

IRIS: USArray Short Course in Bloomington, Indiana
Special focus: Oklahoma Wavefields



A Large N Array at the Nevada National Security Site



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Previously presented at the 2017 Fall AGU

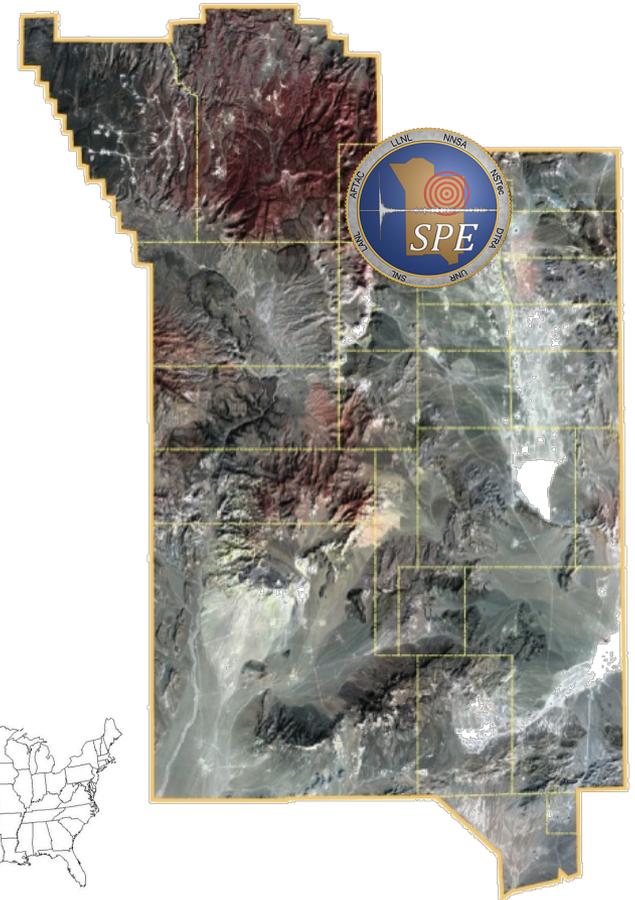
LLNL-PRES-694105

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Source Physics Experiment

- **Series of chemical explosions at the Nevada National Security Site**
 - Understand S wave generation from explosions
 - Validate modeling capabilities at all scales
 - SPE5: 5000 kg, 76 m, 26 April 2016 20:49 GMT
- **Observations**
 - 10 to 100 m
 - Near-field accelerometers (surface and at depth)
 - High-speed video, photogrammetry
 - EM data
 - 100 to 10,000 m
 - Telemetered seismic array
 - Large-N seismic array
 - Infrasound
 - 10 to 1000 km
 - Regional seismic network
- **Multi-institution collaboration**
- **Data release after two years (IRIS DMC)**

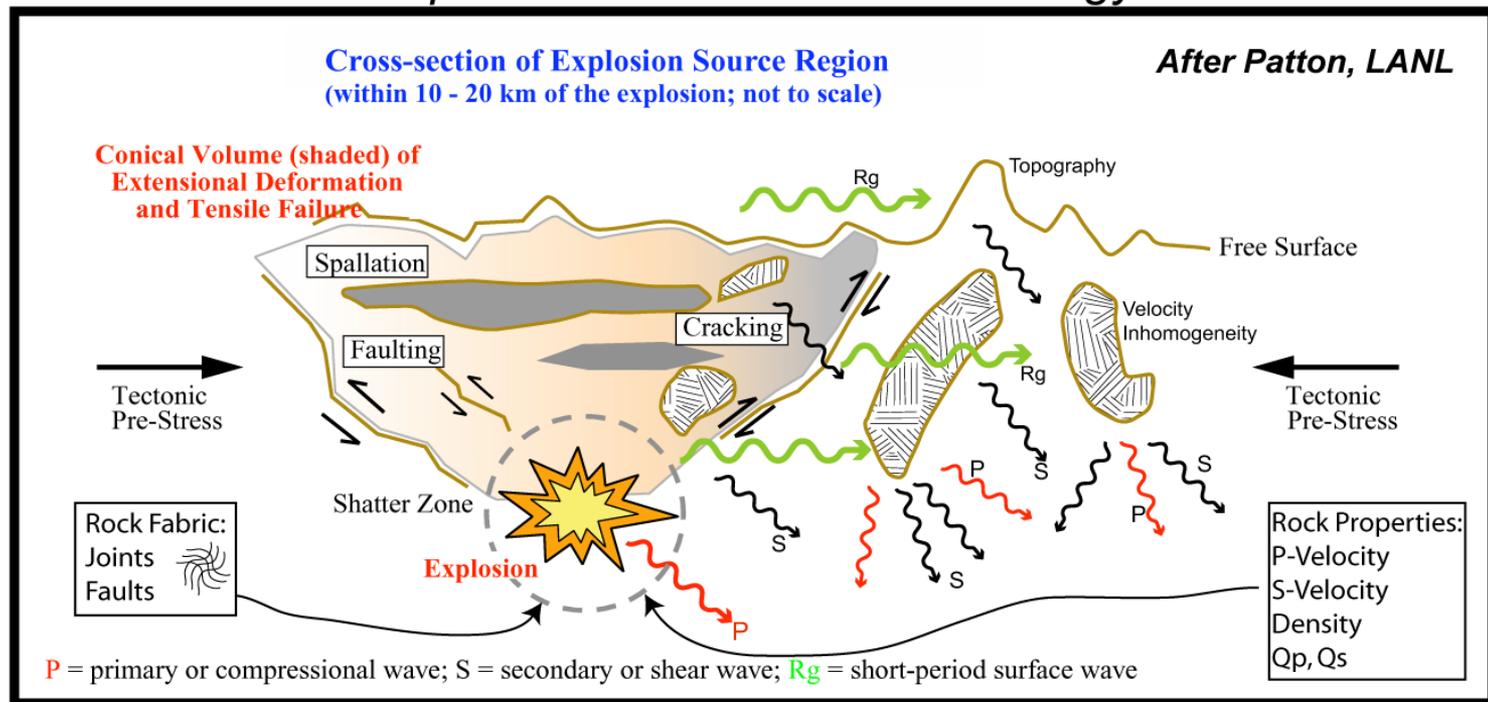


Science goals

Large array goals:

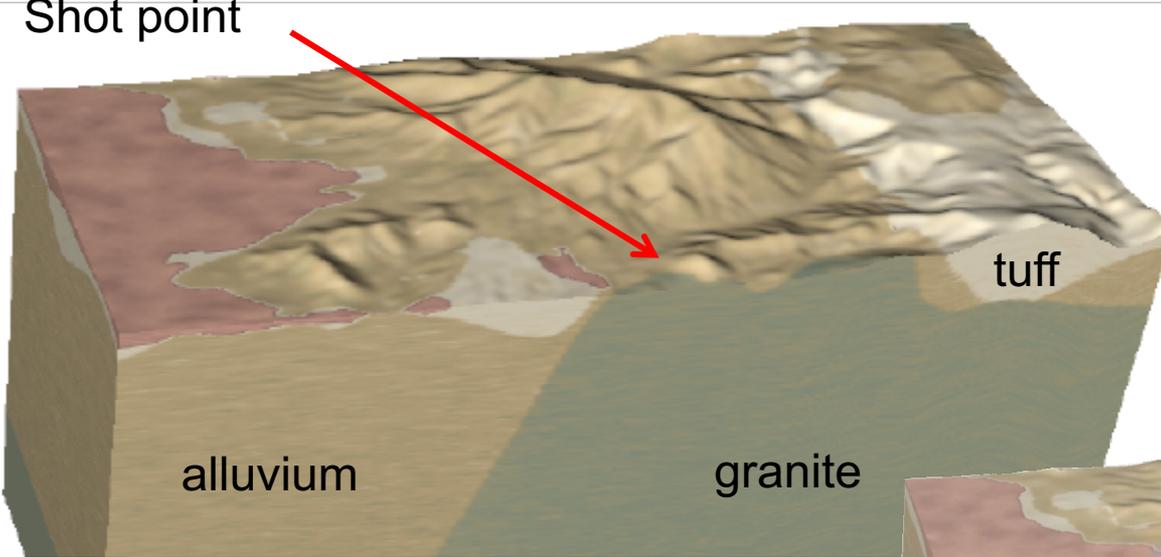
- 1) Origin of S waves: source or path?
- 2) Improved structure

Explosion Source Phenomenology



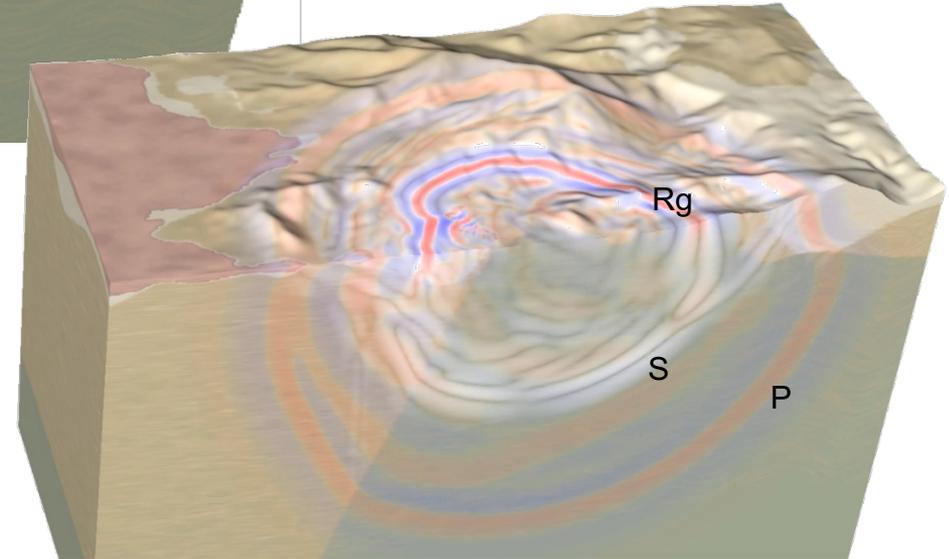
3D model: Geological setting

Shot point



3D velocity model

- Geology and well logs
- Ambient noise
- Added random heterogeneities
- 3D finite difference
- Need to validate and improve!

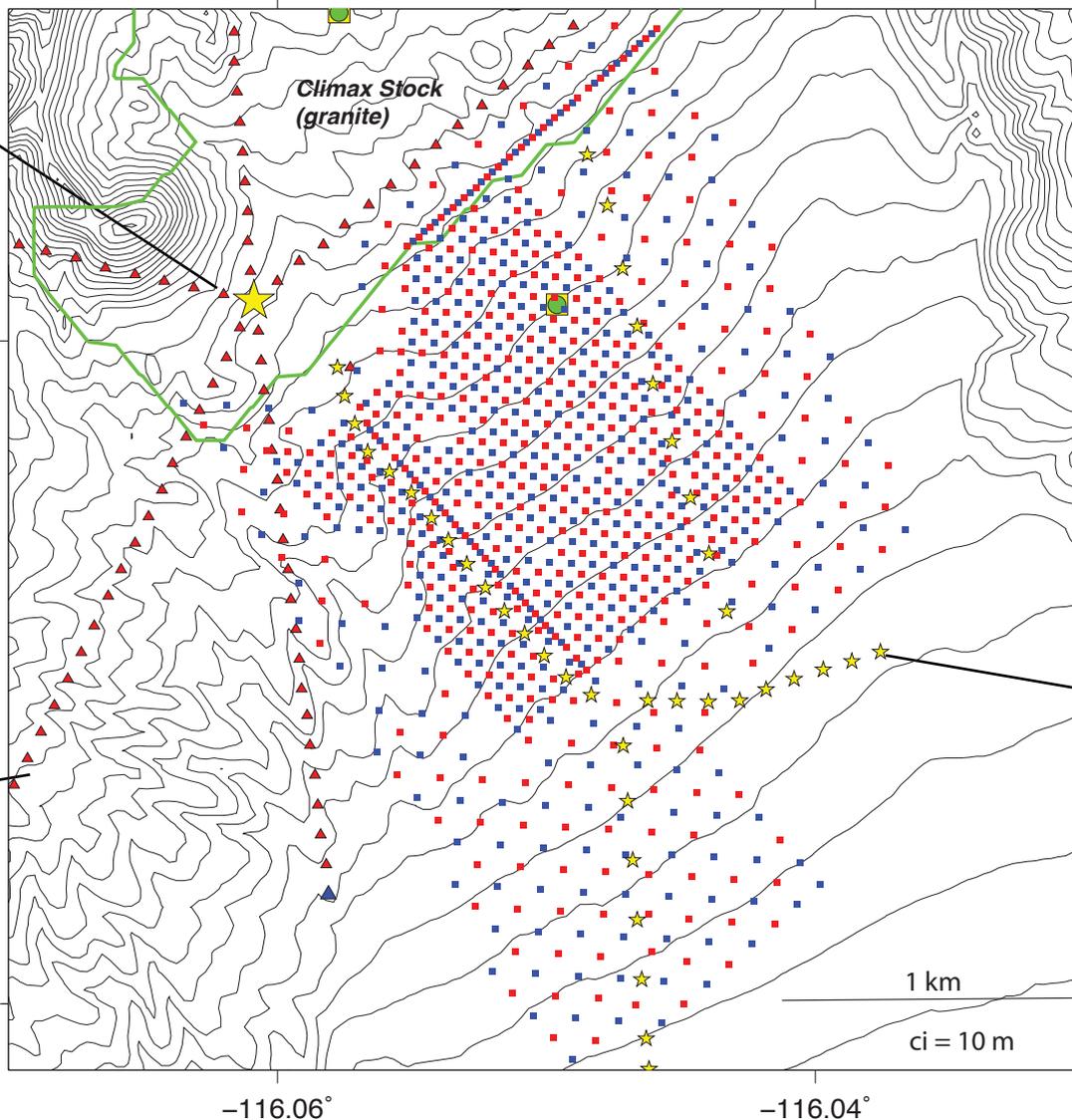


- Quaternary alluvium
- Tertiary volcanics
- Cretaceous granite
- Paleozoic clastics and carbonates

