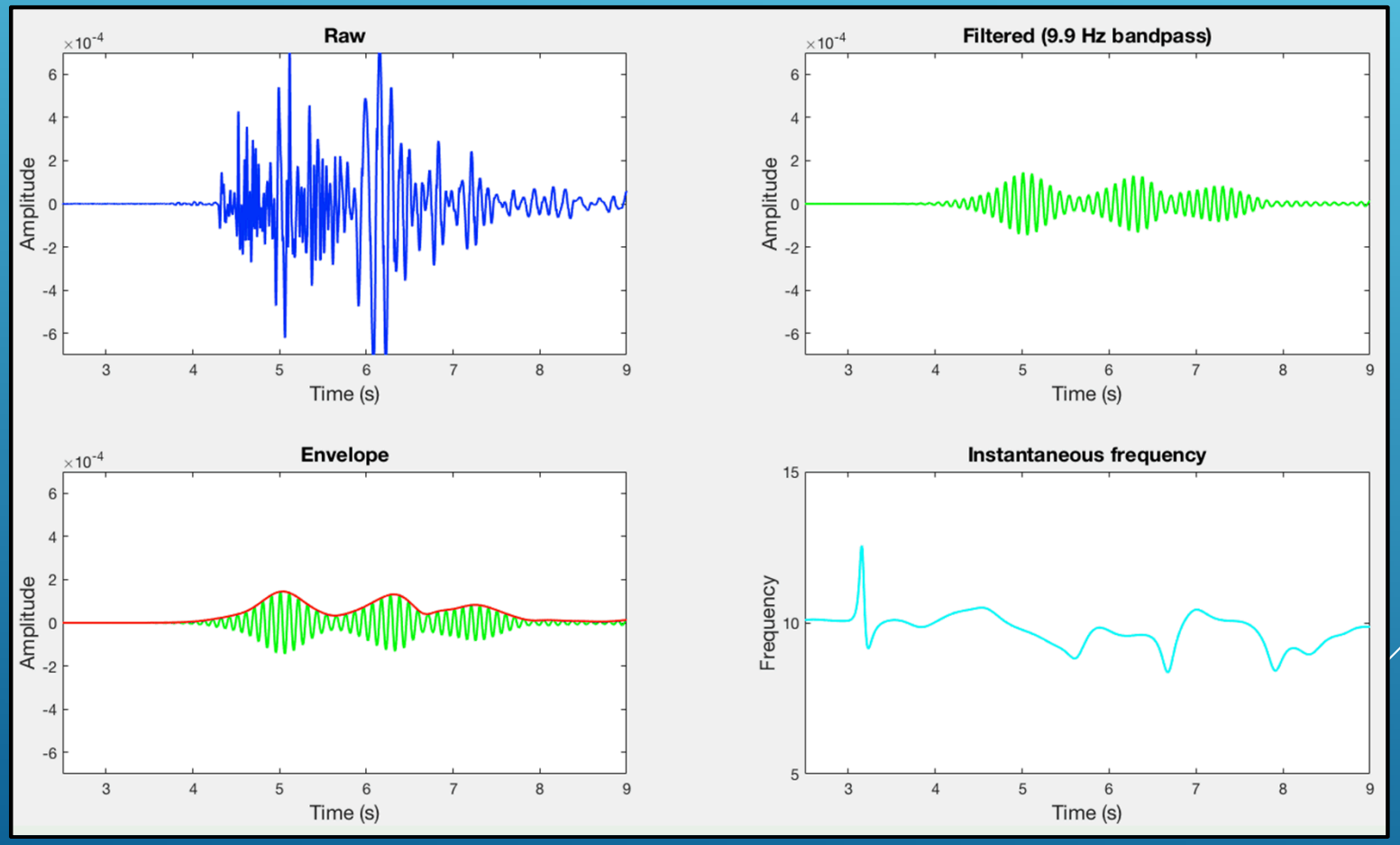
SOLUTION: GROUP VELOCITY

- Multi-filter technique
- 30 Gaussian bandpass filters (1-50 Hz, log spaced)
- Scaled passbands



