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Statistical Rock Physics for Identifying Lithologies and Pore Fluids from Seismic Data

We present current and emerging trends in applied statistical rock physics for reservoir characterization. Integrating deterministic rock physics representations with multivariate statistical techniques can enable us to quantify and reduce uncertainties in reservoir exploration and management. Deterministic rock physics models allow us to establish physical links between seismic response and reservoir properties, such as lithology, porosity and pore fluids. However, reservoir property estimation from geophysical measurements is always subject to uncertainty, not only because of inevitable difficulties and ambiguities in data acquisition and processing, but also due to intrinsic natural variability in rock properties that give rise to ambiguities in the interpretation. It is therefore necessary to express quantitatively the information content, and uncertainty in rock property estimation from seismic data. Statistical probability density functions (pdfs) give us one way to describe quantitatively the state of our knowledge about the targeted rock properties, and the relations between rock properties and seismic signatures, including their inherent uncertainty. Bayesian statistical methods allow us to integrate prior geologic information with results of seismic inversions and well-log calibrated rock physics models to generate training data for lithofacies classification. Statistical rock physics extends the training data by deriving pdfs for scenarios not encountered in the original data. Combining deterministic physical models with statistical techniques helps us to develop new methods for interpretation of reservoir rock properties from seismic data. These formulations identify not only the most likely interpretation but also the uncertainty of the interpretation, and serve as a guide for quantitative decision analysis.