Large array (996 sensors)



SPE5
5000 kg TNT
equivalent at 76
meters



- CMG40T (north/east)
- Episor (north/east)
- ▲ Trillium compact
- ▲ GS11D (radial/tangential)
- 3C Large N
- Z Large N
- ★ weight drop
- ★ SPE5

Long-term
telemetry
stations
(radial lines)

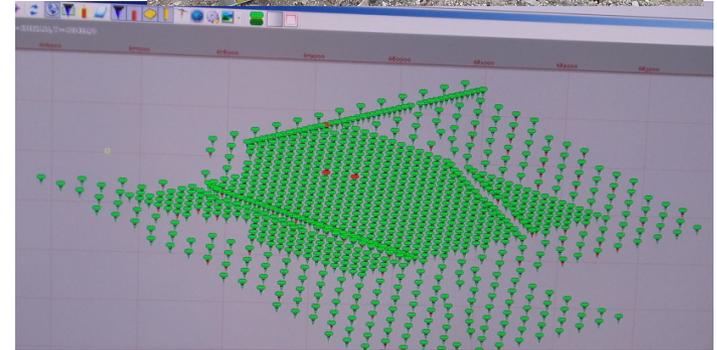


Weight drop

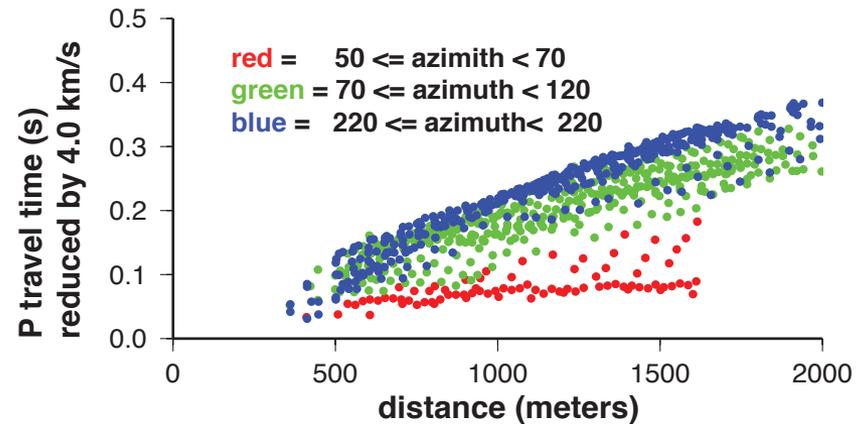
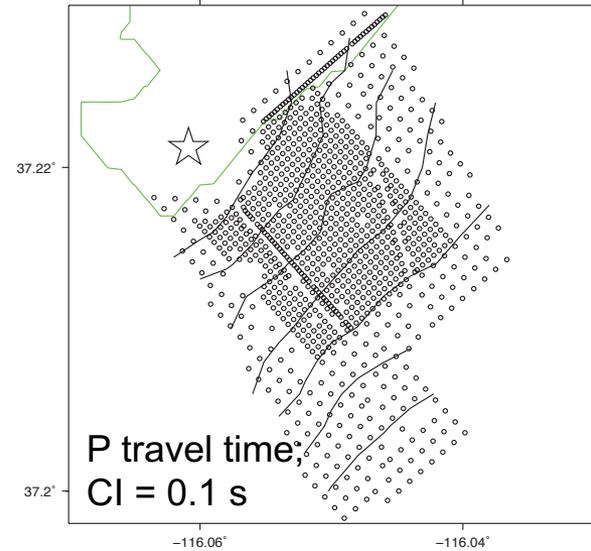
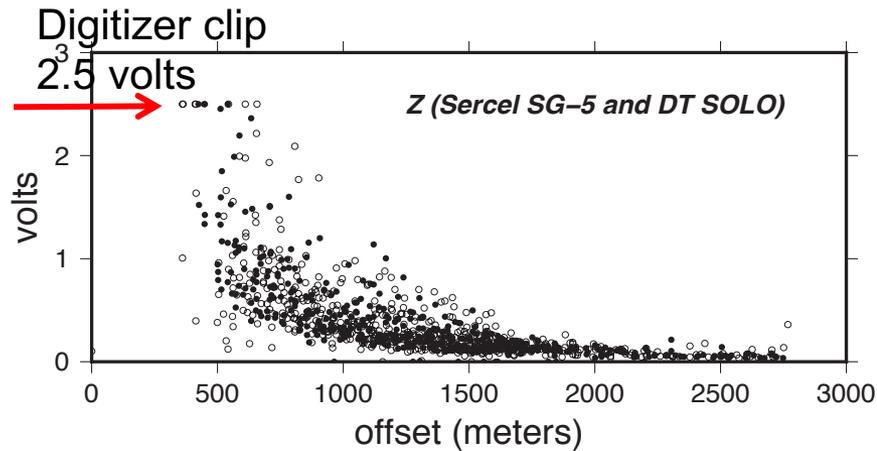
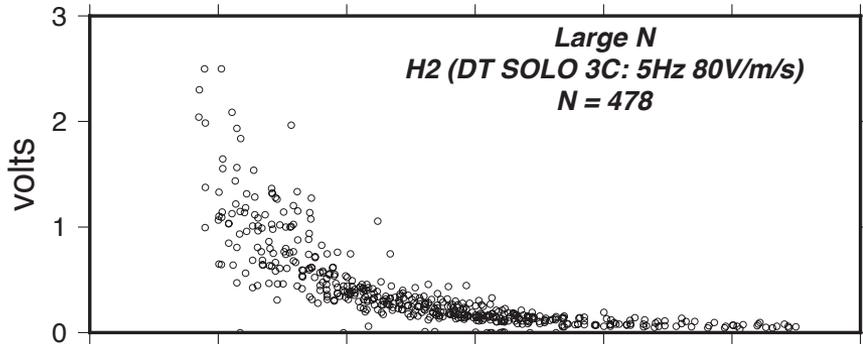
<https://twitter.com/frankklotznnsa>

