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Time-lapse DAS monitoring at the CaMI Field Research Station, Newell County, Alberta

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Summary

Different walk-away and walk-around vertical seismic profiles (VSP) surveys were acquired at the CaMI Field Research Station (FRS) in Newell Country, Alberta. These surveys were recorded with different types of receivers, such as a 24-level three-component geophone array and a fiber optic cable of both distributed acoustic sensing (DAS) and distributed temperature sensing (DTS). Two DAS walk-around VSP datasets used OptaSense ODH-4 interrogetor acquired from September 2020 and March 2021 are processed and discussed in this abstract. The presence of azimuthal anisotropy in this area is indicated by the sinusoidal variation from the plot of first break traveltime versus source-receiver azimuth. The fracture orientation is indicated by the azimuth where the minimum traveltime (trough) in this plot occurs. The application of both median filter and F-K filter sufficiently remove downgoing waves from the DAS datasets. Corridor stacks for the walk-around VSP are obtained from upgoing P waves, and time shift and other time-lapse differences are calculated between the two vintages of DAS datasets. Results show that DAS could be a reliable measurement for time-lapse monitoring of subsurface CO_2 storage and sequestration.

Introduction

The Containment and Monitoring Institute (CaMI), in collaboration with the University of Calgary, established Field Research Station (FRS) which locates approximately 200km southeast of Calgary. The main objective of FRS is for the test and development of different subsurface and surface measurement technologies about carbon capture and storage (CCS) and to efficiently monitor CO_2 sweep. The Basal Belly River Sandstone (BBRS) is the target formation for CO_2 injection at FRS. This formation is composed of fine to medium-grained sandstone with the thickness of 7m (~ 295 to 302m in depth; Macquet and Lawton, 2017). The BBRS injection zone is sealed from above by Foremost formation which is composed of clay sandstone of 152m thickness (Macquet and Lawton, 2017).

There are one vertical injection well and two vertical observation wells at the FRS. Helical and straight fiber optical cables in both borehole and trench are continuously connected in a loop with the total length of about 5km (Figure 1). This abstract focuses on the data with the straight fiber in observation well #2 in Figure 1. The source for the VSP survey of September 2020 is AHV-4 vibe with the sweep of 2–180 Hz and March 2021 is Envirovibe with the sweep of 10–150 Hz. Figure 2 shows the well locations and the walk-around shot locations of the survey September 2020 and survey March 2021. The acquisition repeatability from Figure 2 is considered good. We display a shot gather for the survey 2020 and 2021 respectively of the same location in Figure 3. Black dashed lines in Figure 3 indicate data from the straight fiber of well #2 (Figure 1). The data was then processed through the Vista processing software. As only around 0.85 tonne of CO_2

was injected between September 2020 and March 2021, highly repeatable time-lapse processing and time-lapse equalization procedures (Wang and Morozov, 2020) are necessary.

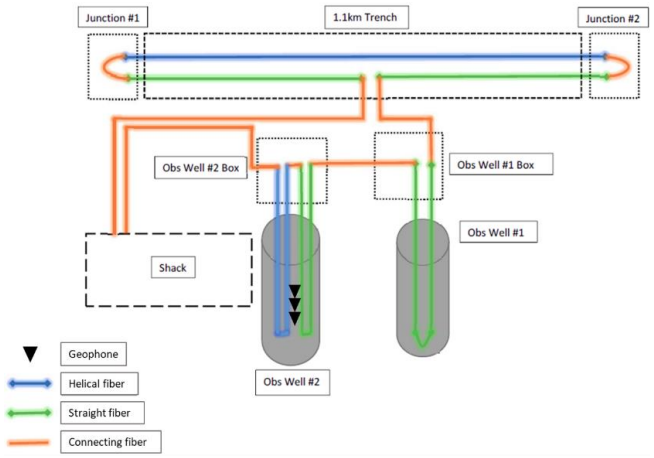

Figure 1. Layout design of optical fiber Cable at the CaMI FRS (Lawton et al., 2019).

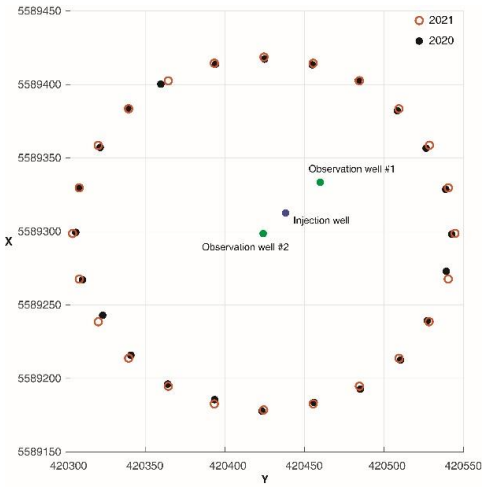

Figure 2. Well locations and walk-around shot locations from survey 2020 and 2021.

