The European project SUCCEED for coupling Geothermal Energy and CCUS: Distributed Acoustic Sensing (DAS) technology for active seismic CO2 storage monitoring

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The SUCCEED project

Geothermal energy is a natural and renewable energy source, but geothermal power production generates greenhouse gas (GHG) emissions, in particular CO_2. Some studies estimated that the GHG emission from geothermal power plant can be higher than 1000 g/kWh (Fridriksson et al., 2017).

In the view of reducing CO_2 emissions (carbon capture utilization and storage - CCUS) from geothermal power plants, for climate change mitigation purposes, the ***Synergetic Utilisation of CO_2 Storage Coupled with Geothermal Energy Deployment (SUCCEED) ACT project (2019-2023)*** aims to prove the feasibility of re-injecting the emitted CO_2 into the same geothermal system to improve its performance and in the meanwhile to permanently storage the CO_2 by mineralization. The project investigated two different existing geothermal power plants, one is the Kizildere geothermal field (East of Büyük Menderes graben in Western Anatolia, Turkey), the other, illustrated here is the Hellisheiði geothermal field (Iceland).

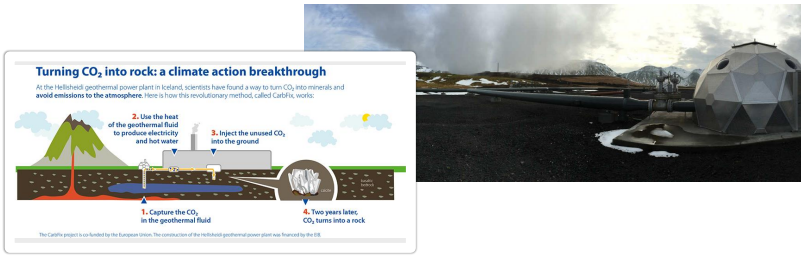

Figure 2: (up) Hellisheidi geothermal field (from SUCCEED website: https://t.ly/jGtru) and (left) working scheme of the Hellisheidi geothermal field (from web – CarbFix project: https://www.eib.org/en/stories/iceland-volcanos-produce-energy-fight-climate-change)

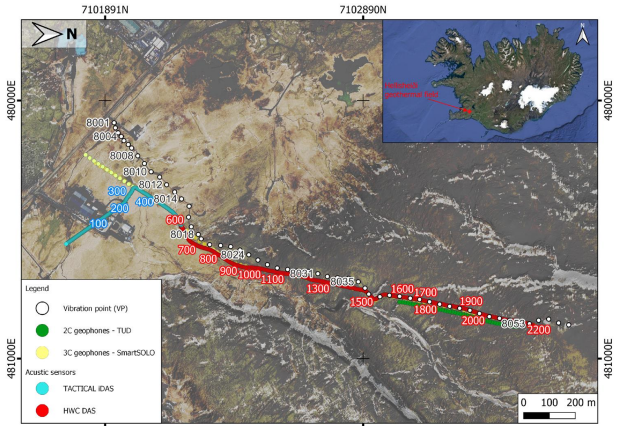

Figure 1: Map of Hellisheidi acquisition, modified after Bellezza et al., 2024.

The Hellisheiði geothermal field

In the framework of the project, our research focused on the ***development of innovative reservoir-monitoring technologies tested at the Hellisheiði geothermal field***, an active geothermal power plant located in the southern part of the Hengill volcanic system in the southwestern Iceland (Figure 1 and 2), close to the city of Reykjavik. The Hengill volcanic system is constituted by a central volcano and a fissure swarm with a graben structure that extends to the northeast and southwest and it is located at the junction of Reykjanes Volcanic Belt (RVB), the Western Volcanic Zone (WVZ) and the South Iceland Seismic Zone (SISZ) (Jóhannesson and Sæmundsson, 1998).

