A directional DAS sensor and multi-component geophone comparison

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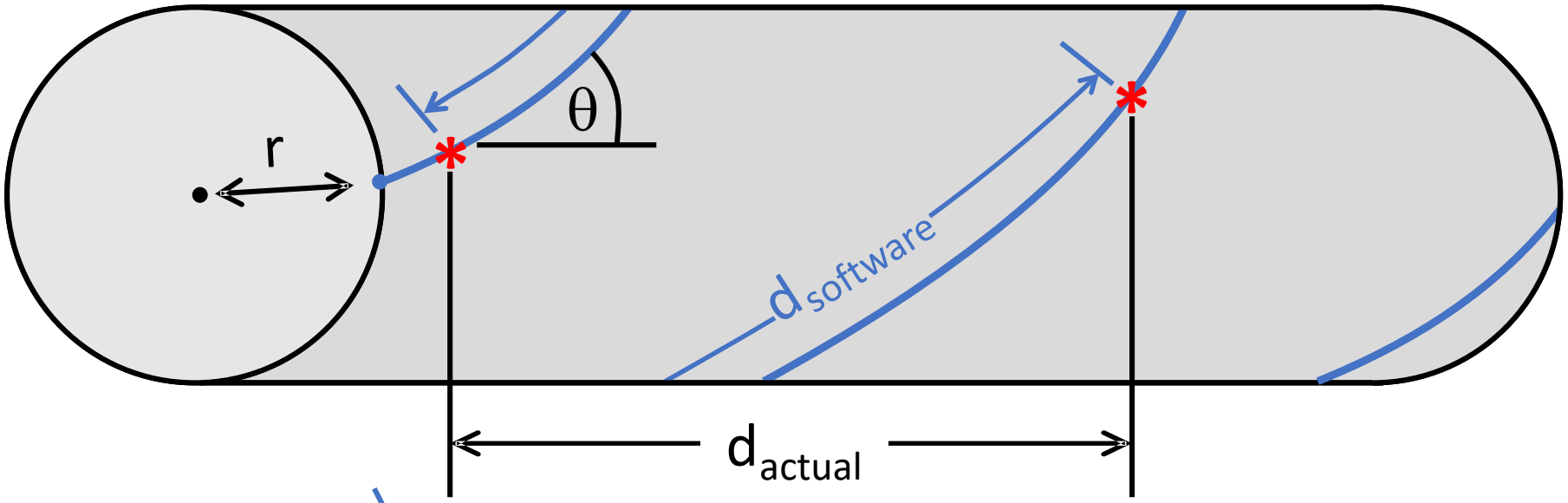
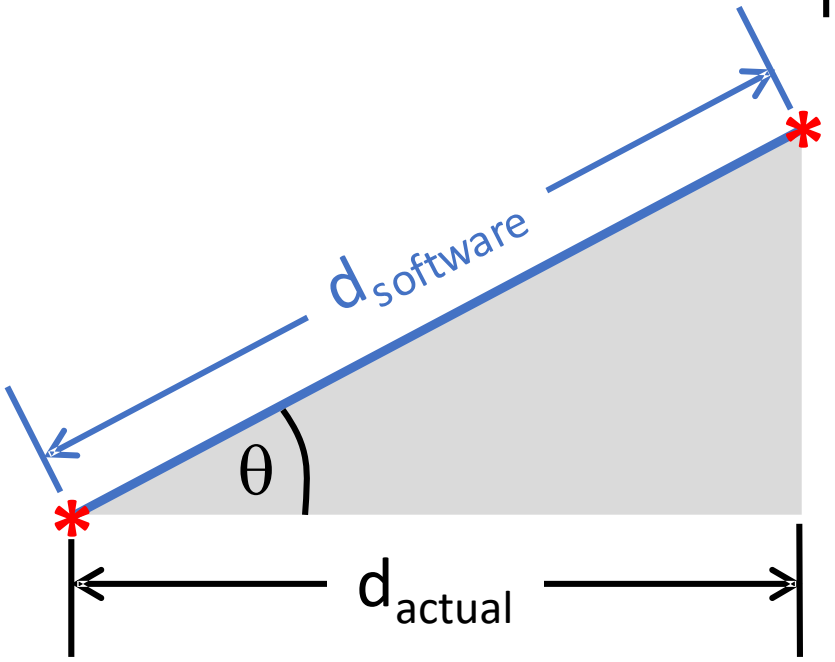
Objective and Outline

- In 2018 a star-shaped fibre loop was buried to investigate the practicalities of multicomponent DAS sensing; 3C surface phones were included for calibration
- Today: convert accelerometer or geophone data to strain rate in order to make better data comparisons to fibre data
- DAS Trace positioning in space, with corrections for:
  - Helical fibre pitch
  - Index of refraction (IR)
- Proposed method to convert seismic data to strain rate
- Vertical component example (VSP)
- Horizontal component example (Directional DAS sensor)

Method: Trace spacing corrections for helical fibre pitch and IR





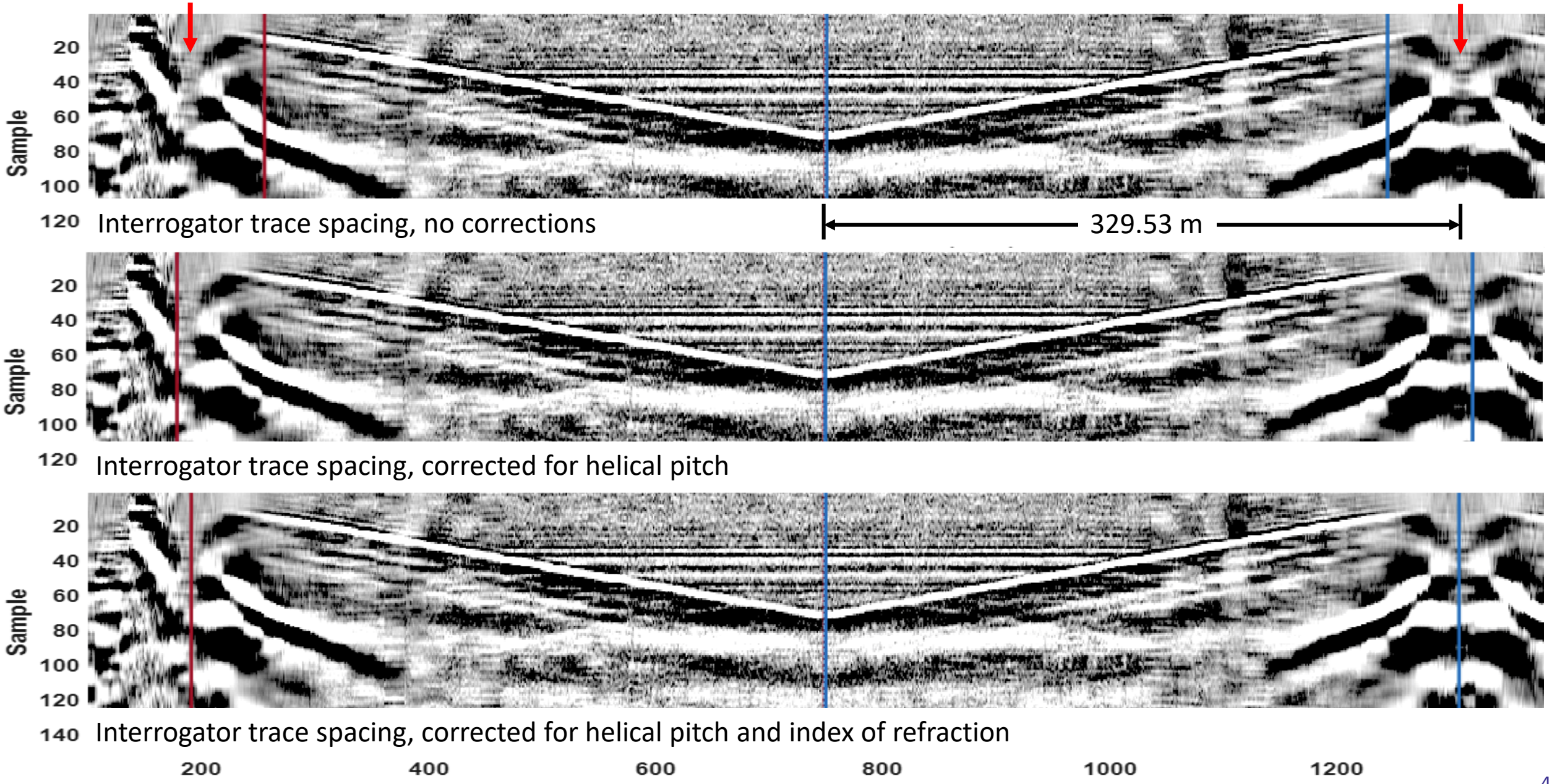
Helical Fibre:

$$d_{actual} = d_{software} * \cos(\theta) * \frac{IR_{software}}{IR_{actual}}$$

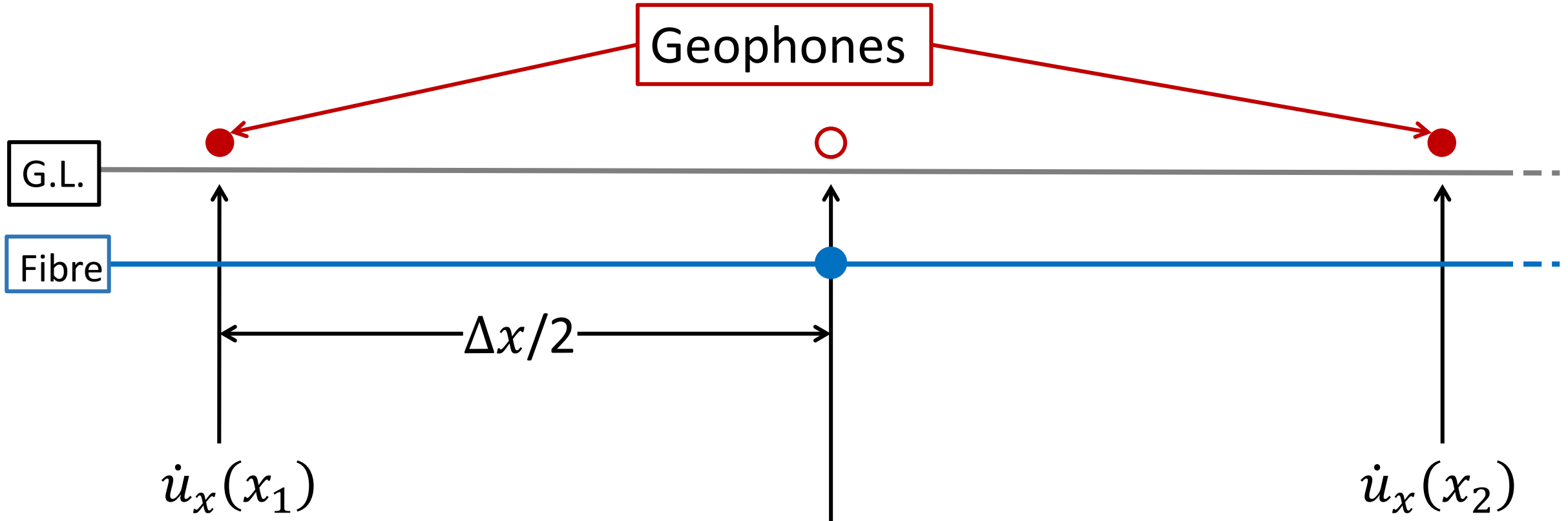
Straight Fibre:

$$d_{actual} = d_{software} * \frac{IR_{software}}{IR_{actual}}$$

Example: Effect of trace spacing corrections



Method: Geophone data conversion to strain rate

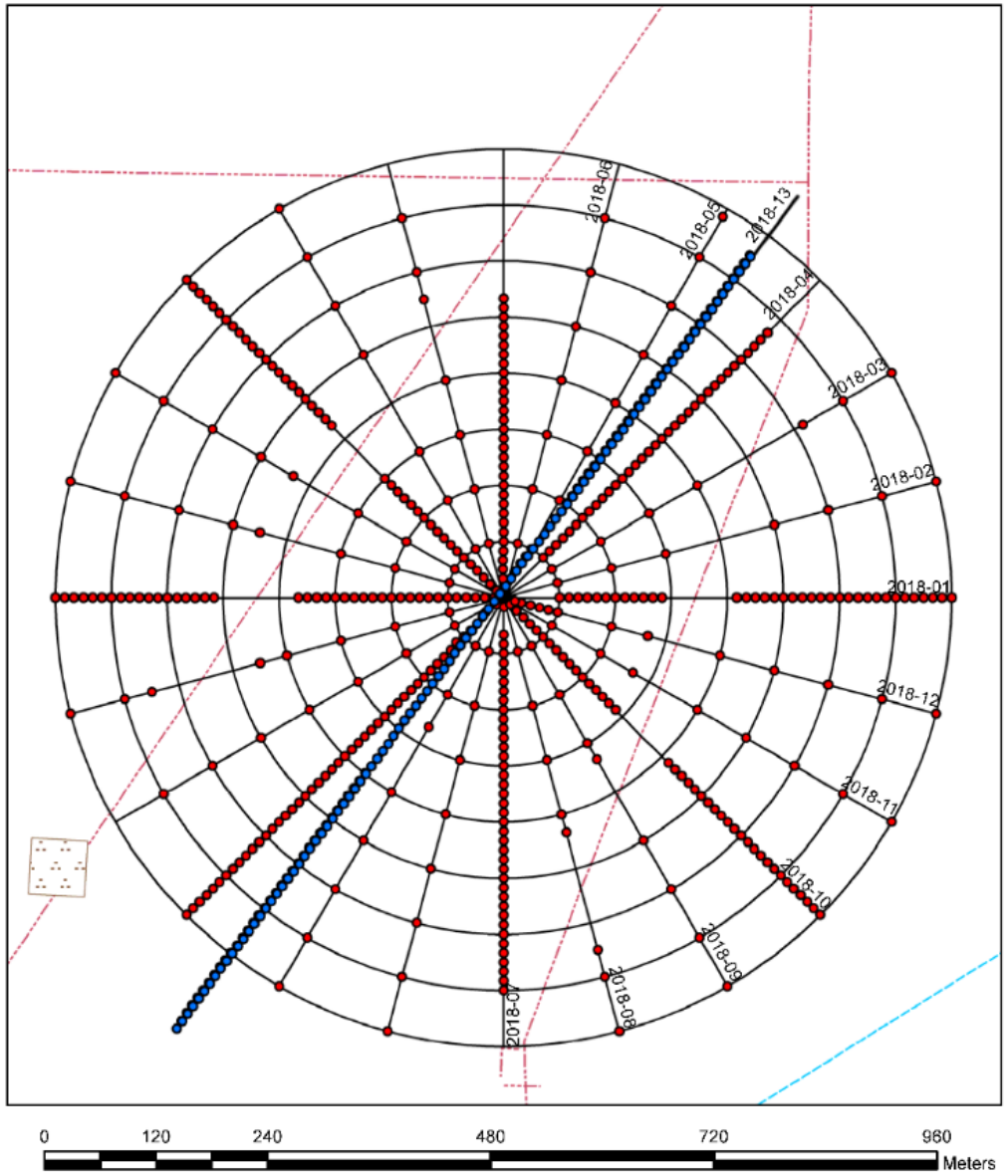


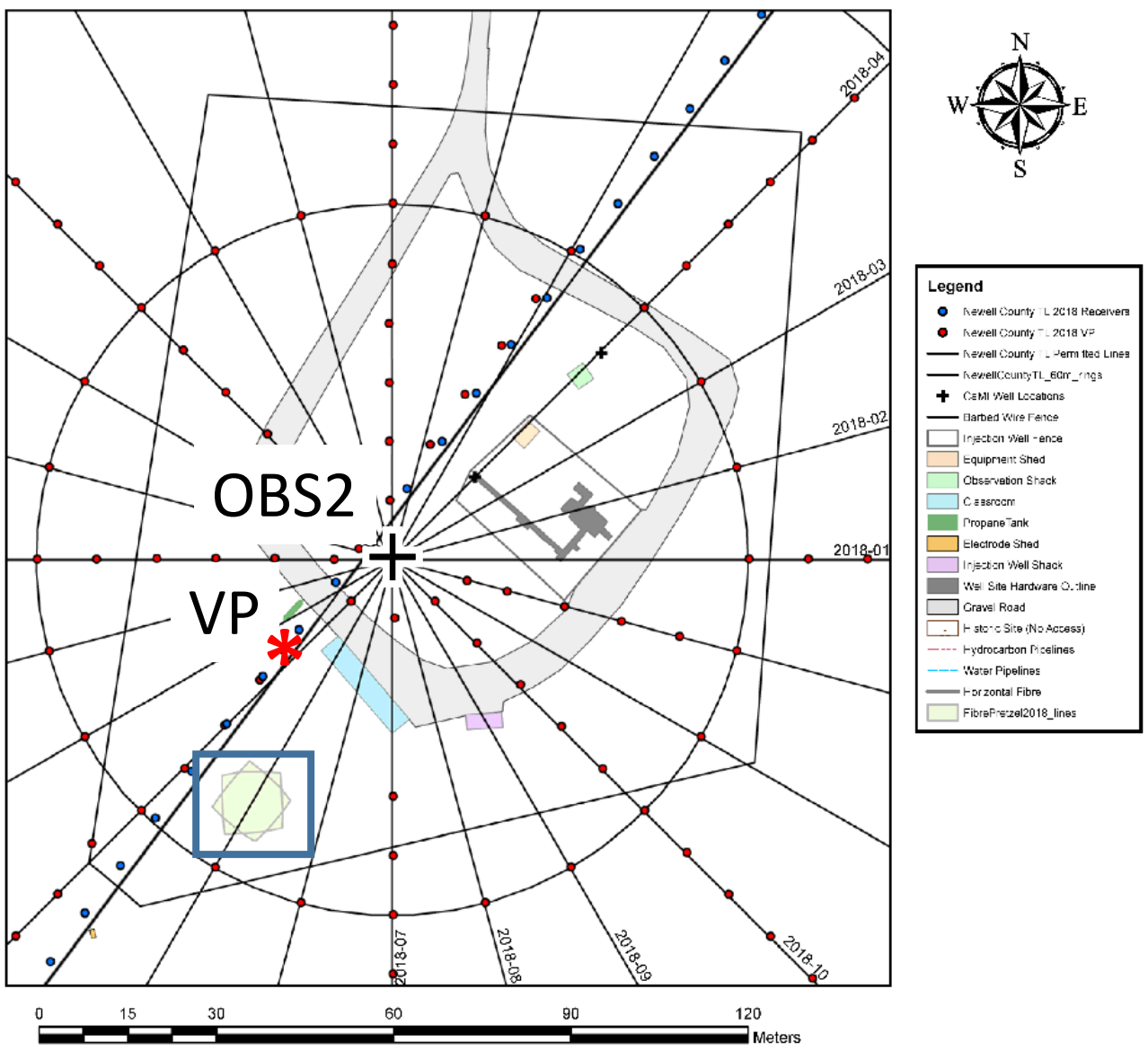
$$\dot{\epsilon}_{xx} = \frac{\partial \dot{u}_x}{\partial x} \approx \frac{\dot{u}_x(x_2) - \dot{u}_x(x_1)}{\Delta x}$$

2018 VSP (Snowflake) example

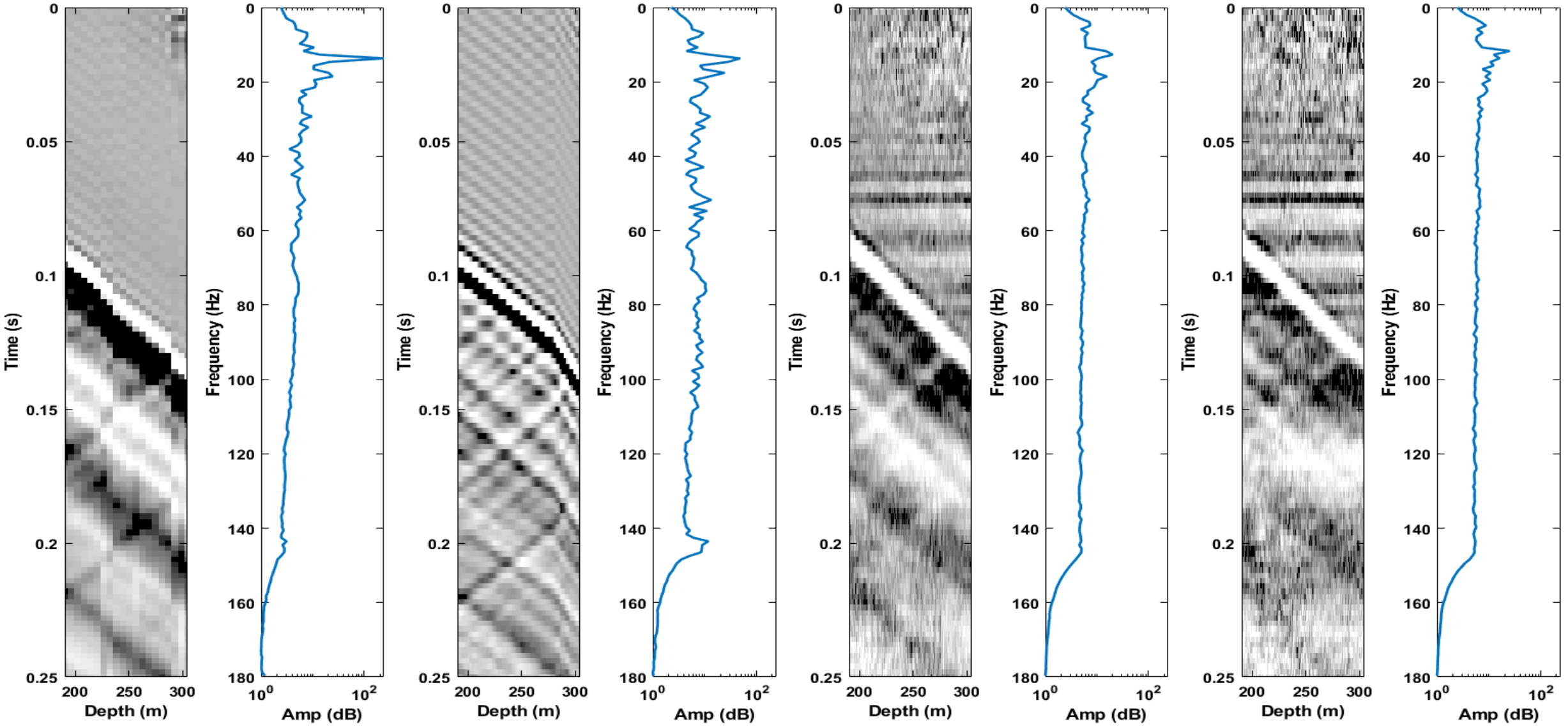
- Inova UniVib
  - 1-160 Hz linear sweep
  - 2 sweeps per VP
- Oyo Geospace 10 Hz 3C geophones
  - 5 m spacing
  - Vertical Component
- Inova VectorSeis 3C Accelerometers
  - 1 m spacing (2m at bottom well)
  - Vertical Component
- Straight Fibre (Fotech Interrogator)
  - 0.67 m spacing
- Helical Fibre (Fotech Interrogator)
  - 0.59 m spacing after correction