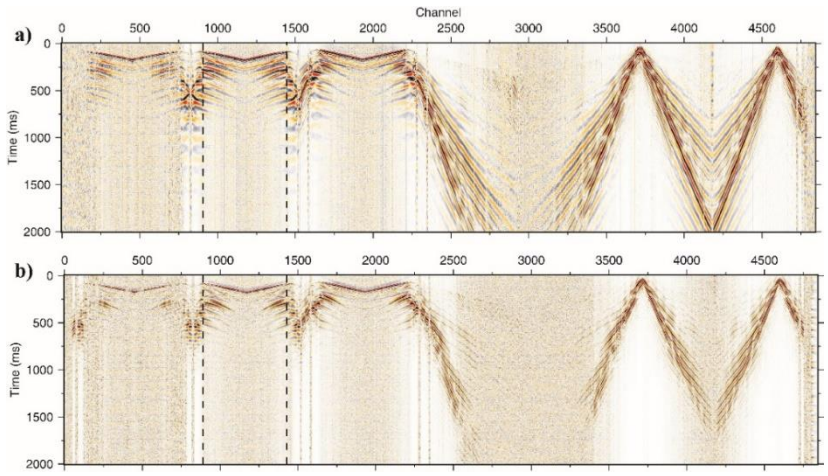

Figure 3. Shot gather of the same location of VSP DAS survey (a) September 2020 and (b) March 2021.

DAS VSP Processing

This section shows the removal of downgoing waves for survey 2020 DAS data from the straight fiber of well #2 (portion between black dashed lines in Figure 3a). After depth registration, the processing for the straight fiber DAS data is the basic steps in VSP processing. Figure 4 shows the shot gather before and after a median filter. First break arrivals are picked from the data in Figure 4a. There are remaining tube and downgoing P or S waves after the median filter in Figure 4b. We then apply a F-K filter, shown in Figure 5. Figure 5a shows that the remaining tube and downgoing waves are removed after the F-K filter, and Figure 5b also displays the rejection zones (shaded areas) of the F-K filter. The rejection zones in Figure 5b cover all the waves with the

negative wave number (downgoing waves), low-frequency noises, tube waves, and upgoing converted (P-S) waves. After other basic VSP processing steps such as deconvolution, bandpass filter and automatic gain control, corridor stacks are obtained for this walk-around VSP survey. We apply the same processing flows and parameters for the survey 2021 DAS data to keep the processing repeatability.

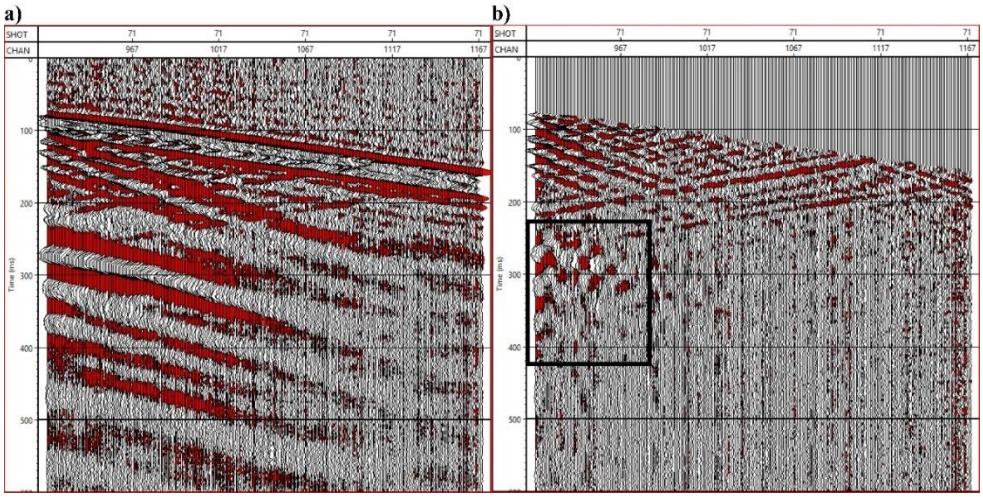

Figure 4. DAS shot gather (a) before and (b) after a median filter. Black rectangle indicates the remaining tube waves.

