Walk away VSP processing of DAS and geophone data at CaMI Field Research Station

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Summary

As part of the FRS baseline assessment, several Vertical Seismic Profiles were acquired with the intention of testing emerging monitoring techniques such as Distributed Acoustic Sensing (DAS). In this report, we describe the processing flow and discuss the results obtained for a walkaway VSP oriented North-South and centred in the observation well 2. This survey was acquired in July 2017 using two recording systems: fibre optic cables (straight and helical wound fibre) for DAS and a 3C 24-level geophone array. Each section of the report displays a comparison between the straight and helical fibre optic cables and the geophone array. After processing the different datasets, we compared the results of the stacked VSP-CDP transforms with an inline section from a 3D seismic survey crossing through the well. Overall, there is a good correlation between the events in the surface seismic and the VSP-CDP. The CO_2 injection target located at approximately 250 ms is noticeable in each dataset. Nevertheless, there is an apparent discontinuity of the event of interest across the mapped result, particularly for the helical fibre. This assessment shows how DAS measurements seem to be a promising approach for subsurface imaging and continuous monitoring. However, further analysis of DAS is essential to obtain better imaging results, especially for the helical wound fibre optic cable dataset.

Objectives and Field Research Station

The Containment and Monitoring Institute, is developing a Field Research Station (FRS) in southern Alberta, near Brooks in the Newell County. One of the main objectives of the FRS is the implementation of new technologies for a better understanding and development of monitoring programs for the CO_2 injection site.

As part of the program, borehole geophones and fibre optic cables were permanently deployed at the site, covering two observation wells each to a depth of 330 m in addition to a horizontal trench crossing the site in the NE-SW direction. In this occasion, we show the processing results of a walk away VSP acquired at the FRS with DAS and geophones permanently installed in the Observation Well 2.

A North-South walk away VSP (Figure 1) was selected for processing since it has a consistent number of vibroseis sweeps per source point (6 in this case).

