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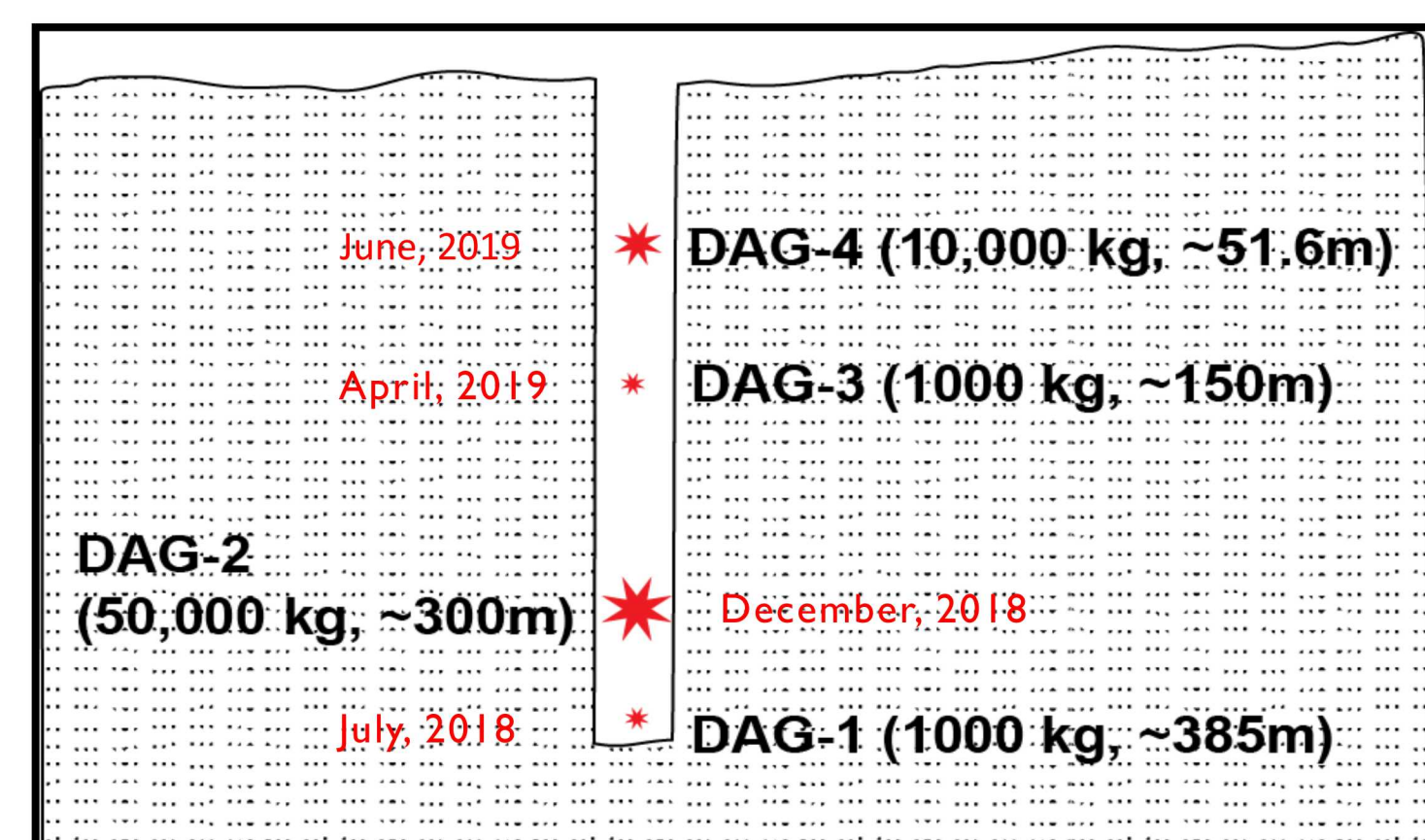
Abstract

The second chemical explosion of the Source Physics Experiment Phase 2 (Dry Alluvium Geology, or DAG) series was a 50,000 kg TNT-equivalent explosion of nitromethane detonated on the Nevada National Security Site (NNSS) on 19th of December 2018. The explosion was followed by a sequence of microseisms that continued with a high rate of seismicity (>30 events per hour) in the first 24 hours (the duration of our recording). Previously, these events were located using an array of surface geophones and accelerometers. To assist the understanding of the of microseism sequence, data collected using downhole fiber optic distributed acoustic sensor (DAS) was analyzed. The two boreholes were 80 meters southwest and 80 meters east of ground zero. The fiber optic diagnostic creates the equivalent of an array of strain-rate meters with approximately one meter spacing. The fiber optic cable extends to a depth of over 300 meters within the boreholes, with channels both above and below the depth of DAG-2, covering the depth range where the majority of microseisms were located using the surface geophone data. By picking the arrival times of microseisms at a range of depths, we were better able to constrain the locations of the microseisms relative to surface-only instrumentation. The fiber optic data has the greatest influence on the depths of the microseisms located in the area close to ground zero. A better understanding of the depths and time evolution of depths for the microseismic events helps to determine the most likely mechanism behind the generation of the microseismic swarm triggered by the detonation.

