Breakthrough in operational model: testing offshore focused seismic for CS monitoring in Denmark

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Introduction

A new offshore monitoring solution has been tested in conjunction with CO_2 injection taking place on project Greensand (EUDP co-funded research project 64021-9005).

The goal of the Greensand monitoring is to focus the measurements on critical areas of the subsurface (spots) to better constrain the existing flow model of CO_2 injection, while not providing a full image of the subsurface (Brun et al, 2022). The main innovation of this operational model is the use of a 600 in^3 tri-gun source, containerized with all its equipment on a standard supply vessel, to perform a static shooting.

This low-cost operational model with a low impact on the environment and offshore activities, has proven its efficiency in detecting CO_2 injection.

Operations

The seismic baseline was acquired in January 2023, before CO_2 injection in the North Sea. Two monitors were then acquired in March 2023.

The operational model makes use of one source and one node location per spot to monitor specific locations in the subsurface (Szabados et al., 2022).

The seismic source consisted of three 200 cui airguns, shooting 80 times at each of the 7 stationary source locations (Figure 1). 25 ocean bottom nodes were deployed by ROV at 20 different positions. Nodes stayed at sea floor between the 3 acquisitions.

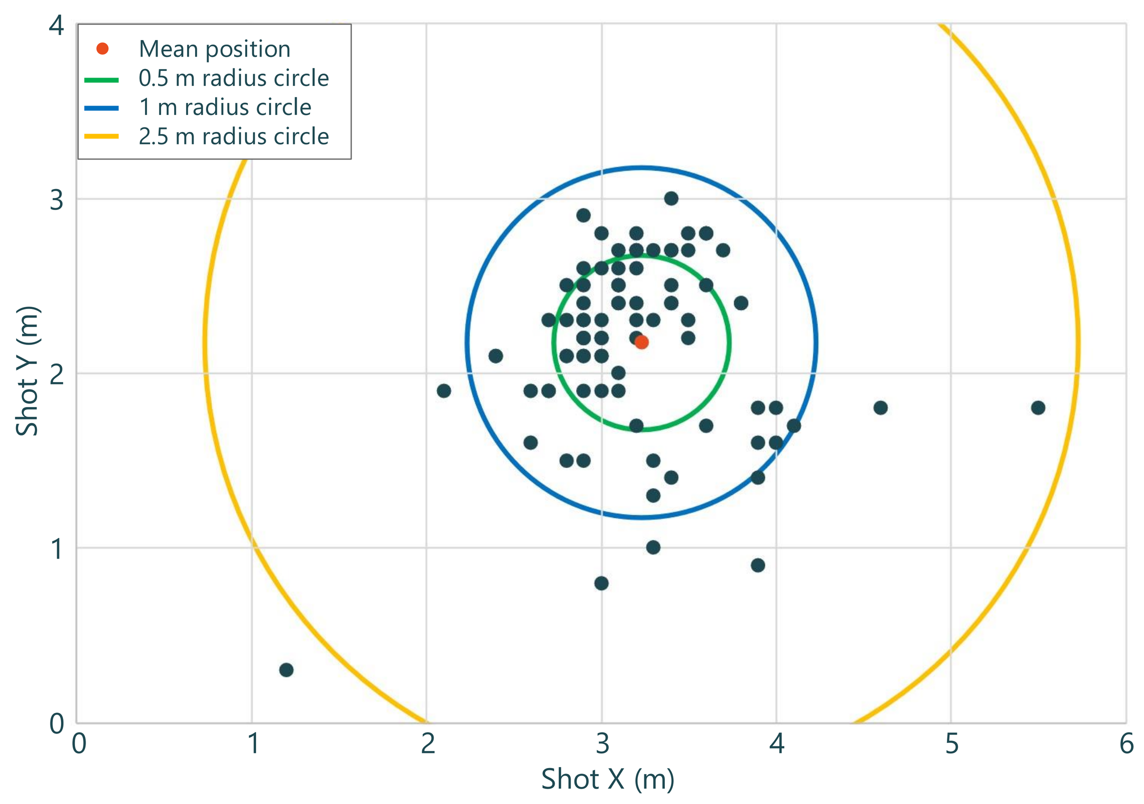

Figure 1 : Source position during each of the 80 shots over one acquisition. 90% of the shots are inside a 1 m radius circle, which is deemed acceptable (Brown et al., 2011).

