UR14

Application and Importance of Orthorhombic AVAZ Inversion

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Summary

Amplitude variation with azimuth (AVAZ) analysis plays an important role in characterizing both conventional and unconventional reservoirs. The AVAZ technique can provide information about stress and/or existing fractures in the reservoir, thus improving the ability to identify sweet spots and optimize drilling and fracking processes. In the case of fractured reservoir, orthorhombic symmetry can be considered the simplest realistic rock model. The unfractured reservoirs and shale, in particular, can be approximated as a transversely isotropic media with vertical symmetry (VTI). Adding a vertical fracture set to a VTI background rock results in orthorhombic symmetry. Unconventional reservoirs can also display strong reflectivity due to strong contrast between the layers. This is often seen in reservoirs located below high-velocity carbonates. Linearized AVAZ equations assume weak anisotropy and small contrast interfaces. as a results the linearized approximation of the PP-reflectivity will not adequately represent the AVAZ response and nonlinear Zoeppritz equations are required to model the PP-reflectivity correctly. This presentation will focus on the importance and the application of the orthorhombic AVAZ inversion and inversion results from examples from the unconventional play in the Middle East and North America will be shown.

Introduction

Amplitude variation with azimuth (AVAZ) analysis plays an important role in characterizing both conventional and unconventional reservoirs. The AVAZ technique can provide information about stress and/or existing fractures in the reservoir, thus improving the ability to identify sweet spots and optimize drilling and fracking processes. In the case of fractured reservoir, orthorhombic symmetry can be considered the simplest realistic rock model. The unfractured reservoirs and shale, in particular, can be approximated as a transversely isotropic media with vertical symmetry (VTI). Adding a vertical fracture set to a VTI background rock results in orthorhombic symmetry. Unconventional reservoirs can also display strong reflectivity due to strong contrast between the layers. This is often seen in reservoirs located below high-velocity carbonates. Linearized AVAZ equations assume weak anisotropy and small contrast interfaces. as a results the linearized approximation of the PP-reflectivity will not adequately represent the AVAZ response and nonlinear Zoeppritz equations are required to model the PP-reflectivity correctly. This presentation will focus on the importance and the application of the orthorhombic AVAZ inversion and inversion results from examples from the unconventional play in the Middle East and North America will be shown.

Method

Orthorhombic AVAZ is an extension of the amplitude versus offset (AVO) inversion. It is an inversion of pre-stack wide azimuth (WAZ) seismic dataset in which P-impedance, VP/VS ratio, density, the direction of the principal axis and the azimuthal anisotropy are inverted for. The inversion workflow (Figure 1) is a 3-step workflow in which step 1 includes feasibility test aimed to analyse the expected model resolution and uncertainty. In the second step, we estimate the azimuth of the principal axis associated with the orthorhombic symmetry and the last step includes the orthorhombic inversion. In the case of strong contrast interfaces, we use non-linear orthorhombic Zoeppritz equations to improve the model estimated by the linearized inversion (Gofer et al., 2017).

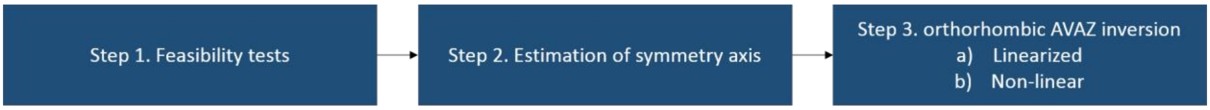

Figure 1 *Orthorhombic AVAZ inversion workflow*

Conclusion

Orthorhombic model is the simplest realistic model that can characterize AVAZ response from fractured reservoirs. The AVAZ inversion solves for a more realistic reservoir model in both conventional and unconventional plays. Finally, inversion results can be used to estimate fracture density and orientation, stress anisotropy, storage and access which will have a large impact on drilling, stimulation and completion decisions.

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References

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