# Multicomponent DAS sensing: smaller sensors and field testing

Kevin Hall[1], Kevin Bertram[1], Kris Innanen[1], Don Lawton[1,2]
[1]CREWES, [2]Carbon Management Canada

## ABSTRACT

We installed an experimental multi-component fibre sensor called the Pretzel at the Carbon Management Canada Newell County Facility in 2018 (Green; Figure 1). The 10 m sides of the Pretzel are longer than the 7 m gauge length that we typically use for DAS acquisition, so that we can be assured of at least one data trace that is unaffected by the corners of the sensor. The Pretzel is unfeasibly large to incorporate a vertical component. A sensor with 1m sides (the Croissant) was proposed in 2022. Initial testing in the field showed that a 1 m long frame with fibre wrapped around it sampled using a gauge length greater than the frame size has a directional response, but no geophones or other seismic receivers were deployed for ground truthing. Lab tests in early 2023 comparing temporary sensors with small and large straight lengths of fibre (Figures 2-4) proved that we can (1) wrap our chosen fibre around plastic pipes without having access to either end of the fibre, and (2) record very similar looking data regardless of the length of fibre on the ground (Figure 4). The lab results were encouraging enough to go ahead and bury three Croissant style sensors in late 2023 (Figures 1 and 5). Three-component geophones were deployed on the surface for data comparisons. Figure 6 shows stacked and correlated Pretzel and Croissant DAS data. While it is difficult to pick a single data trace that represents each side of the Pretzel with no edge effects, Croissant data is easily interpreted. Figure 7a shows geophone data for a single VP, and 7b shows a direct comparison of unprocessed horizontal component Croissant data to geophone horizontal component data that has been converted from velocity to strain-rate. These data are very comparable, although the geophone traces had to be individually bulk shifted anywhere from 2 to 20 ms to align them with the DAS traces. Figure 8 shows receiver gathers for source line 41 (Figure 1), where the Pretzel's eight horizontal components and Croissant station one's two horizontal components have been converted to radial and transverse components. First impressions are that the Pretzel data contains more low-frequency noise, and the Croissant data has more high-frequency noise (eg. air blast).

In future, we will be conducting more tests on these sensors, as well as thinking about other designs. The Pretzel and Croissant fibre have been left attached to the end of the main fibre loop on the site, so we will be able to gather more data every time another seismic survey is acquired.

## ACKNOWLEDGEMENTS

The sponsors of CREWES are gratefully thanked for their continued support. This work was funded by CREWES industrial sponsors, NSERC (Natural Science and Engineering Research Council of Canada) through the grant CRDPJ 543578-19, and Emissions Reduction Alberta (ERA) as part of the Accelerating Carbon Technologies (ACT) 4 project SPARSE (Sparse Passive-Active Reservoir monitoring using Seismic, Electromagnetics, gravity, and surface deformation). We would also like to thank Schlumberger for the use of donated Vista software, and all Carbon Management Canada Newell County Facility JIP subscribers for their continued support. This work would not have been possible without the assistance of Malcolm Bertram, Marie Macquet, Brendan Kolkman-Quinn, and Franki Race.