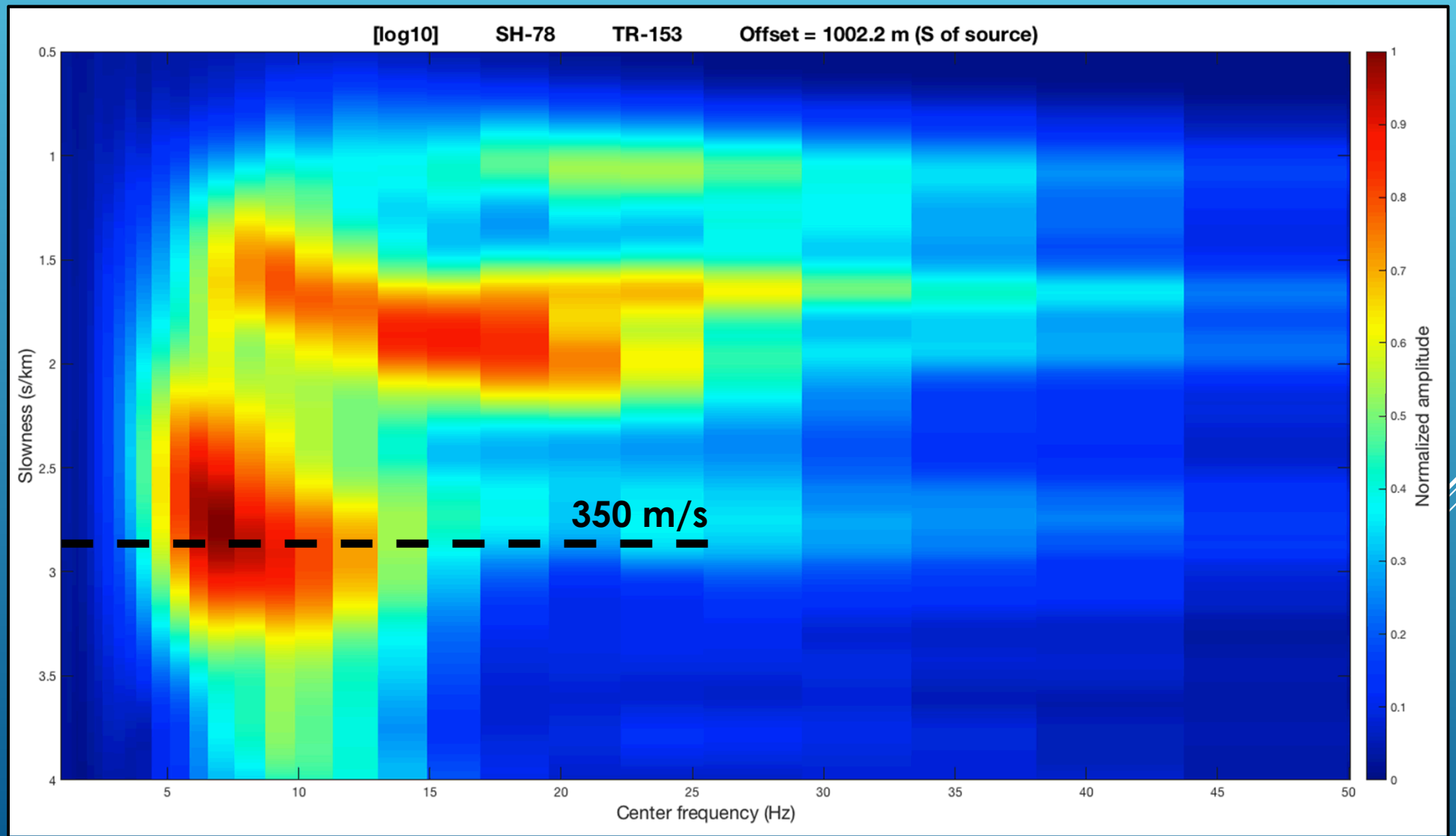
THE HILBERT TRANSFORM

Raw → Filtered → Envelope → Pick peak



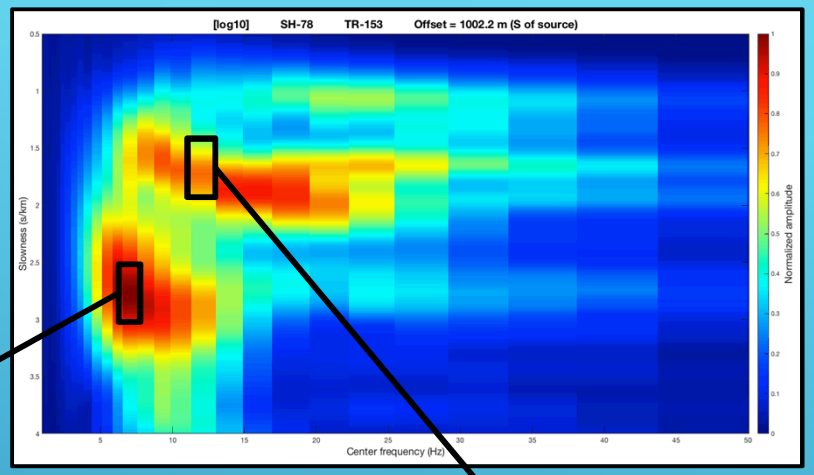
DISPERSION

What's up with the Big Red Blob?

