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Comparison of fracture detection with P- and S-wave based on walkaround vertical seismic profiling data

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Fracture-introduced anisotropy in subsurface strata can lead to S-wave splitting and the variations of P wave velocity and amplitude at different directions of shots to geophones. These P- and S-wave characteristics can be used to detect fractures. The fracture parameters can be calculated by P- or S-wave signals from multicomponent data with omnidirectional coverage. Owing to the different responses of P- and S-wave to fractures, the accuracy, robustness, and applicable conditions of such waves in practical applications are different, which requires comparison testing. We use a set of three-component walkaround vertical seismic profiling (VSP) data to conduct comparative experiments to explore how the two waves can jointly describe fractures. By comparing and analyzing the fracture prediction results of P- and S-wave, we draw the following conclusions: (1) For the fracture direction of the target layer, the P- and S-wave are consistent in terms of general trend. (2) The anisotropy of the P wave in the near-zero-offset range is weak, and that in the far offset is strong, while the shear wave is not effected by offset. (3) Shear-wave-splitting analysis method can predict the orientation and relative density of the fracture at every imaging point in the survey area. P-wave method can only predict the direction and strength of the dominant fractures in the entire survey area. (4) P-wave method is more robust than S-wave splitting analysis method. Therefore, S-wave splitting is the main method used to describe the distribution of fracture details in the entire area, and P-wave method is usually used as a verification tool to determine the overall fracture trend. Our work was supported by the National Natural Science Foundation of China (41804132, 41574126, 41425017) and the Fundamental Research Funds for the Central Universities (2-9-2017-452).