Instrumentation and logistics

- Equipment and deployment
 - 500 Z (5 Hz DT-SOLO); 500 3C (5Hz Sercel SG-5)
 - Spacing from 25 to 100 m
 - Deployment about 5 days plus QC (crew of 6)
 - 5 week deployment ranging from 300 to 2000 m from shot
 - Contractor: Optim, Inc.
- Data
 - Gain = 1 for shot; then set at 36 db
 - 500 samples/s
 - Continuous recording for interferometry
 - 96% return for shot; 99 % later
- Challenges
 - Shot schedule
 - NNSS rules and regulations
 - Communication between all groups
 - Sensor orientation



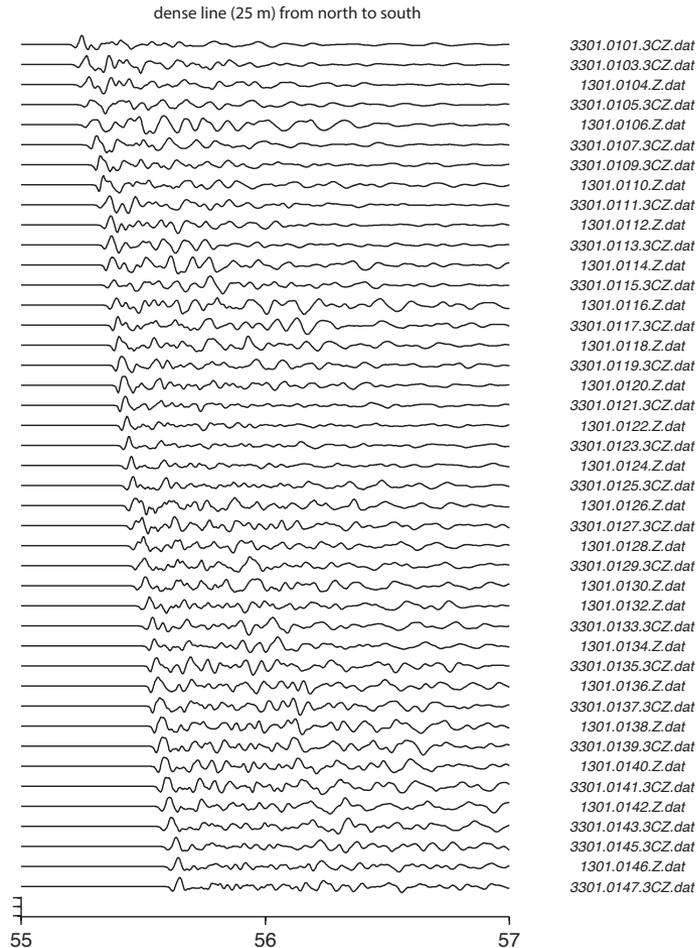
QC: Amplitudes and travel times



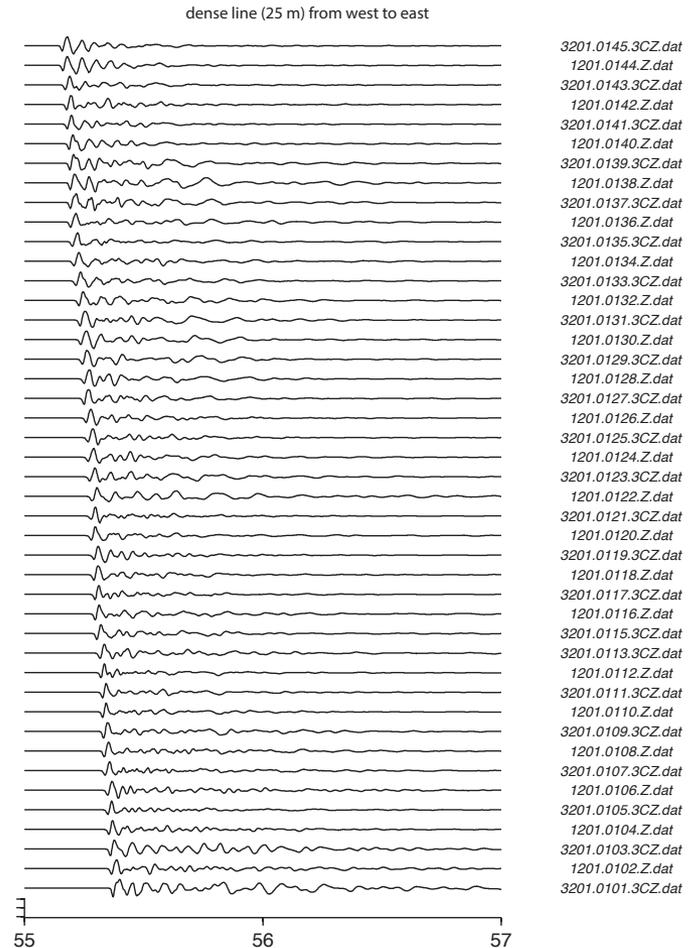
~96% data return for SPE-5; 98% for weight drop

QC: Some waveforms

South (into Yucca Flat alluvium)



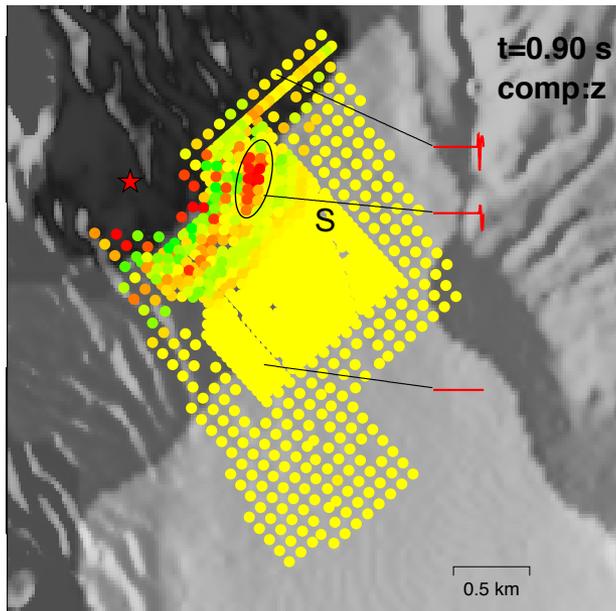
East (along Climax Stock granite)



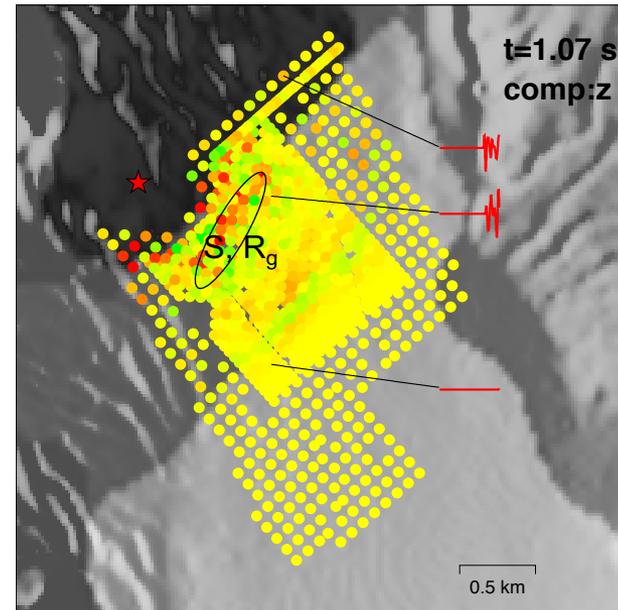
Z component; 25 m spacing (SEG polarity)