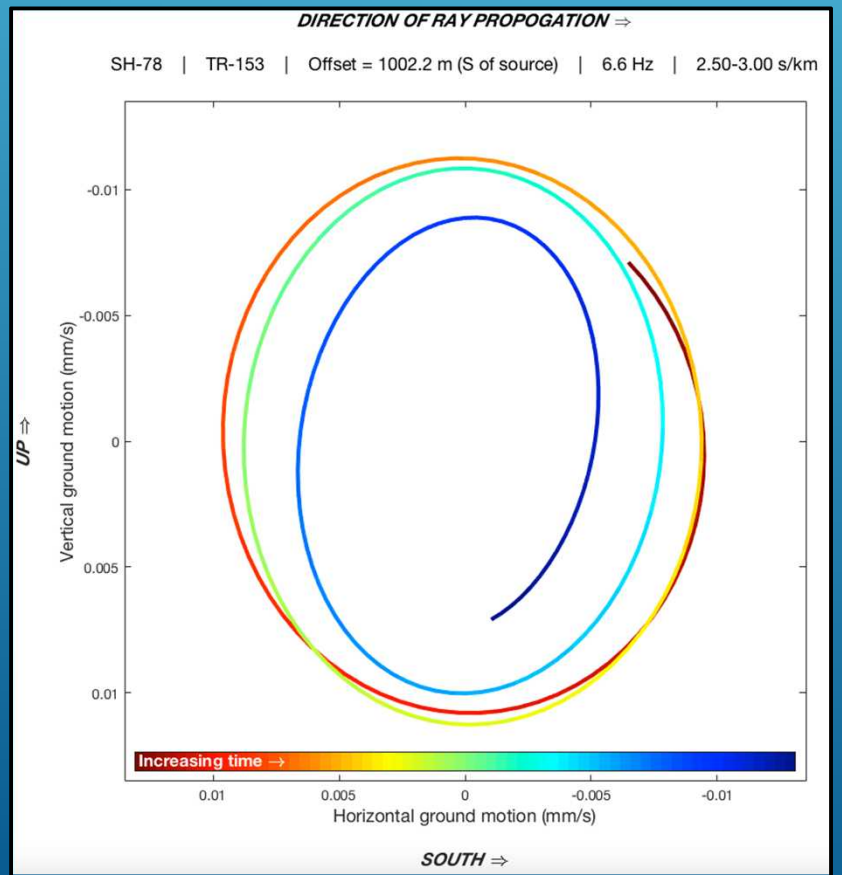


HODOGRAMS

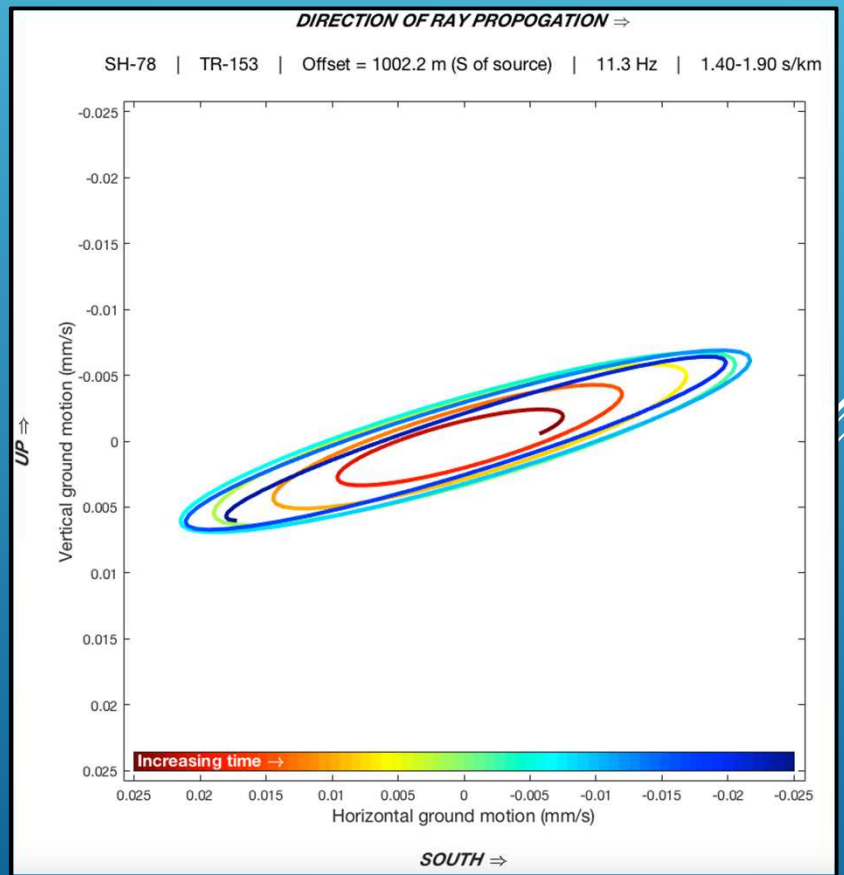
- We now know what to window out



Airwave



Rayleigh fundamental



MOVING FORWARD

- Window to eliminate airwave
- Ensure fundamental arrival is picked (vs. modes)
- Develop method to estimate pick error

THANK YOU:

Rob, Hunter, Rebekah, Stephanie, Charles, **IRIS**

Attenuation Tomography at the Nevada National Security Site using the Seismic Hammer™