Newell County 2018 VSP Map

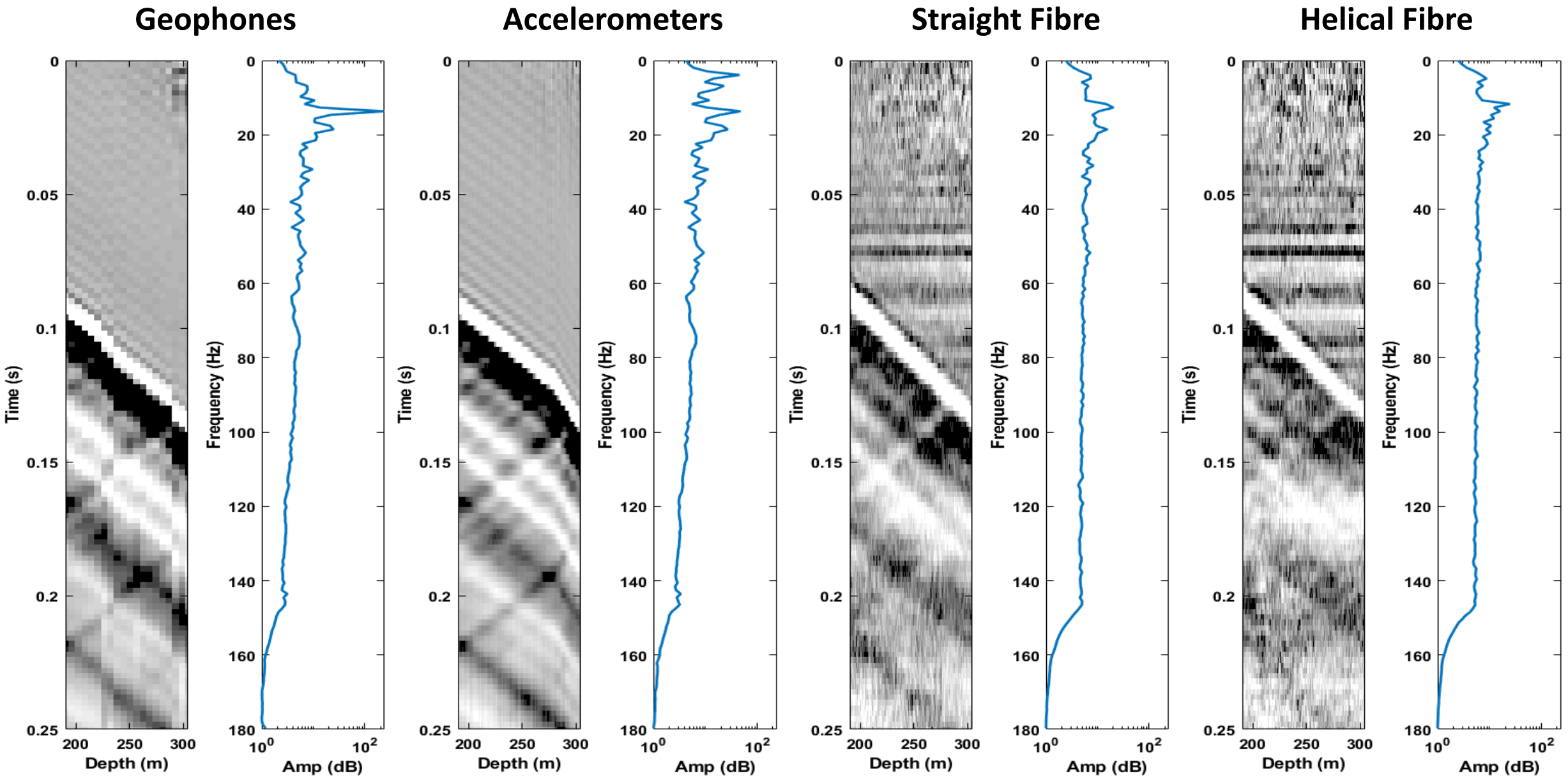




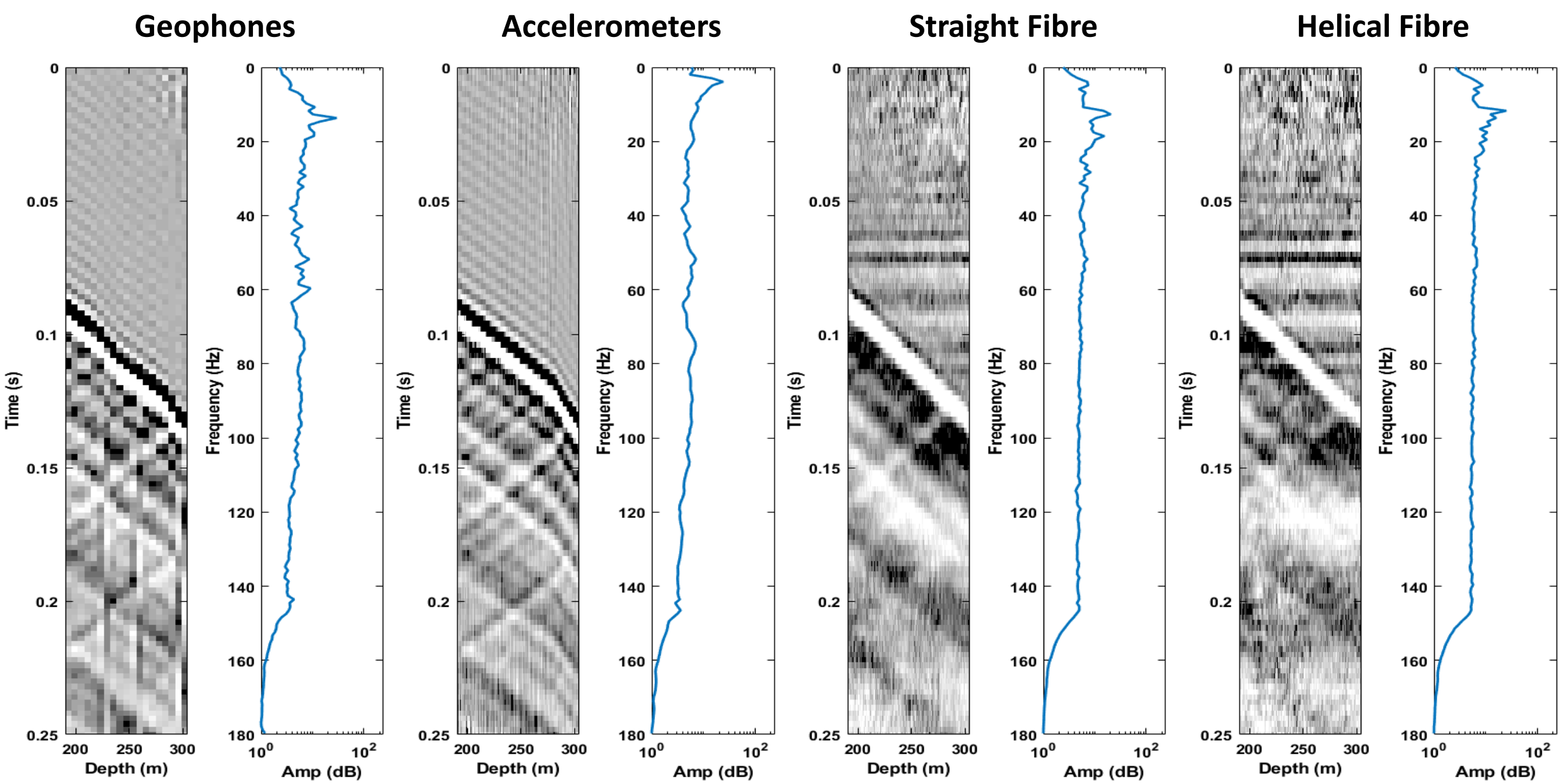
Field Data


Geophones
Accelerometers
Straight Fibre
Helical Fibre
Time (s)
Depth (m)
Frequency (Hz)
Amp (dB)