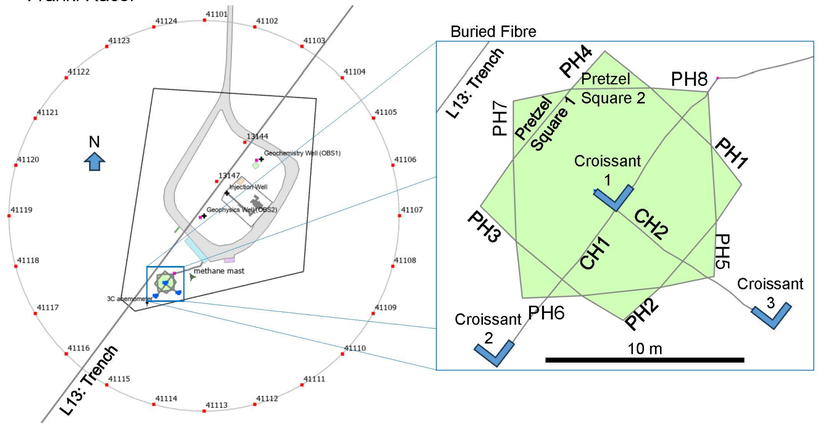


FIG. 1. Map of field area showing test sweep locations on source lines 13 and 41 (left). Buried fibre on site includes trenched fibre along line 13, borehole fibre in the OBS1 and OBS2 wells, as well as the Pretzel and the Croissant. Details of the Pretzel (Two 10x10 m horizontal squares at 1.82 m depth; green) and Croissant receiver stations 1, 2, and 3 (0.15 – 1.15 m depth; blue V's) locations are shown on the right. Pretzel horizontal component directions are labelled PH1-PH8. Croissant horizontal component directions are labelled CH1-CH2.

## LAB TESTS

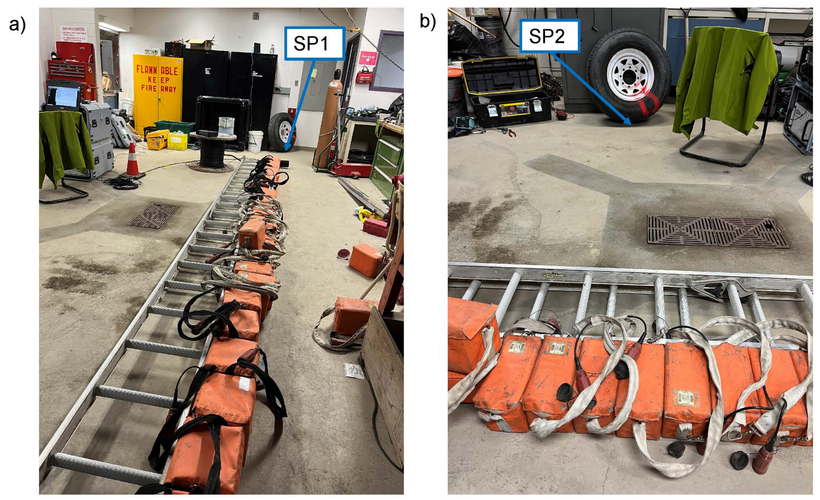


FIG. 2. Experimental setup with a 7 m sensor containing 28 m of fibre (4x 7 m gauge length) on the floor showing (a) the source (trailer tire) at SP1 (5.5 m in-line) and (b) SP2 (3.5 m cross-line), where in-line and cross-line distances are measured from the center of the sensor. Seismic batteries were piled on top of the fibre for coupling.

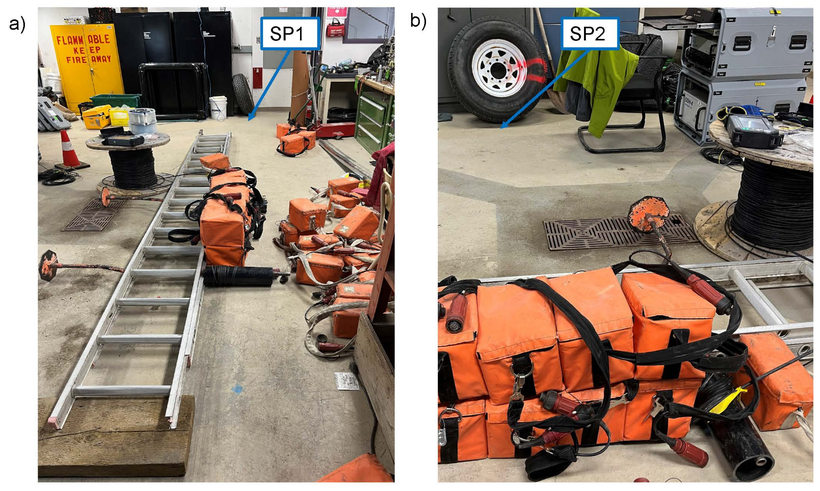


FIG. 3. Experimental setup with a 1 m sensor on the floor containing 28 m of fibre (4x 7 m gauge length) showing (a) the source (trailer tire) at SP1 (5.5 m in-line) and (b) SP2 (3.5 m cross-line), where in-line and cross-line distances are measured from the center of the sensor. Seismic batteries were piled on top of the fibre for coupling.

