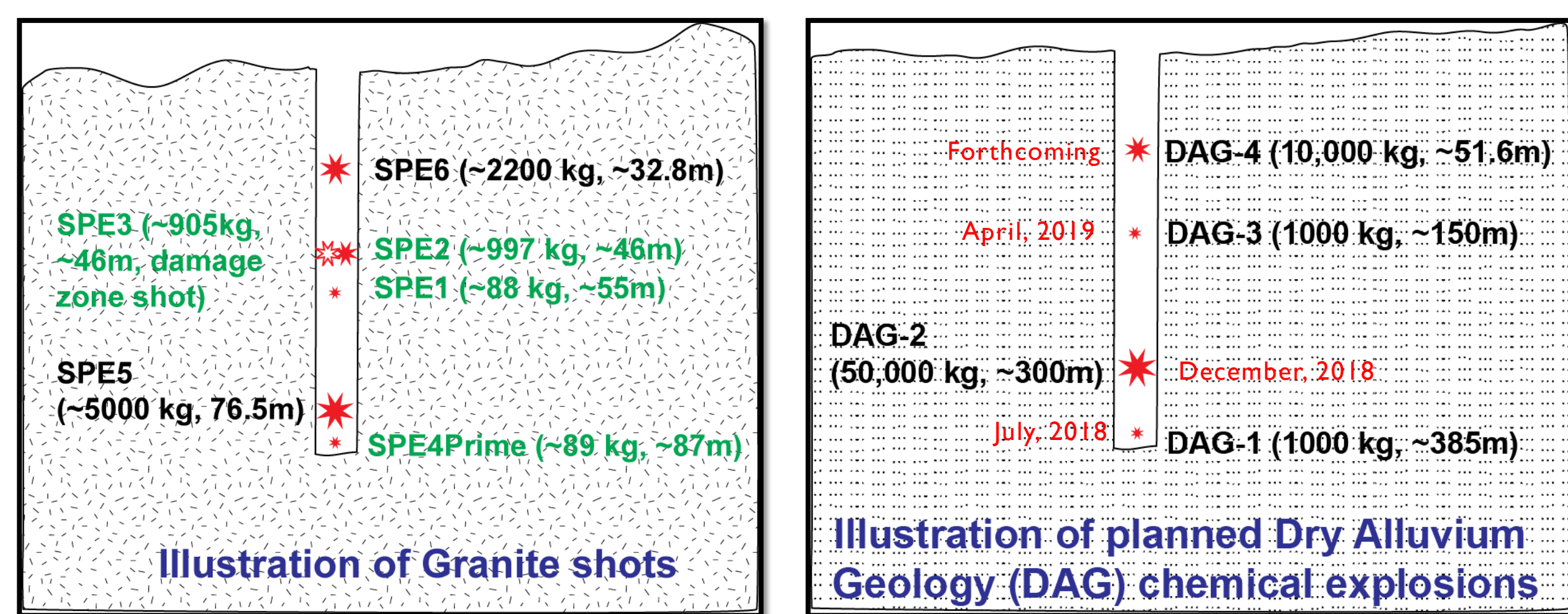


## Abstract

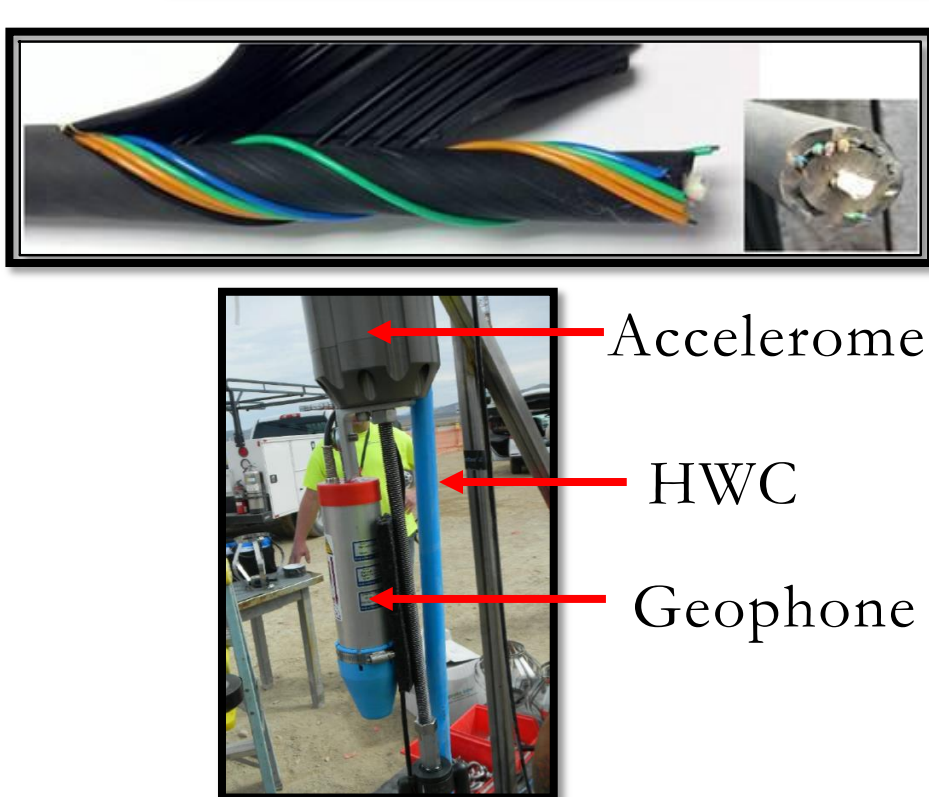
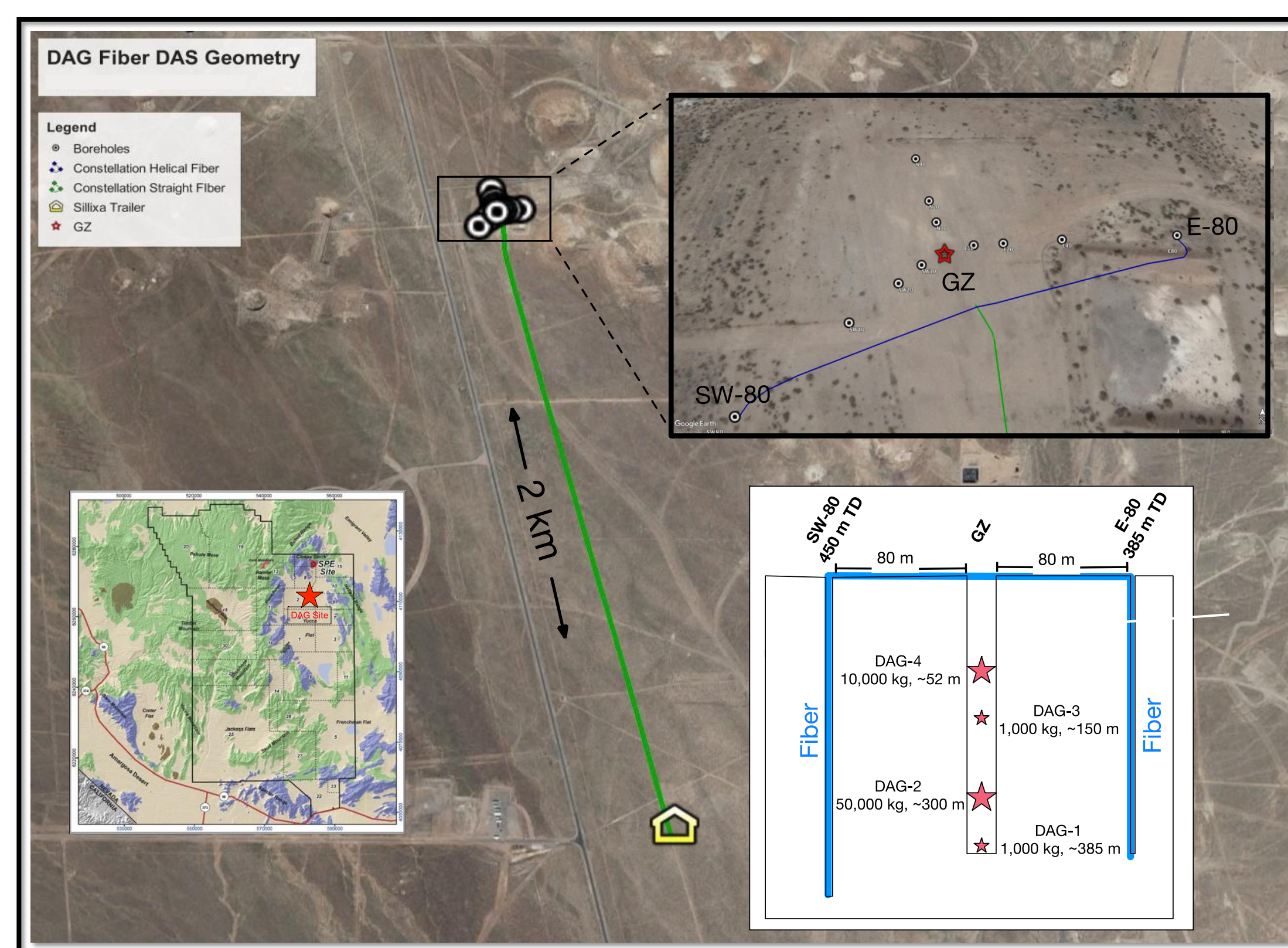
The Dry Alluvium Geology (DAG) series of chemical explosions aim to increase our understanding of explosion-source seismic, acoustic, and electromagnetic phenomenology. The explosion series takes place on the Nevada National Security Site (NNSS) in an alluvium geology. As of December 2018, two of the planned four explosions have been detonated in a common borehole on Yucca Flat: 1,000 kg TNT-equivalent at 385-m depth-of-burial and 50,000 kg TNT-equivalent at 300 m. A component of the DAG diagnostic instrumentation consists of surface-laid and downhole fiber optic distributed acoustic sensing (DAS) cables. A helically-wound fiber installed in two vertical boreholes 80-m from ground zero (GZ) and a traditional surface-laid straight fiber extending from GZ to 2 km recorded the explosions. We present both modeling and observations of the explosions. Phenomenology observed thus far include near-source generated S waves, post-event microseismicity, and surface spall.