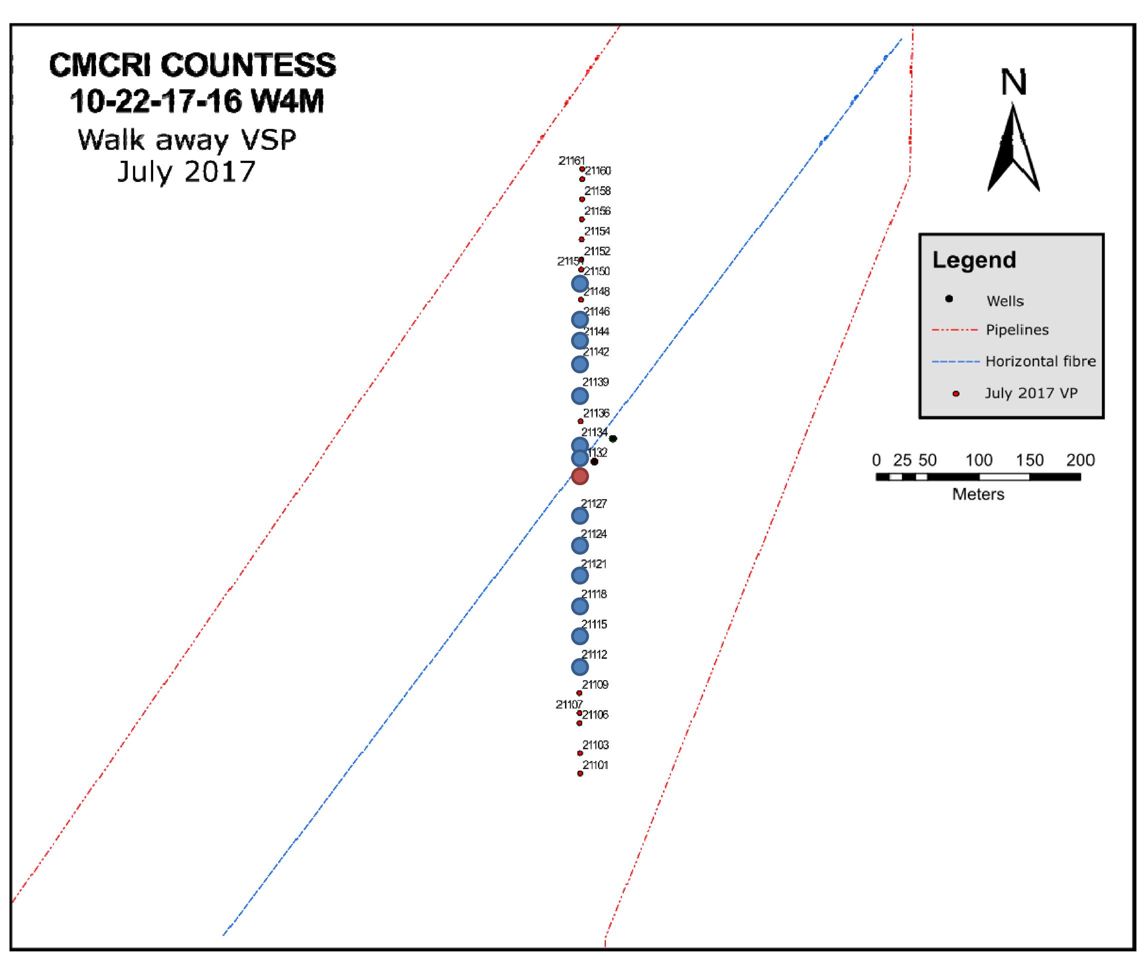

Figure 1. Geometry survey of walk away VSP. Vibe points processed (blue circles), Observation well 2 (red).

Processing flow

The processing flow applied to the datasets is shown in Figure 3. Additional steps were completed for the processing of the multicomponent geophone data.

The helical wound data seems to have a lower signal to noise ratio than the straight fibre of approximately of 30%. Figures 3 - 6 show the results obtained at different steps of the processing flow.

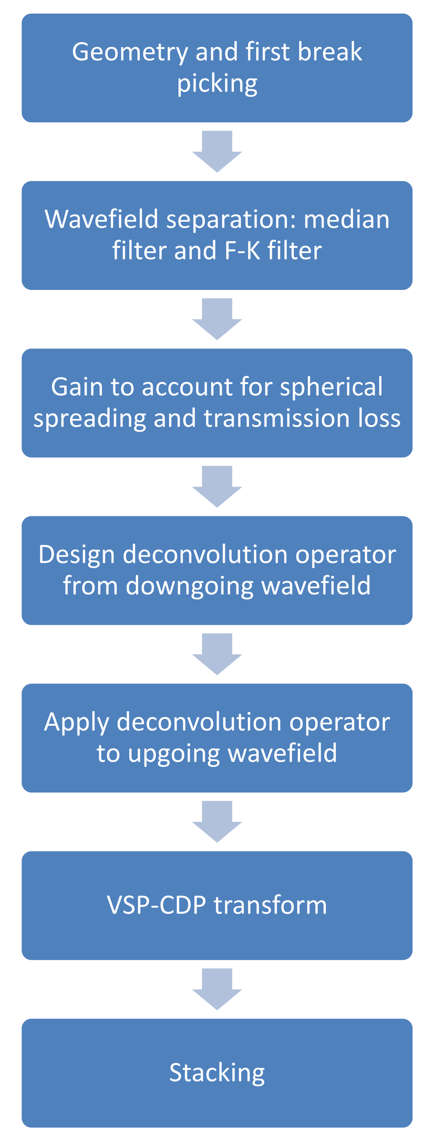

Figure 2. Processing flow followed for each dataset.

