

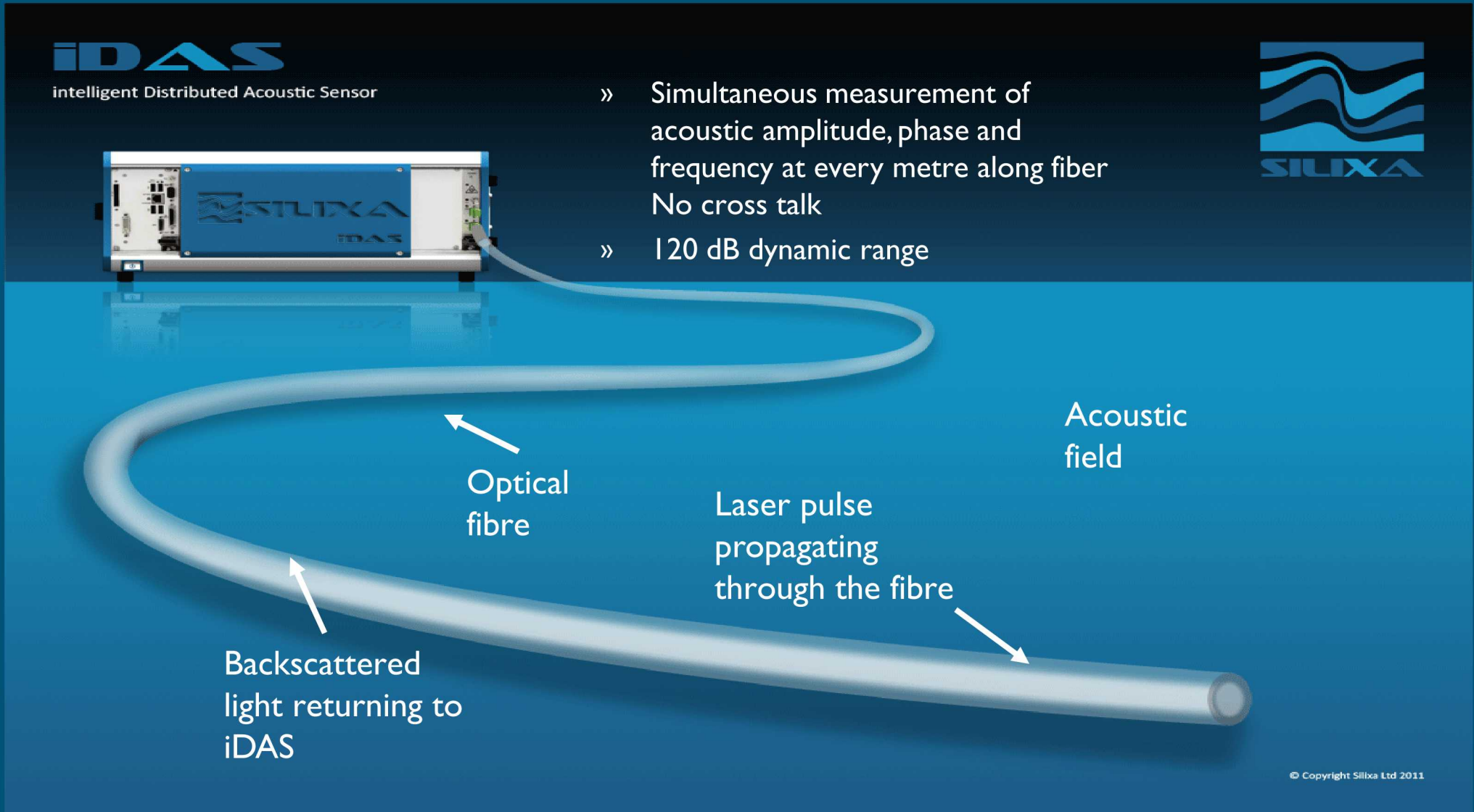
Distributed Acoustic Sensing Observations and Modeling of the DAG Series of Chemical Explosions