Accelerometer data converted to velocity



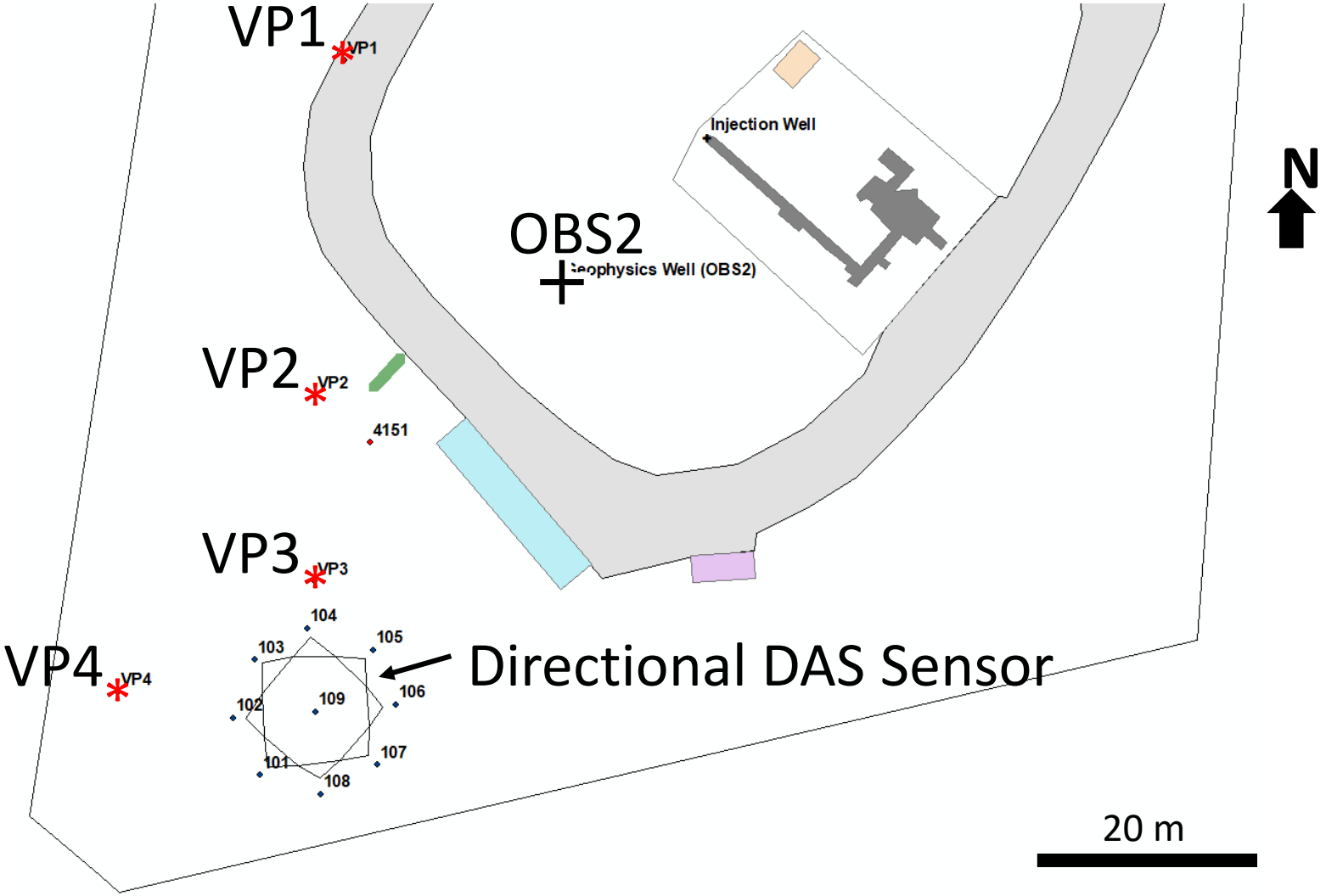
Geophone and accelerometer data converted to strain rate



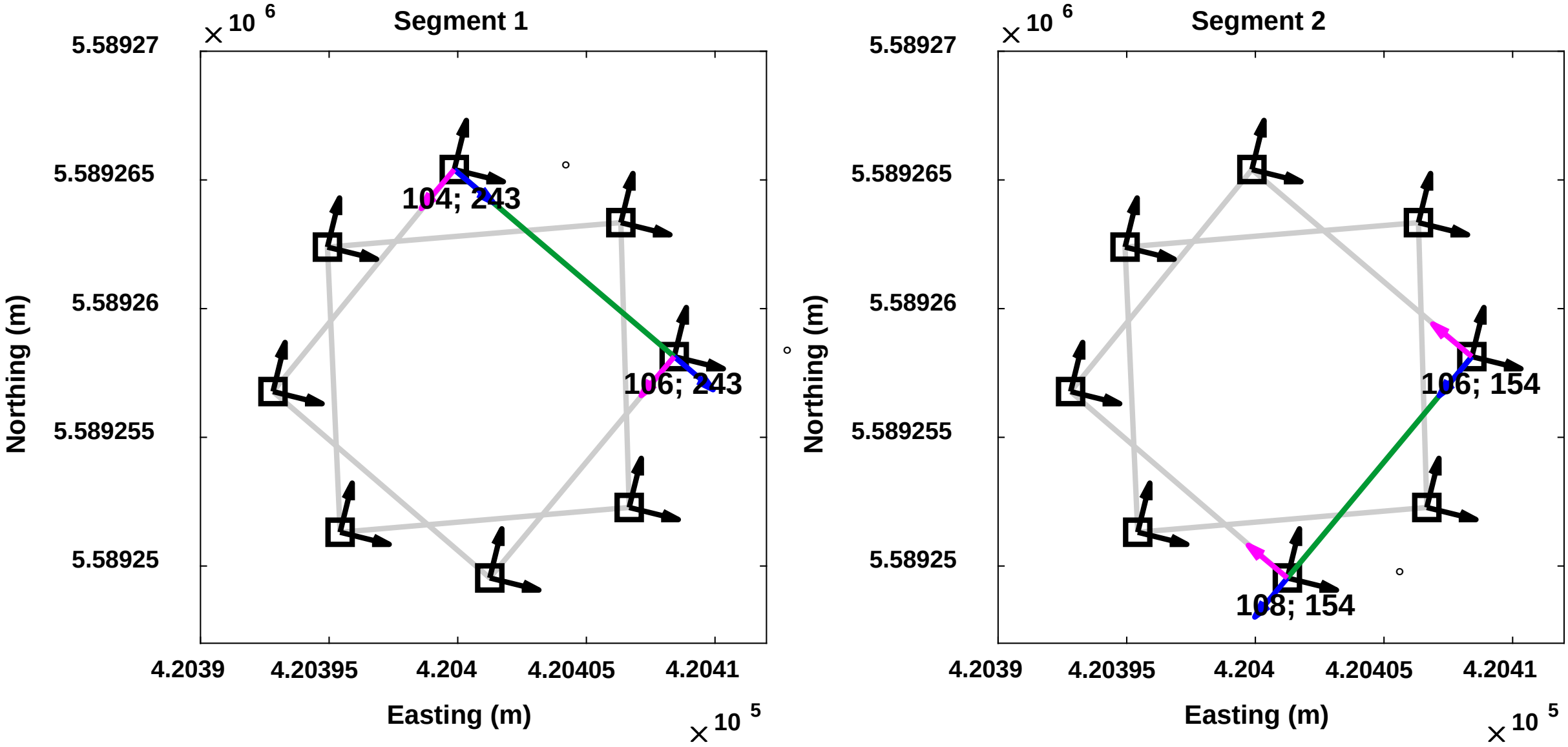
Directional DAS (Pretzel) example

- IVI EnviroVibe
  - 10-160 Hz linear sweep
  - 10 sweeps per VP
- Inova SM7 10 Hz 3C geophones
  - 11 m spacing
  - Horizontal Components
- Straight Fibre (Halliburton Interrogator)
  - 1.02 m spacing
- Helical Fibre (Halliburton Interrogator)
  - 0.91 m spacing after correction