Charles Hoots

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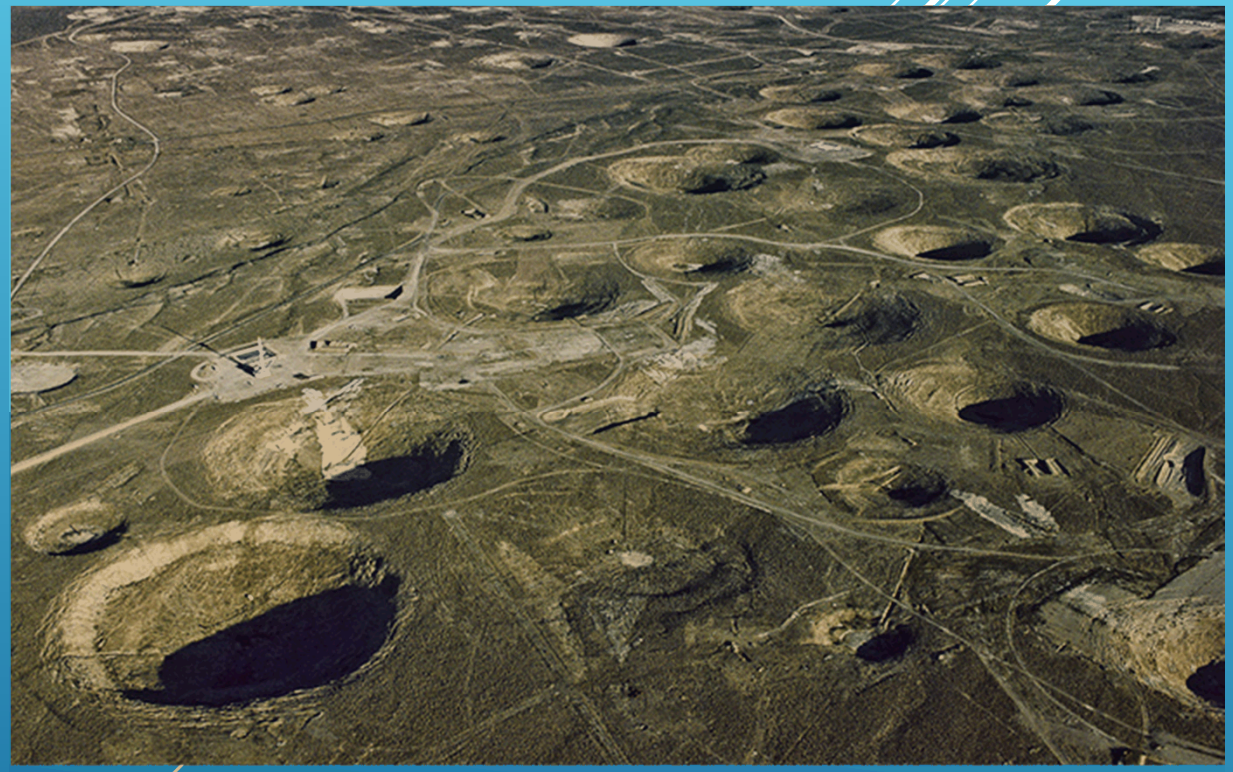
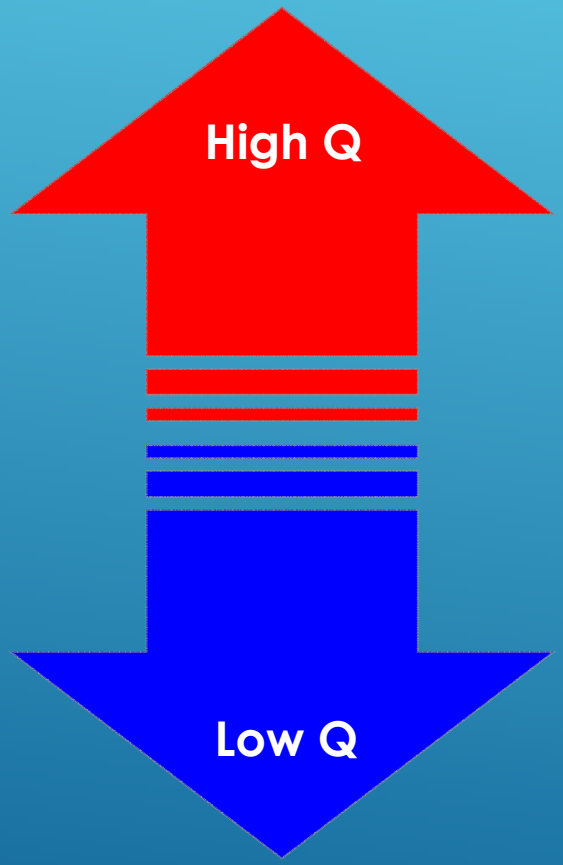
Importance to the Source Physics Experiment (SPE)

- How are attenuation characteristics changed in a post-detonation terrane?
- How do conventional methodologies for imaging attenuation change at near distances and high frequencies?
- What can be gained in learning how a media attenuates a signal when the source is a very well known, and largely, impulsive compressive force?
- Better geophysical characterization for model inputs (full waveform inversion)



