Metadata describing seismic data recorded at San Emidio, Nevada in April-May 2021 as part of WHOLESCALE project

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Description: These metadata describe **seismic data recorded at San Emidio, Nevada in April-May 2021.** The seismic data set contains recordings from an array of 37 short-period, 3-component seismographs deployed near the geothermal power plant San Emidio, Nevada, U.S.A. between April 6th and May 10th 2021. The array is 1.8 km in diameter and centered on 40.367278 deg N, 119.409019 deg W. The experiment was designed to monitor seismic activity before, during, and after the planned three-day plant maintenance shutdown from April 19th through 21st, 2021. The pumping stopped on 2021/04/19 at approximately 12:52 UTC and resumed on 2021/04/21 at approximately 21:00:00 UTC. The seismographs include two types: (a) SmartSolo IGU-16HR 3C and (b) HGS HG-6(B coil) triaxial geophones with DataCube recorders.

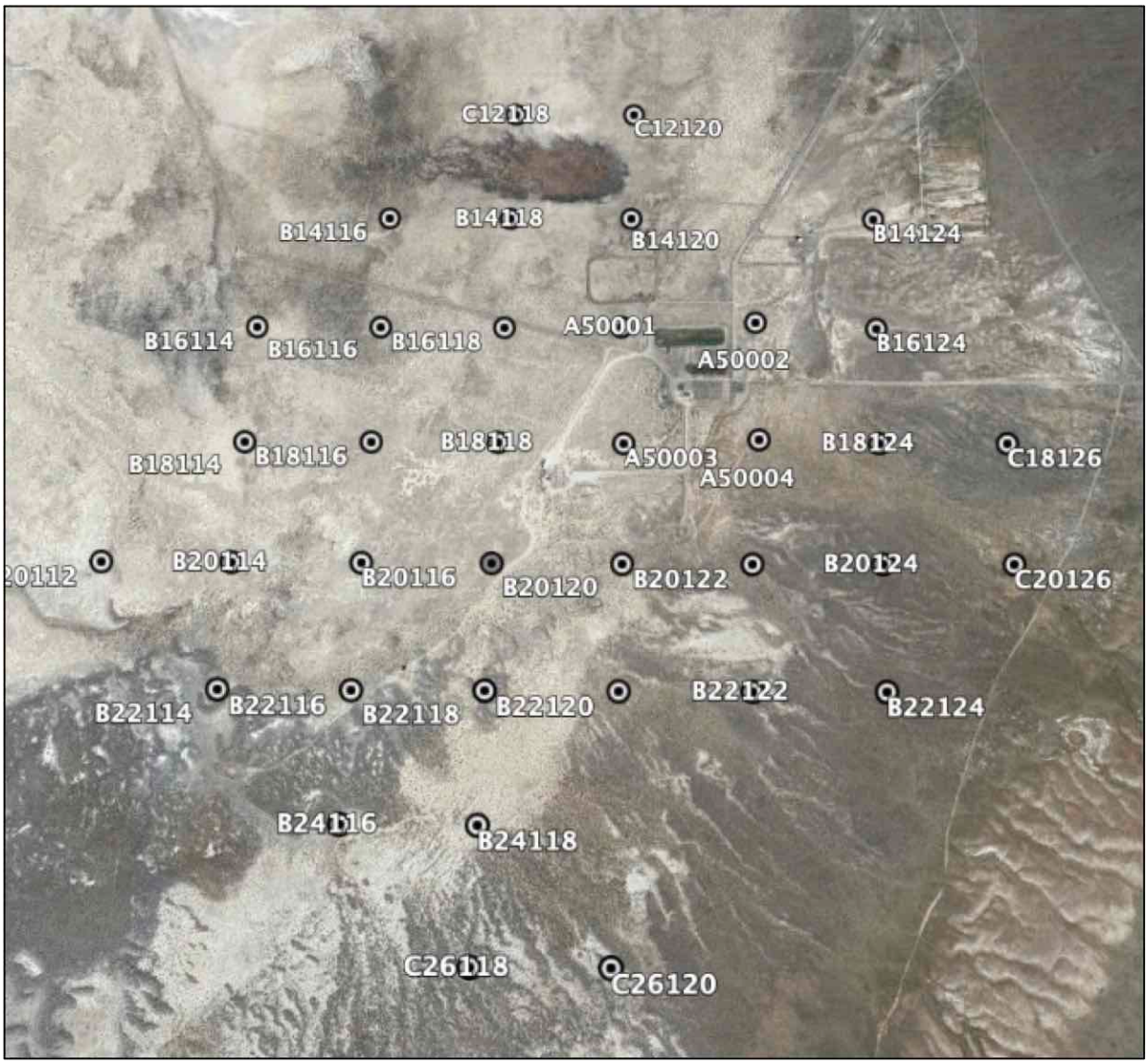

Figure 1. Map of stations with labels. Stations are spaced aproximately 240 meters apart.

