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Exploration Risking -- Bayesian Methods Applied to Petroleum Systems Models

Exploration Risking is directed at key geological features such as the Charge (source rock richness, thickness, maturity), and the Trap (prospect geometry, reservoir and seal qualities) of a prospect or play. These features are all included in Petroleum Systems Models which can be simulated to determine the thermal, pressure and hydrocarbon generation and migration history throughout the entire geologic evolution of the system. This enables the Timing risk to be addressed, as the dynamics of the system and the evolving processes are modeled.

Risk analyses commonly apply a 'scenario' approach: parameters are changed, the model is processed and the results are compared with those from previous runs. This procedure is time-consuming, incomplete and lacks objectivity. A better approach is to apply classical 'frequentist' statistical approaches in which variations in the input parameters of the model are defined and multiple simulation runs are performed using, for example, Monte Carlo or Latin Hypercube methods. This enables probabilities and correlations in the results to be determined. However, calibrations cannot be performed as there is no feedback from the results back into the input data of the model.

Recently developed Bayesian statistical methods enable models to be calibrated and can take Prior Information into account which enables the experience and knowledge of the geologist to be directly incorporated into the risking process, leading to a significant improvement in the quality of the geologic models and their predictive capabilities. Classical and Bayesian approaches are compared and the relevance of the new methods to exploration risking is demonstrated.