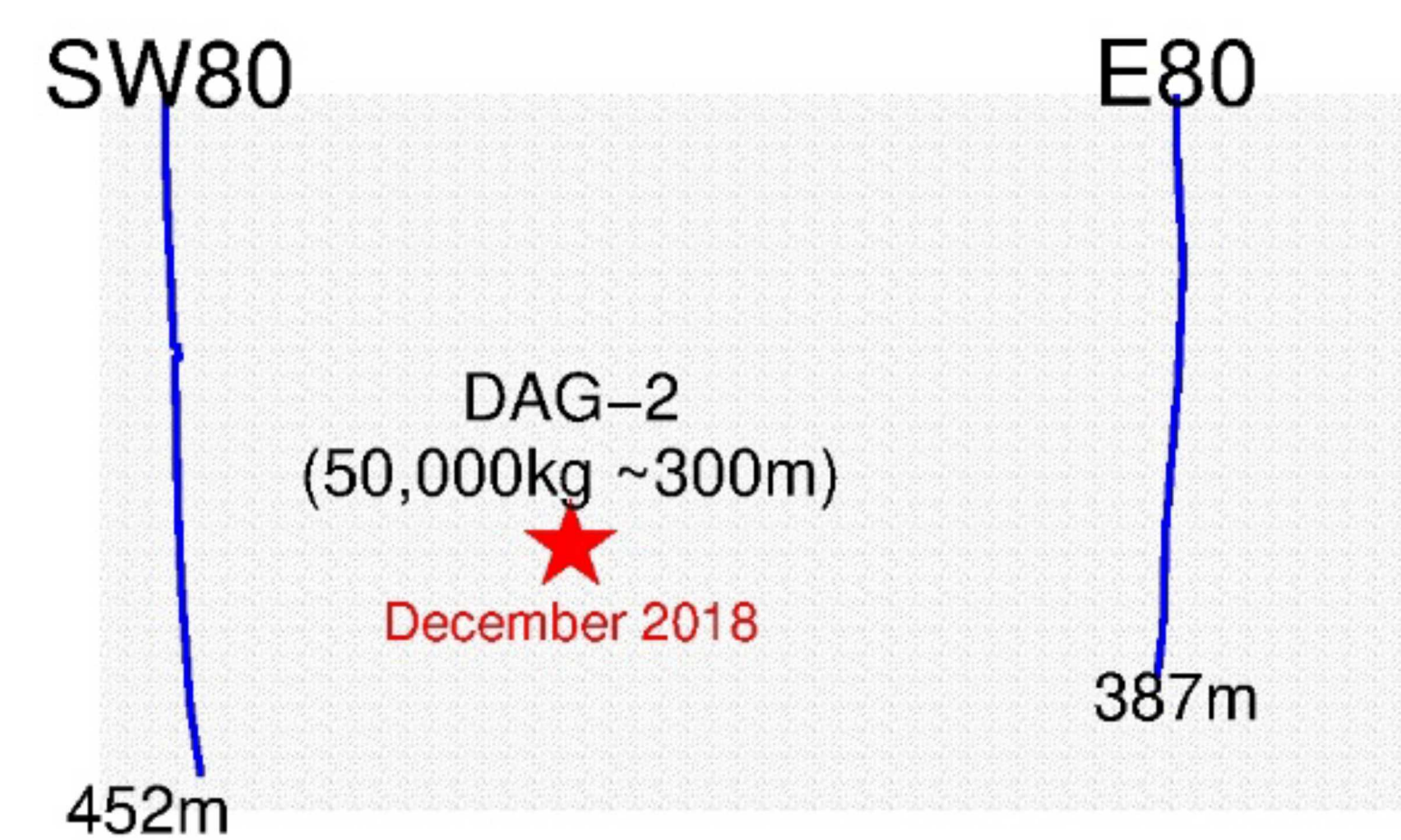
Introduction

The second chemical explosion of the Source Physics Experiment Phase 2 (Dry Alluvium Geology, or DAG) series was a 50,000 kg TNT-equivalent explosion of nitromethane detonated on the Nevada National Security Site (NNSS) on 19th of December 2018. The explosion was followed by a sequence of microseisms that continued with a high rate of seismicity (>30 events per hour) in the first 24 hours (the duration of our recording). None of the explosions of the first phase of SPE or DAG-1 produced a similar sequence of microseismic events, however, there were a reduced number microseismic events following DAG-4 and just a few following DAG-3.