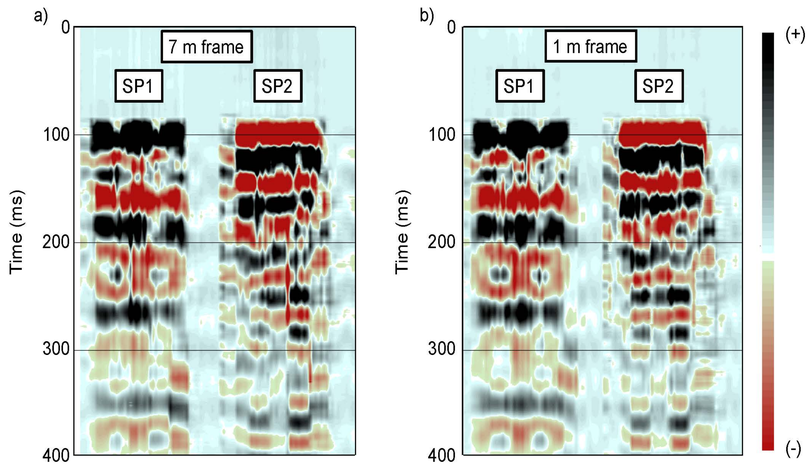


FIG. 4. Stacked data recorded for the experimental setups shown in Figures 2 and 3 using (a) a 7 m sensor and a 7 m gauge length (a) and a 1 m sensor and a 7 m gauge length (b). The tire was dropped 10 times per SP. Direct arrivals were arbitrarily aligned at 100ms by cross-correlations before stacking. Data recorded with a gauge length greater than the length of the sensor (b) appear to be functionally identical to data acquired with a gauge length equal to the length of the sensor (a).

## FIELD TESTS

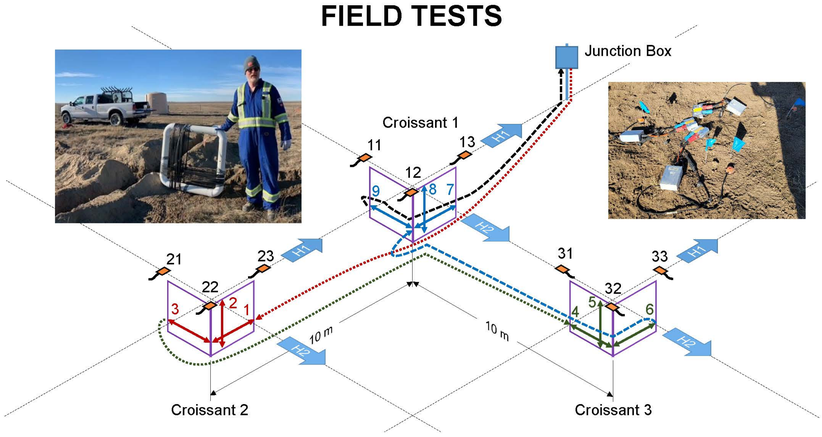


FIG. 5. Schematic of Croissant install (cf. Figure 1). Vertical 1x1 m plastic frames were installed at Croissant stations 2 (fibre wraps 1,2,3), 3 (fibre wraps 4,5,6) and 1 (fibre wraps 7,8,9). Each Croissant component contains 28 m of fibre (4x 7 m gauge length). Three-component geophones were placed at the corners of the Croissant V's (orange squares).