The monitoring experiment

The Hellisheiði geothermal field has a temperature higher than 300°C at a depth of 1000 m below sea level and the steam combined heat and power plant is one of the biggest in the world with an installed production capacity of 303 MWe and 210 MWh of energy. The CO_2 is added to the re-injected geothermal fluid as dissolved gas. The monitoring experiment consisted in a baseline and a time lapse survey after a long-lasting, continuative (a few months) injection of CO_2.

The monitoring is performed by active-source seismic data acquisition using a novel electric seismic vibrator source (E-Vibe) and permanently installed Helically Wound Cable (HWC) fibre-optic distributed acoustic sensors (DAS) in shallow trenches. Figure 3 illustrates the resulting time-stacked section from the baseline HWC DAS acquisition (July 2021) to investigate the complex basaltic system prior the CO_2 injection. At the same time, two co-linear acquisitions have been done with two- and three-components geophones (2-C and 3-C) to validate the results from the baseline HWC DAS system.

The results showed a good consistency in the reflected events and helped to define the reservoir where we expect the injected CO_2 to be stored (Bellezza et al., 2024). We also show the preliminary results from the time-lapse acquisition (Figure 4) acquired by the only HWC DAS system (June 2022) to highlight the variation in the reflected events after the injection of the CO_2 (Figure 4).

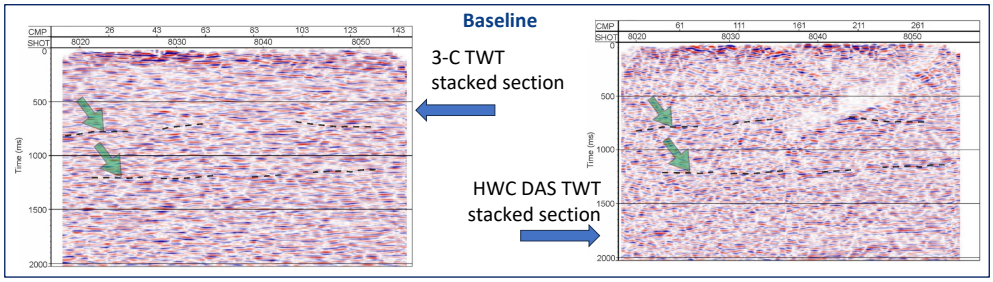

Figure 3: Base line time stacked section from 3C (left) and HWC (right) survey. The green arrows and the dashed lines indicate the expected reservoirs in two-way travel time.

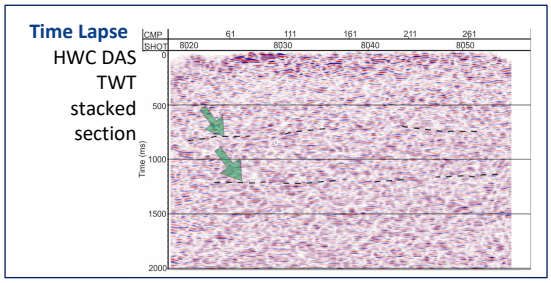

Figure 4: preliminary results from the time-lapse acquisition. The green arrows and the dashed lines indicate the expected reservoirs in two-way travel time.

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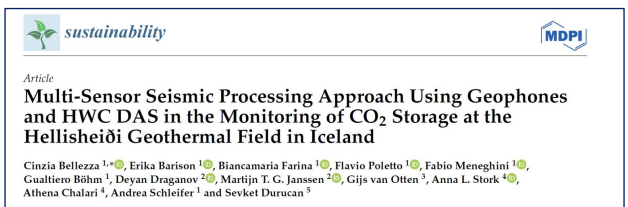
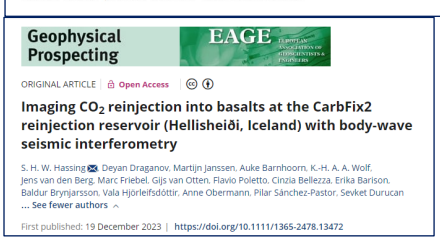
Acknowledgements

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