## SPE Chemical Explosions



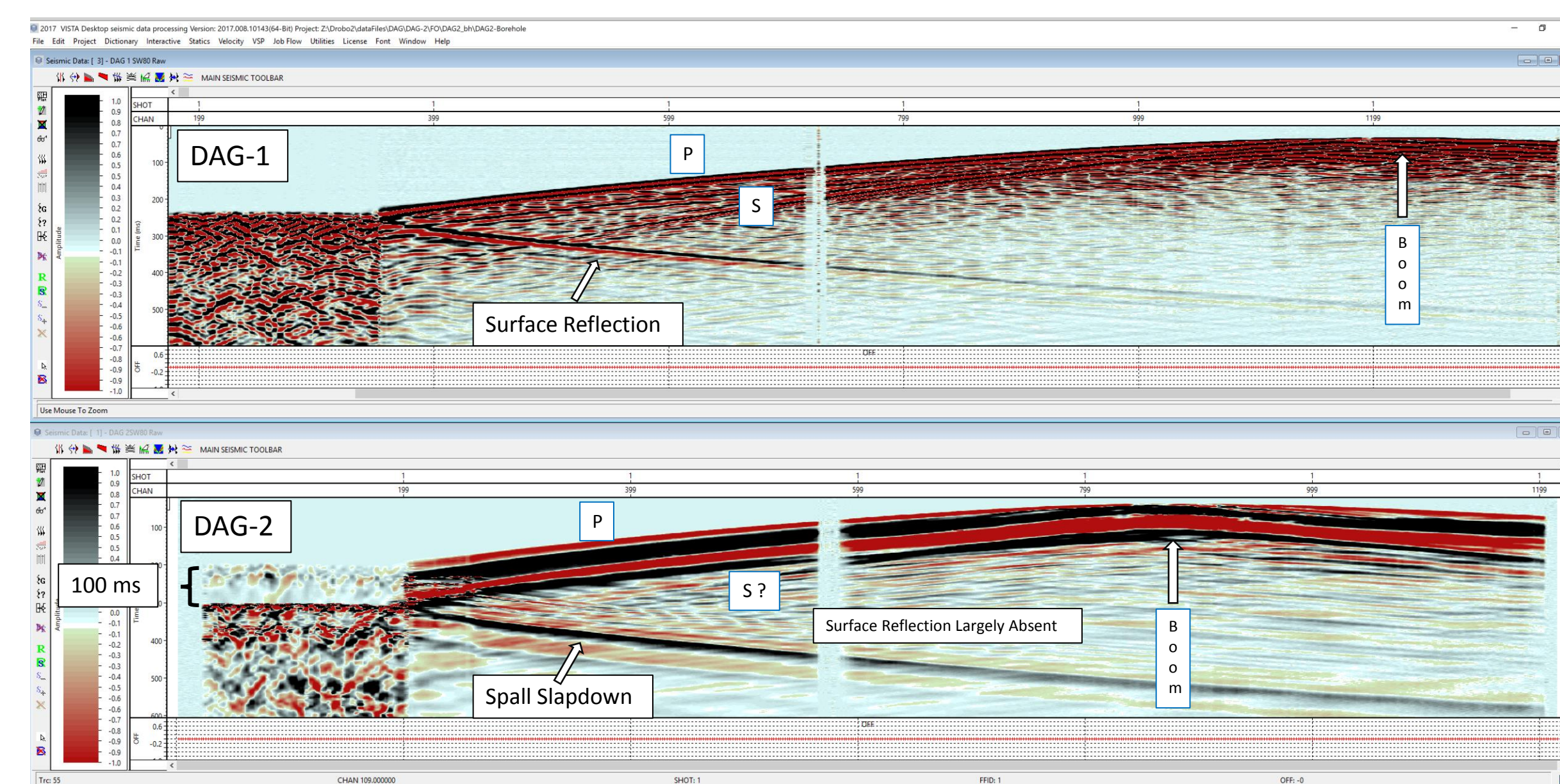
Two dissimilar geologies (granite and alluvium) have hosted the two phases of the Source Physics Experiment. The fiber optic data presented here are for the first two explosions in alluvium. No DAS data was acquired in granite.