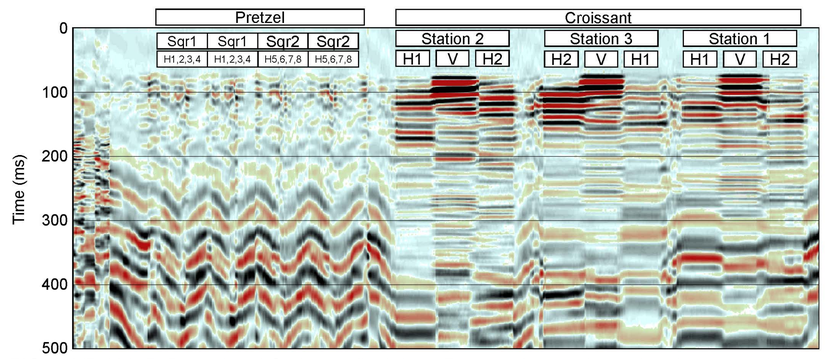


FIG. 6. VP 13147, Pretzel and Croissant field data. Four stacked and correlated sweeps (16 s sweep, 10-150 Hz).

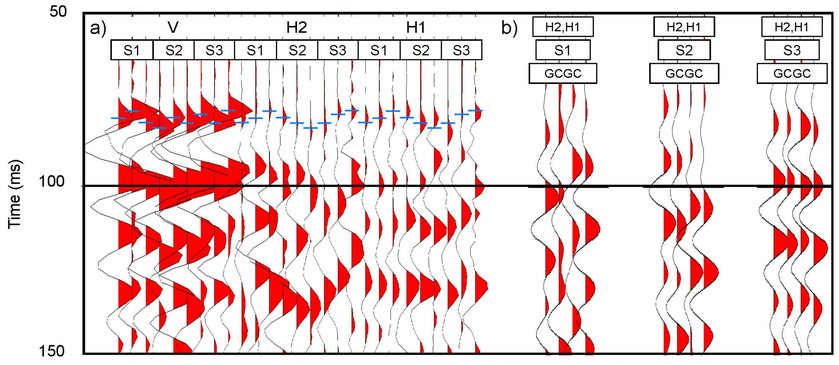


FIG. 7. VP 13147, Geophone data sorted by component, Croissant station (S1-S3), and geophone station (a). Four stacked and correlated sweeps (16 s sweep, 10-150 Hz). Geophone horizontal components were converted to strain rate (G) and interleaved with Croissant traces (C) for each station (b).

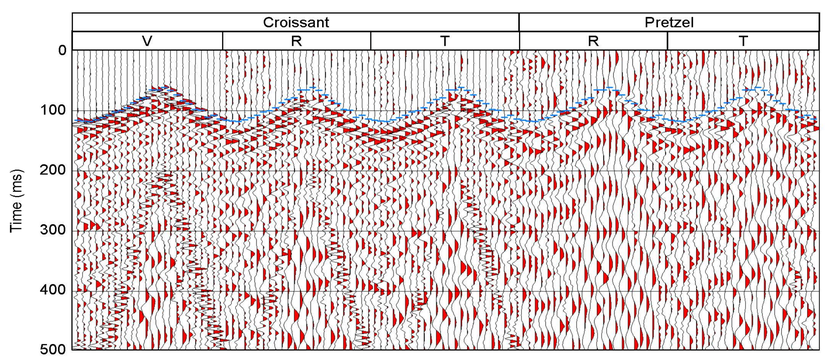


FIG. 8. Croissant station 1 and Pretzel vertical, radial, and transverse component receiver gathers for source line 41 (41101-41124). 150 ms AGC, no filters. First-break picks from the Croissant vertical component have been copied to radial and transverse receiver gathers. In this plot, the Croissant data appear to contain higher frequencies (including air blast) than is observed on the Pretzel data.

NSERC CRSNG
UNIVERSITY OF CALGARY
FACULTY OF SCIENCE
Department of Earth, Energy, and Environment
Carbon Management Canada