Structural effects on wave generation

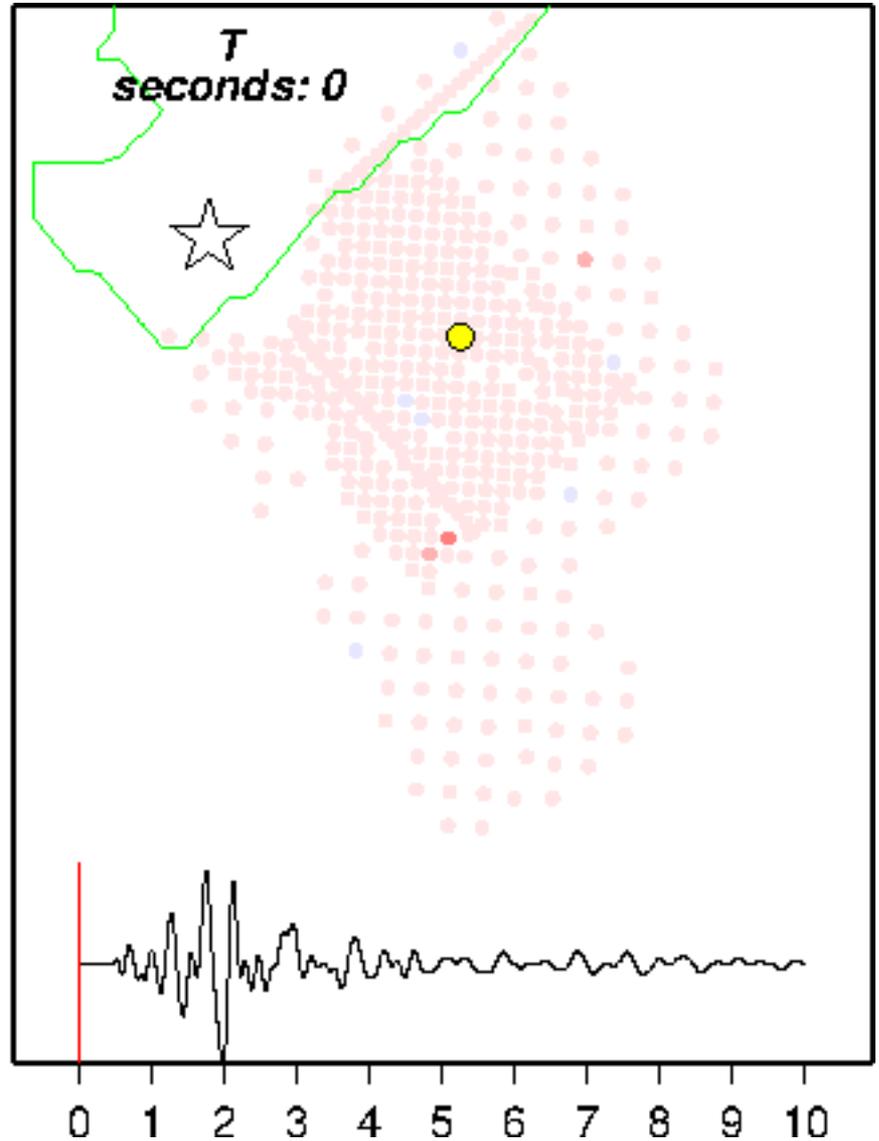
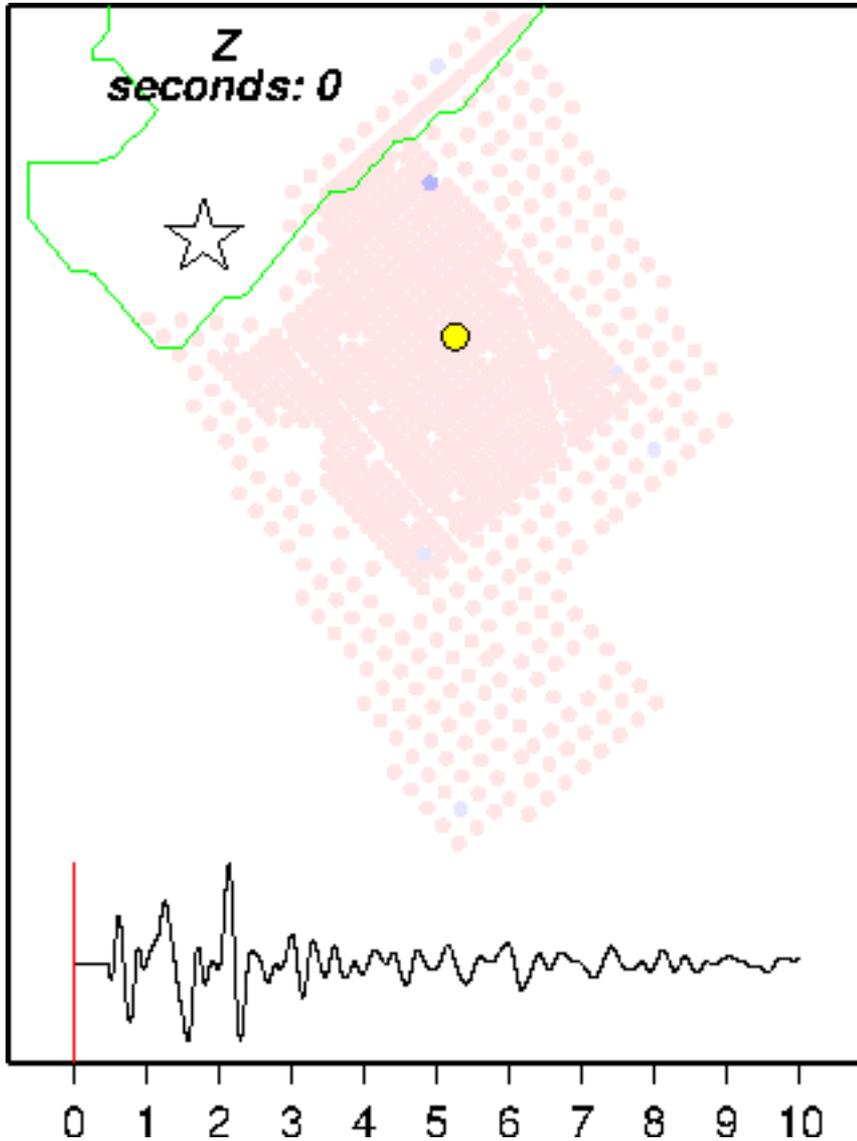
*pS converted + source
generated S waves*