Lower seismic attenuation



High seismic attenuation

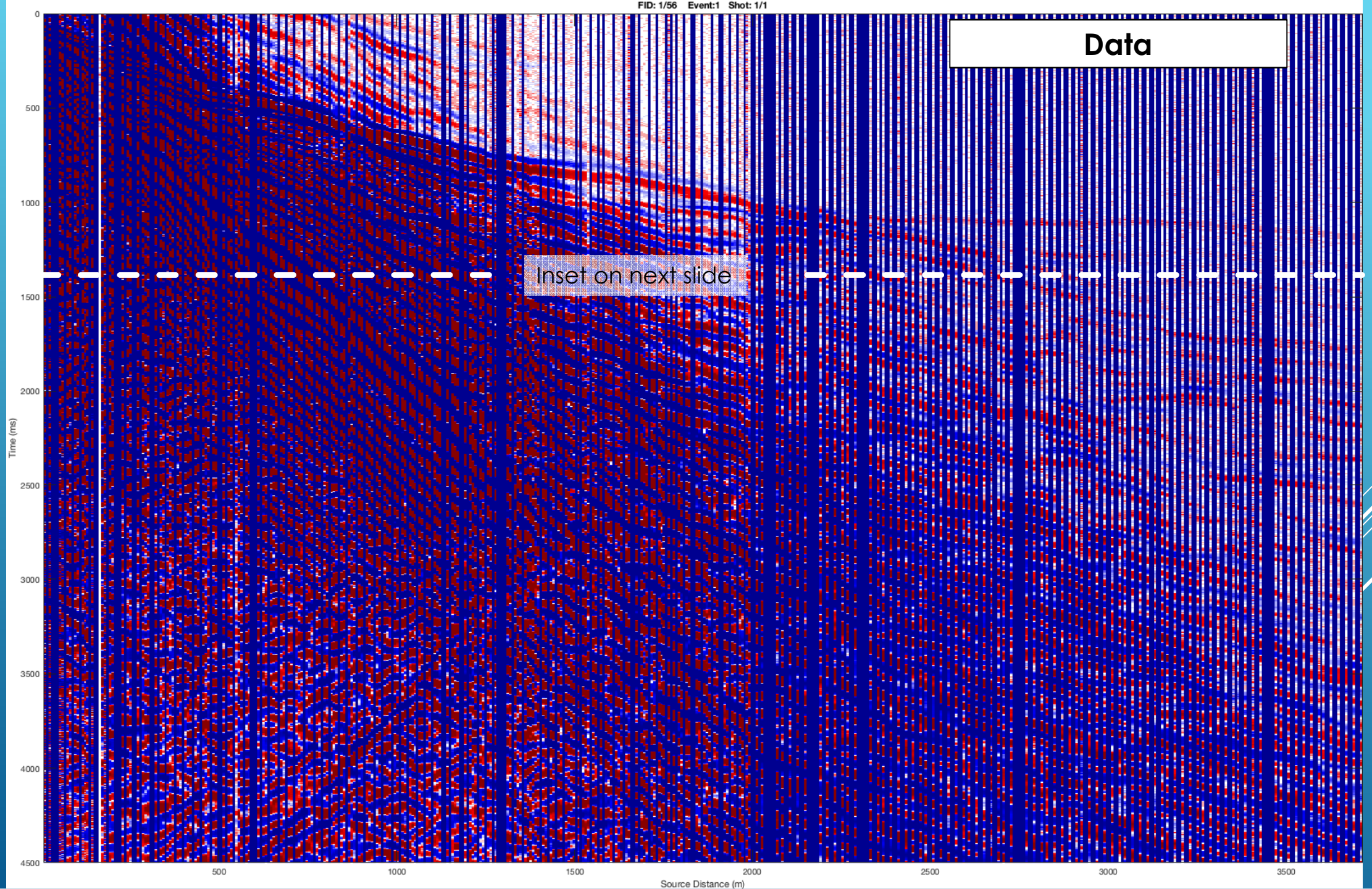
Attenuation Tomography Background

Inverse problem:

$$A(x) = \frac{A_o}{r} \exp\left(-\frac{\pi f}{Q v} x\right)$$

Forward problem:

