APPLICATION OF ROCK-PHYSICS MODELING, GRID SEARCHING, AND PRESTACK SEISMIC INVERSION IN SEISMIC RESERVOIR CHARACTERIZATION OF THE HAYNESVILLE SHALE

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ABSTRACT
Seismic reservoir characterization of unconventional gas shales is challenging due to their heterogeneous and anisotropic complexity. Rock properties of unconventional gas shales such as porosity, pore-shape distribution, and lithology are important for interpreting seismic data amplitude variations for shales. The study presented here estimated these rock properties at the seismic scale by applying rock-physics modeling, grid searching, and prestack seismic inversion, using the Haynesville Shale as a case study. This seismic reservoir characterization procedure accounted for the complex composition, pore-shape distribution, and anisotropy. All the above rock properties affected the seismic velocities, and the combined effects of these rock properties on the seismic amplitude were investigated simultaneously. The P- and S-impedances correlated negatively with porosity. The $V_P/V_S$ correlated positively with clay fraction and negatively with the pore-shape distribution and quartz fraction. These estimated rock properties at the seismic scale were validated further through the comparisons between the elastic properties derived from the estimated rock properties and the ones inverted from the prestack seismic data. The differences between the two sets of elastic properties were less than a few percent. These correlations between the seismic amplitude variations and the rock properties contribute to the seismic reservoir characterization of the Haynesville Shale.
a) Porosity estimation. The hot colors indicate large values, and cold colors indicate smaller values. The porosity estimation is negatively correlated with P-impedance and S-impedance. b) Standard deviation of the porosity estimation, showing the estimation uncertainty. The black dashed line indicates Well A.

a) Clay fraction estimation. The hot colors indicate large values, and cold colors indicate smaller values. The clay fraction is correlated with $V_p/V_s$. b) Standard deviation of the clay fraction estimation, showing the estimation uncertainty. The black dashed line indicates Well A.