Application of Isotropic Inversion to Orthorhombic Media: The Barrett Unconventional Model

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ABSTRACT

Geophysicists often relegate shale reservoirs as having higher symmetries (e.g., transversely isotropic or isotropic) than what reality demonstrates. Routine application of TI (or even isotropic) algorithms to orthorhombic media neglects the associated errors because we never know the true model in practice. We provide a genuine evaluation of isotropic post-stack and pre-stack seismic inversion to orthorhombic media using the SEAM Barrett Unconventional Model, the most realistic depositional model to date. The Barrett Model contains buried topography, simulated stratigraphy, isolated geobodies of varying elasticity, lateral heterogeneity, designated reservoirs zones, thin layer sequences, and orthorhombic anisotropy. We inverted the Barrett data volume for isotropic elastic property cubes, which we compared to the model volume in each symmetry-plane of an orthorhombic medium.

If the stacked seismic data contained only the near offsets, post-stack inversion resolved acoustic impedances that closely matched the true model both within and outside of the reservoir zones at all well locations. Anisotropy most affected the far offsets, so muting them predictably enhanced the inversion in comparison to maintaining all offsets without correcting for nonhyperbolic moveout. The pre-stack impedance attributes adequately described the vertical heterogeneity of the true model at a cross-validation well, but the inverted values increasingly relied on the initial model with depth. The inverted density estimates experienced notable oscillations relative to the initial model, particularly where steep contrasts in elastic properties occurred. Away from the well locations, the isotropic inversion gave no visual indication of reservoir geobodies, but it sufficiently described the elastic property variations near reservoir mid-sections. Moreover, we showed that the inverted elastic properties differ from their orthorhombic models by no more than 35%. The computed impedance models in each symmetry-plane have distinctive differences, but isotropic inversion dismisses these variations entirely. Consequently, isotropic inversion should not be a surrogate for orthorhombic methods in data preconditioning and quantitative reservoir characterization.

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