## Acquisition Geometry

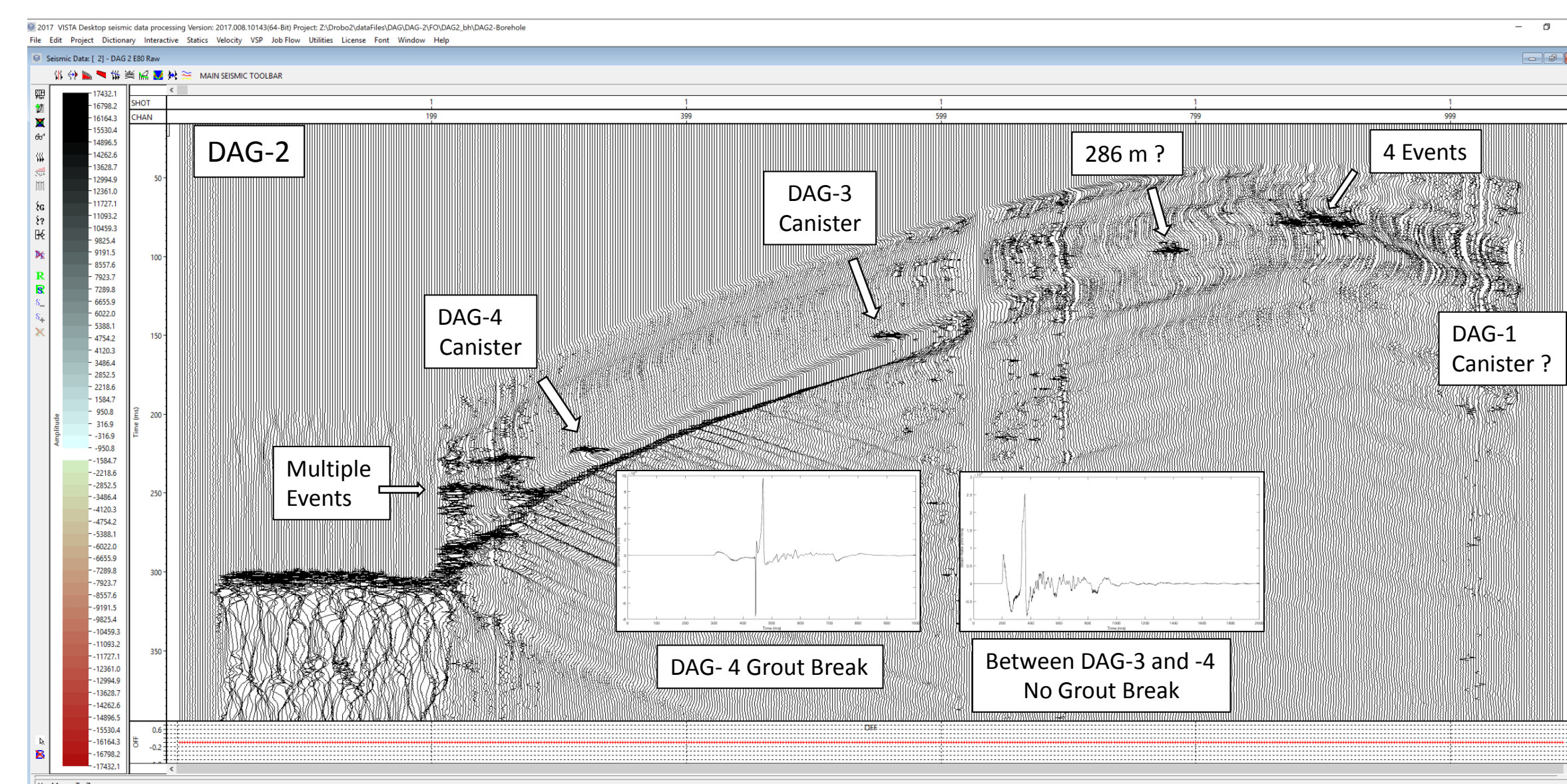


- 1 km of helically wound cable (HWC, blue)
- HWC cable grouted in two boreholes 80 m from GZ
- HWC surface-trenched cable between the two boreholes
- 2 km of straight Constellation cable (green)
- Straight cable runs in trench to recording trailer ~ 2 km from GZ
- Triaxial accelerometers at level of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