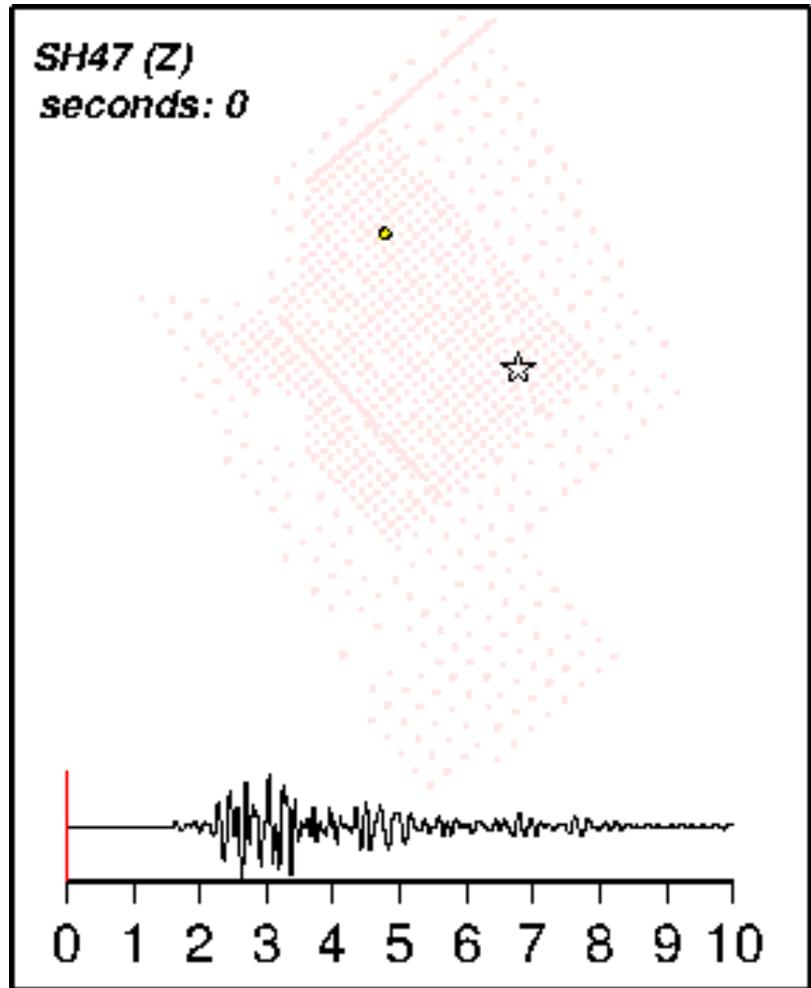
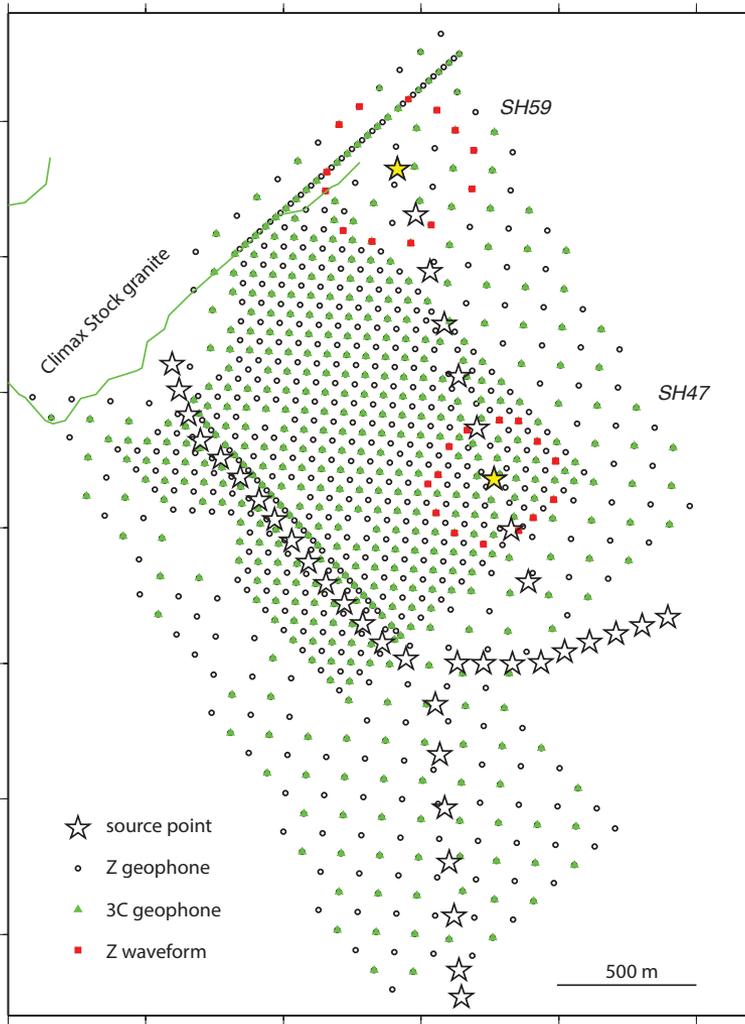
*Basin generated S
+R_g waves*