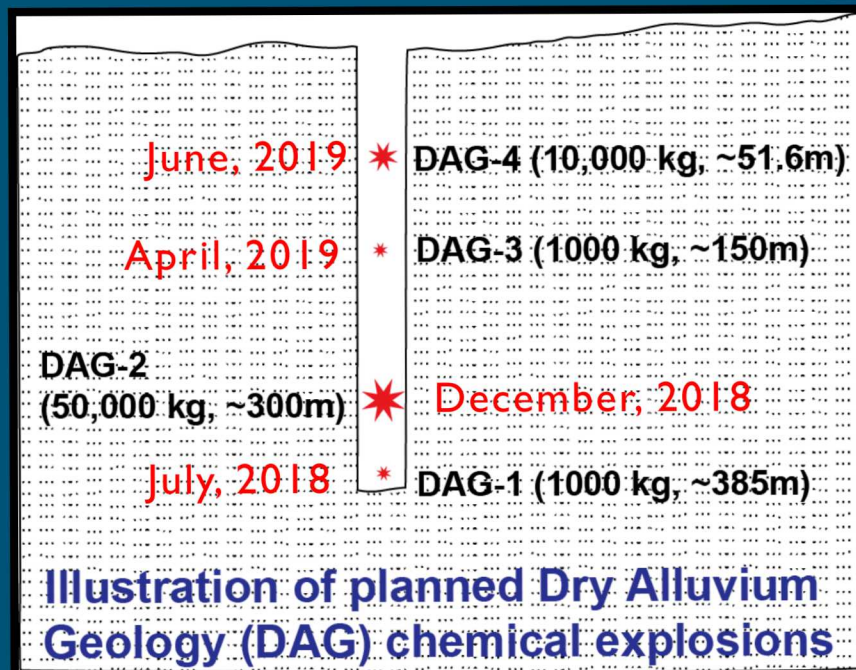
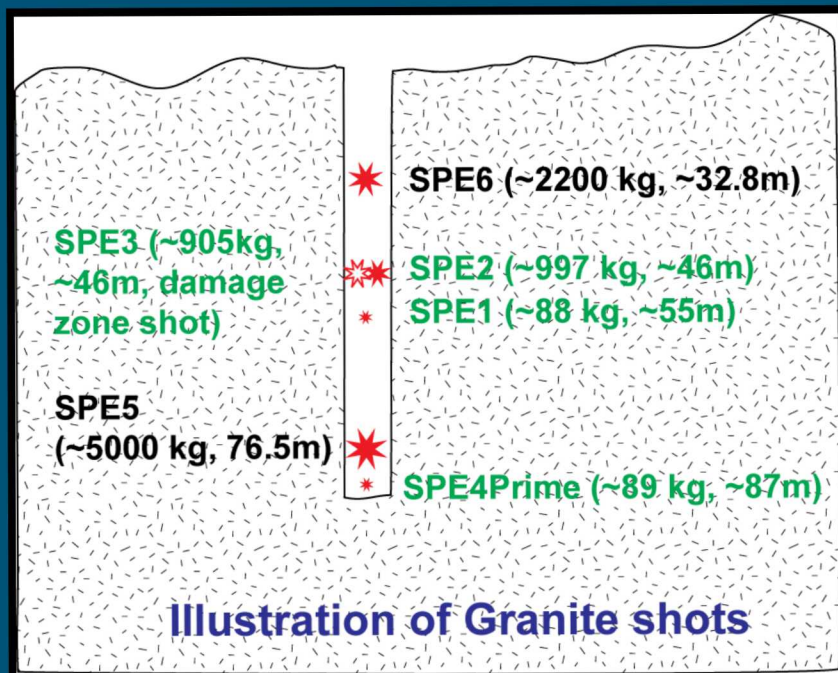
PRESENTED BY

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National Laboratory



Completed and Planned SPE Chemical Explosions



Phase I (granite) is complete

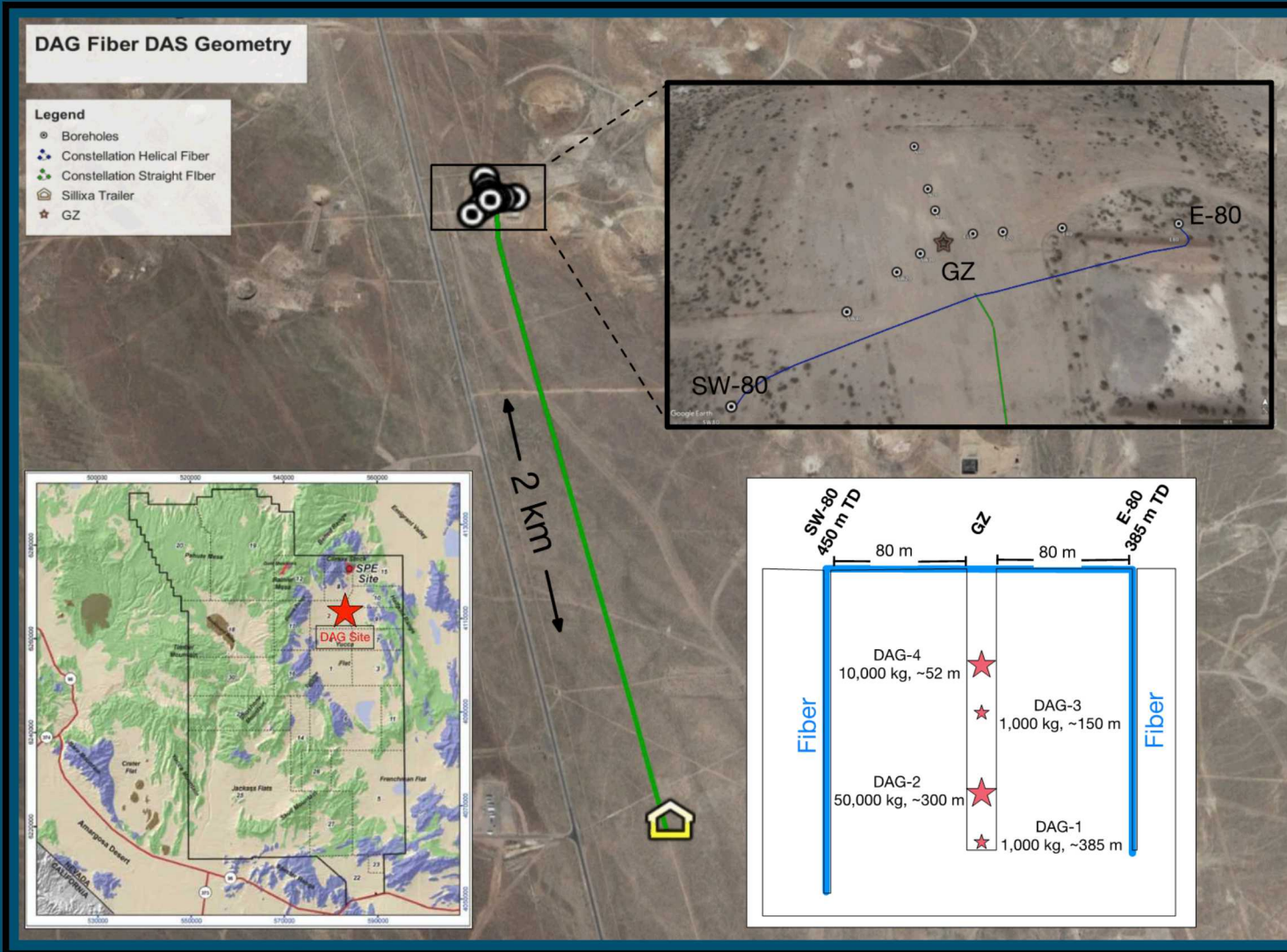
- Seismo-acoustic data is available for download at Iris
- No DAS data acquired