$$Q(x) = -\pi f x \ln\left(\frac{A(x) r}{A_o}\right)^{-1}$$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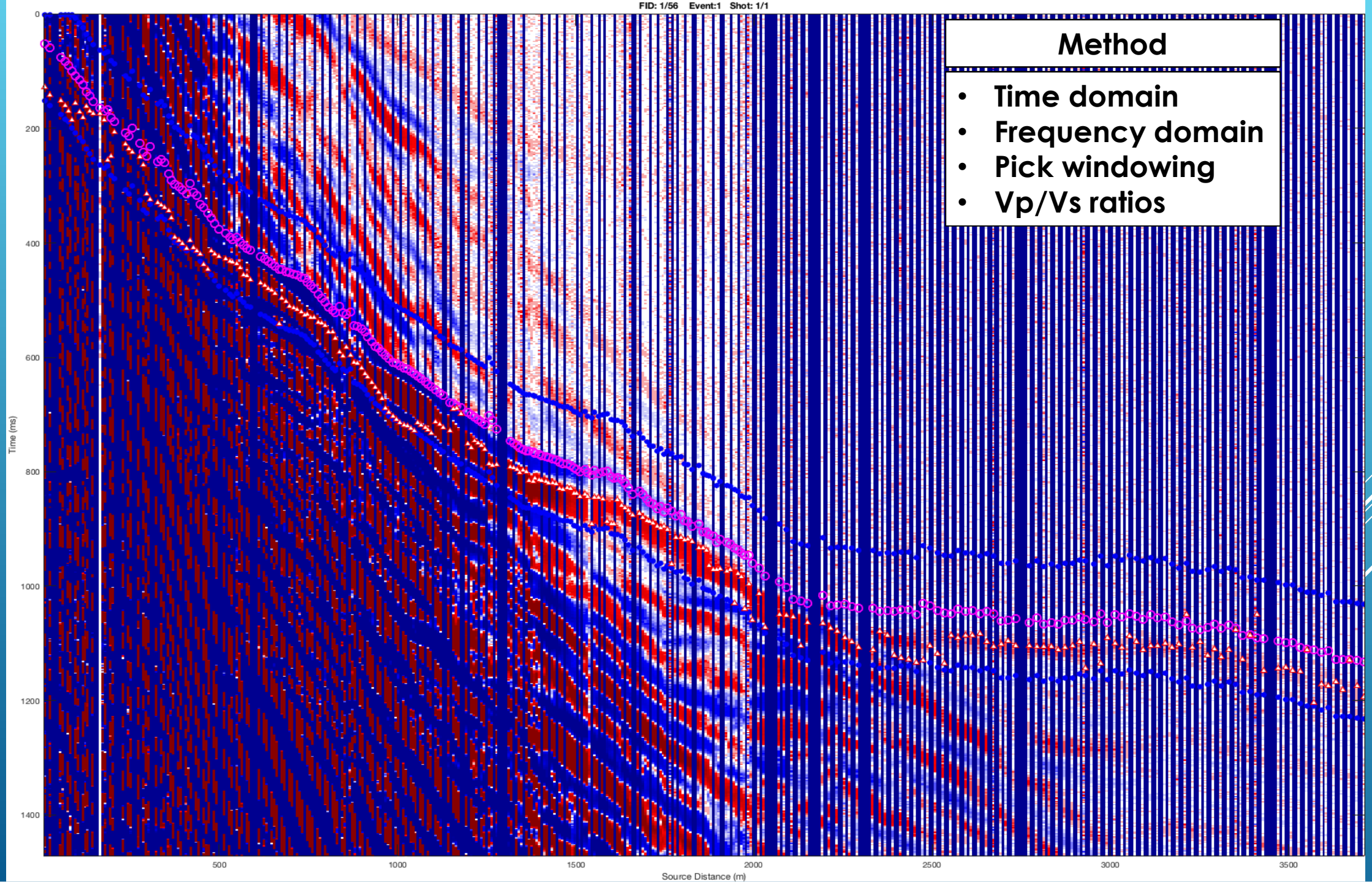
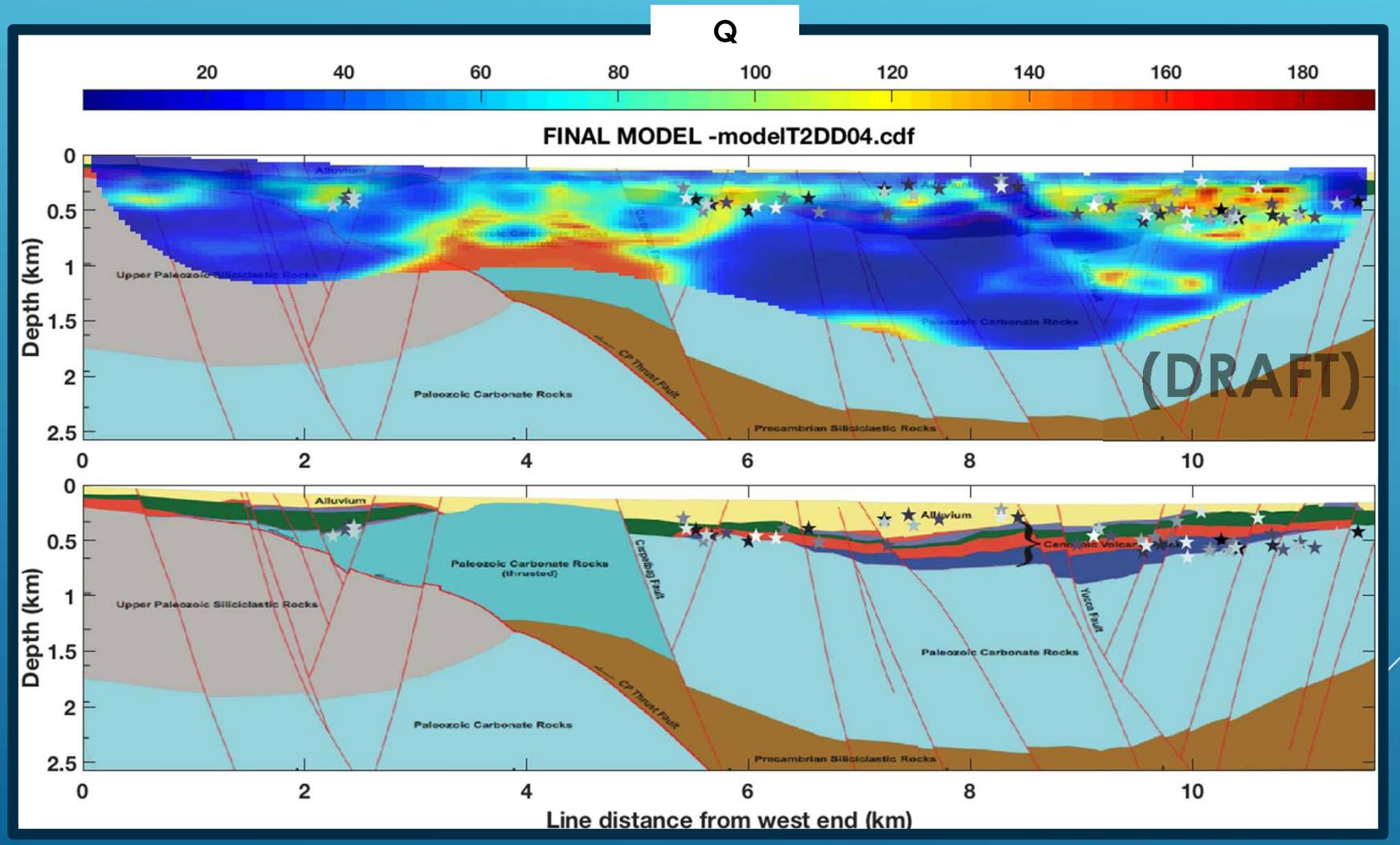