Illustration of DAG shots

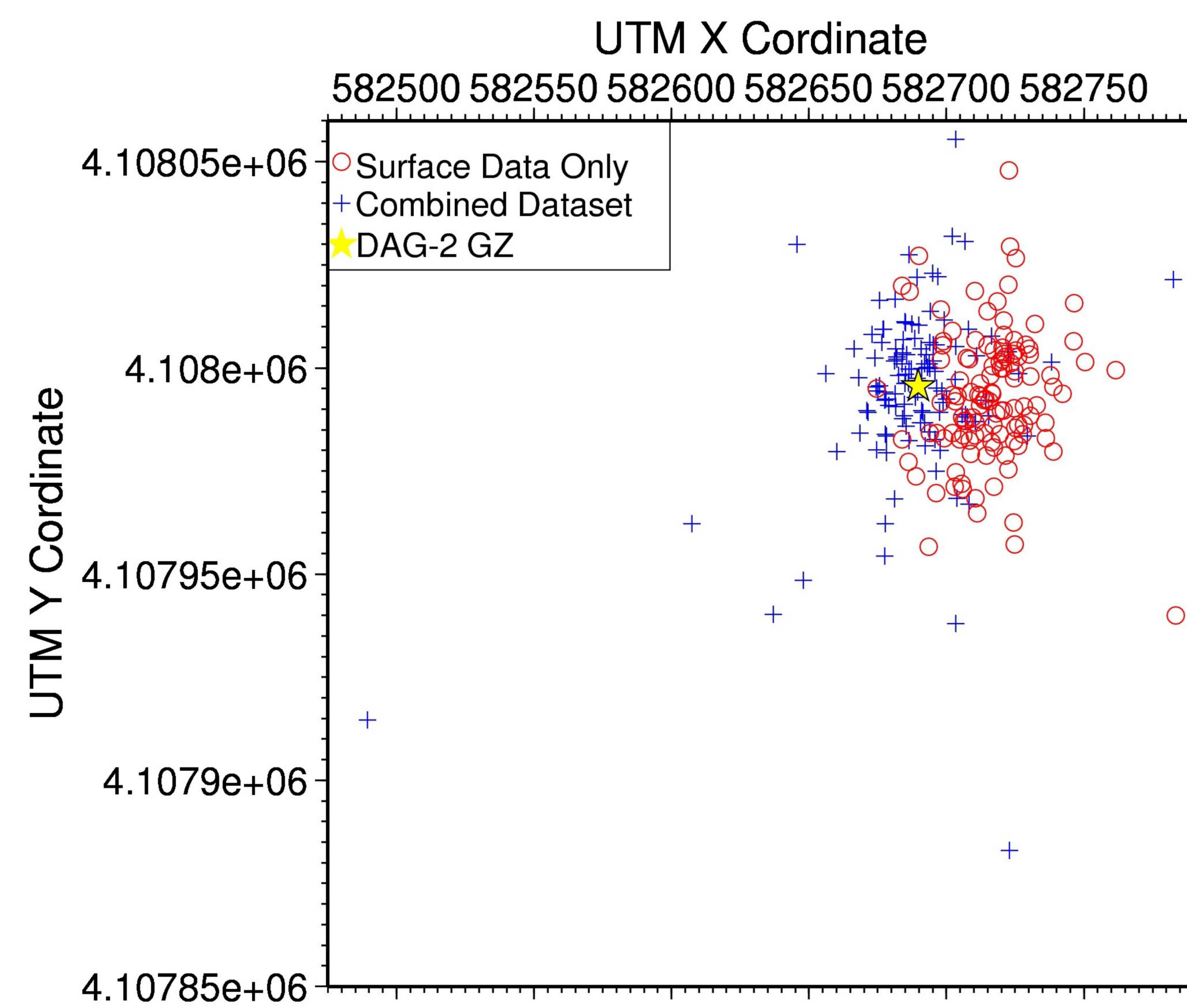


The series of chemical explosions that make up the Dry Alluvium Geology phase of the source physics experiments occurred at a number of yields and depths.



