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Wavelet transform-based 3D seismic facies analysis for geothermal exploration in Groß Schönebeck, NE German Basin

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At the geothermal site near Groß Schönebeck (NE German Basin), a new 3D seismic reflection experiment was carried out in February/March 2017. The location serves as a research platform to test technologies for the geothermal usage of porous and/or fractured sedimentary and volcanic rocks of the Rotliegend formation. Within those target layers, temperatures of around 150 deg C are encountered between 4000 and 4300 m depth. A background geological model was established from existing 2D seismic reflection lines and borehole information during an early stage of the research activities. Over the last 15 years, a broad spectrum of geoscientific studies and a series of geothermal stimulation tests were carried out by use of boreholes GrSk 3/90 and GrSk 4/05. A review of lessons learned so far and problems encountered in the past led to suggestions for new drilling concepts and modified stimulation strategies. The new 3D seismic survey was conducted to deliver detailed knowledge on geological structures and reservoir characteristics which are required for the implementation of the new concept of geothermal exploitation.

We show results of a full waveform-based seismic facies analysis of the 3D seismic data applied to the Rotliegend reservoir horizons. First, the input data used in this study were generated by application of a processing sequence which included two types of stacking: NMO-based stacking and more advanced Common-Reflection-Surface (CRS) stacking.
The facies analysis is then carried out in the time domain in which stacked and time-migrated data are considered. Horizons to be analysed are identified by time-depth conversion at borehole GrSk 3/90 and comparison with lithostratigraphy. Full waveforms are analysed along horizons by application of a continuous Morlet wavelet transform. For comparison, a set of complex trace-based attributes is determined for each signal. The derived waveform characteristics serve as input information for a cluster analysis which is carried out using the method of self-organizing maps. As a result, the waveforms observed along the horizons are sub-divided into groups, where each group shows specific signal characteristics. The mapping of the class members reveals waveform variations which are interpreted in terms of sedimentological heterogeneity across the horizon. This kind of seismic reservoir characterization can be used to identify reservoir compartments and to design optimal drilling pathways.