As a result, the baseline survey was performed in approximately 30 hours.

This static operational model has a reduced environmental and operational footprint with regards to marine life and fishing activities. The solution can be adapted to temporary local obstructions (maritime traffic for example) or permanent obstructions (offshore wind farms for example).

Geophysical results

To assess the data quality, a frequency filter of 30-70 Hz was applied to remove low frequency noise. Thanks to the good quality of this seismic data, the strong event (base reservoir) visible at the spot target on the 3D migrated stack (NODAB97) is also visible on the 2023 acquisition (Figure 2). Seismic events above and below the area of interest are clearly visible on 2023 Greensand data acquired with the 600 in^3 tri-gun source.

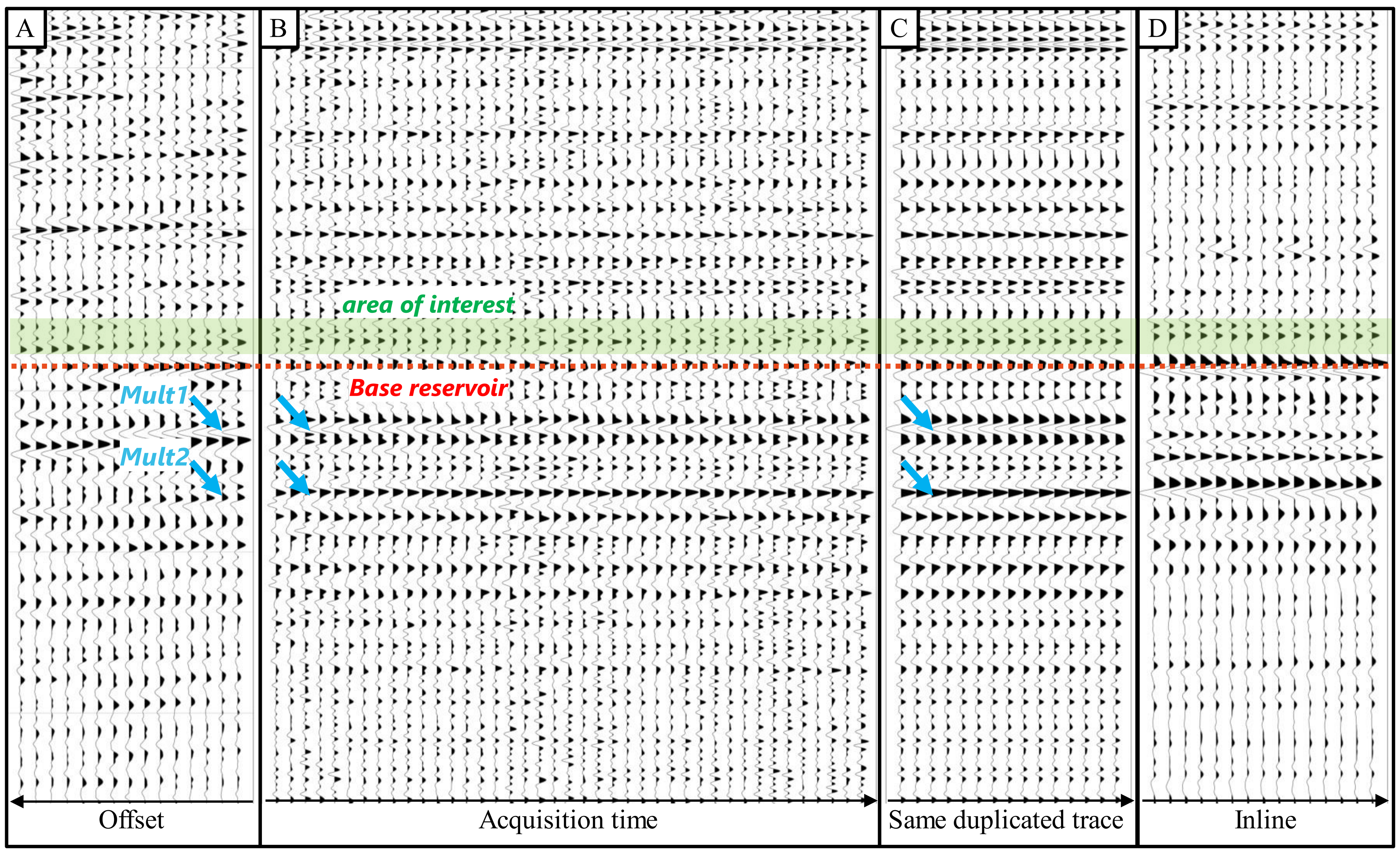

Figure 2 : Comparison between data from 1997 NODAB survey and 2023 Greensand acquisition. A) Shot point of streamer NODAB97 acquisition, corrected by normal move-out. B) 2023 Greensand baseline acquisition (40 traces out of