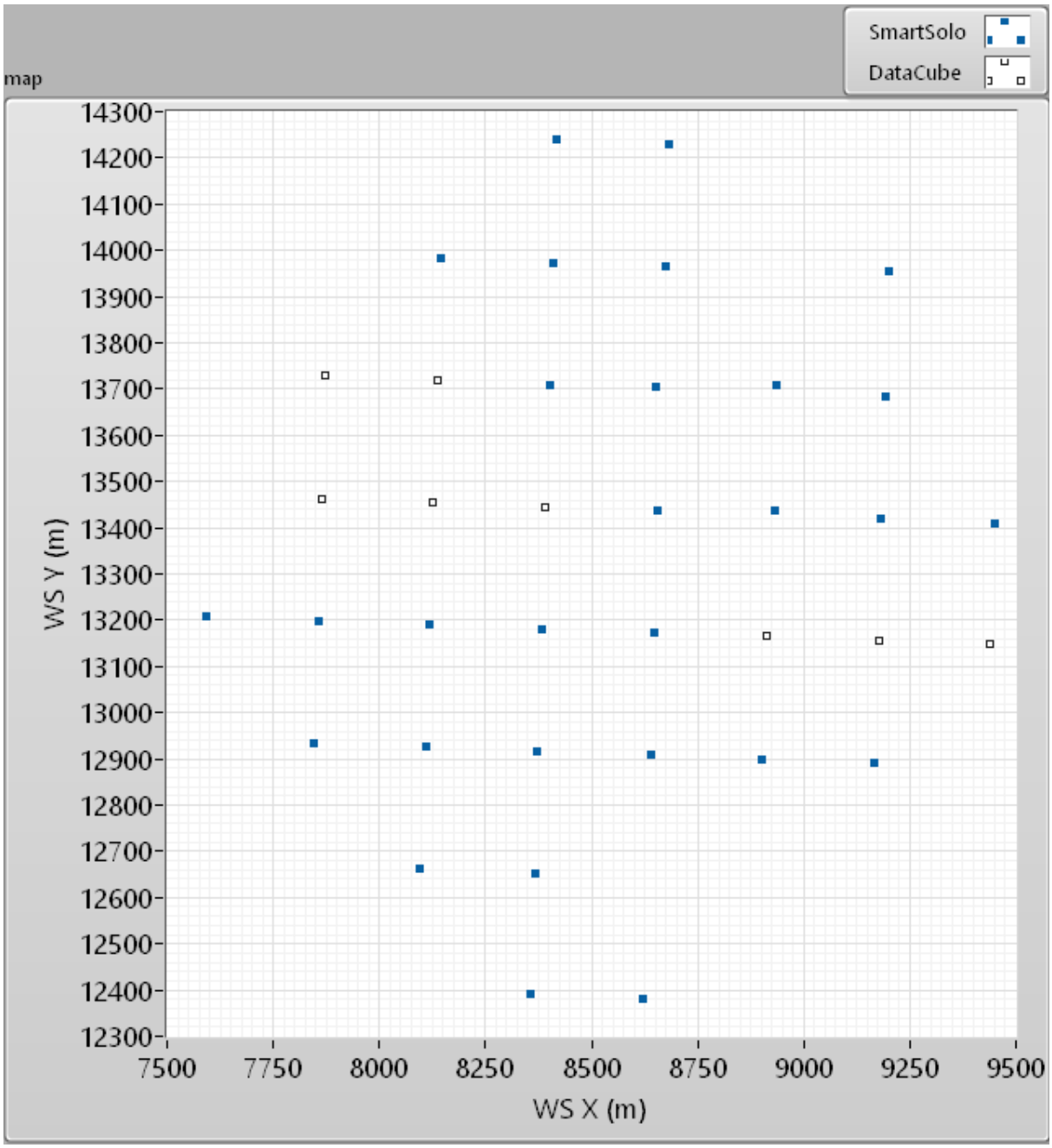

Figure 2 Map of the Wholescale 2021 seismic array consisting of 37 seismographs (29 SmartSolos and 8 DataCubes) shown on the WholeScale local XY grid (zone 11 UTM coordinates with a local origin at UTM easting 286924.277 m, northing 4457966.689 m, Orthometric Height above geoid 0.000 meters above sea level.

SAC data file folder structure and naming convention

```
WHOLESCALE2021\data\level1\SAC\YYYY\DOY\HH\NNNNNN.YYYY.JJJ.HH.MM.SS.SSSS.CCC.sac
WHOLESCALE2021\data\level1\SAC\2021\127\04\A50001.2021.127.04.00.00.0000.DP1.sac
```

where:
YYYY year, DOY day of year, HH hours
NNNNNN station name, MM minutes, SS.SSSS seconds,
CCC channel names:

The Z, N, E channel names are DPZ, DP1, DP2 for the SmartSolos.
The Z, N, E channel names are p0, p1, and p2 for the DataCubes.

Seismic Instruments

	SmartSolo IGU-16HR 3C	DataCube + HGS HG-6(B coil) triaxial geophone
		
Sample Rate:	500 sps, 2 ms	400 sps, 2.5 ms
Maximum input range (@0 dB gain)	+/-2.5 Volts	+/-2.048 Volts
AtoD resolution:	24 bit	24 bit
Gain:	18 dB (x8.0)	24 dB (x16.0)
Anti-Alias Filter	Minimum phase	Minimum phase
Low Cut Filter (Hz)	Disabled	Disabled
Natural Frequency:	5 Hz	4.5 Hz
Damping:	0.70	0.70
Sensitivity:	76.7 V/m/s	28.8 V/m/s
Positive Voltage:	Down, South, West	Up, North, East

Instrument and sensor responses

SmartSolo:

The SmartSolo SAC data files values contain the number of millivolts which appear at the AtoD input and have not been adjusted for the internal geophone gain settings. To convert the values to case velocity in m/s the formula below should be used:

$$\text{Velocity (m/s)} = \frac{\text{SAC\_mv}}{\text{Preamp\_gain}} \times \frac{1}{\text{geophone\_sensitivity}} \times \frac{\text{volt}}{1000\ \text{mv}} = \frac{\text{SAC\_mv}}{8\ \text{V/V}} \times \frac{1}{76.7\ \text{V/m/s}} \times \frac{1\ \text{V}}{1000\ \text{mV}}$$