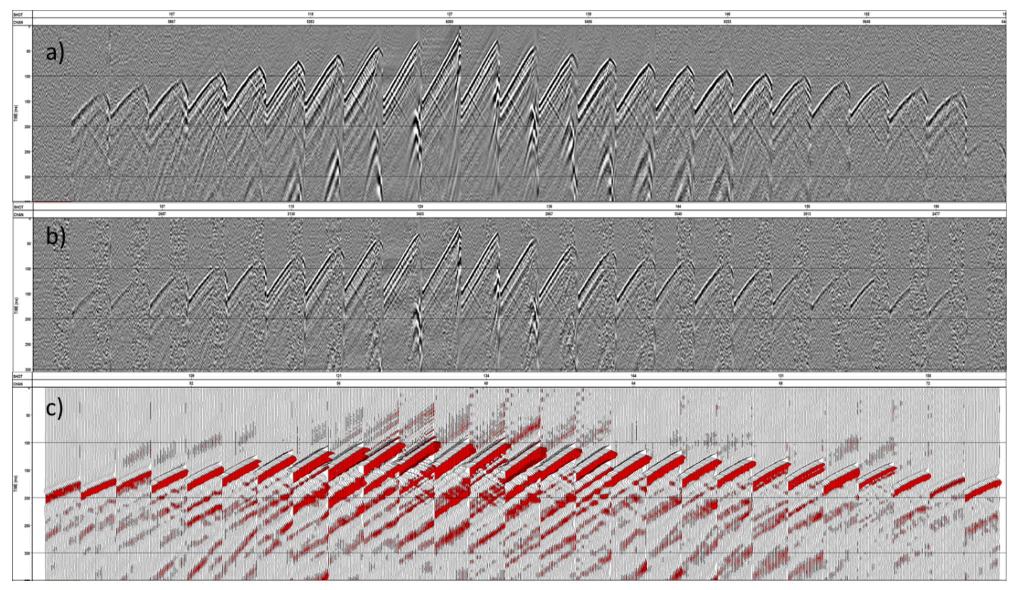

Figure 3. Raw DAS and geophone gathers of walk away VSP. a) Straight fibre, b) helical fibre, c) geophone vertical component.