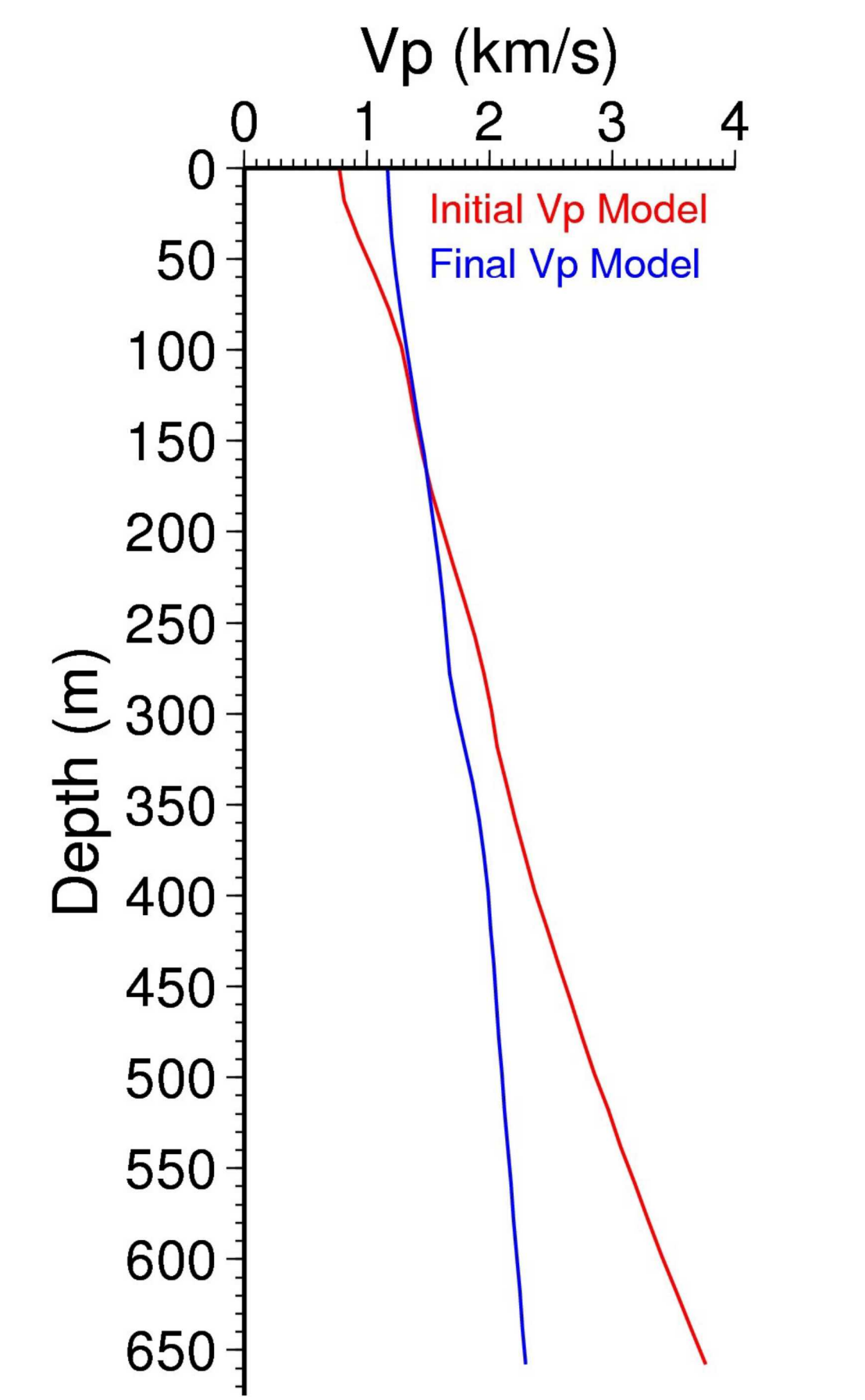
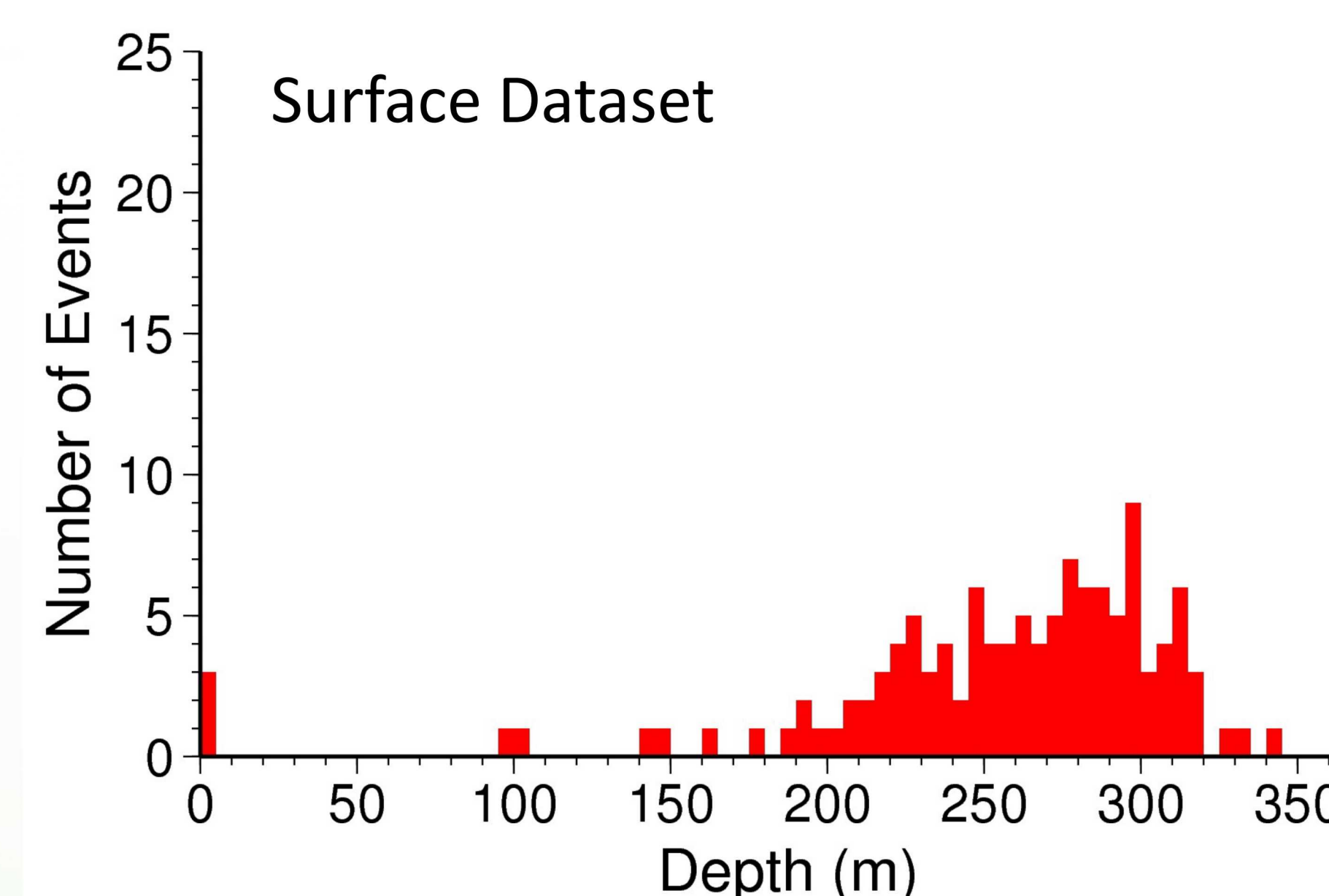
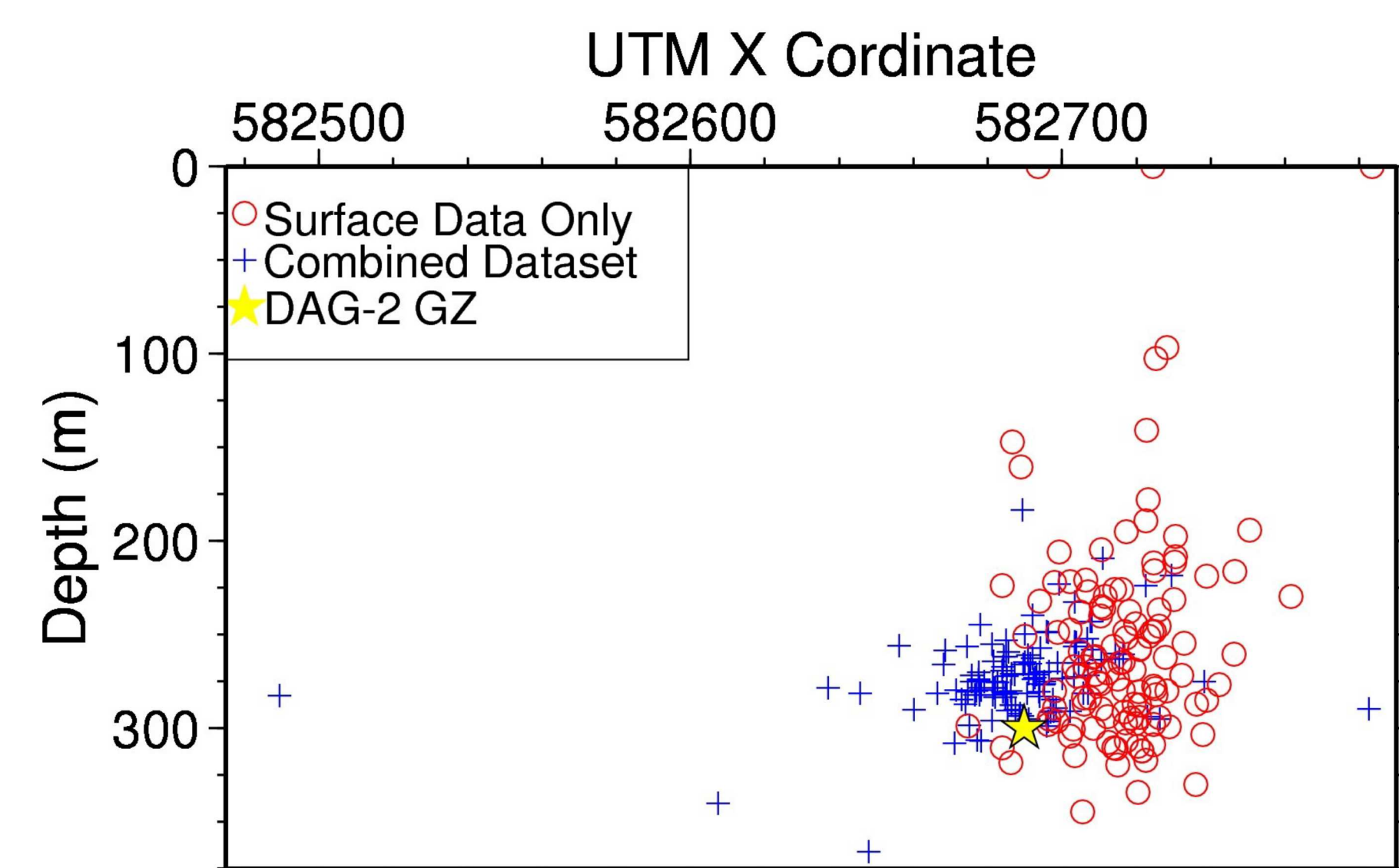
Fiber optic acquisition geometry. SW80 extends deeper than E80. Both extend deeper than the depth of DAG-2