Thus (note negative sign to make positive velocity Up, North, and East)

velocity(m/s) = –1.6297e–6 m/s/mV * SAC_mv

DataCube with HGS HG-6(B coil) triaxial geophone:

The DataCube SAC data files values contain the AtoD counts and have not been adjusted for the internal geophone gain settings. To convert the values to case velocity in m/s the formula below should be used:

$$\text{Velocity (m/s)} = \frac{\text{SAC\_counts}}{\text{2\^24 counts}} \times \frac{4.096\ \text{V}}{\text{preamp\_gain}} \times \frac{1\ \text{V}}{\text{geophone\_sensitivity}}$$

$$\text{Velocity (m/s)} = \frac{\text{SAC\_counts}}{\text{2\^24 counts}} \times \frac{4.096\ \text{V}}{16\ \text{V/V}} \times \frac{1}{28.8\ \text{V/m/s}}$$

Thus, noting (note positive sign to keep positive velocity Up, North, and East):

velocity(m/s) = +5.29819E–10 m/s/count * SAC_mv

Geophone compensation

We consider a M 4.7 earthquake 127 km away with an origin time of 2021 May 7 04:35:14 UTC and an epicenter 39.461 N, 120.315 W, 10.1 km depth (19 km NW of Truckee, CA). After compensating for both the instrument response and geophone parameters, we see a SmartSolo and a DataCube located 300 m apart recorded very similar particle velocities in all three components.

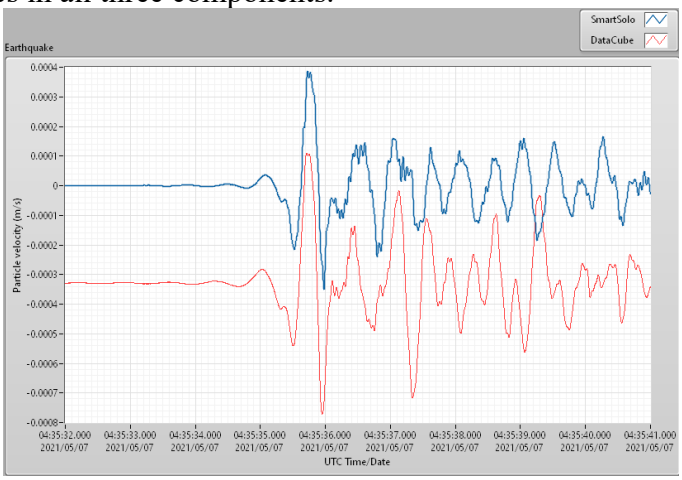

Figure 3. Vertical particle velocities for selected event.

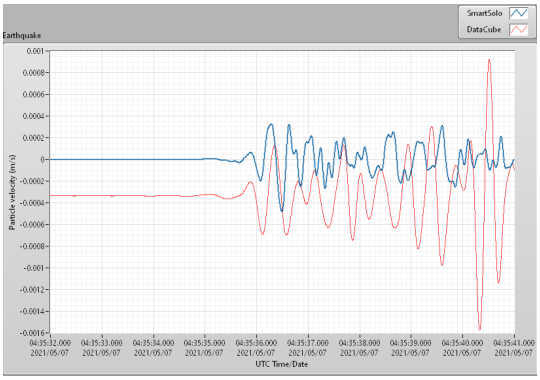

Figure 4. East component particle velocity.

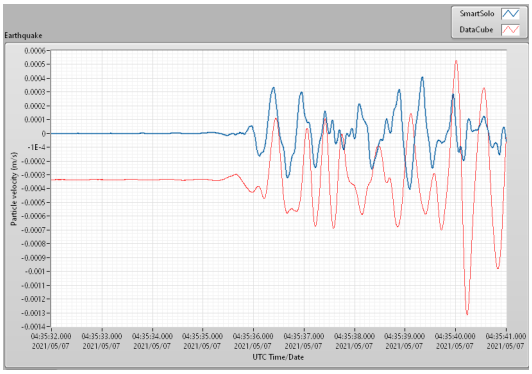

Figure 5. North component particle velocity.