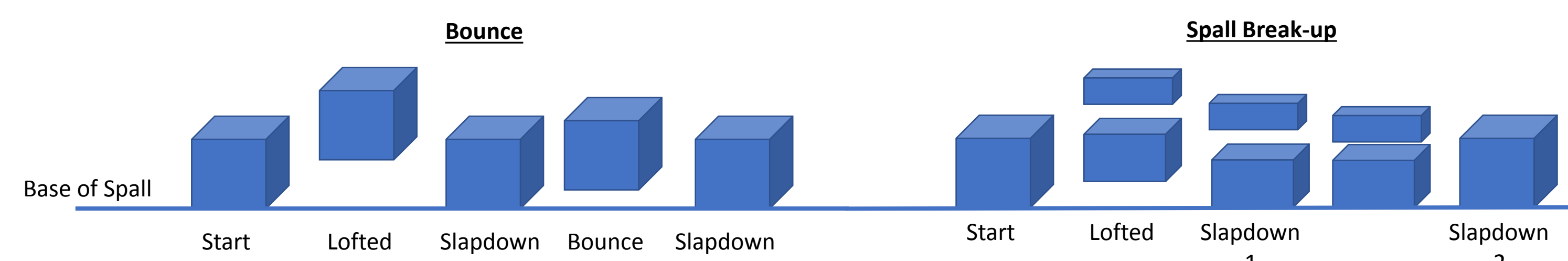
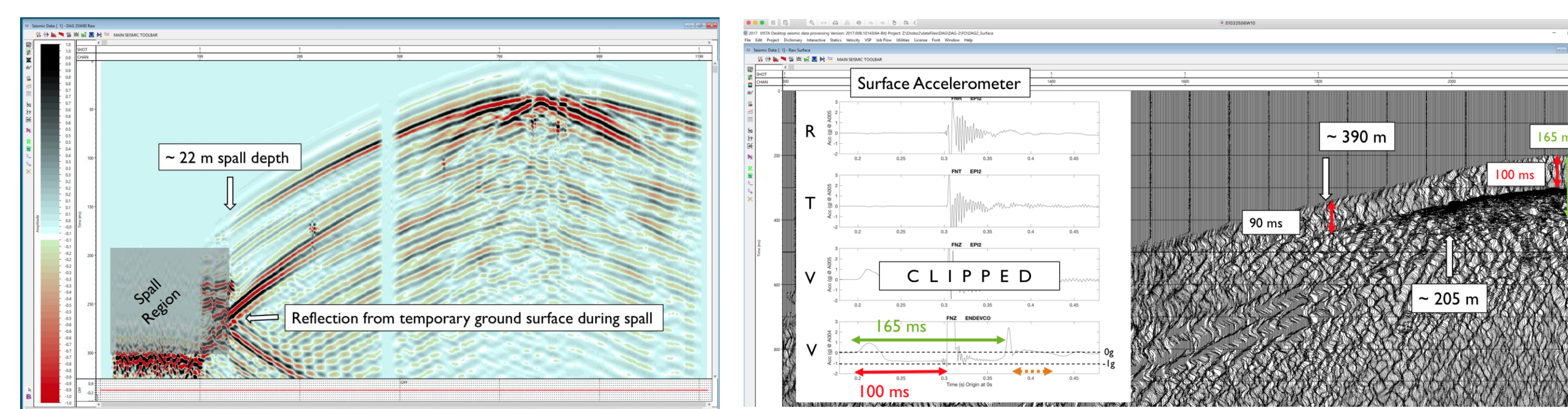
## DAG-1 and DAG-2 Observations



