

# **Quantifying Uncertainty in Reservoir Properties by Integrating: Statistical Rock Physics, Deterministic Seismic Attributes and Geostatistical Stochastic Simulation**

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## **Abstract**

Mapping the uncertainty of heterogeneous reservoirs is a critical step in the delineation, development, and production of hydrocarbon reservoirs. Heterogeneity occurs due to several reasons, including variations in lithology and pore fluids. These variations significantly affect fluid flow and hence reservoir production and recovery rate. There are several approaches to map the heterogeneity of the reservoir. Some of these methods employ statistical analysis while others utilize deterministic approaches based on laboratory measurements and physical models. The objective of this study is to quantify the uncertainties and map the probability of occurrences of different types of lithology and fluids that cause heterogeneity in Stybarrow field. In addressing these challenges, we establish the framework for an optimal strategy to account for reservoir heterogeneity by integrating statistical rock physics with seismic inversion and geostatistics to produce results that are more reliable than those derived from merely one method. Seismic inversion is an effective technique to predict elastic properties (acoustic and shear impedance) from seismic data. However, reservoir characterization requires inverting for reservoir properties, such as lithology and pore fluids. Statistical classification and pattern recognition methods, on the other hand, use results from seismic inversion to predict lithology distribution based on algorithms such as discriminant analysis, Bayesian classification, and neural networks. Therefore, statistical rock physics serves as the bridge that correlates the elastic properties to the physical reservoir properties. As a result, we utilized statistical rock physics based on discriminant analysis to convert acoustic and shear impedances into lithofacies maps. Moreover, we used geostatistical stochastic simulation to enhance the mapping of spatial correlation by taking into account the small-scale variabilities encountered in well logs but not resolved by seismic. This study demonstrates that an integrated workflow allows quantification of the uncertainties associated with prospect generation, and can be used as a guide for quantitative decision analysis and risk assessment. The statistical rock physics approach provided accurate lithofacies prediction using pre-stack seismic-derived attributes. Compared to the deterministic approach, the use of geostatistical stochastic simulation improved accuracy of seismically derived probabilities by taking into account the spatial correlation and conditioning to the lithofacies observed at the wells. Therefore it provided higher resolution maps