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Doctoral Thesis

Exploration of the practicality of walk-away VSP to specify elastic properties of geological medium

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The doctoral dissertation aims to investigate the usefulness of walk-away vertical seismic profiling (walk-away VSP) to specify elastic anisotropy of geological medium by using information only from P-wave.

Measurements were obtained at the well Wysin-1; it was the first walk-away VSP survey in Poland. An experiment was performed using a set of 96 geophones probe, which allowed for simultaneous measurement over a distance of 1425 meters. The research additionally used *Wysin-3D* seismic data and well log data from the well Wysin-1.

The research presents a detailed outline of VSP measurements supplemented by processing theory along with a description of a geophysical theory of elastic anisotropy and the slowness-polarization inversion of P-wave for obtaining anisotropy parameters. Grechka and Mateeva used this inversion for the first time on walk-away VSP data from the Gulf of Mexico; it was proven that this method can be used in a geological medium with notable contrast and elastic properties. The major goal of this study was to examine if the method can be used in the Silurian complex with very small differences between layers, where the anisotropy is extremely low (according to surface seismic studies).

The experimental measurements took place during heavy rain and poor weather conditions, therefore the quality of the recorded signal was low. To perform the P-wave slowness-polarization inversion, determining the errors of inclinations and slowness estimation was crucial. There were four different processing sequences studied. The purpose was to obtain the most accurate polarization angles in the entire depth range. Quantitative and qualitative analysis permitted selection of the best sequence and the additional signal-matching procedure was introduced before vertical stacking to minimize the polarization estimation errors.

The research allowed to determine the anisotropy parameters of the rock medium by only using information from the P-wave in the case of rocks with very small anisotropy. The presented processing scheme showed that the influence of highly attenuating seismic signal Zechstein formations can be overcome. It has been proven that the mentioned parameters can be useful for lithological correlation even when the receivers were placed almost entirely in the Silurian formations composed mainly of clay and mudstone with similar physical properties. It has been shown that placing only one receiver in a thin layer allows it to be distinguished in terms of elastic properties from the surrounding layers.

The presented analyses recommend further research of this method; they also show the validity of performing further acquisitions of this type in Poland, which will enable a better understanding of the observed wave phenomena in the context of the anisotropy of elastic properties of the rock medium.