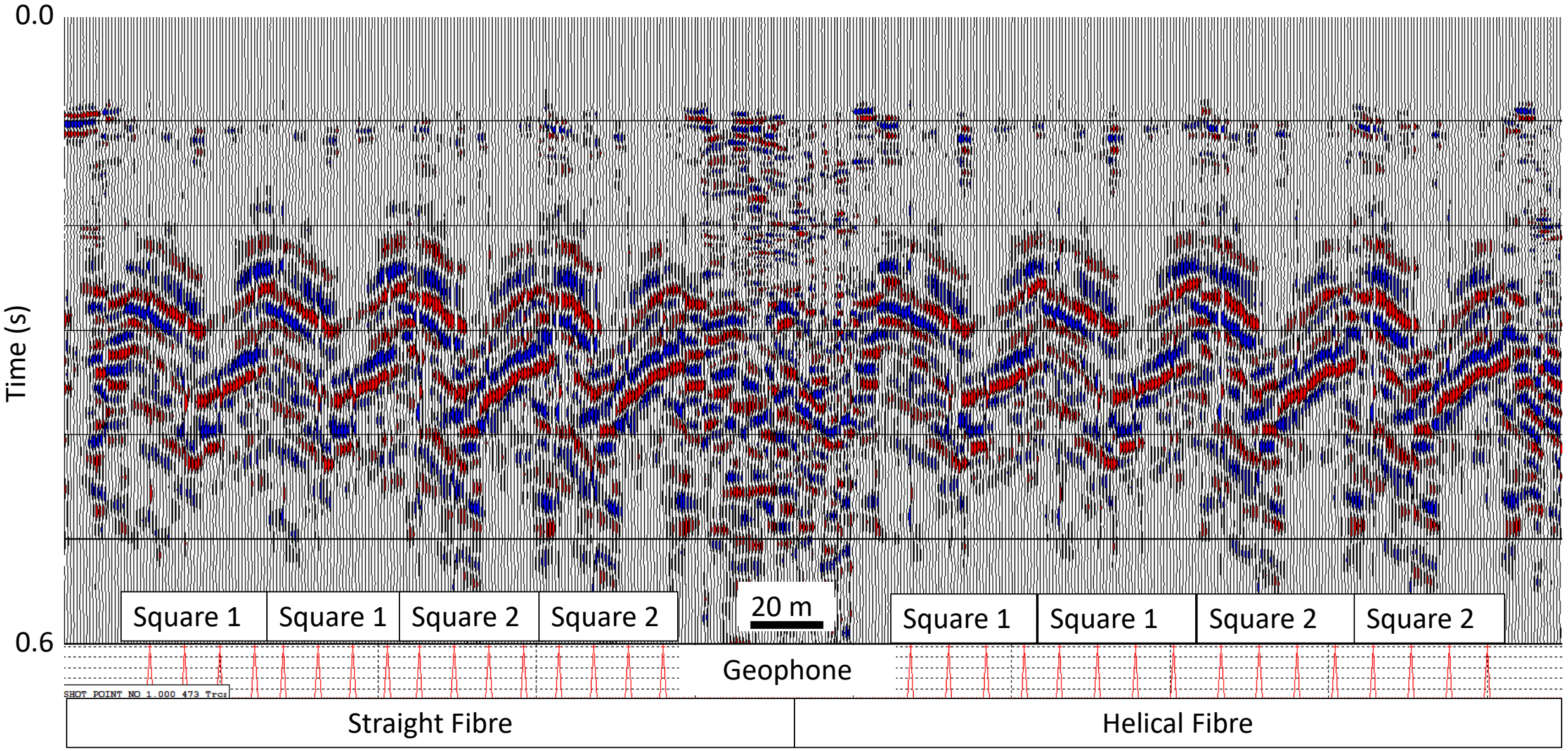
VSP and Directional DAS Sensor Map



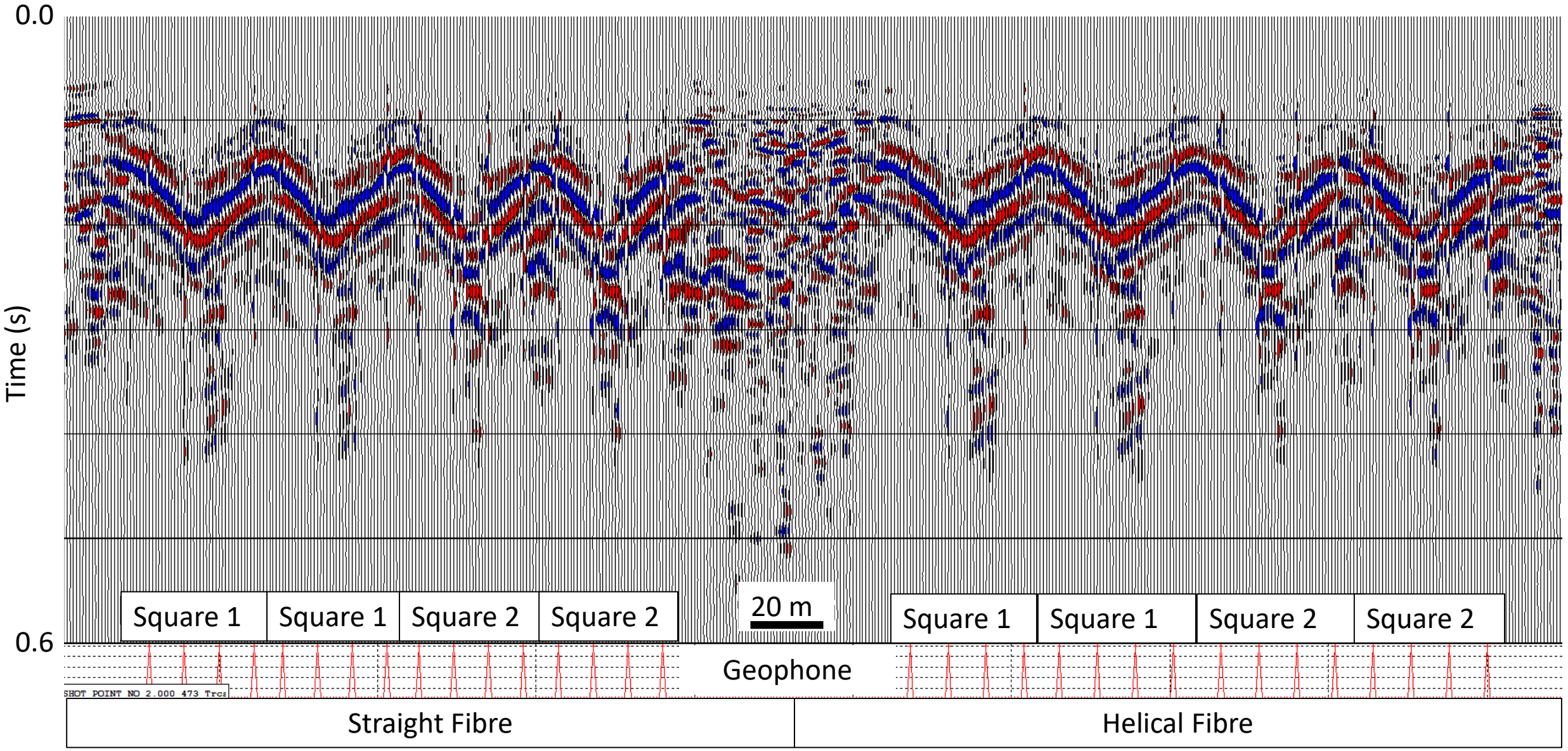
Example component rotations to inline for fibre segments