Results

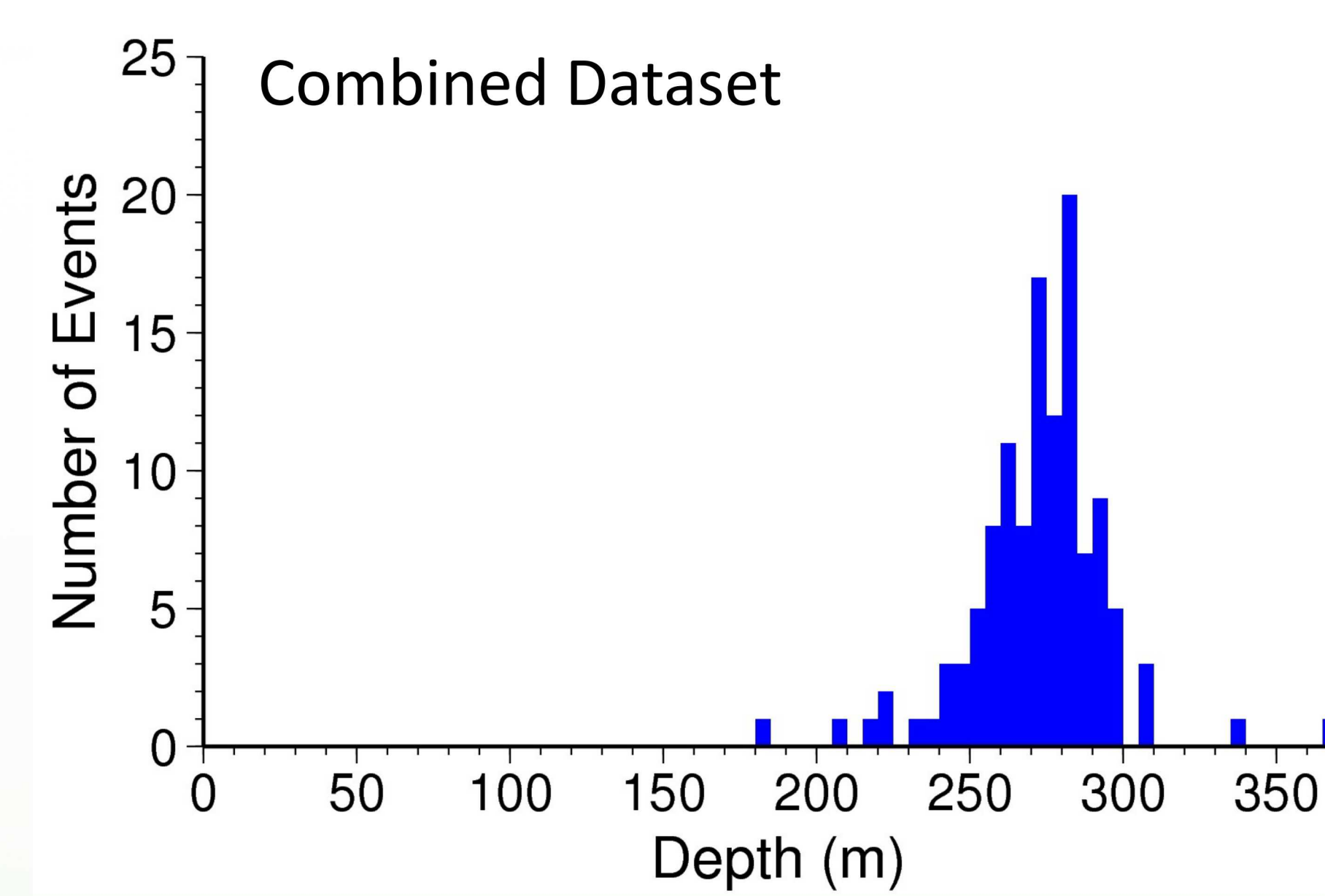
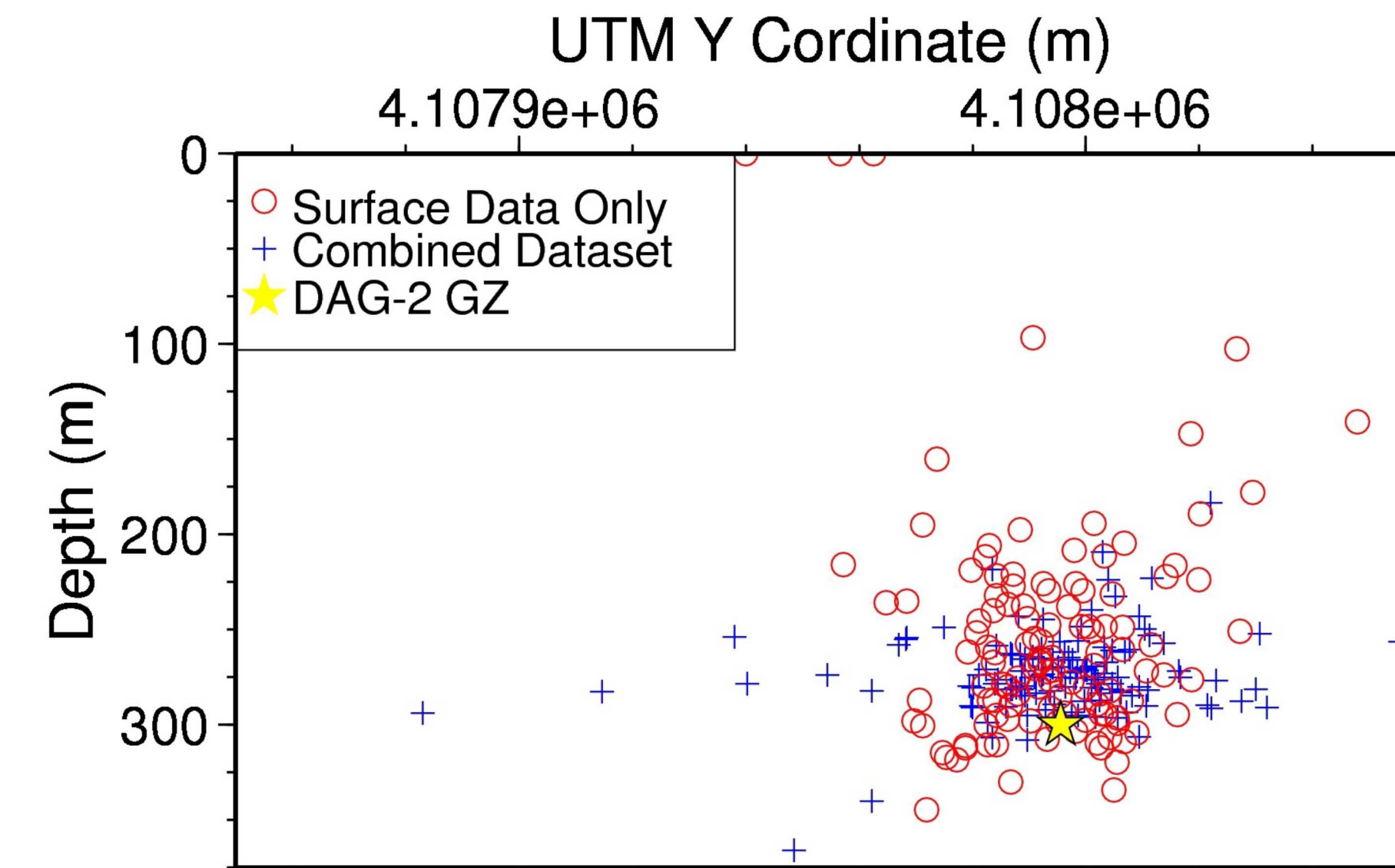


Map showing the locations of microseismic events located with only the surface data (red circles) and with the combined dataset (blue crosses) with the location of the DAG-2 explosion plotted as a yellow star.

