FEASIBILITY OF ISOTROPIC POST-STACK SEISMIC INVERSION IN ORTHORHOMBIC MEDIA USING THE BARRETT UNCONVENTIONAL MODEL

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ABSTRACT
High-symmetry (i.e., isotropic) algorithms are commonly applied to quantify elastic properties in unconventional shale reservoirs that have orthorhombic symmetry. In this study, we apply isotropic post-stack seismic inversion to a synthetic orthorhombic dataset to understand the viability of resolving elastic parameters with orthorhombic anisotropy but assumed isotropic. Previous efforts to explore the validity of isotropic inversion in anisotropic media have been limited to simplistic three layer models that are laterally homogeneous and might not even consider the orthorhombic case. Our work is done on the SEAM Barrett Unconventional Model. This model contains simulated stratigraphy, lateral heterogeneity, designated reservoir zones, and thin-layer sequences in addition to orthorhombic anisotropy—a much more realistic host than the aforementioned models. When the stacked seismic data contained only the near offsets, the inverted acoustic impedance profiles matched the true model very well within and outside of the reservoir zones among 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. Mismatch of the inverted impedance profiles at the well locations was attributed to noise, thin layers, band limitations, AVO signatures stacked into the data, an inaccurate starting model, and remnant effects of anisotropy not muted in the stacked section. Primary events with anomalous moveout behavior in the near offsets were removed. Elimination of these events caused inaccurate wavelet estimation and greater inversion error.
Inverted acoustic impedance profiles (red) overlain on the true model values (grey) and the initial model (blue) for each well location, including our cross-validation location at Well C. The reservoir zones are indicated. We can clearly see the close match between the inverted and true impedance values at the well locations used for calibration. The inverted $Z_p$ profile at Well C roughly matches the true model in the Woodford segment but underestimates the true $Z_p$ values in the Eagle Ford segment. The cause of the model misfit in the Eagle Ford is an initial model that guided the inversion to an incorrect local minimum. In general, isotropic inversion within effectively orthorhombic media is feasible in the post-stack case.