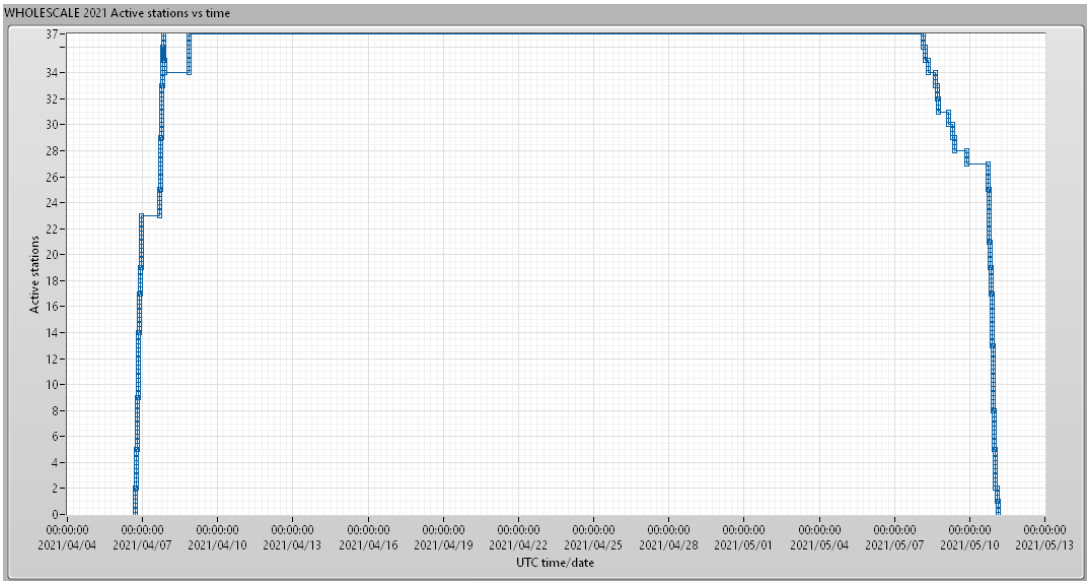

Figure 6 Plot showing the number of stations active during the WHOLESCALE21 seismic experiment. The first station started recording 2021/04/06 07:09:10 UTC and the last station stopped recording 2021/05/11 02:58:52 UTC. All 37 stations recorded from 2021/04/08 20:43:40 to 2021/05/08 03:41:40 UTC. Three stations (A50001, B16116, and B24116) were taken offline between 2021/04/07 20:15:20 and 2021/04/08 20:43:40 UTC to check data quality. 10 SmartSolo seismographs shut down early due to low battery power from 2021/05/08 03:41:40 to 2021/05/09 21:07:24 UTC. The remaining seismographs were shut down manually when they were removed on May 11, 2021.

Data quality

The deployment was designed to capture changes associated when normal operations at the geothermal power plant were temporarily suspended for several days in April 2021. The pumps at production and injection wells were turned off on 2021/04/19 at approximately 12:51 UTC. Pumping resumed gradually at on 2021/04/21 at approximately 21:35 UTC.

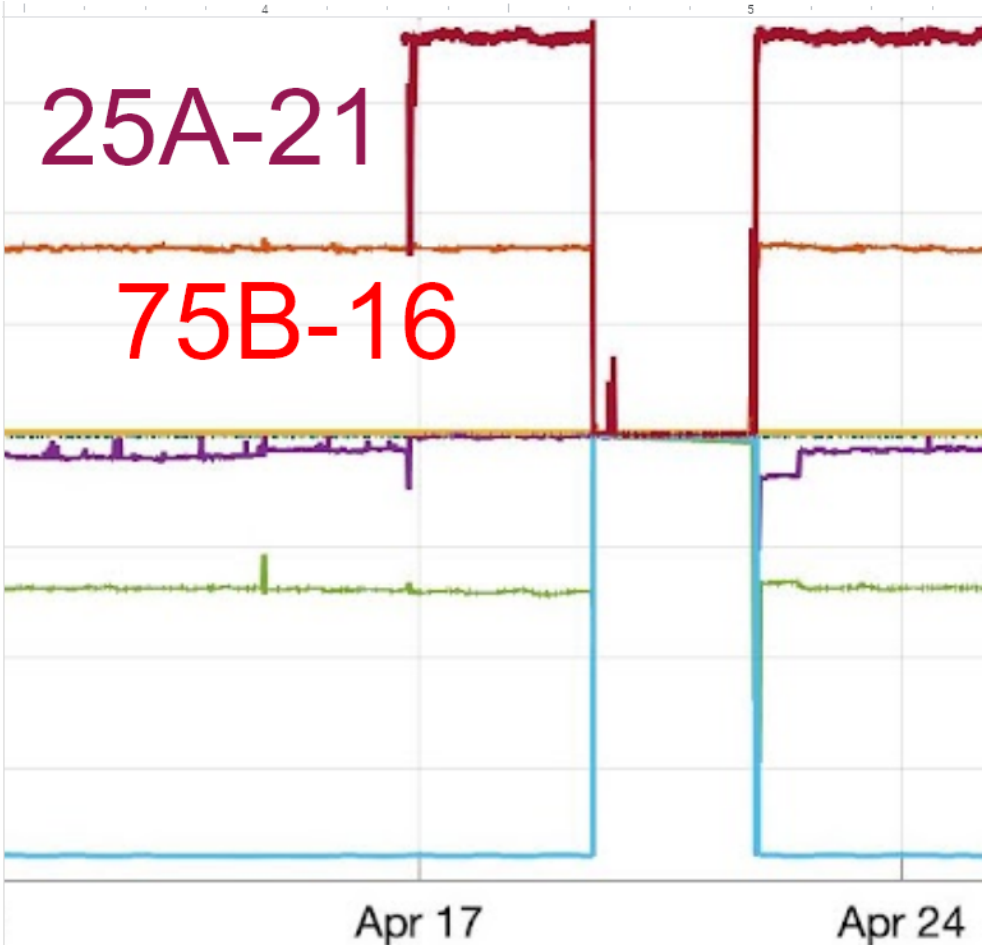

Figure 7. Plot showing the pumping rates at production and injection wells near the times of the start of the planned shutdown and gradual resumption of pumping.

