

Shear Wave Splitting Analysis of Borehole Microseismic Reveals Weak Azimuthal Anisotropy Hidden Behind Strong VTI Fabric of the Lower Paleozoic Shales in Northern Poland

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ABSTRACT

Seismic anisotropy is an important factor when using geophysical techniques such as microseismic monitoring to image hydraulic fracturing. On the one hand, seismic anisotropy can affect the accuracy of event locations. On the other hand, measurements of azimuthal anisotropy can be used to image aligned natural fracture systems, and provide information about the orientation of the in situ stress tensor. The Lower Paleozoic shale plays in northern Poland are characterized by a strong (15-18%) Vertical Transverse Isotropy (VTI) fabric which dominates weak azimuthal anisotropy being of the order of 1-2%. Shear Wave Splitting (SWS) is a useful tool for estimating anisotropy from both surface seismic and microseismic data. When a shear wave travelling in the subsurface enters an anisotropic medium it is split into two orthogonally polarized waves travelling with different velocities. Splitting parameters which can be assessed using a microseismic array are polarization of the fast shear wave and time delay between the two modes. The polarization of the fast wave characterizes the anisotropic system on the wave path while the time delay is proportional to the magnitude of anisotropy along a ray path. We employ SWS technique for a borehole microseismic dataset collected during a hydraulic stimulation treatment located in northern Poland. Using a 11-receiver string located 150-300 m above the target shale formation we image fracture strike masked by a strong VTI signature. During the inversion part, the VTI background parameters were kept constant using information from 3D seismic (VTI model used for pre-stack depth migration). Due to integration of parameters obtained by microseismic monitoring and 3D seismic it became possible to characterize weak azimuthal anisotropy hidden behind strong VTI. Obtained fracture azimuths averaged over fracturing stages are consistent with the available XRFMI imager logs from the nearby vertical well, however they are different from the large-scale present-day maximum stress direction (by 40-45 degrees). Inverted Hudson's crack density (ca. 2%) is compatible with the low shear-wave anisotropy observed in the cross-dipole sonic logs (1-2%). This work has been funded by the Polish National Centre for Research and Development within the Blue Gas project (No BG2/SHALEMECH/14). Data were provided by the PGNiG SA. Collaboration with University of Bristol was supported within TIDES COST Action ES1401.