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# First results of 3D VSP imaging with DAS technology at the geothermal research site Groß Schönebeck /Germany

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In early 2017, a high-resolution 3D reflection seismic and an extended Vertical Seismic Profile (VSP) survey were conducted at the Groß Schönebeck in-situ geothermal laboratory situated 50 km northeast of Berlin. The site offers geological conditions typical for a broad part of Northern Europe. Therefore, the gained knowledge can be generalized to the region or applied to other regions with similar geological conditions. The target reservoir zone is represented by siliciclastic sediments and volcanic rocks of Lower Permian (Rotliegend) age, and overlain by Zechstein salt.

The 3D surface seismics covers an area of 8 km x 8 km with a focus on reservoir depths of 4000 to 4300 m to improve the comprehension of the geological structures (specifically the spatial distribution of the fault systems). The main objectives for the 3D VSP survey were to derive a detailed imaging around the existing boreholes, to improve the seismic interpretation in the reservoir interval (horizon allocations, stratification, litho-units, spatial distribution of reflection interfaces) and to map potential occurrences of free gas and fractures generated by hydraulic stimulation. Results of both methods will be combined and support the planning of a new research well at the site.

The VSP measurements were performed in the two 4.3 km deep wells E GrSk 3/90 and Gt GrSk 4/05 using Distributed Acoustic Sensing (DAS) technology on wireline cable with a channel spacing of 5 m. DAS is a relatively young method of data acquisition, which allows to use a fiber optic cable as an array of sensors for the measurement of particle motion. This method measures the strain variation on the fiber to characterize the acoustic signal. Limitations of the method currently include e.g. higher noise levels, uncertainty of depth determination, and directional dependence of the amplitude response on the angle of incidence. The VSP datasets were recorded during four days with one day for pre-survey start-up tests and three days of data acquisition. The 61 vibro source points (VP) were arranged in a spiral pattern around the target area, with offsets of 200 to 2000 m.

Datasets from all source points were processed uniformly, followed by Kirchhoff depth migration. During data analysis, a strong coherent noise was discovered, possibly caused by poor coupling of the sensor cable to the borehole casing. A time-frequency domain noise attenuation procedure was applied in affected depth intervals, and resulted in improved image quality for the reservoir analysis. DAS VSP images provide higher vertical and lateral resolution than surface seismics in the target zone. Reaching a depth of greater than 4.2 km , it has moreover been proven the first time that such depths can be surveyed with DAS, allowing for widespread future applications.