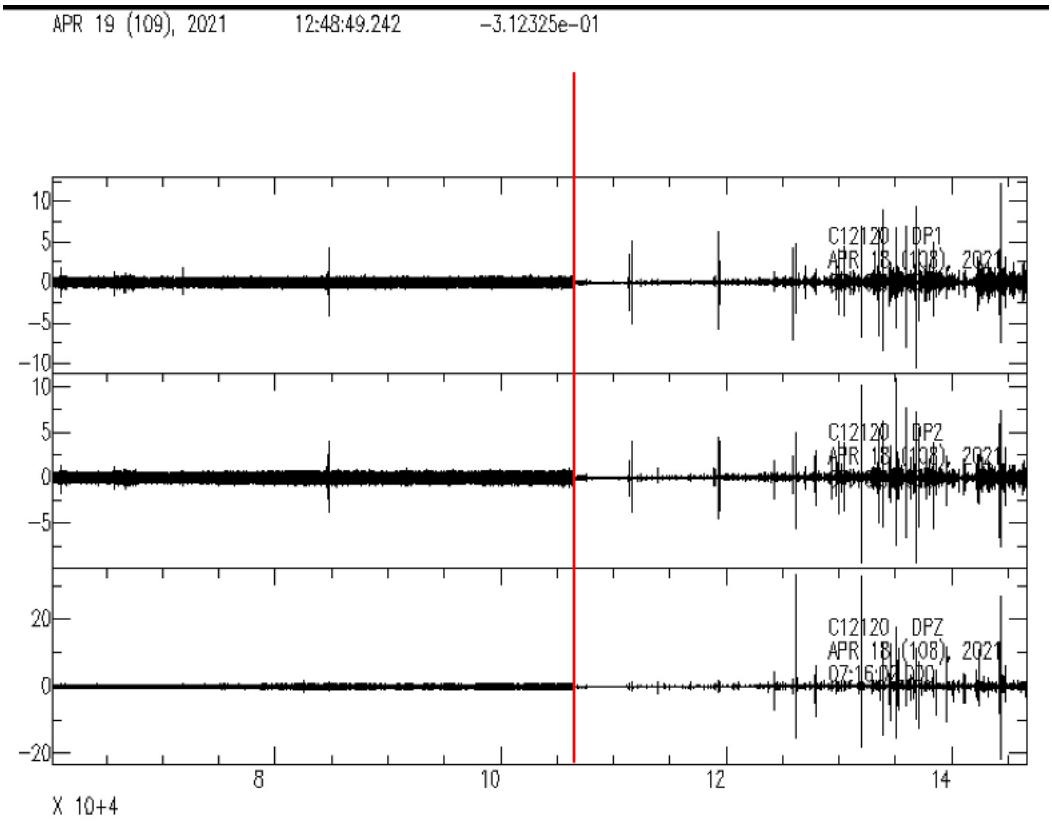

Figure 8. Example seismograms from station C12120, located at the northern edge of the array, showing the start of the shutdown on 2021-04-19 at around 12:49 UTC

The following drum plots show 24 hours of the vertical component recorded at a single station. Each hour is scaled to the largest amplitude during that hour. They show the start of the planned maintenance shutdown at 2021/04/19 12:51:45 and the subsequent seismic events (short impulsive events). A few vehicles passing the station can also be seen (wider events).

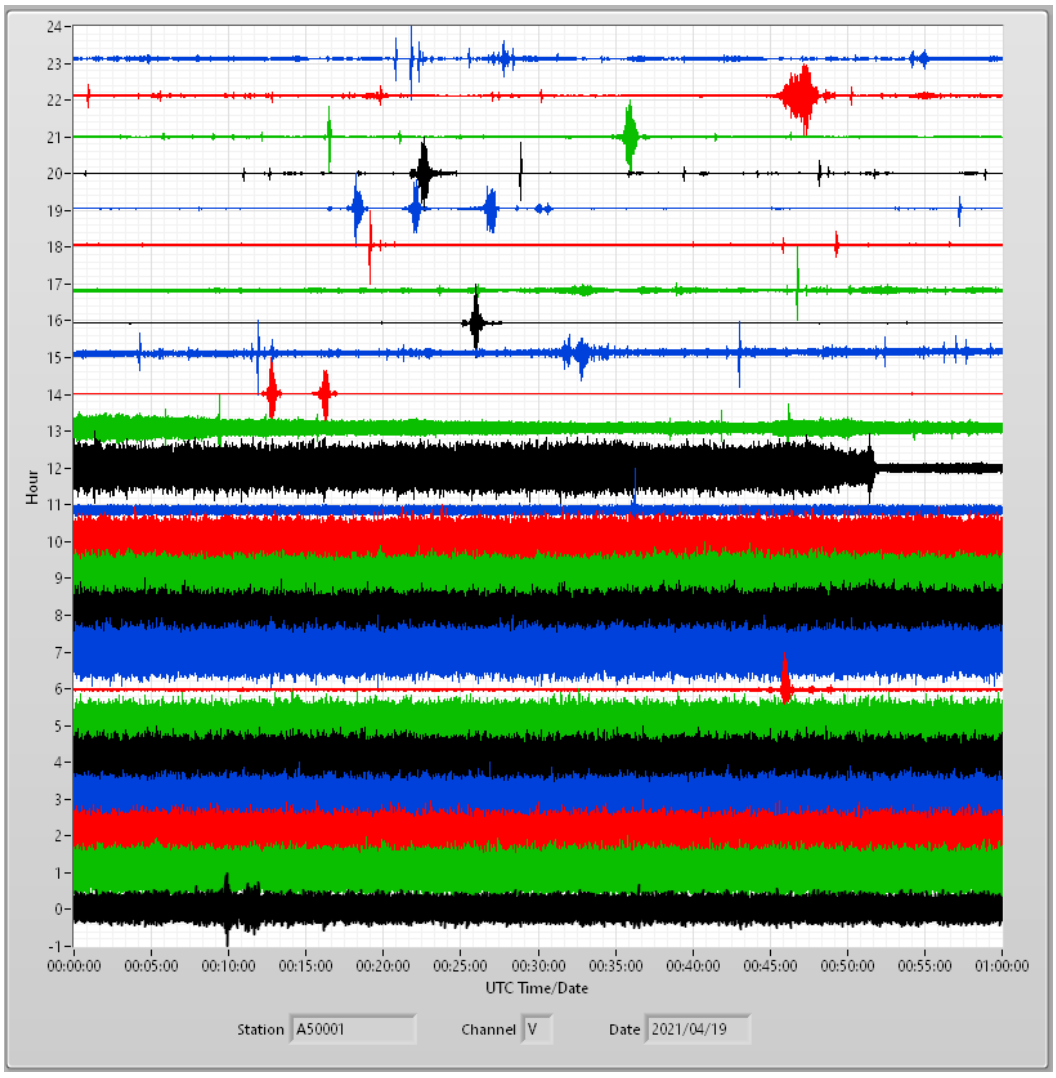

Figure 9. Drum plots showing 24 hours of the vertical component at station A50001 on the day shutdown began. Each hour is scaled to the largest amplitude during that hour.