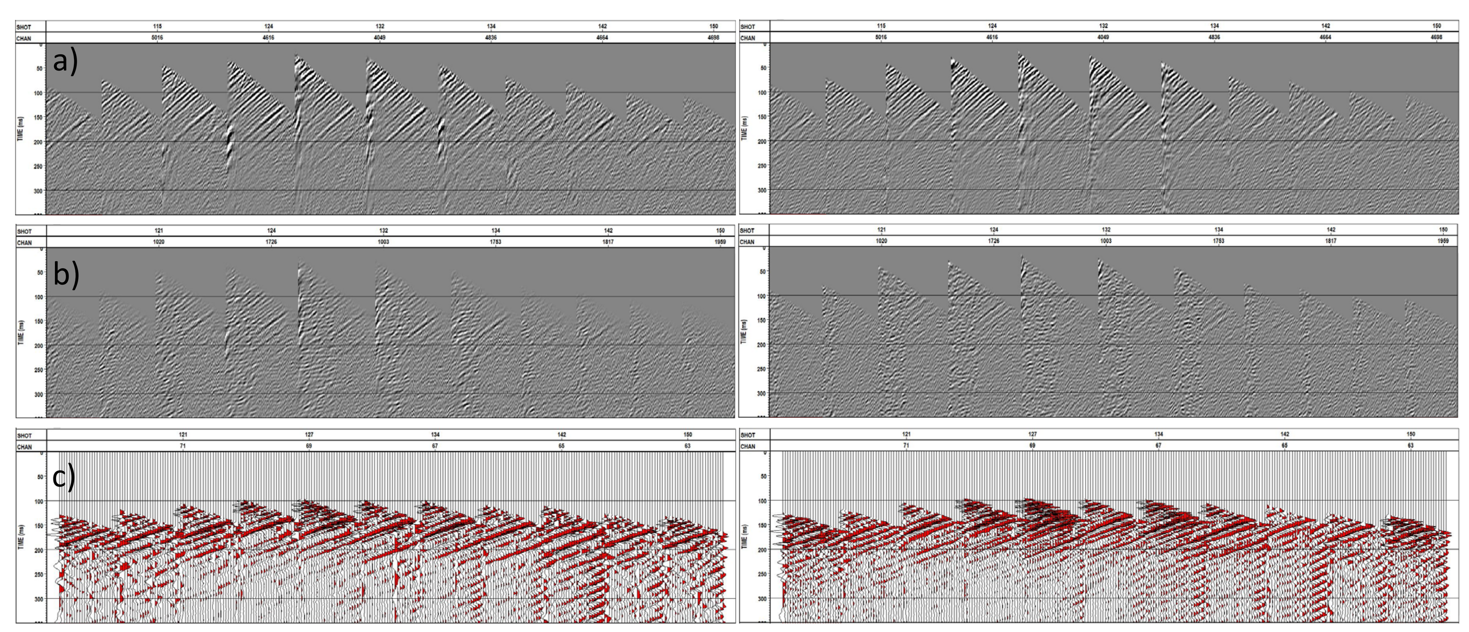

Figure 4. Upgoing wavefield before (left) and after (right) deconvolution. a) Straight fibre, b) helical fibre, c) geophone vertical component.

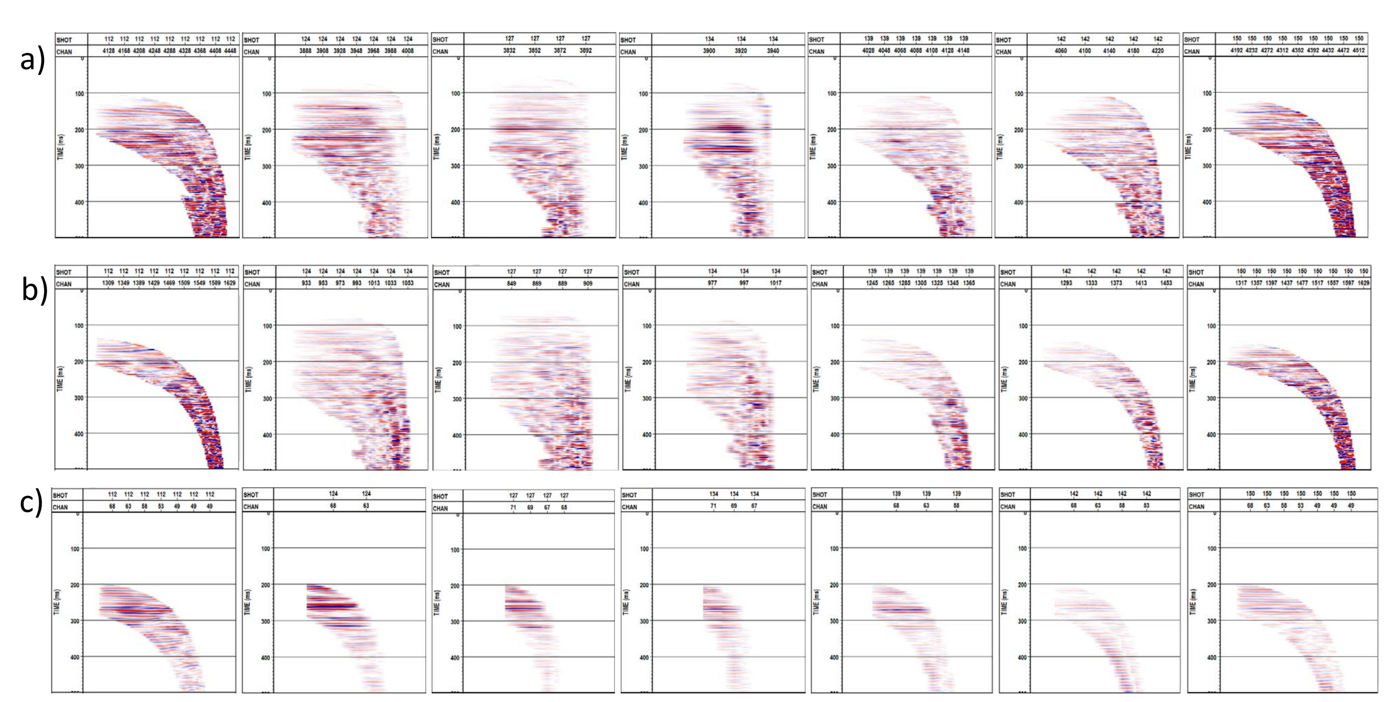

Figure 5. VSP-CDP transforms at different offsets. a) Straight fibre, b) helical fibre, c) geophone vertical component.