Method

- Time domain
- Frequency domain
- Pick windowing
- Vp/Vs ratios

Results

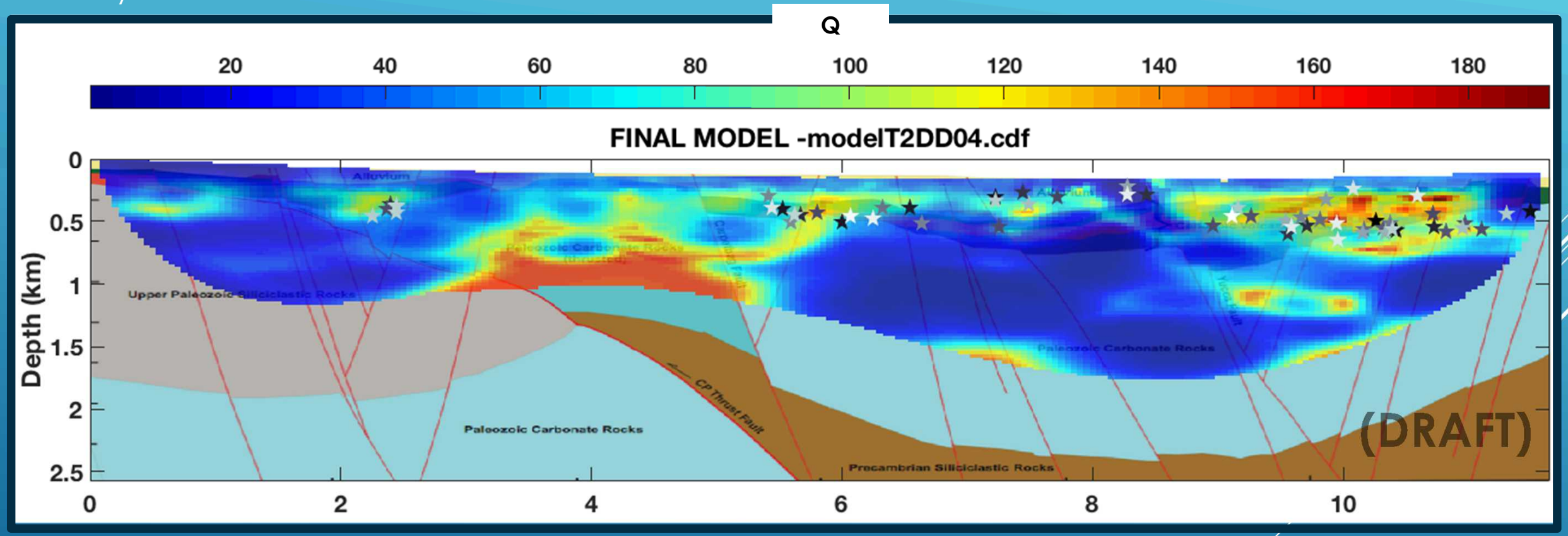
Thor 2



Observations and Possible Causes

Observations:

1. High Q anomalies immediately above the depth for nuclear tests
2. Low Q anomalies highly localized around the nuclear tests
3. 'Ray tube' at ~4.5km



Possible Causes:

1. Principal direction of detonation force mechanism?
2. Detonation cavity, increased porosity at the source?
3. Pick anomaly, regularization criteria?

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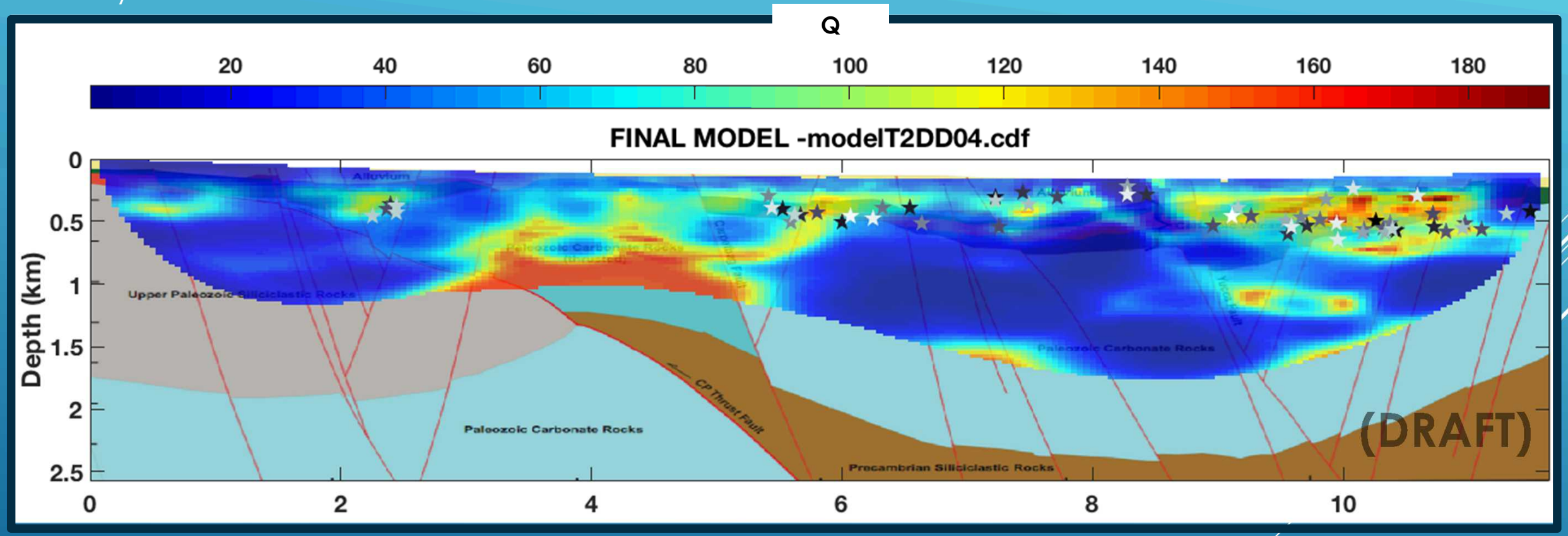

