



D1.7 Project report on capabilities of new SV-wave source

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Digital monitoring of CO₂ storage projects

Abstract

D1.7 Project report on capabilities of new SV-wave source

by

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The full elastic seismic wavefield propagates through an isotropic Earth consisting of a P-wave component and two shear wave (SV and SH) components.

Usually, the near-surface shear-wave seismic surveys typically employ horizontally polarized (SH) waves because they are more easily distinguished from compressional (P) waves, and they generally do not convert to P waves as readily as vertically polarized shear (SV) waves (Haines 2007). Also, at the moment, there are no high-power SV-sources on the market. Therefore, Geotomographie GmbH developed a novel SV source which is described in Deliverable D1.7. The following steps in the process of development were described in detail:

- design and construction of a test rig;
- the execution of experiments to determine the optimal coil configuration (number of turns, wire thickness) to obtain statements regarding the adequate immersion depth of the soft metal core for a resulting optimal acceleration strength and a measurement of the rise time up to the max. acceleration;
- Since we could not say with certainty for a long-time which principle of action delivers the best signals, we pursued a parallel source development with two different principles of action based on the induction principle and the alternating current principle.
- Design of both sources with a selection of optimal materials;
- Necessary optimization of laboratory tests for both operating principles;
- Construction of the prototype of the novel SV probe (BIS-SV);
- Field tests for handling and reproducibility of the measured signals of the novel SV probe in Hannover, Germany;
- 10-day field experiment at the CCS site in Svelvik/Norway; successful test of the novel SV-source;
- Improvement of the SV source design, especially with respect to the coil formers and materials based on the experiences during the first field tests;
- Further field tests from May- October 2022;

This deliverable D1.7 describes the application and the benefit of using SV-data for (1) joint inversion of P-, SH-, and SV-data, (2) the determination of anisotropy effects, and (3) stress history of soils. The performance of tomographic measurements with simultaneous acquisition of P-, SH- and SV-waves enables the provision of a complete data set for the calculation of elastic moduli, the change of stress states during, e.g., the injection of CO₂ as well as the measurement with fiber optic sensors.

Thus, due to its physical properties, the storage of CO₂ in a formation may result in a change in stress due to changes in the elastic properties of the soil (local uplift), and changes in stress states could potentially be detected with SH- and SV- wave measurements. Also, this novel SV-source improves the practicability of S-wave tomography by faster handling (up and down shooting). All seismic sources available at Geotomographie GmbH (P-wave: SBS42; SH-wave: BIS-SH and SV-wave: BIS-SV) are powered by the same HV impulse generator (IPG5000), which leads to reduced costs. The novel SV source will be added to Geotomographie's portfolio and marketed starting in spring 2023.

Source:

Haines, S. S. (2007). A Hammer-impact, aluminum, shear-wave seismic source, U.S. Geological Survey