- The complete dataset (surface data and downhole data combined) produces a wider horizontal spread in the event locations



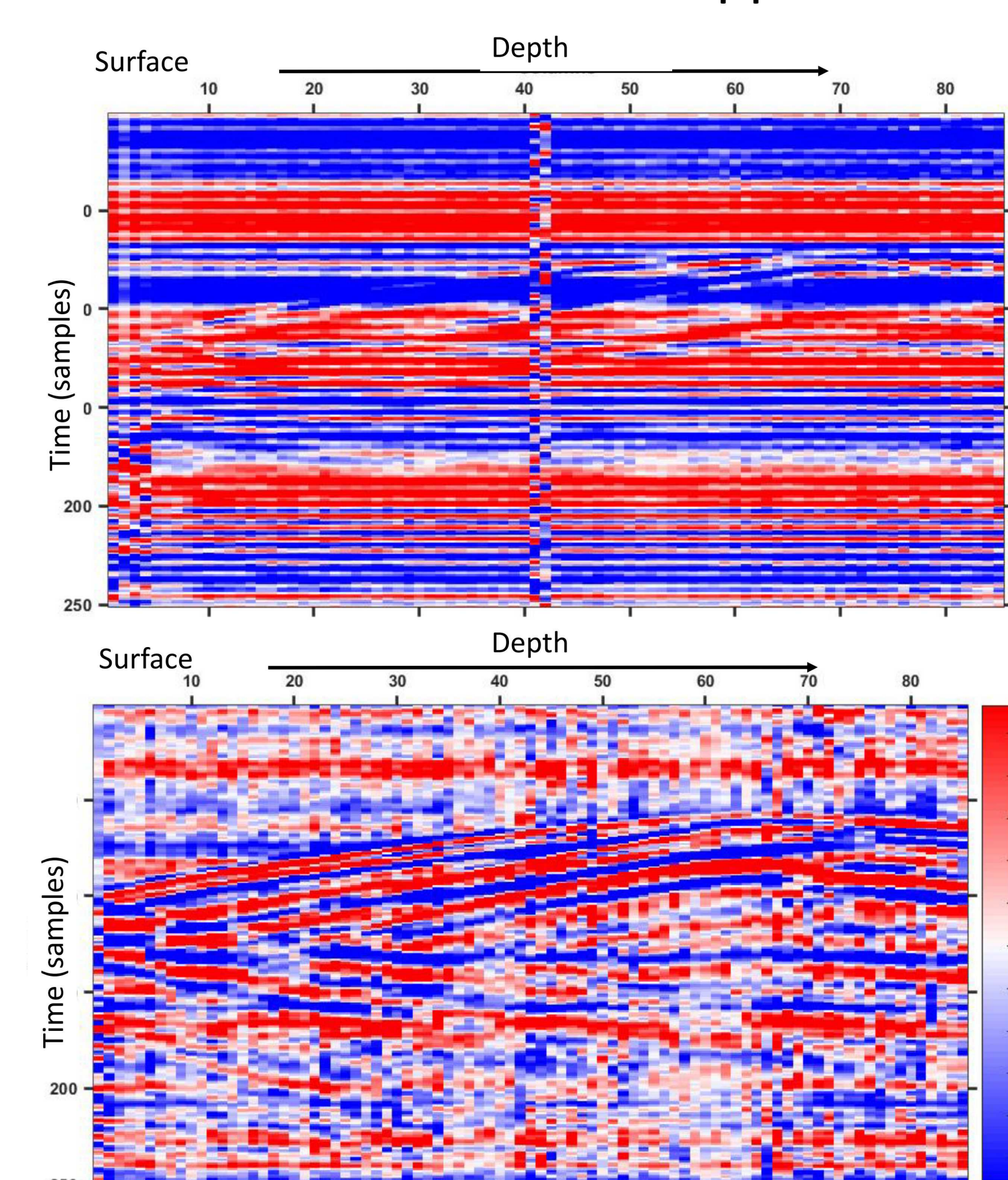
The p-wave velocity model produced by the inversion (blue) compared to the initial velocity model (red)