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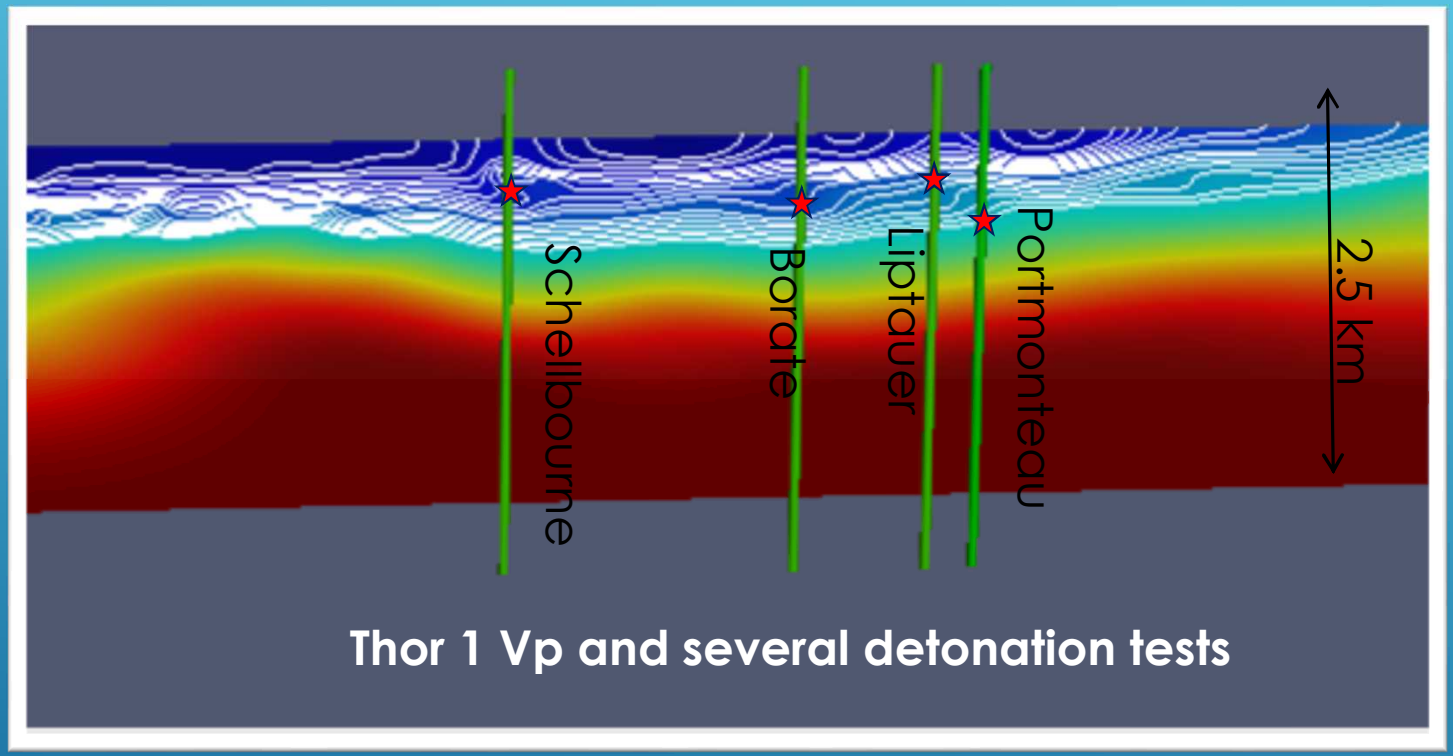

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Concerns and Future Work

Concerns:

1. Time domain picks for attenuation tomography is a nuanced problem that requires highly specialized methods unique to the study area when performed at these distances and frequencies.

Future Work:

1. Apply method in the frequency domain.
2. Improve regularization criteria.
3. Use a more complete S wave model in conjunction with P to more accurately window around the P-wave.
4. Improve overall quality control and data anomaly checks, e.g. frequency content, naturally avoiding picks on contaminating phases.