Red-circled experiments include DAS



DAG-2 Canister
50,000 kg TNT-equivalent

DAG Fiber DAS Acquisition and Geometry



- 1 km of helically wound cable (HWC)
 - HWC cable grouted in two boreholes 80 m from GZ
 - HWC surface-trenched cable between the two boreholes
- 2 km of straight Constellation cable
 - Straight cable run in trench to recording trailer ~ 2 km from GZ
- Triaxial accelerometers at level of each explosion in 12 surrounding boreholes
- Single triaxial geophone

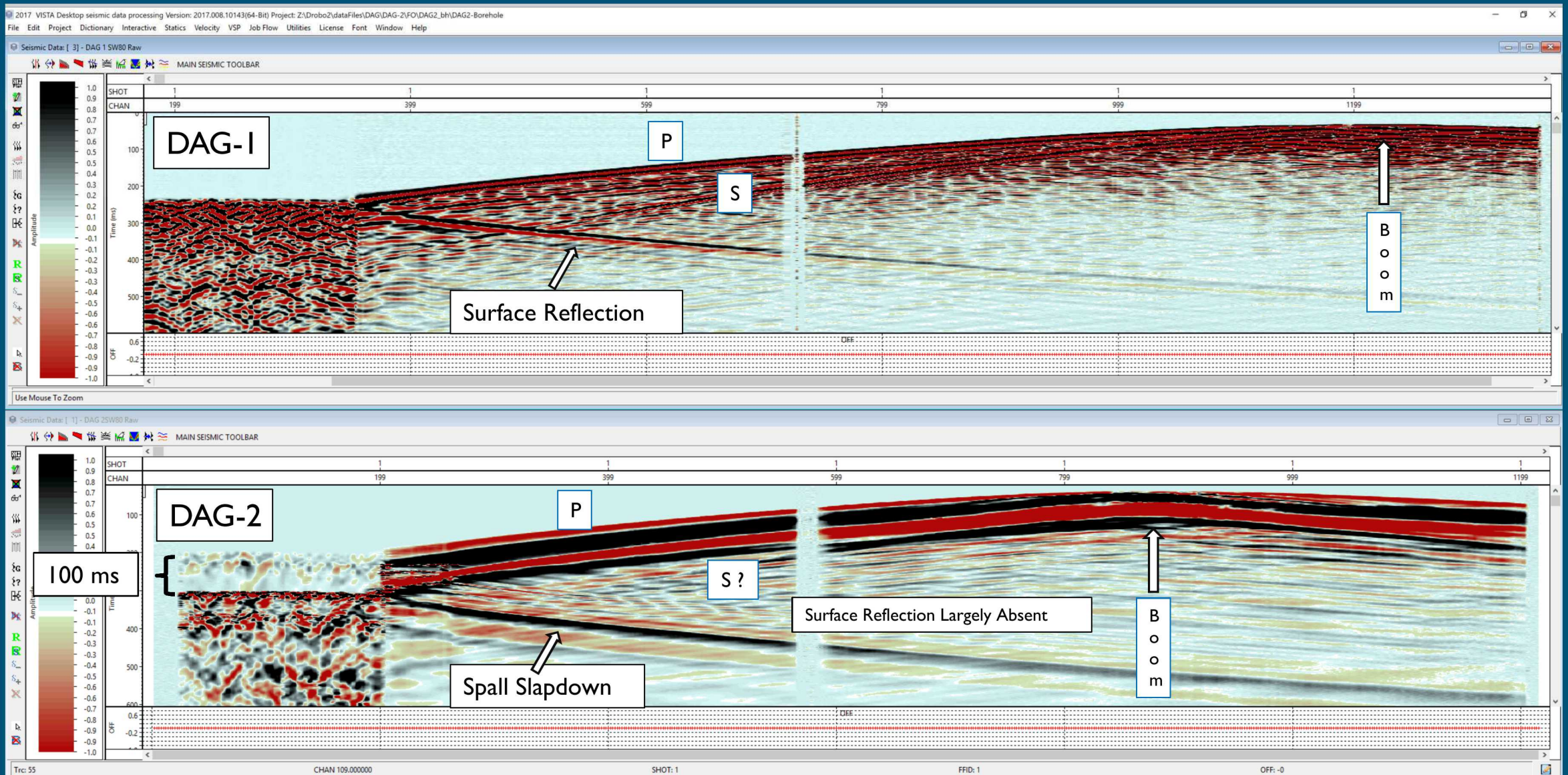


Accelerometer

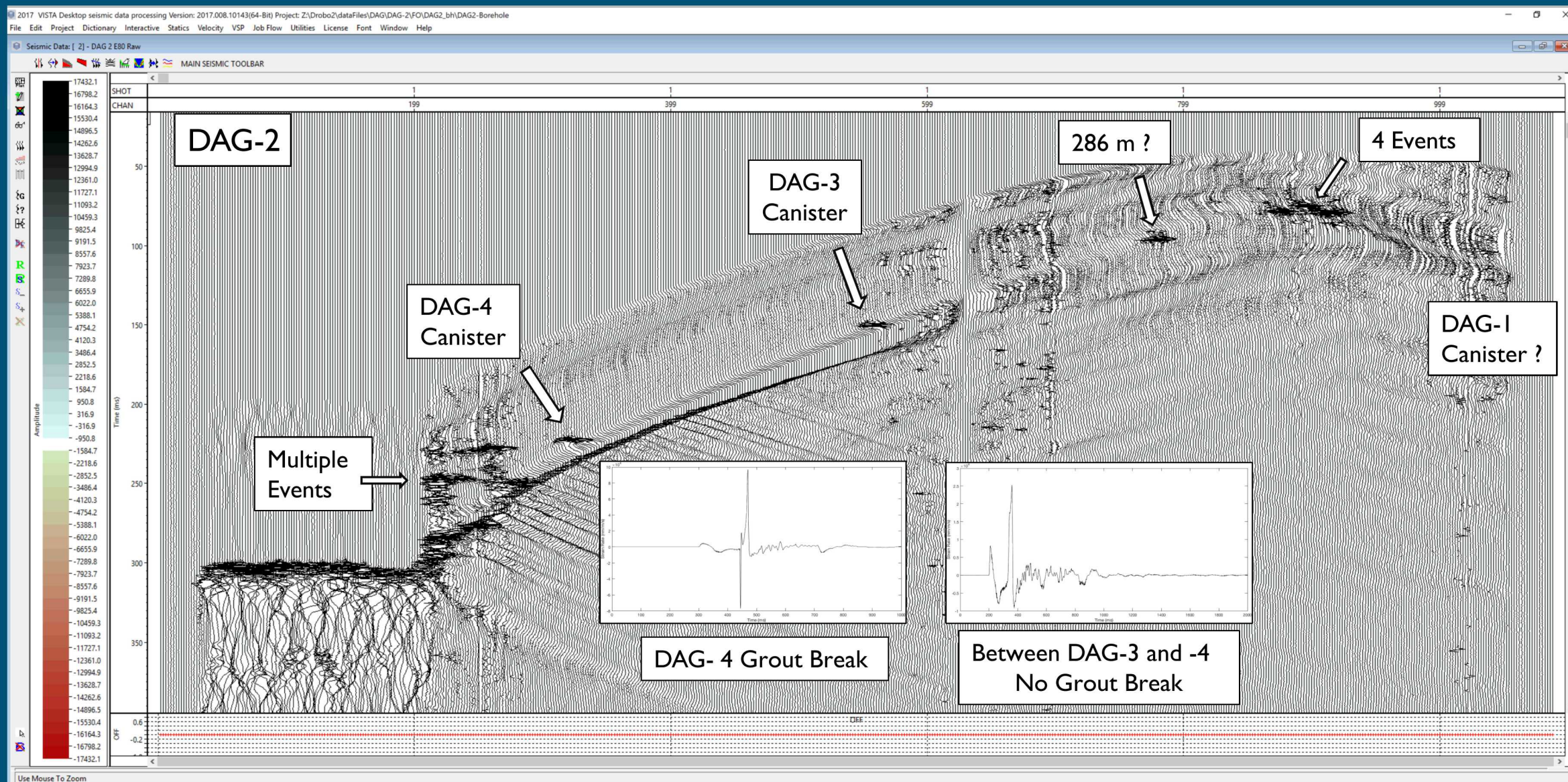
HWC

Geophone

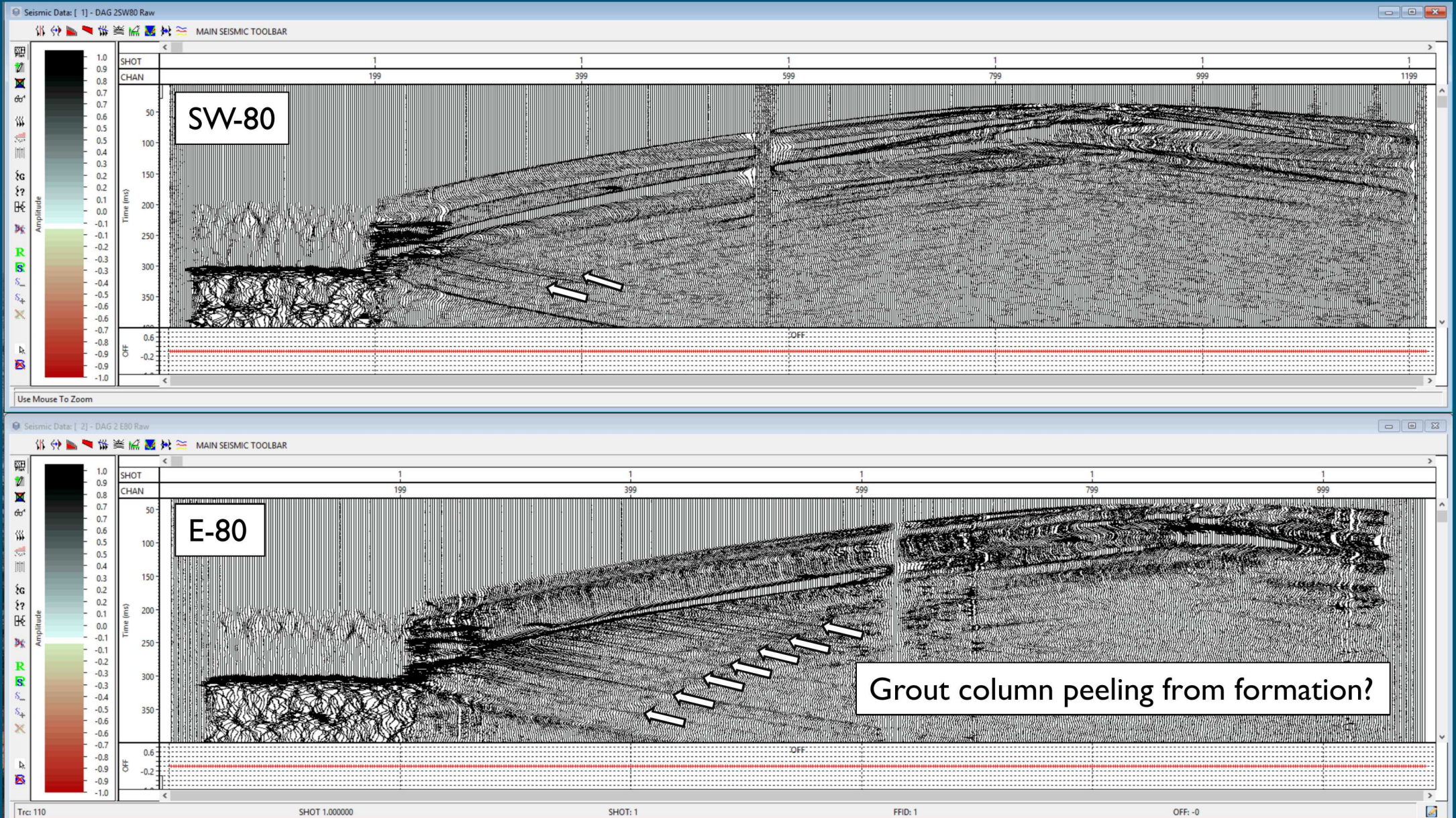
DAG-1 vs. DAG-2 SW80



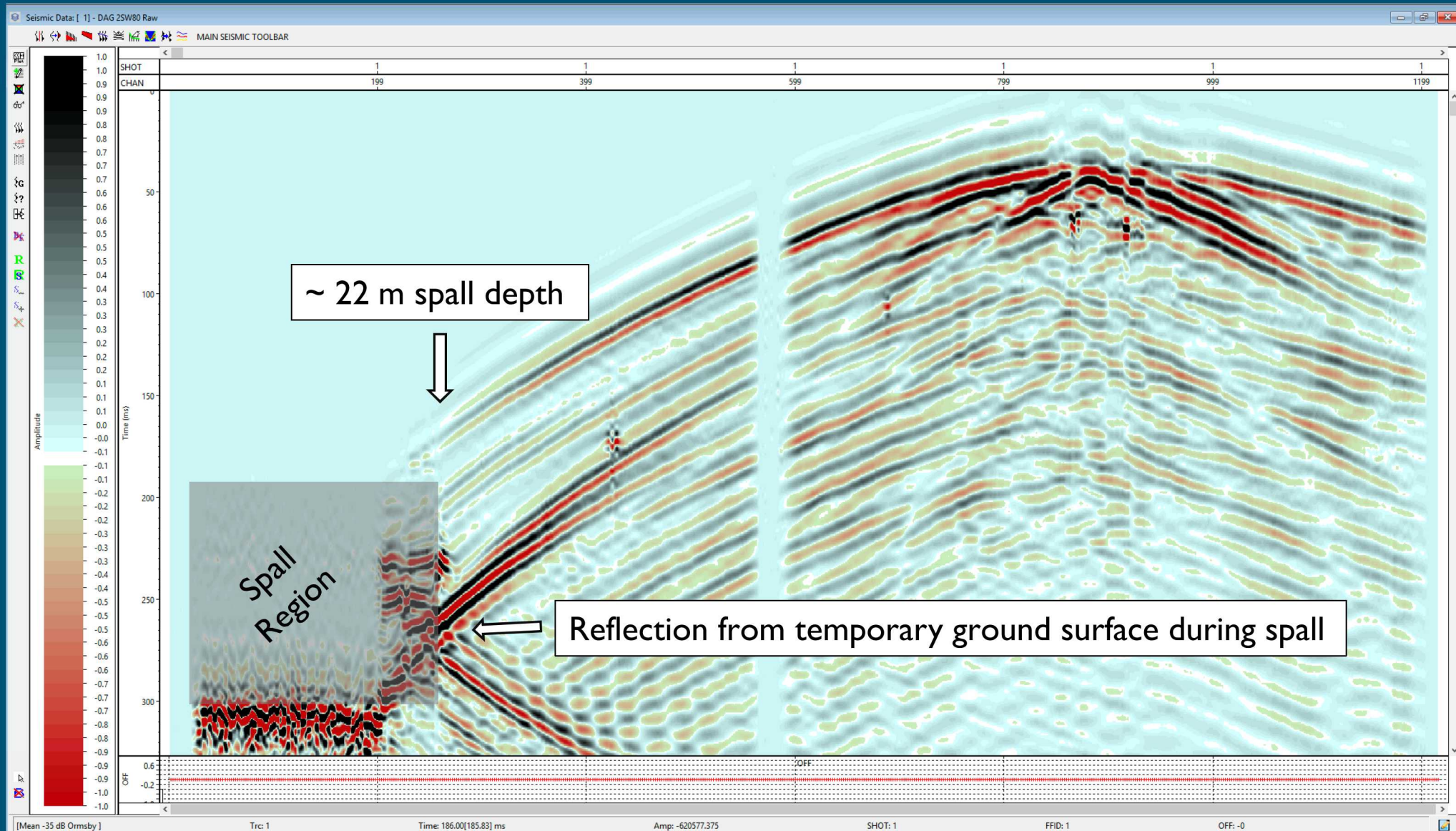
DAG-2 E80 Multiple Phenomena Imaged



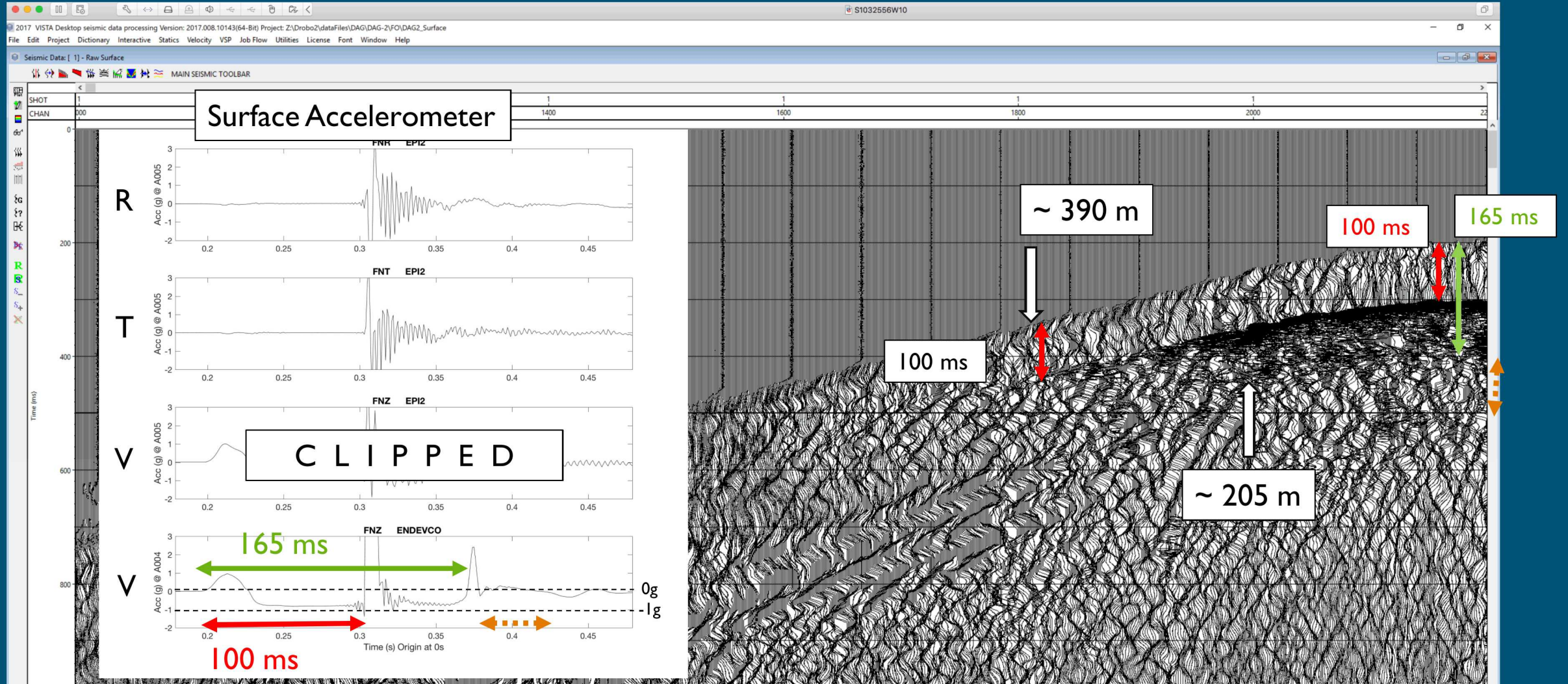
Mystery Arrivals in E-80



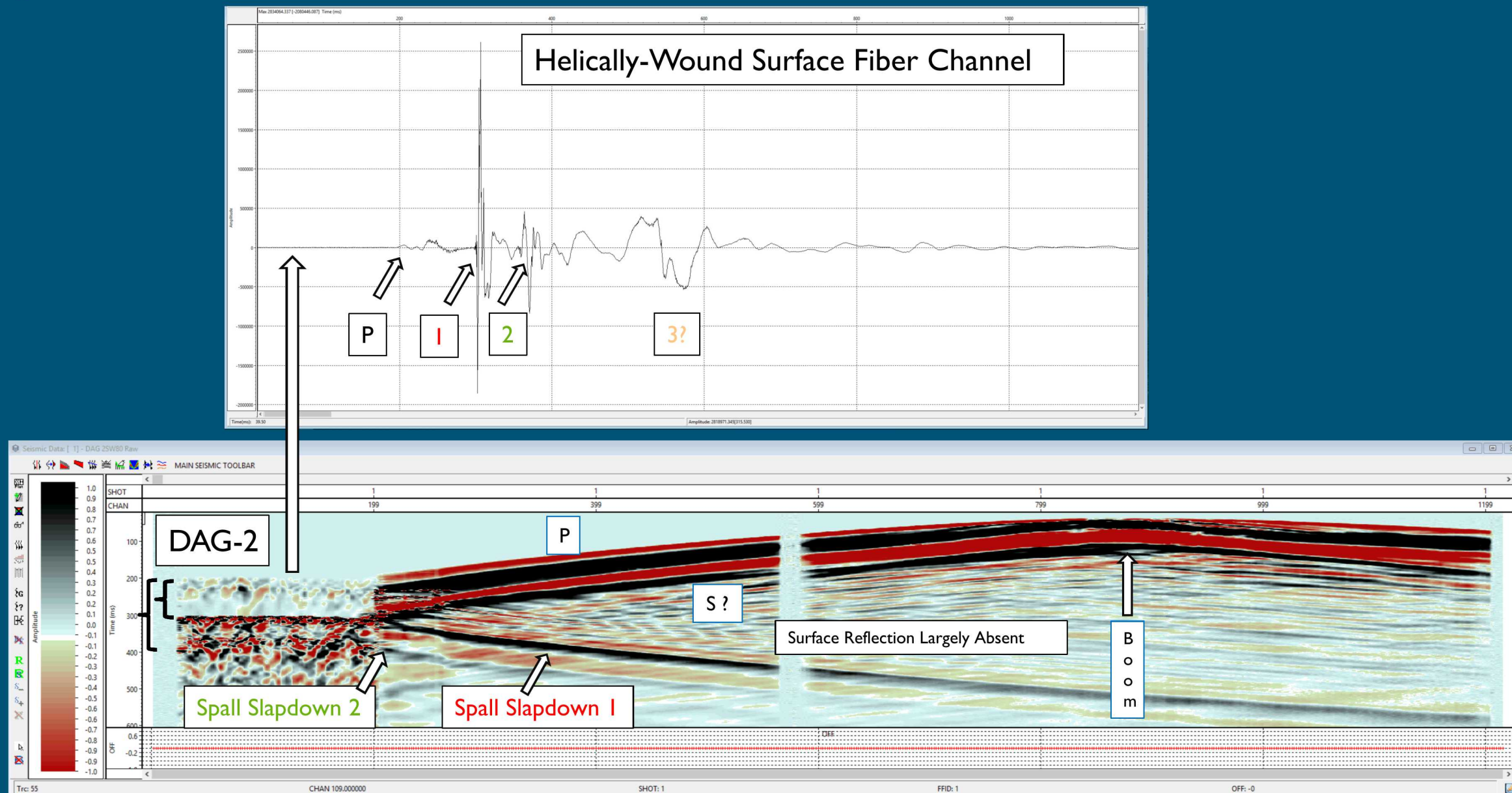