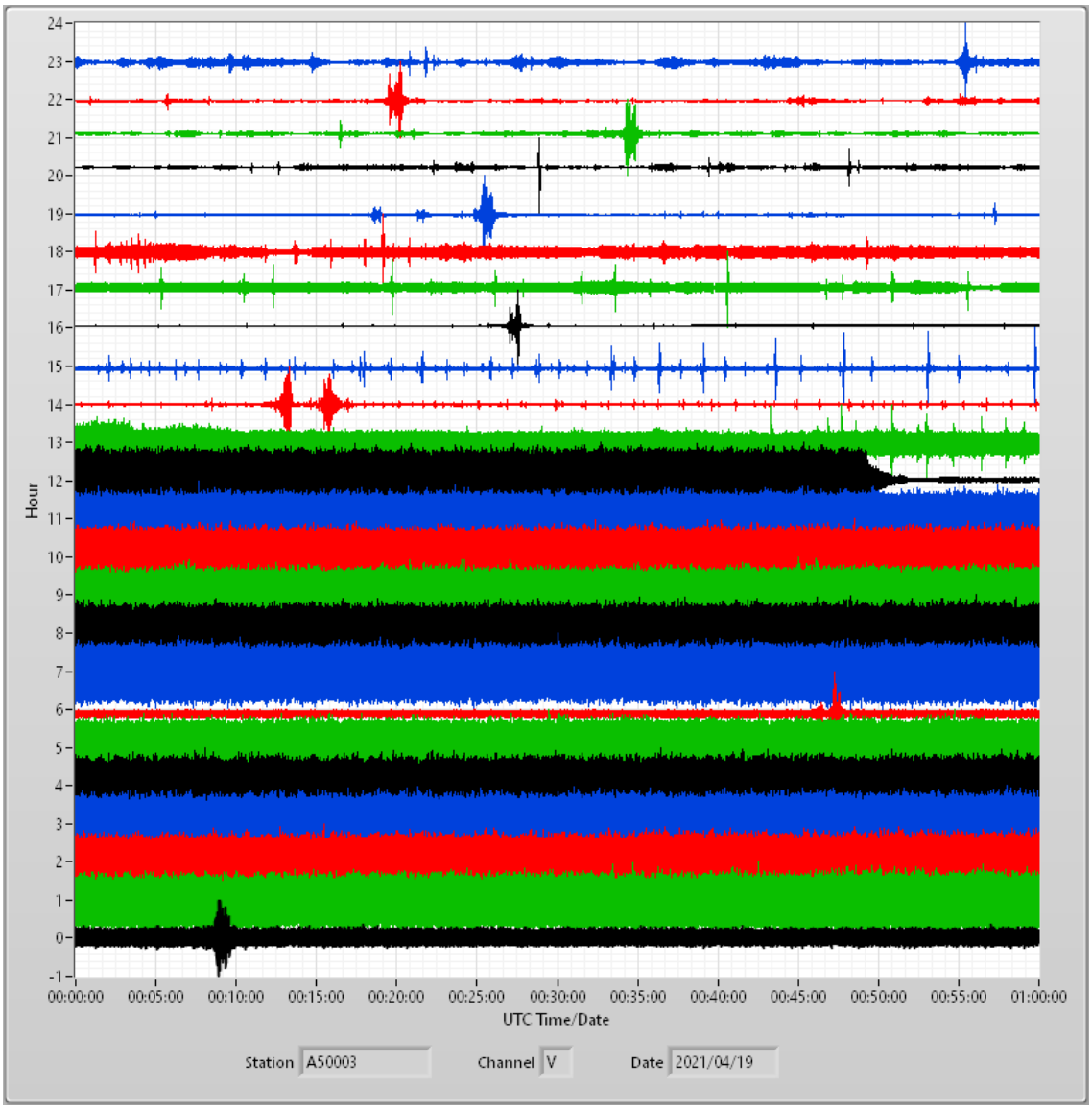

Figure 10. Drum plot showing 24 hours of the vertical component at station A50003 on the shutdown began.

The following drum plots show the gradual restart of pumping at the end of the planned maintenance shutdown near 2021/04/21 21:00:00 and numerous seismic events (short impulsive events). A few vehicles passing the station can also be seen (wider events).

