

## Multi-component accelerometer and geophone comparison to fibre-optic (DAS) data

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### Summary

We wish to better compare the accelerometer (acceleration) and geophone (velocity) data to distributed acoustic sensing (DAS) fibre-optic data (strain-rate), and consider this is best accomplished by converting accelerometer and geophone data to strain-rate, as this parameter is what is of most interest to engineers.

### Method

In a one-dimensional sense, strain rate can be thought of as the velocity at which the two ends of a rod are moving towards or away from each other divided by the length of the rod. In the seismic case, geophone or integrated accelerometer data at two different locations measure the velocity of ground motion at those locations. So, we propose to convert geophone data at two points on the ground to strain-rate using:

$$\dot{\epsilon}_{xx} = \frac{\partial \dot{u}_x}{\partial x} \approx \frac{\dot{u}_x(x_2) - \dot{u}_x(x_1)}{\Delta x}, \quad (1)$$

where  $\dot{\epsilon}_{xx}$  is the strain rate over some distance along the media ( $\Delta x$ ), and  $\dot{u}_x(x)$  represents velocity data recorded at position  $x$ . The resulting strain-rate trace should then be located at position  $\Delta x/2$  for comparison to fibre data. A further conversion to strain can easily be obtained by integrating  $\dot{\epsilon}_{xx}$  with respect to time. As fibre data have a broadside insensitivity, (eg. Mateeva et al., 2014), it makes sense to use vertical component data in a vertical well for this comparison, or inline component data along fibre in a trench.

In order to plot converted accelerometer or geophone traces in the correct place on fibre data we must landmark the fibre data, so we know where a given fibre trace is located relative to a well or ground surface. This turns out to be non-trivial. The trace spacing of fibre data may have to be corrected for index of refraction (IR) if the actual IR is different from that programmed into interrogator software by the operator. Trace spacing is measured along the axis of the fibre, so a cosine(pitch) correction for distance must be applied if using helically wound fibre.

### Results

The method has been tested on common vib point accelerometer, geophone, straight fibre and helical fibre VSP in a vertical well at the Containment and Monitoring Institutes' Field Research Station (CaMI.FRS) in Newell Country, Alberta (Hall et al., 2019a, 2019b). Accelerometer and geophone data converted to strain-rate show a better visual match to the phase of up-going reflections observed on the fibre data, although the frequency content is different (not shown). Figure 1 shows an example of surface geophone data compared to straight fibre data from an experimental directional DAS sensor described by (Innanen et al., 2019a, 2019b). In this case, horizontal components were rotated to inline with sensor line segments before applying Equation 1.

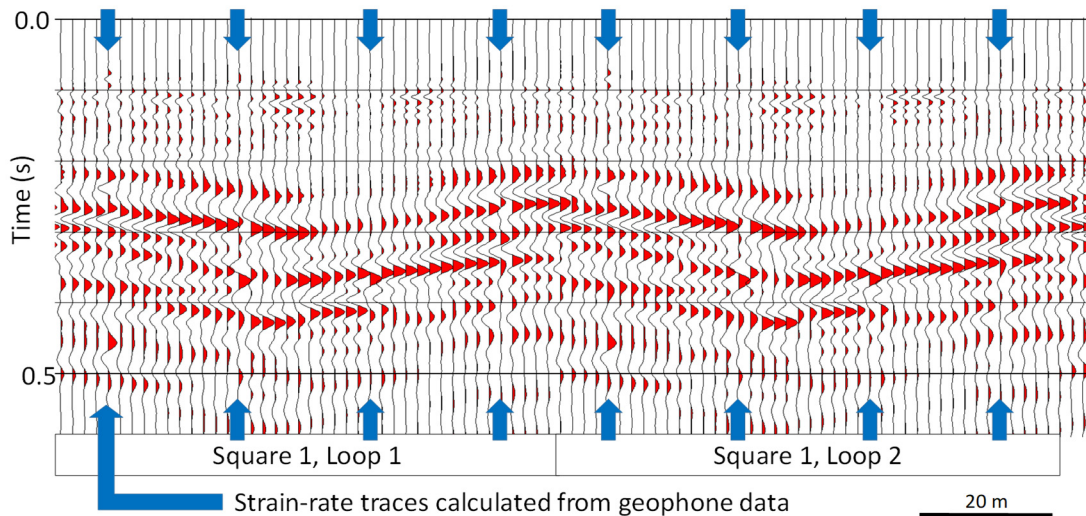


Figure 1: Close-up of geophone data converted to strain-rate and interleaved with straight fibre data. Peaks in the red graph along the bottom highlight the location of converted geophone traces.

## Discussion

A method to convert seismic data with amplitudes proportional to particle velocity to strain rate for comparison to distributed acoustic sensing (DAS) fibre data has been proposed and some initial testing has been carried out on surface and borehole data acquired at the CaMI.FRS. Results for both datasets are encouraging, and we feel that further work is warranted.

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