DAG-2, 75 Hz High-Pass



9 Spall Recorded on Surface Fiber vs. Co-located Accelerometer



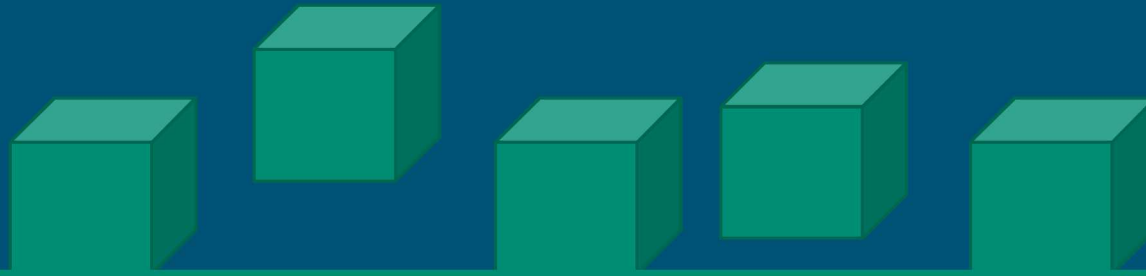
DAG-1 vs. DAG-2 SW80 Revisited



Two Simple Models

Bounce

Base of Spall



Start Lofted Slapdown 1 Bounce Slapdown 2

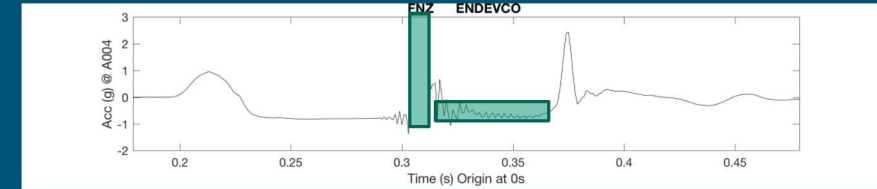
Spall Break-up

Base of Spall



Start Lofted Slapdown 1 Slapdown 2

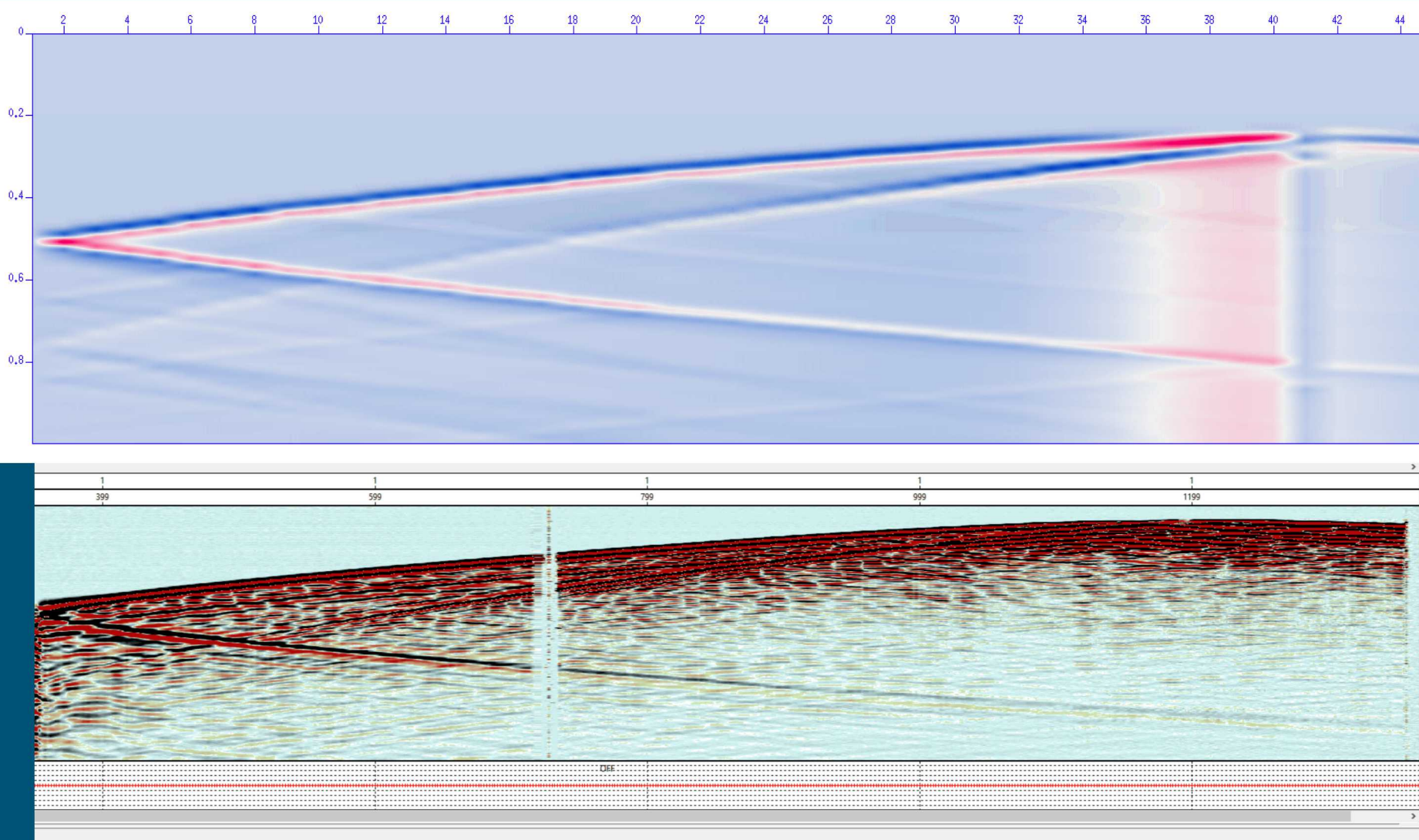
Supporting Evidence:
Inelastic Bounce Kinematics
Seem Reasonable



Supporting Evidence:
Evidence of grout column failure
Pre-Slapdown 1



Modeling DAG-I vs. DAG-I Recording



Assumptions:

- 1) Fiber/cable perfectly coupled
- 2) Grout neglected
- 3) Cable jacket neglected
- 4) Radial stress on fiber neglected
- 5) Refractive index of fiber due to change in strain neglected
- 6) Signal in fiber is due to longitudinal extension of fiber
- 7) First pass attempt.
 - 1) Ignore helical response.
 - 2) Estimate linear elastic only (e.g. no spall)

Summary

Unqualified success in recording DAG-1 and DAG-2

- Two orders of magnitude more data relative to traditional geophones/accelerometers
- Recorded complete seismic wavefield instead of a few waveforms
- Helical cable performed well in recording relevant phases
- Greatly aids in interpreting primary diagnostics

Evidence for multi-phase spall or spall bounce

- Depth of main spall is approximately 22 m
- Secondary spall separated by 65 ms
- Possible 3rd rebound event (not true spall)
- Evidence for spall signatures out to ~390 meters

Progress is being made in modeling the fiber response

- Need to add helical fiber response

Thanks to Jesse Bonner (MSTS) and Christian Poppeliers (SNL) for helpful discussions

Thanks to Silixa, LLC for recording the dataset