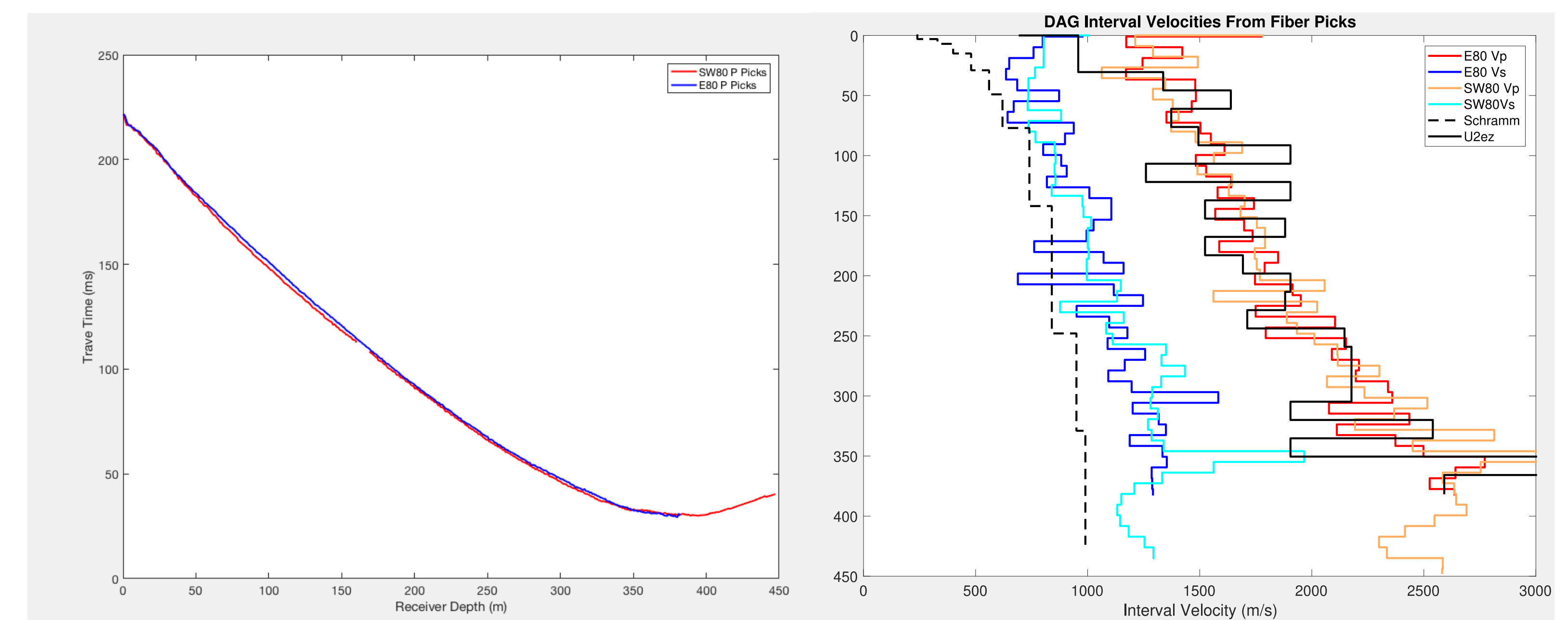
**DAG-1 and DAG-2 Recording in hole SW80.** Deeper portions of the hole is to the right. The abrupt change in character to ground surface where the fiber transitions to laying on the surface. Notice the immediate reflection from the surface for DAG-1 which delayed 100 milliseconds for DAG-2. We interpret this to be related to surface spall.



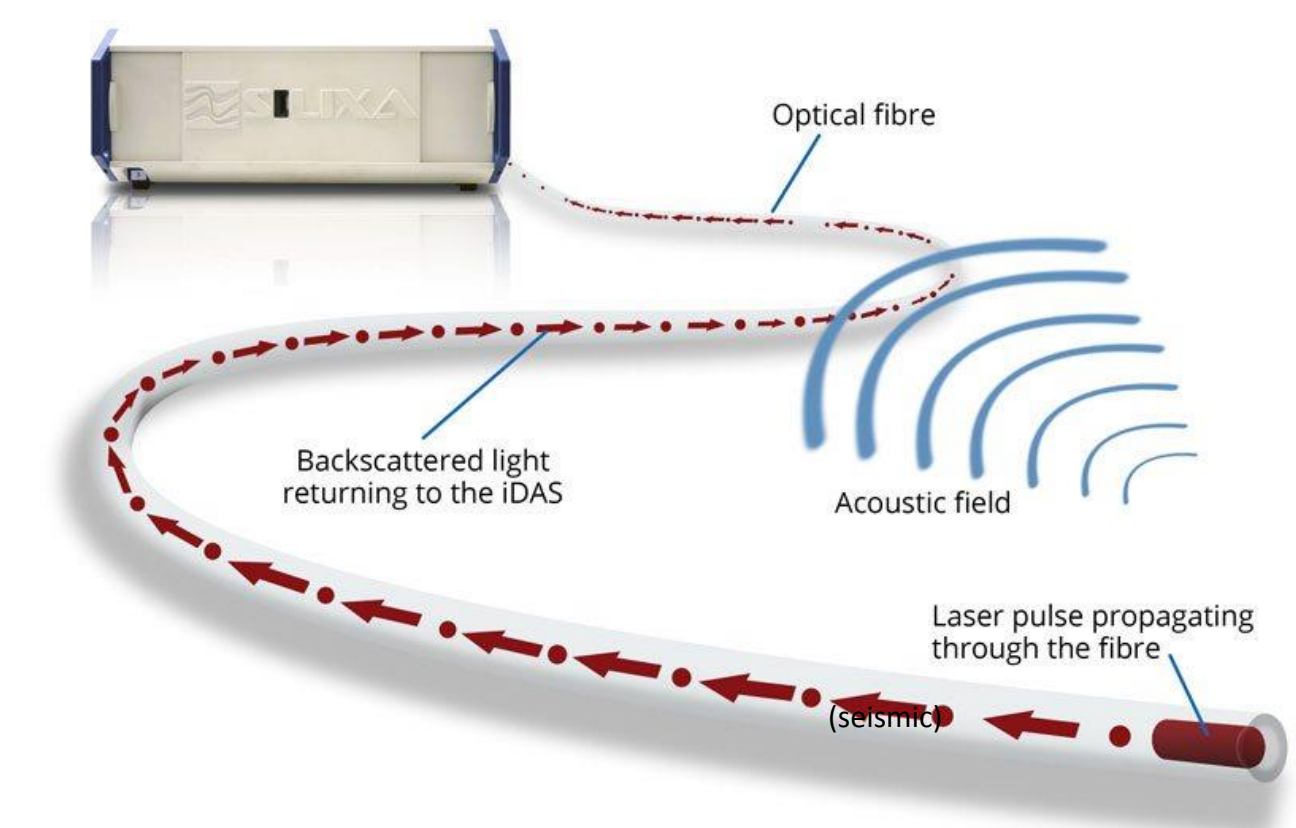
**DAG-2 in SW80:** Spurious high-amplitude, high-frequency signals were observed in the co-located accelerometer data. Examination of the DAS data reveals that these signals are local to the accelerometer packages ("Canisters" in above figure) and located along a wavefront of maximum dilation. We interpret this to be grout damage caused by grout separating from the smooth packages. This was not observed for DAG-1 with lower ground motion. Additional grout damage was seen in the spalled region near the surface ("Multiple Events", above).