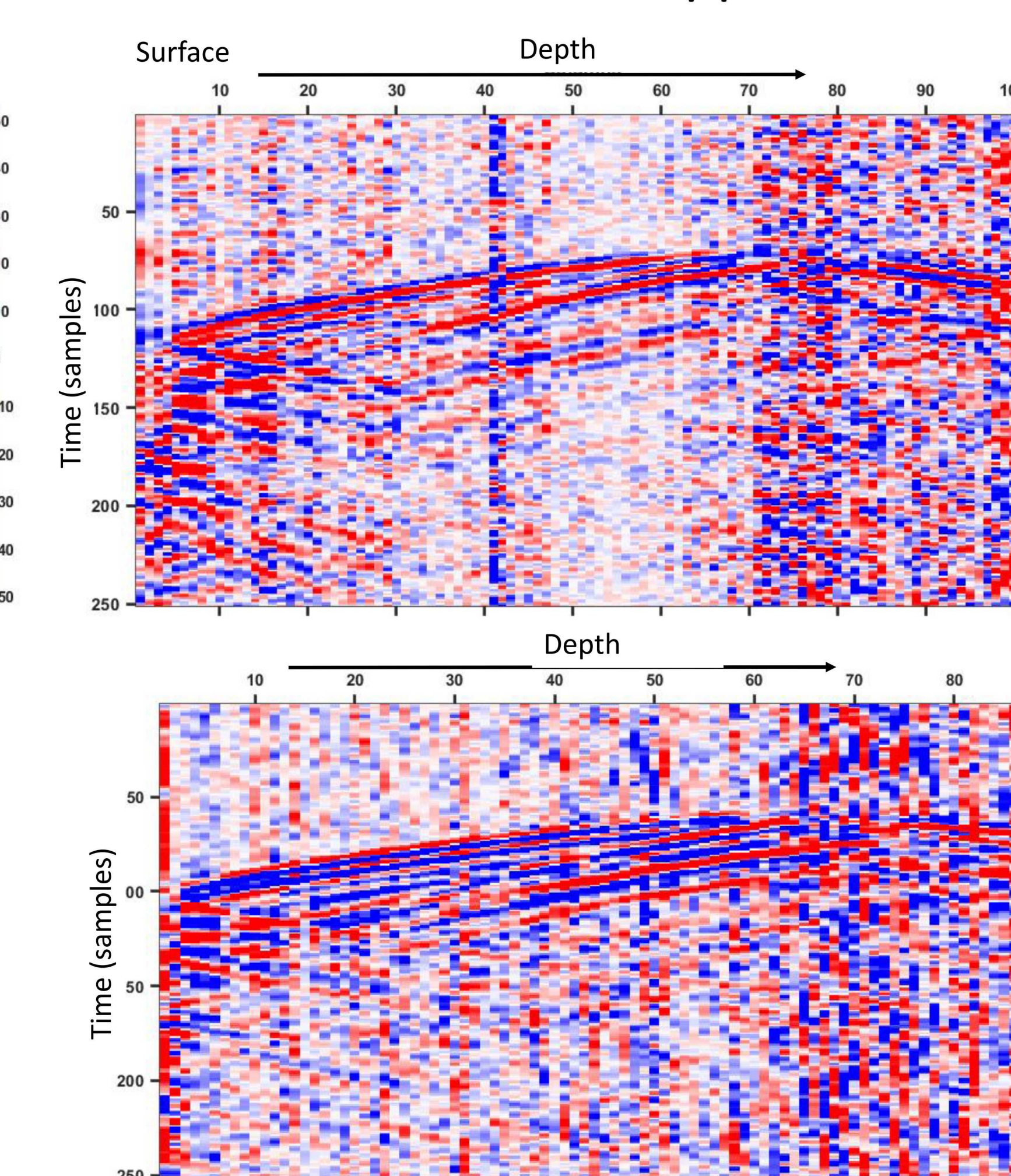
- The depth distribution in the events is 3 times smaller for the complete dataset than for the surface picks alone with a median depth of 275 m (compared to a DAG-2 depth of 299.8 m)

Common Mode Noise

Before Mean filter application



After Mean filter application



Example of the effect of the alpha trimmed mean filter. Top SW80, bottom E80. All are showing the same microseismic event.

- Until the application of the mean filter, there was a significant influence of common mode noise on the data which made it difficult to see the microseismic events
 - This was likely caused by shaking of the interrogator rather than downhole motion
- SW80 was more heavily impacted by the common mode noise than was E80
- Removing the common mode noise required significant data processing time, but also substantially increases the number of events that can be identified
 - Approximately 200 events before noise removal and approximately 700 after were manually identified by searching through the data

Conclusions

- Microseismic events can be viewed on down hole fiber optic DAS
- Significant data processing can be necessary to make the data useable due to common mode noise likely from interrogator shaking
- The addition of down hole data can influence the locations of microseismic events and allow for constraint on the depth of events
- With the addition of the downhole fiber data the model produced:
 - ~50% the travel time error compared surface only locations
 - 3x smaller depth spread compared to surface only locations
 - 6x smaller error ellipsoids compared to surface only locations

Acknowledgements

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- The Source Physics Experiments (SPE) would not have been possible without the support of many people from several organizations. 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.
- Silixa, LLC recorded the fiber dataset

Data Processing

- Raw data consisted of a series of 30 second, multiple channel SEG-Y files that covered a period of ~25 hours following the DAG-2 chemical explosion
 - SW80 only recorded for about 12 of those hours due to a power outage, but E80 recorded for the entire interval
- The raw data underwent downsampling to 250Hz, stacking of five adjacent channels, alpha-trim mean filtering and bandpass filtering with corners of 5 to 20 Hz
- The downsampling step was for processing efficiency and reduced the size of the 30 second SEG-Y data files significantly
- Events were identified and picked by hand to produce arrival times to supplement the data collected from the surface stations
 - This added up to 100 new picks for some events that were picked on both the fiber optic and the surface stations
- A double-difference relocation algorithm was employed to solve for the locations and origin times of the events in addition to the velocity model simultaneously