the 80 shots). C) Stacked and duplicated traces from the 2023 Greensand baseline acquisition. D) Migrated stack (NODAB97). On raw data (a-b-c), the first and second multiples (Mult1 & Mult2) of the base reservoir are visible. The area of interest is located above the base reservoir.

Conclusion and acknowledgements

The demigration of the original 3D seismic (Morgan et al., 2020), the very good data quality and the temporal stack of the 80 repeated traces allows for the detection of CO_2 injection in the reservoir after processing. A local polarity inversion is visible only at the injection spot (Figure 3), as was expected after the initial modelling phase.

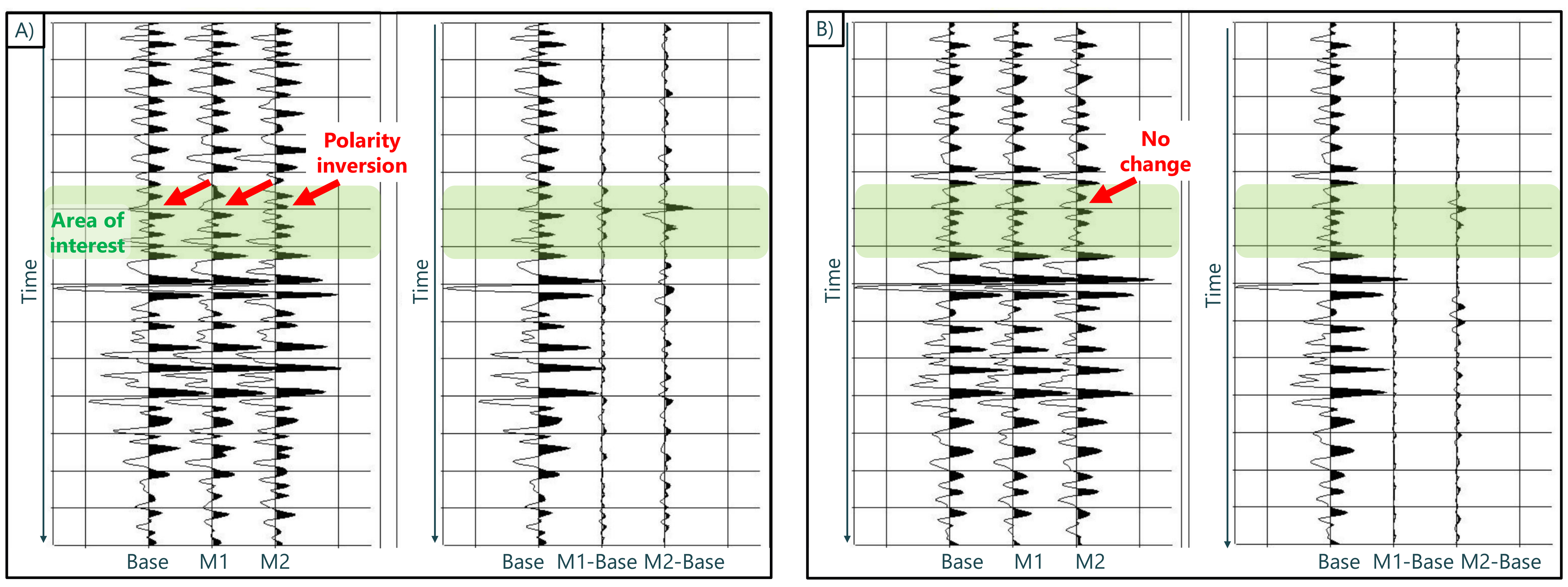

Figure 3: Seismic traces of base, monitor 1 (M1) and 2 (M2) after processing, following the method presented in Al Khatib & Mari 2023. A) Injection spot showing a polarity inversion (red arrow). B) Control spot 150 m away from the injection, showing no change.

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Refences

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