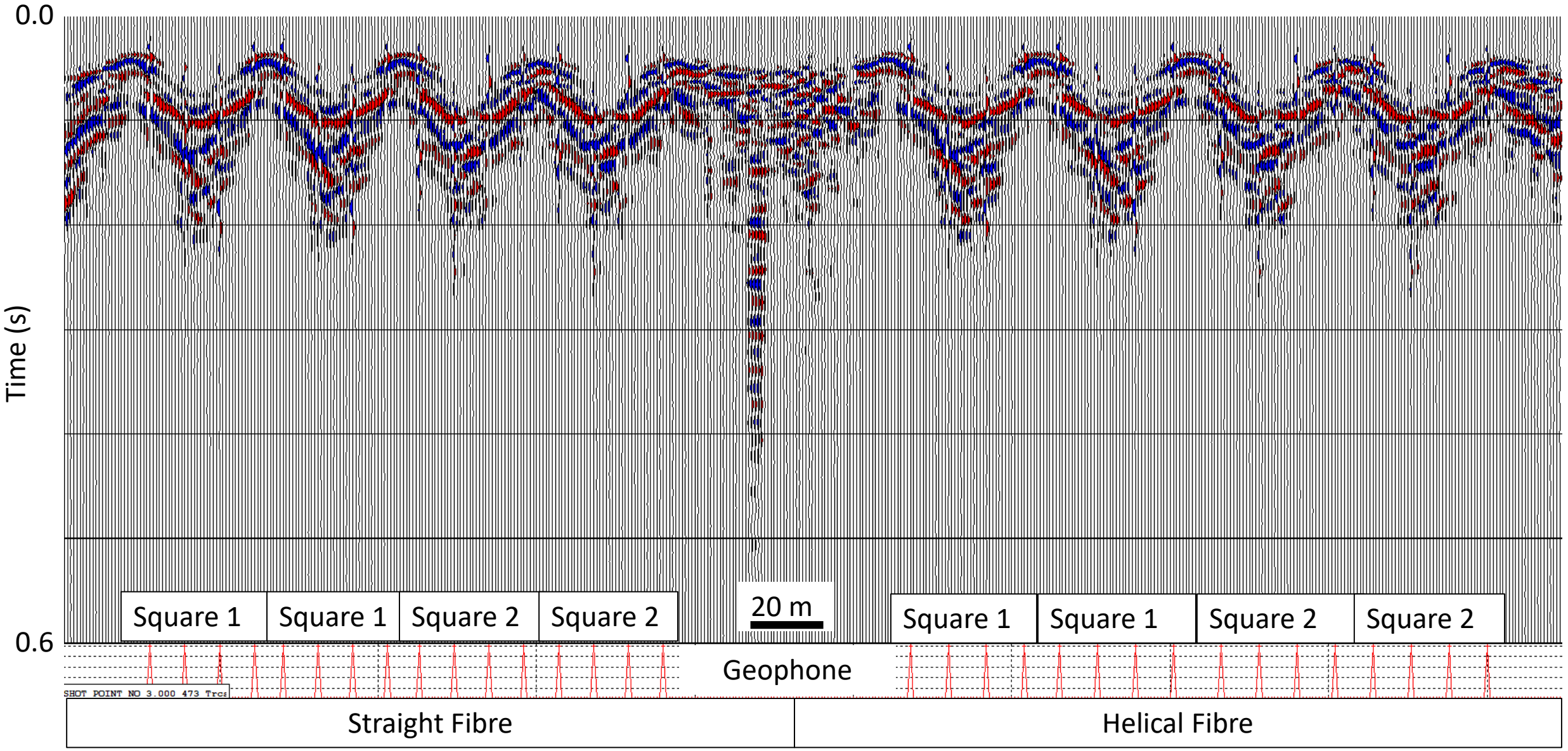
VP1


0.0
Time (s)
0.6
Square 1
Square 1
Square 2
Square 2
20 m
Square 1
Square 1
Square 2
Square 2
Geophone
SHOT POINT NO 1.000 473 Trcs
Straight Fibre
Helical Fibre

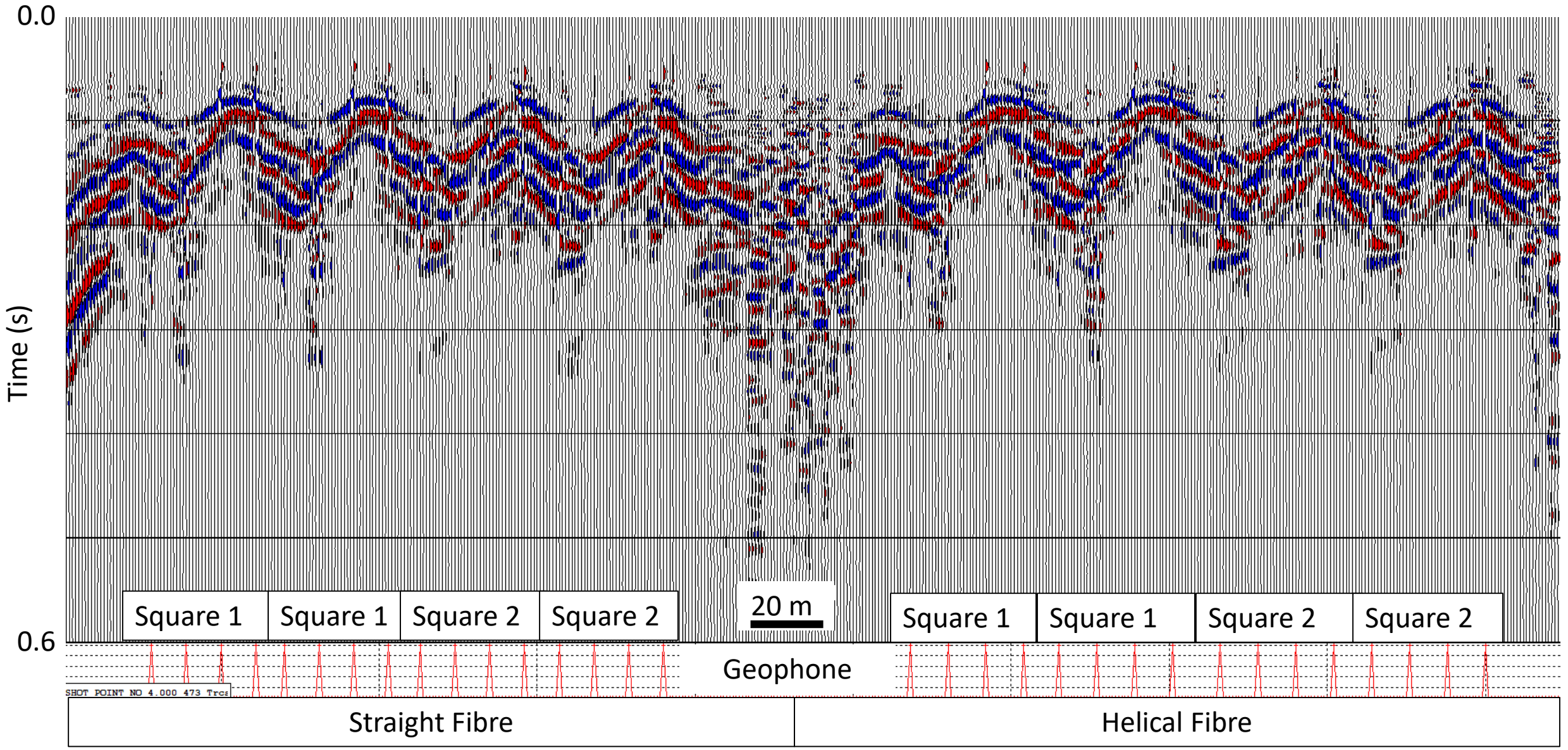
VP2


0.0
Time (s)
0.6
Square 1
Square 1
Square 2
Square 2
20 m
Square 1
Square 1
Square 2
Square 2
Geophone
SHOT POINT NO 2.000 473 Trcs
Straight Fibre
Helical Fibre