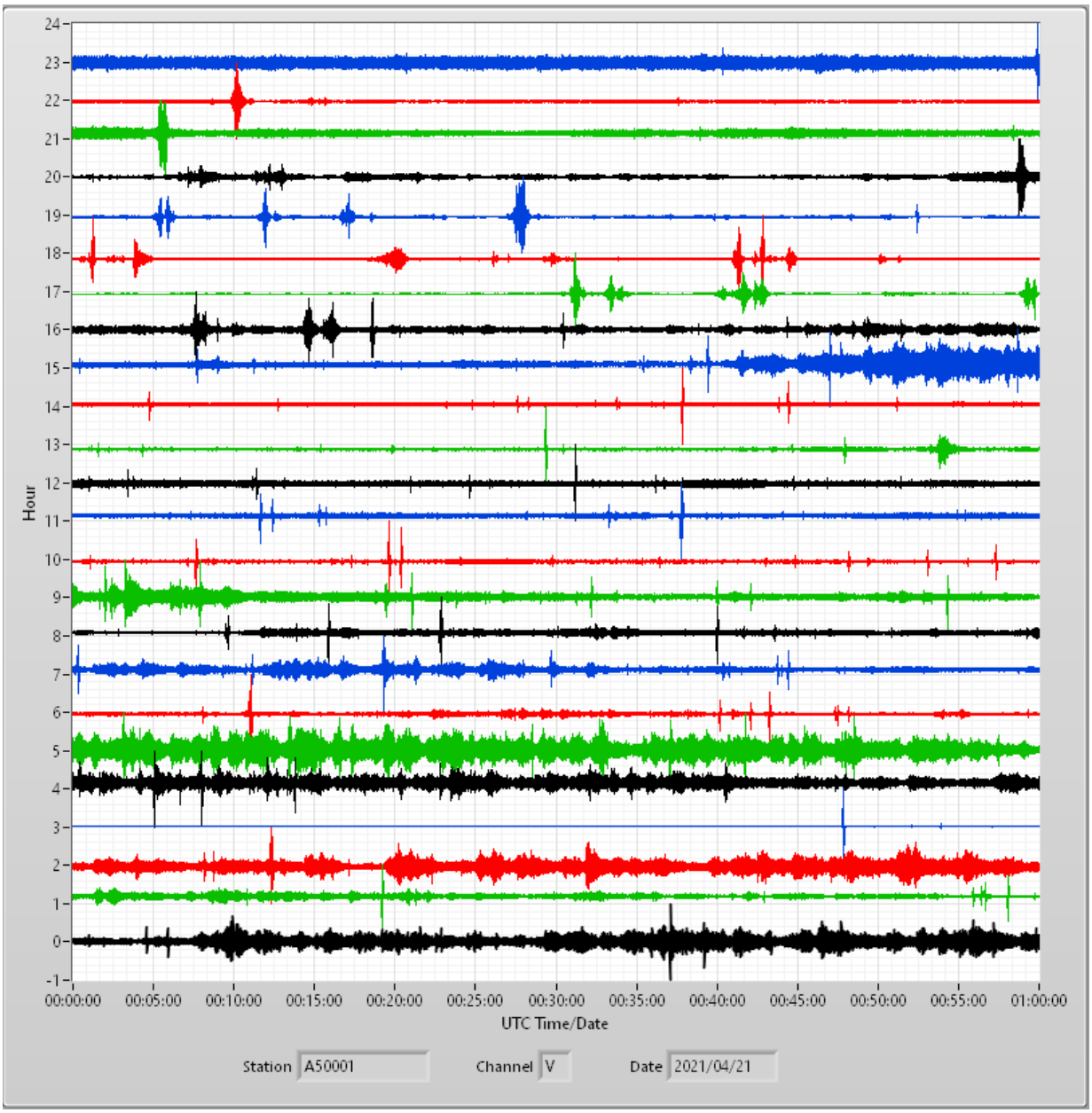

Figure 11. Drum plot showing 24 hours of the vertical component recorded at station A50001 on the day pumping resumed.

