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Combined interpretation of 3D seismic reflection attributes for geothermal exploration in the Polish Basin using self-organizing maps

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Self-organizing maps (SOM) are neural network techniques which can be used for the joint interpretation of multi-disciplinary data sets. In this investigation we apply SOM within a geothermal exploration project using 3D seismic reflection data. The study area is located in the central part of the Polish basin. Several sedimentary target horizons were identified at this location based on fluid flow rate measurements in the geothermal research well Kompina-2. The general objective is a seismic facies analysis and characterization of the major geothermal target reservoir.

A 3D seismic reflection experiment with a sparse acquisition geometry was carried out around well Kompina-2. Conventional signal processing (amplitude corrections, filtering, spectral whitening, deconvolution, static corrections, muting) was followed by normal-moveout (NMO) stacking, and, alternatively, by common-reflection-surface (CRS) stacking. Different signal attributes were then derived from the stacked images including root-mean-square (RMS) amplitude, instantaneous frequency and coherency. Furthermore, spectral decomposition attributes were calculated based on the continuous wavelet transform. The resulting attribute maps along major target horizons appear noisy after the NMO stack and clearly structured after the CRS stack. Consequently, the following SOM-based multi-parameter signal attribute analysis was applied only to the CRS images.

We applied our SOM work flow, which includes data preparation, unsupervised learning, segmentation of the trained SOM using image processing techniques, and final application of the learned knowledge. For the Lower Jurassic target horizon Ja1 we derived four different clusters with distinct seismic attribute signatures. As the most striking feature, a corridor parallel to a fault system was identified, which is characterized by decreased RMS amplitudes and low frequencies. In our interpretation we assume that this combination of signal properties can be explained by increased fracture porosity and enhanced fluid saturation within this part of the Lower Jurassic sandstone horizon. Hence, we suggest that a future drilling should be carried out within this compartment of the reservoir.