AVO Modeling and Inversion of Anisotropic Effects in Shale

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Abstract

Velocity of seismic waves depends on the angle or direction of propagation, which is known as seismic anisotropy. Shale constitutes a major part of sedimentary basins and exhibits intrinsic anisotropy due to the grain alignment and mineral composition. The reflection coefficients within a reservoir are affected by the anisotropy of over and underlying shale. Reflection amplitudes also depend on the angle of incidence of the original ray, and the presence of anisotropy tends to give a group (ray) angle which is greater than the phase angle. If we know how the amplitudes of a reflector from a CMP, change with angle of incidence, we can estimate the physical properties of the rocks.

This study examines the effects of shale anisotropy (VTI) on AVO. Three gas sand models of different AVO classes (Class-I, Class-II and Class-III) with different degree of anisotropy were considered for AVO analysis. The AVO response from top of the reservoir is analyzed for all models whereas for base of the reservoir the AVO analysis results are poor and negligible. The AVO analysis reveals that the AVO effect increases with the increase of anisotropy. For class-I and class-II gas sands with overlying weak anisotropic shale, a decrease in amplitude and shifts in polarity reversal are observed respectively. For class-III gas sand with moderate to strong anisotropy assumption in overlying shale, more rapid increase in amplitude is observed.

AVO inversion results showed that under the assumption of isotropy, the elastic parameters (contrasts in acoustic impedance, shear impedance and density) are underestimated. In case of weak anisotropy the errors in elastic property estimation are small (5 % – 10 %) and negligible but in the case of moderate to strong anisotropy, such error can range from 25 % to 60 % respectively. Such large errors can make our results worthless.