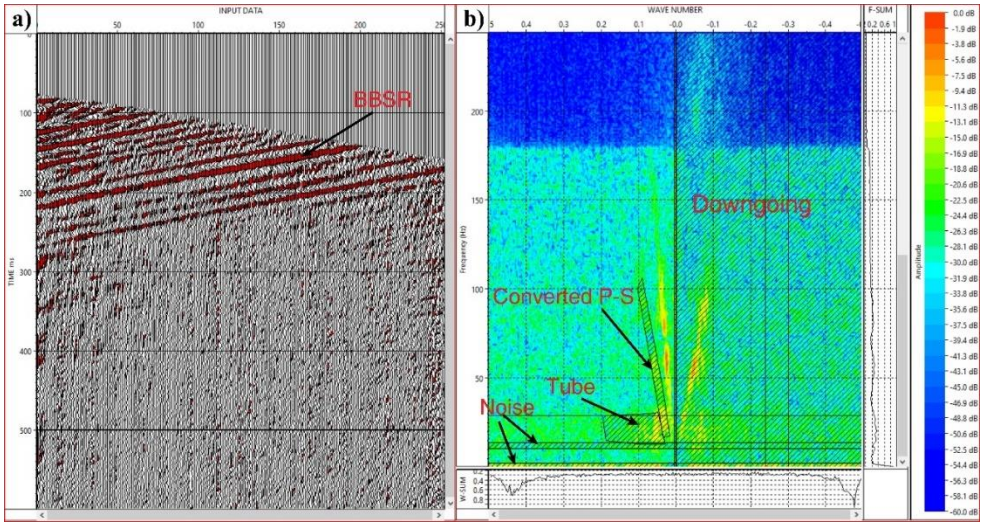

Figure 5. (a) DAS shot gather in Figure 4b after F-K filter and (b) F-K panel with rejection zones. BBSR reflection is indicated in plot (a). The F-K panel is calculated from Figure 4b and the corresponding waves of rejection zones are indicated.

Results

The first break traveltime of the walk-around VSP versus source-receiver azimuth is shown in Figure 6. The minimum traveltime of about 90E azimuth may indicate the orientation of vertically aligned fractures. The outside corridor stacks of walk-around VSP from survey 2020 and 2021

are shown in Figure 7. The BBSR injection zone is indicated. Before any time-laps equalization, there is about 1ms time shift between the BBSR reflections of the two DAS vintages. The small amount of injected CO_2 (0.85 tonne) during this period requires further processing and analysis.

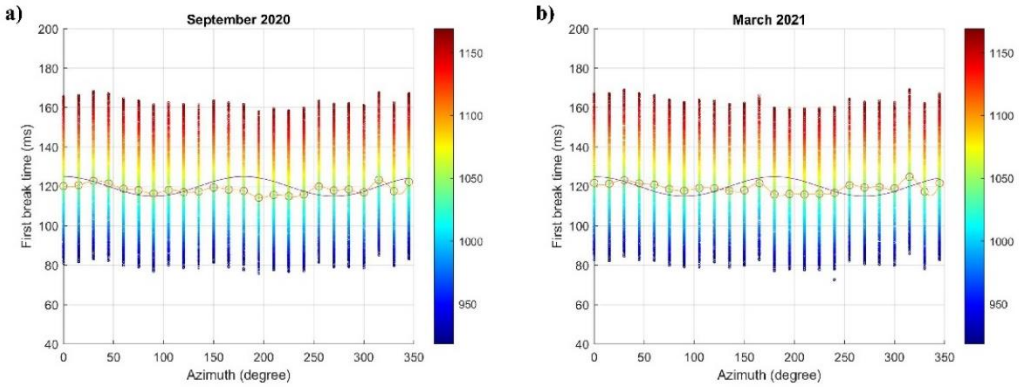

Figure 6. First break traveltime versus azimuth for survey (a) September 2020 and (b) March 2021. The colorbar indicates the channel number (larger number of deeper depth). The dot of each azimuth is the median value of all the first break traveltimes. The solid line is a cos(2ϕ) fit.

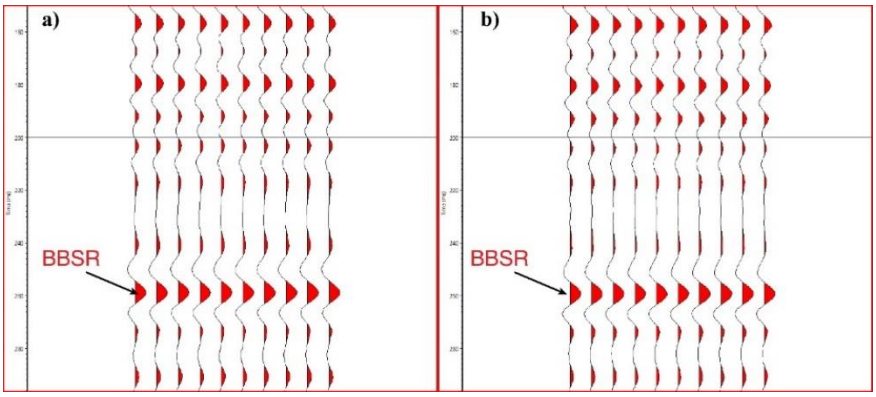

Figure 7. Outside corridor stack of survey (a) September 2020 and (b) March 2021.

Acknowledgements

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