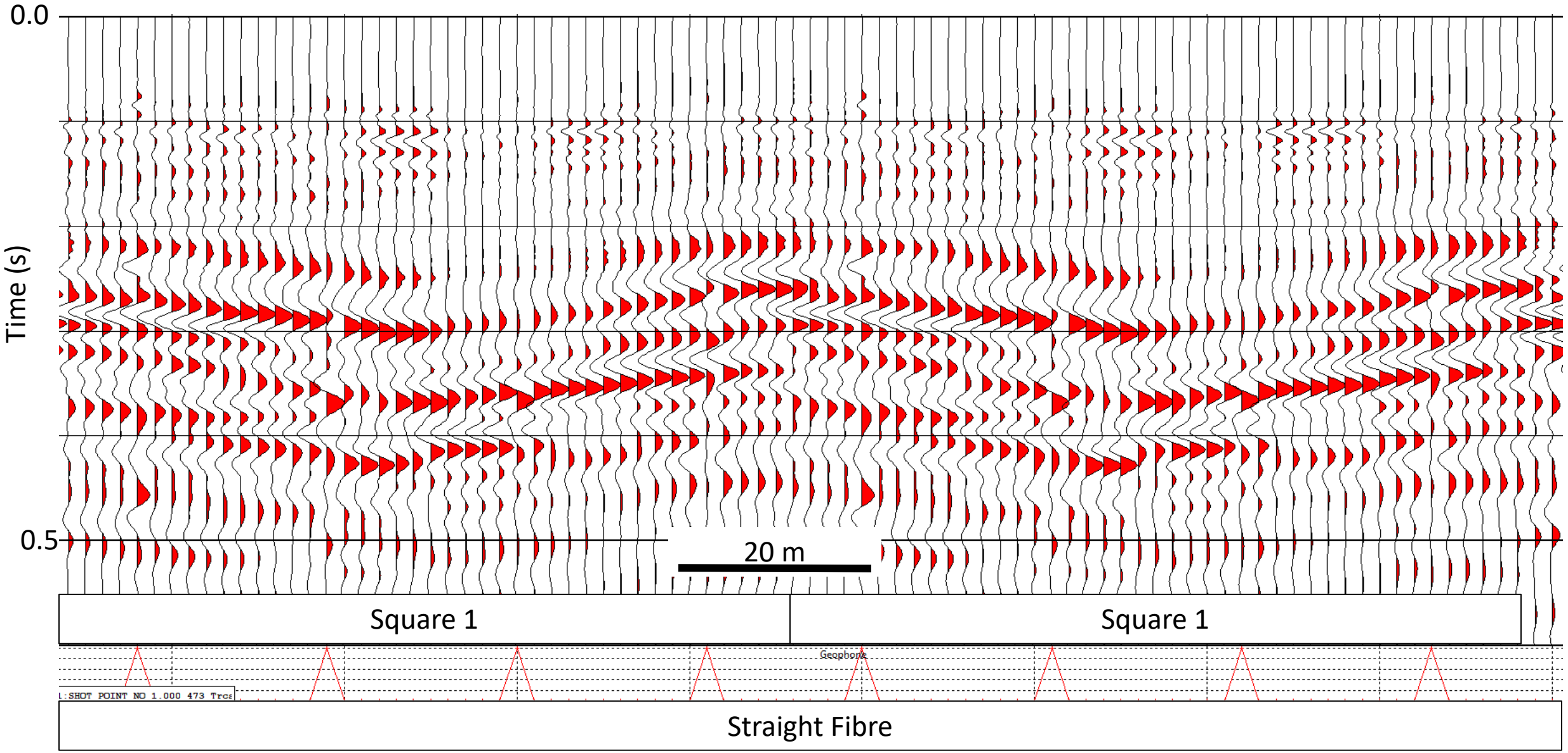
VP3


0.0
Time (s)
0.6
Square 1
Square 1
Square 2
Square 2
20 m
Square 1
Square 1
Square 2
Square 2
Geophone
SHOT POINT NO 3.000 473 Trcs
Straight Fibre
Helical Fibre

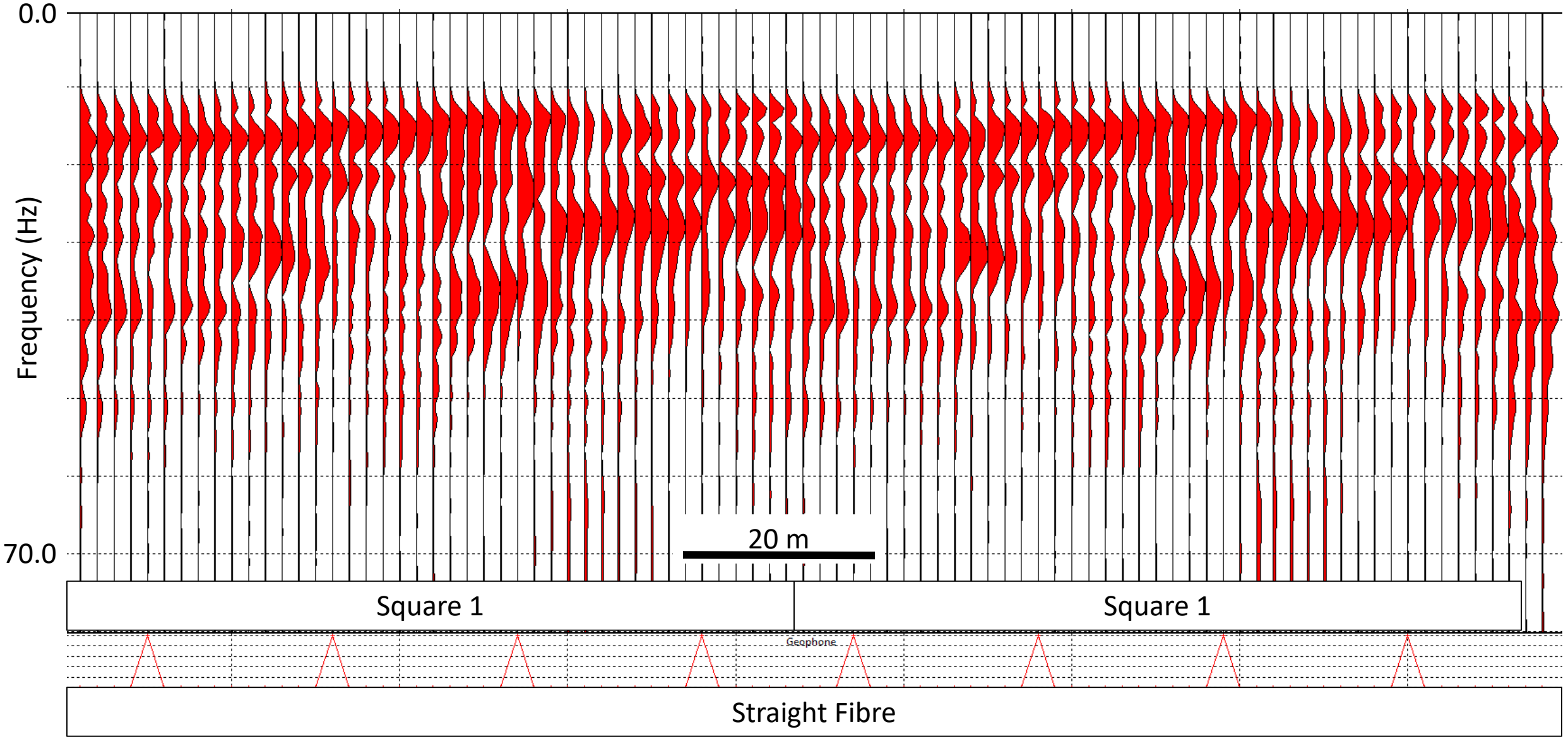
VP4


0.0
Time (s)
0.6
Square 1
Square 1
Square 2
Square 2
20 m
Square 1
Square 1
Square 2
Square 2
Geophone
SHOT POINT NO 4.000 473 Trcs
Straight Fibre
Helical Fibre

VP1, square 1


0.0
Time (s)
0.5
20 m
Square 1
Square 1
Geophone
SHOT POINT NO 1.000 473 Trcs
Straight Fibre

VP1, square 1, straight fibre, amplitude spectra



Discussion

- Trace spacing corrections for helical wind and index of refraction
- Method to convert Accelerometer and Geophone data to strain rate for comparison to fibre data
- Strain rate conversion method tested on:
  - Vertical component VSP data
  - Horizontal component directional DAS sensor data
- Encouraging results

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