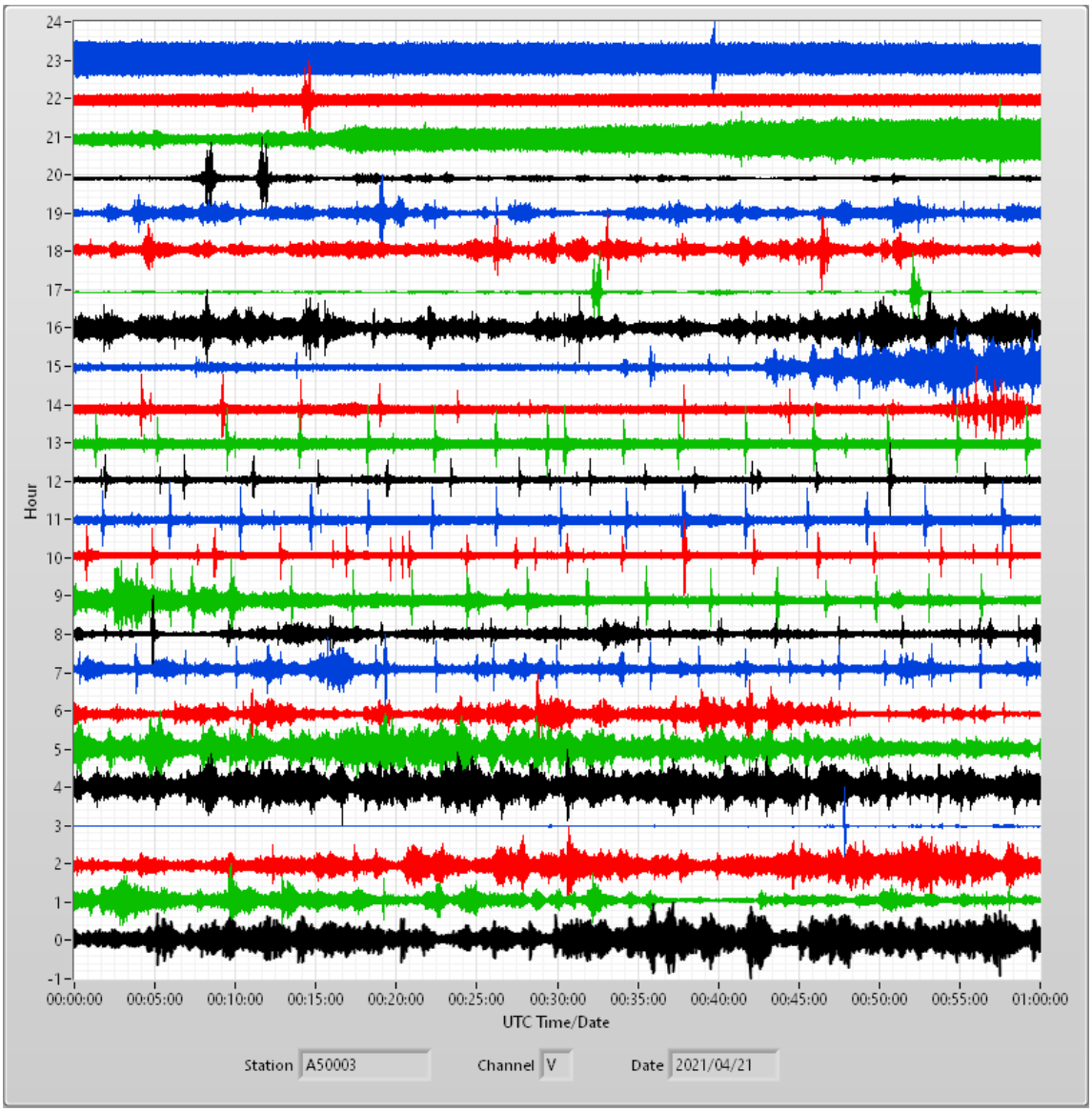

Figure 12. Drum plot showing 24 hours of the vertical component recorded at station A50003 on the day pumping resumed.

APR 19 (109), 2021 16:17:48.750 2.88575e-02
APR 19 (109), 2021 16:18:14.016 6.03156e-02

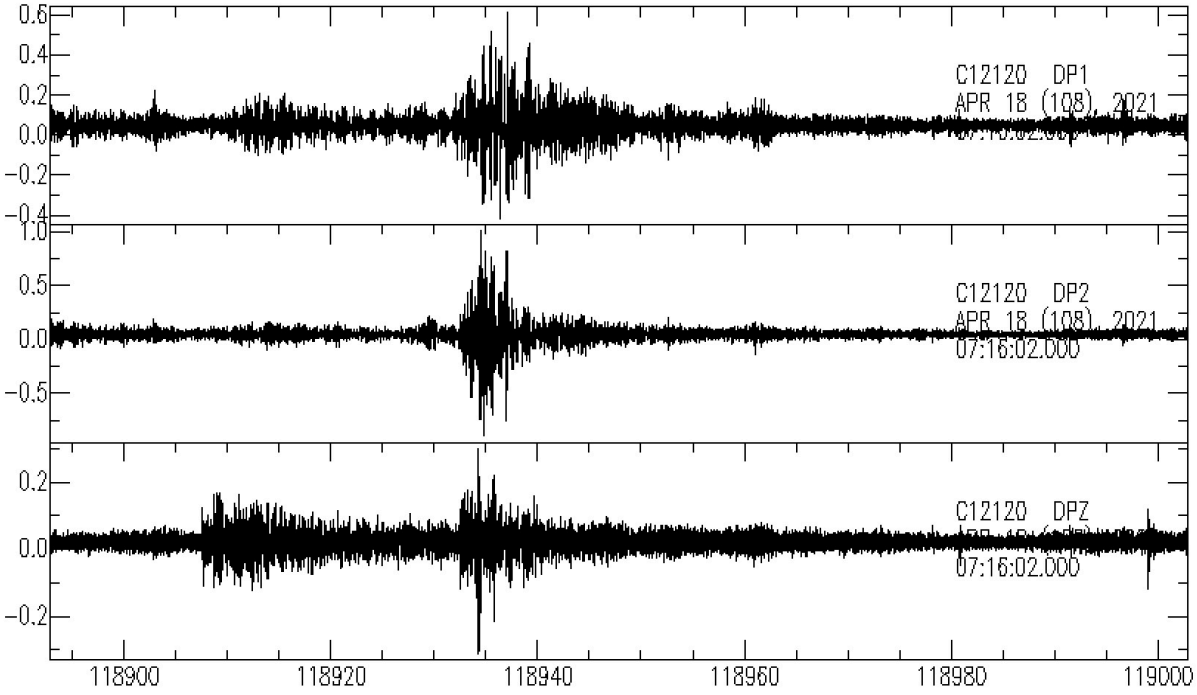

Figure 13. Example seismograms from station C12120, located at the northern edge of the array, showing a regional event with an S-P time of ~26 s

Relevant websites:

https://www.passcal.nmt.edu/content/instrumentation/all-one-systems/smart-solo
https://smartsolo.com/igu-16hr-3c/
https://smartsolo.com/wp-content/uploads/2020/07/smartsolo-igu-16hr-3c_en-brochure.pdf
https://smartsolo.com/wp-content/uploads/2020/02/smartsolo_brochure_web_en_feb2020-v2.pdf
https://smartsolo.com/iris-share-smartsolo-useful-information-on-their-official-database/
https://ds.iris.edu/NRL/
https://ds.iris.edu/NRL/sensors/dtcc/dtcc_sensors.html
https://ds.iris.edu/NRL/sensors/dtcc/RESP.XX.NS680..SPZ.DTSOLO.5.1850.43000.76_6