## Velocity Model

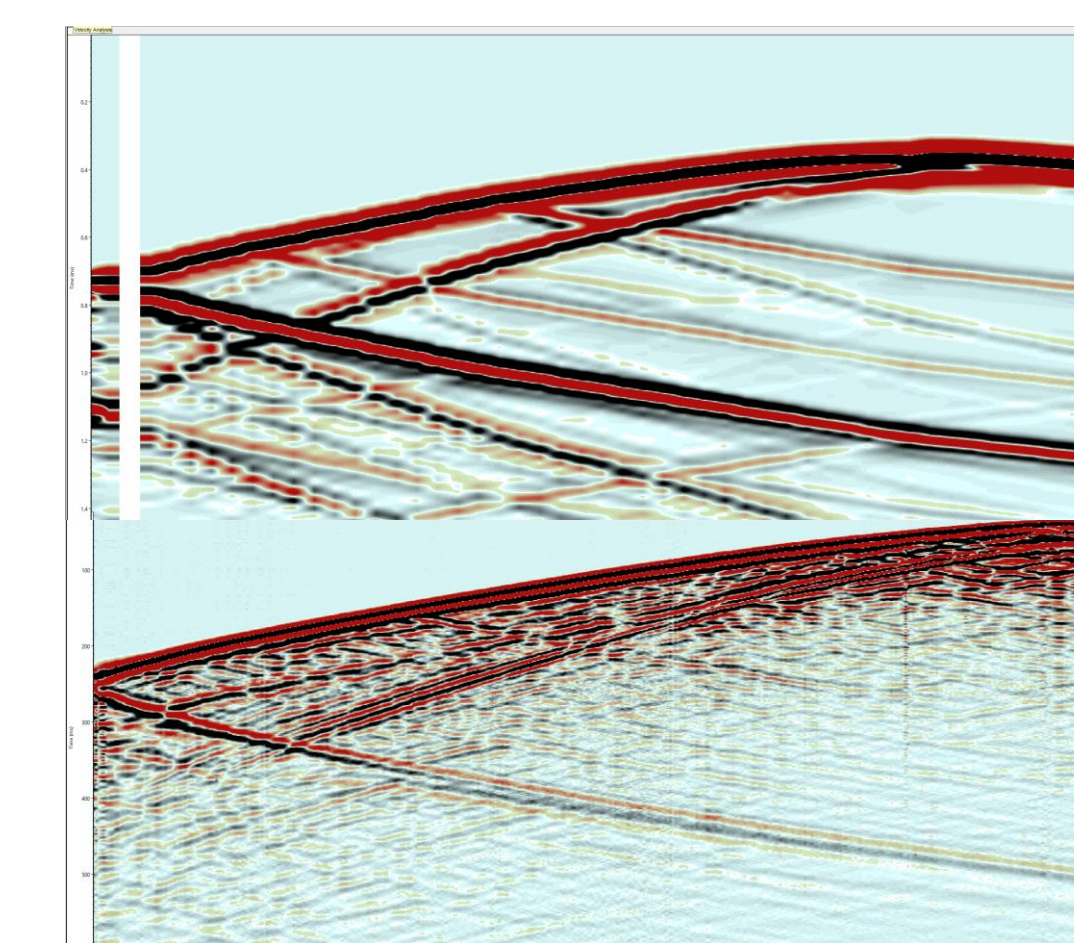
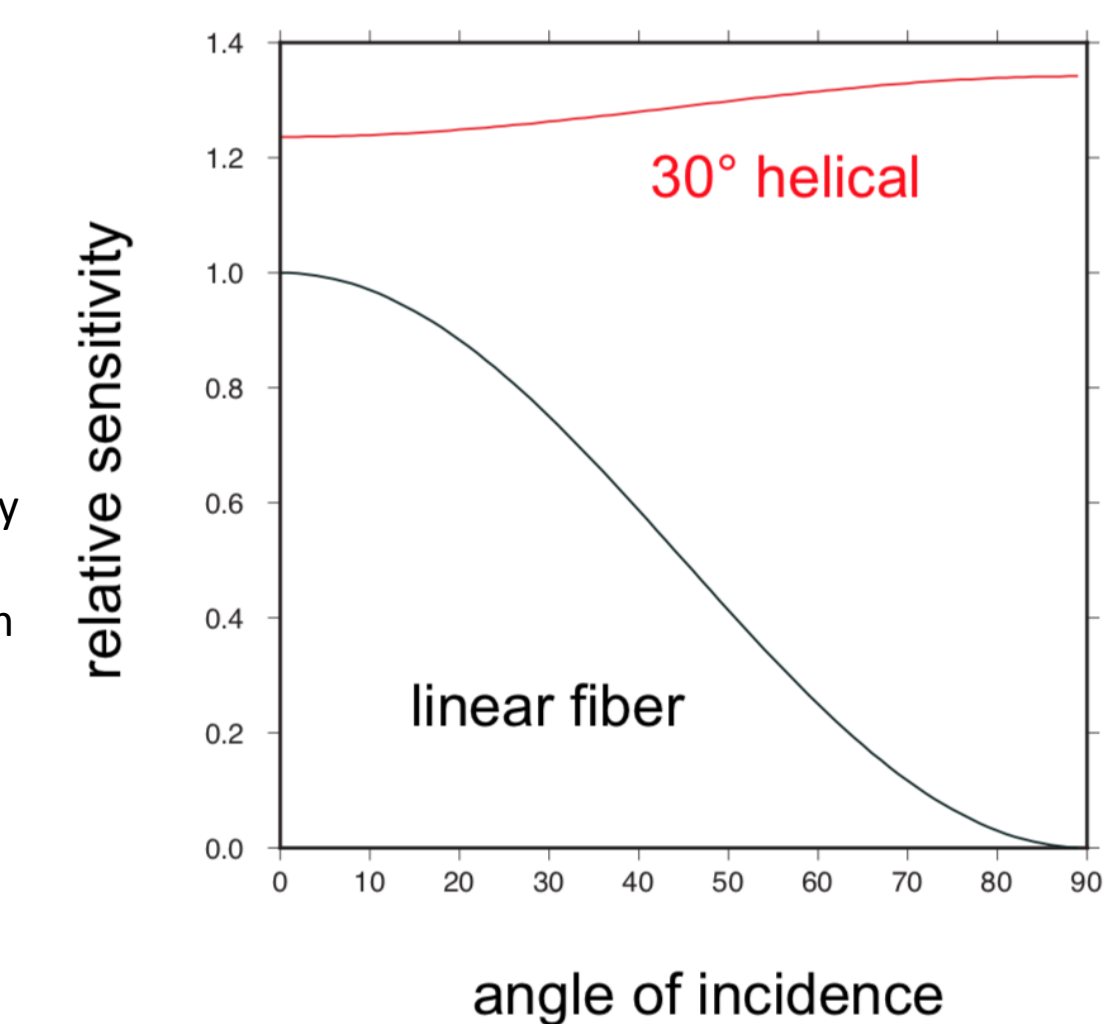


## Numeric Modeling



Schematic courtesy of Silixa, LLC. Silixa is subcontracted to Sandia to acquire the field data

**Straight vs Helically-Wound.** Since the strain-rate measurements are sensitive to the distance between the scatterers along the long axis of the fiber (the path of the laser pulses), for straight fibers the sensitivity to ground motion falls off rapidly with seismic angle of incidence. The helically-wound cable has a much less pronounced sensitivity variation with AOI and was better suited for our downhole application.



## 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
  - Width of spall zone at least 390 m
- Progress is being made in modeling the fiber response

The authors wish to express their gratitude to the National Nuclear Security Administration, Defense Nuclear Nonproliferation Research and Development (DNN R&D), and the SPE working group, a multi-institutional and interdisciplinary group of scientists and engineers.

**Disclaimer:** The views expressed on this poster are those of the author and do not necessarily reflect the view of the CTBTO

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