Wave motion – vertical and tangential

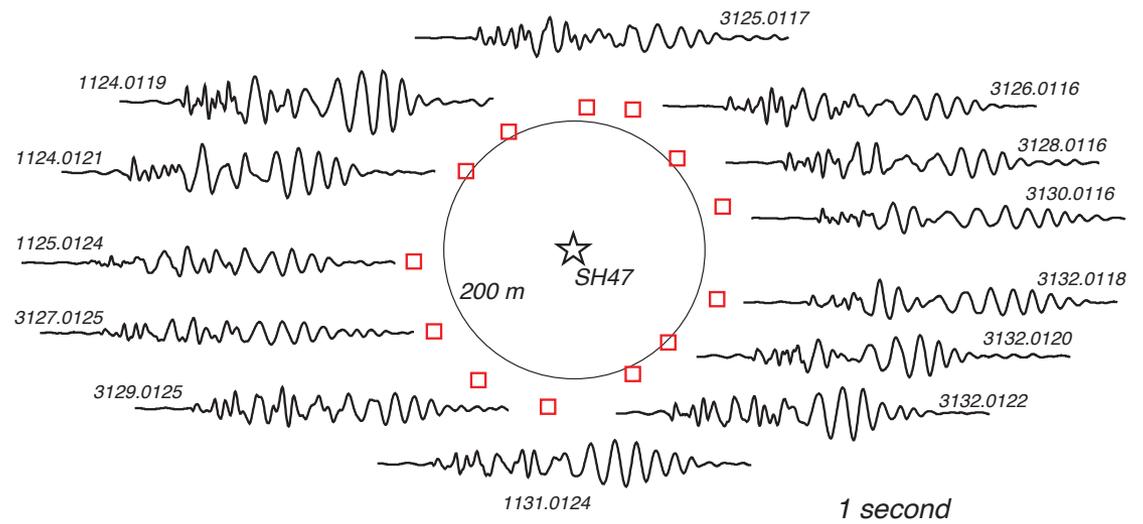
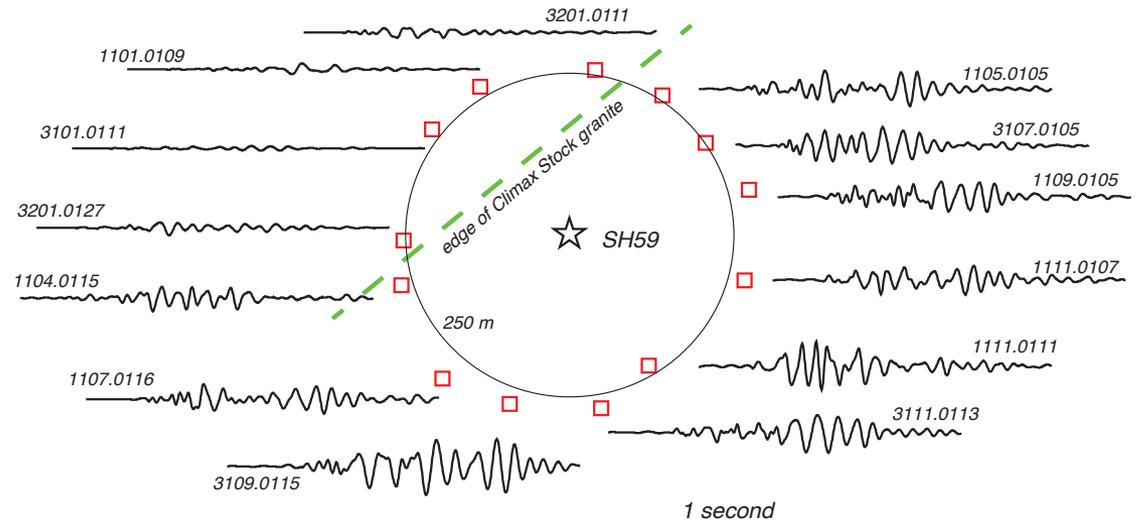
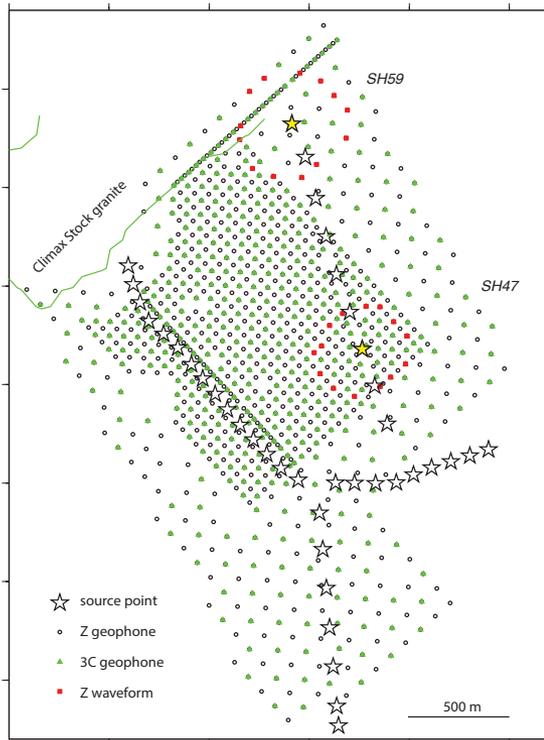


Weight drop



Waveform variation from weight drop

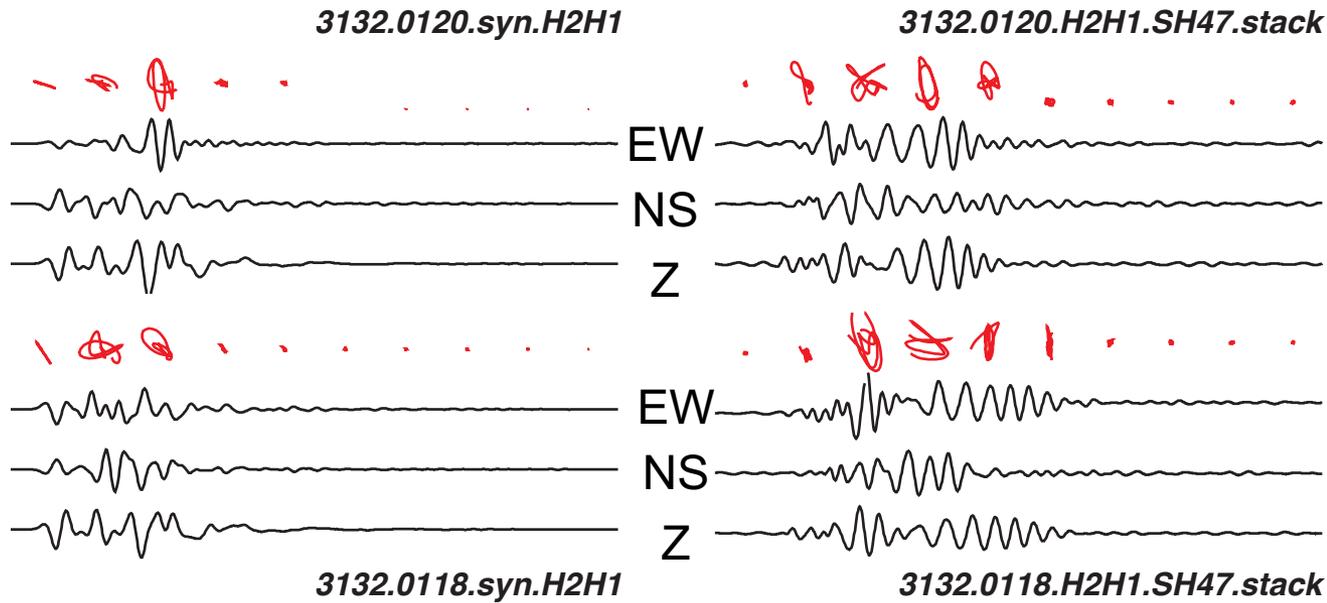
- Considerable azimuthal variation
- Related to geology



Horizontal particle motion (hammer)