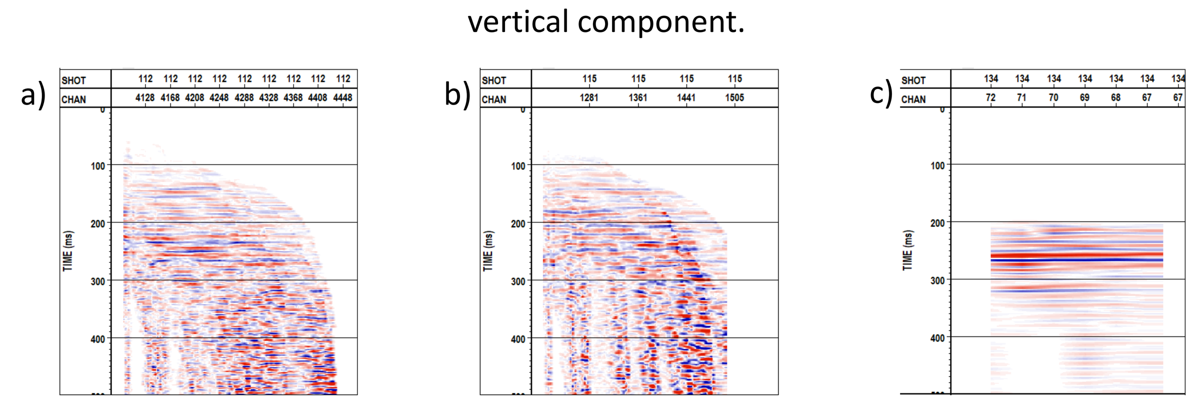

Figure 6. VSP-CDP stacks. a) Straight fibre, b) helical fibre, c) geophone vertical component.

Results

The stacked sections obtained were compared with an inline of a 3D seismic survey acquired at the FRS in 2014 that crosses the observation well 2.

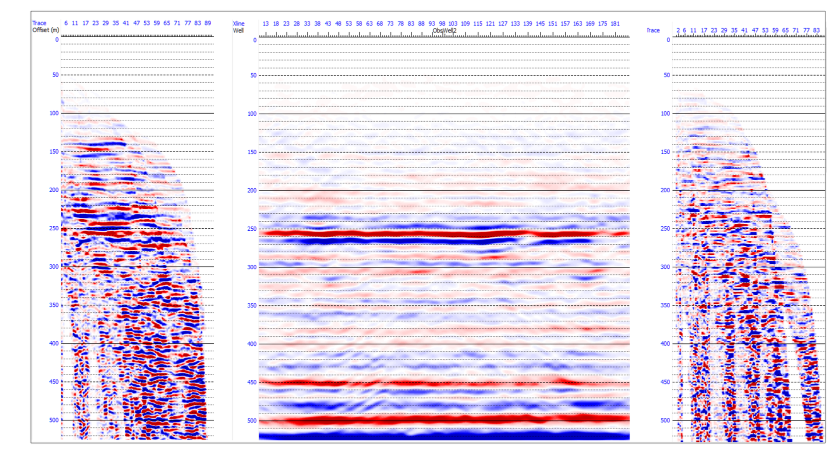

Figure 7. Raw DAS stacked section compared to surface seismic section. Straight fibre (left) and helical fibre (right).

Figures 7, 8 and 9 display the stacked sections of raw DAS, integrated DAS and geophones with the surface seismic in the centre. The CO_2 injection target located at 250 ms is noticeable in each data set. However, straight DAS seems to have a better display of the target of interest compared to the helical fibre.

