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The Prediction of Orthorhombic Differential Horizontal Stress Ratio for Shale Reservoir

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ABSTRACT

The effective prediction of in-situ stress plays an important role in the exploration and development of shale reservoirs. The differential ratio of the maximum and minimum horizontal stresses (DHSR) is one of the important parameters for prediction of hydraulic fracture. Here we present a new equation which is derived for expressing the differential ratio of the maximum and minimum horizontal stresses in orthorhombic anisotropic media. Apart from that, the new approach based on azimuthal anisotropic elastic impedance inversion is proposed to evaluate Orthorhombic Differential Horizontal Stress Ratio (Named as ODHSR) robustly. In this paper, we considered the effects of vertical anisotropy and horizontal anisotropy on shale reservoirs. According to the linear slip theory of Schoenberg and Sayers, the compliance matrix of orthorhombic anisotropic media can be simplified to the sum of the background compliance matrix and the excess compliance matrix. The background media is vertical transverse isotropy (VTI) or some lower symmetry. Incorporating the generalized form of Hook's law, we derived the equation of principal stresses and Orthorhombic Differential Horizontal Stress Ratio. This equation establishes the relationship between seismic data and anisotropy parameters together with elastic parameters like S-wave velocity and density. With this equation, we estimate the stress indicator (ODHSR) with S-wave velocity, density, normal fracture compliance and anisotropy parameters. These parameters are derived from azimuthal-angle stack seismic gathers by azimuthal anisotropic elastic impedance (EI) inversion. One field case study from shale reservoir in the east of China is used to validate the application of azimuthal anisotropic elastic impedance inversion for ODHSR. Amplitude-preserved processing procedure has been implemented before inversion of the full azimuth real data. Subsequently, the six azimuthal-angle stack seismic gathers are used to obtain the inverted results of azimuthal anisotropic elastic impedance. The elastic parameters and anisotropy parameters for ODHSR are estimated from the inverted results of azimuthal anisotropic elastic impedance. It is seen that the ODHSR shows anomalously low value at well location obviously. Compared with the conventional inversion results, we can conclude that the proposed method can improve the accuracy in the prediction of optimal zones for hydraulic fracturing.