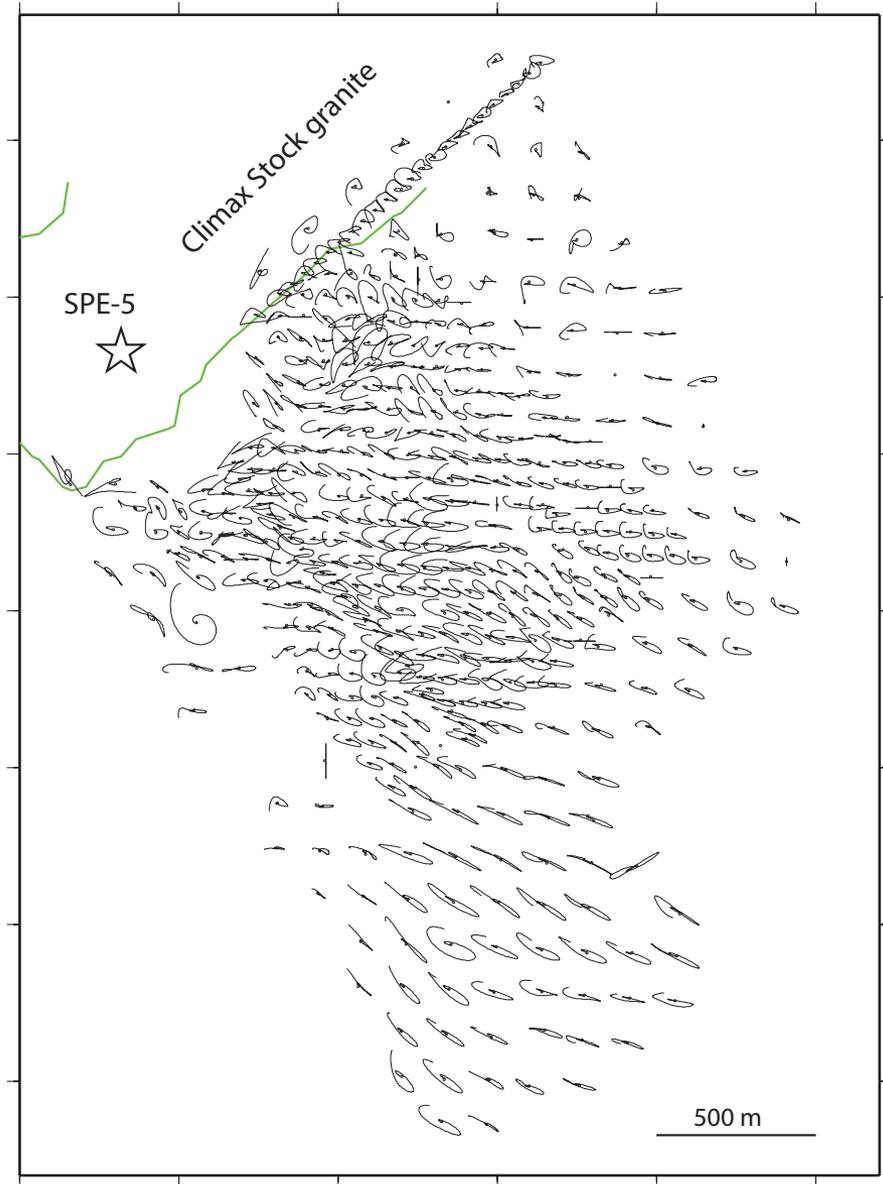
synthetics

data



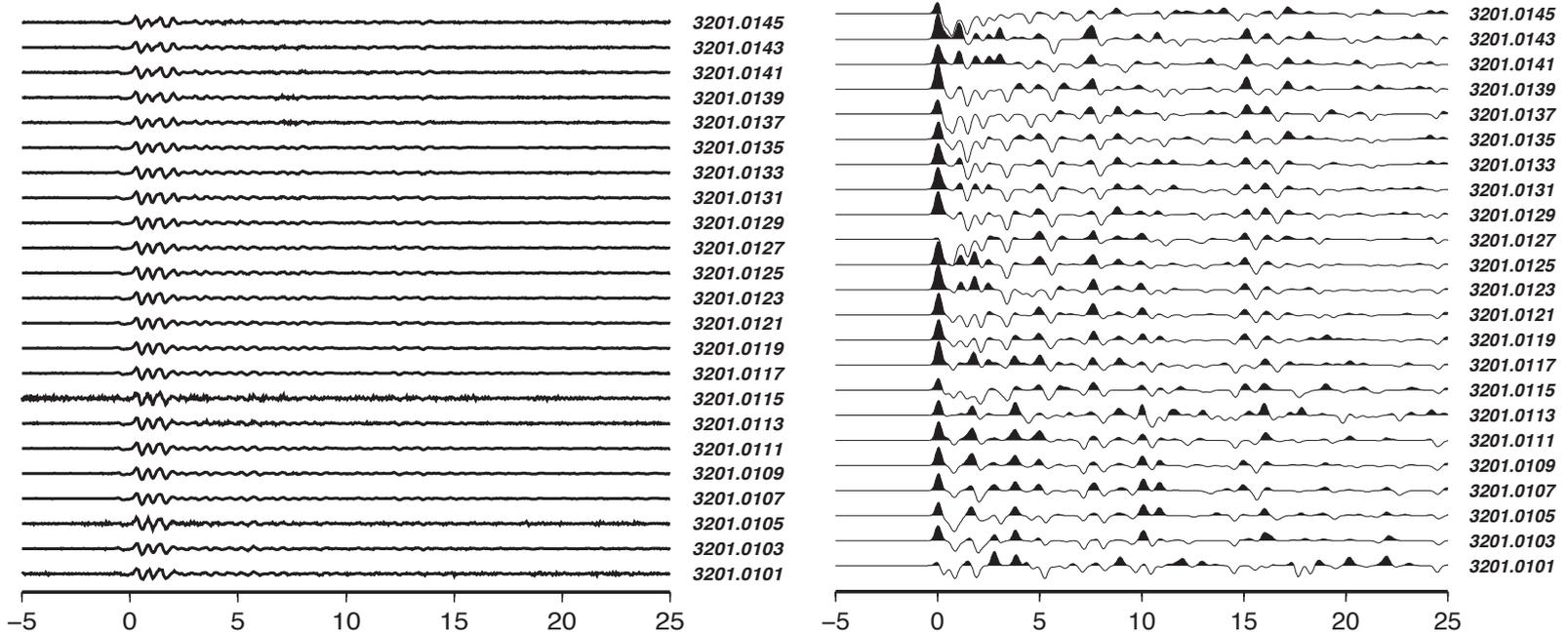
Horizontal particle motion (SPE5)

- Horizontal
- 0.25 after P arrival
- 5Hz lowpass
- Sensor orientation:
 - Nominal magnetic N
 - Re-checked in field
 - 80% within 10 degrees



Receiver functions

EW Climax Stock



Data: 1 Hz lowpass (Z)

Receiver function

- Will combine with ambient noise for joint inversion

Conclusions and future plans

- Deployment of approximately 1000 nodes was a success.
- With modern systems, good data recovery (>95%) is expected.
- Rich data include SPE5, hammer source, local, regional and teleseismic data.
- Initial analysis shows clear conversions and scattering.
- Data will be available at IRIS DMC in mid-2018.



Thank you!

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