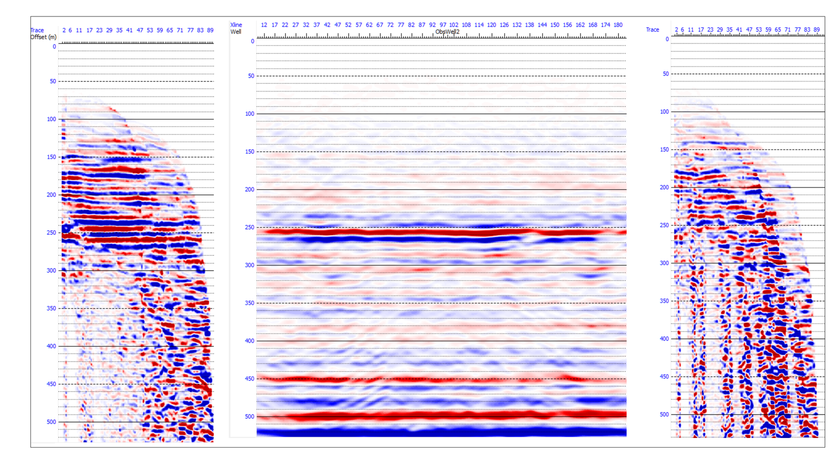

Figure 8. integrated DAS stacked section compared to surface seismic section. Straight fibre (left) and helical fibre (right).

The geophone dataset shows a good correlation between the surface seismic and the stacked sections of the walk away VSP. The vertical component section yields flatter events compared to the rotated geophone data. This might be associated with remaining SV waves after the rotation and time-variant orientation.

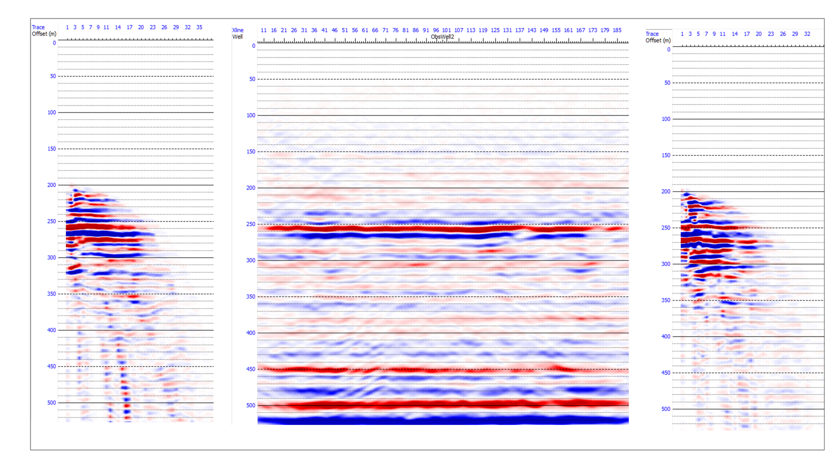

Figure 9. Geophone stacked section compared to surface seismic section. Geophone vertical component (left), rotated geophone (right).

Overall, the three datasets yield a good imaging result that can be correlated to surface seismic data. The event of interest was identified in each dataset and it also matched the surface seismic. DAS dataset also shows more seismic events in the shallow section that could be helpful for further studies of the overburden section.

Conclusion

- A walk away VSP line acquired at the Field Research Station in July 2017 was processed while performing a thorough comparison between the DAS and geophone datasets. The analysis included the assessment of the straight and helical wound fibre optic cables as well as the geophones vertical component and multicomponent data. Additionally, the same procedure was applied to the integrated DAS datasets.
- There is a good correlation between the DAS datasets and the geophones. Having a full coverage of the fibre optic cables in the well yields better imaging results in the shallow section. A clear identification of the target was achieved for the raw and integrated straight fibre, although the results obtained for the helical fibre seem less continuous in the zone of interest.
- The stacked sections also show a good correlation with an inline from a 3D surface survey passing through observation well 2. This comparison gives us a positive effect on DAS applications for subsurface imaging while encouraging us to continue with the study of DAS measurements in particular for the helical fibre.

ACKNOWLEDGEMENTS

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