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Effect of Rock Physics Uncertainties on Reservoir Flow Simulations

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Summary

This talk will explore the link between seismic rock physics and reservoir flow simulation models. How does rock physics interpretation uncertainty affect the flow simulator response? What are the sensitivities between rock physics model parameters and flow simulations? Two cases will be discussed: one where the well-log rock physics interpretation of facies can affect the static model that goes into the simulator, and another where the dynamic time-response of the simulator is influenced by the rock physics model parameters, thus impacting the interpretation of time-lapse seismic data used in seismic history matching.

Introduction

Reservoir flow simulation models are used to understand and predict field performance (oil recovery, sweep efficiency etc.) under different production scenarios. Large scale computational flow simulators involve many millions of grid blocks with their associated rock and fluid properties. For conventional flow simulators reservoir engineers are typically concerned with rock (and fluid) properties that impact flow – e.g. porosity, permeability, relative permeability net-to-gross, and lithofacies. Conventional seismic rock physicists on the other hand are typically concerned with models that describe elastic rock properties (e.g. bulk and shear moduli, P- and S-wave velocities etc.) that can be related to various seismic attributes e.g. seismic impedances, AVO intercept and gradient, etc. This talk will explore the link between seismic rock physics and reservoir flow simulation models. How does rock physics interpretation uncertainty affect the flow simulator response? What are the sensitivities between rock physics model parameters and flow simulations? Two cases will be discussed: one where the well-log rock physics interpretation of facies can affect the *static model* that goes into the simulator, and another where the *dynamic time-response* of the simulator is influenced by the rock physics model parameters, thus impacting the interpretation of time-lapse seismic data used in seismic history matching.

A reservoir flow simulation model starts with a good static model describing the architecture (horizons, layers, faults etc.) of the reservoir. The layers are then discretized into grid blocks and populated with rock and fluid properties. Often multiple realizations are generated, using different geostatistical methods, in an attempt to capture some uncertainty in the future predictions. These geostatistical realizations are conditioned to well data, such as porosity and facies, considered as “hard data” at the well location. However, what about the uncertainty of the facies interpretation at the wells? Quantitative log interpretation workflows (Grana et al., 2012) allow assessment of uncertainty of lithofacies classification from rock-physics modeling and formation evaluation analysis. This uncertainty needs to be incorporated in the static model realizations as they can influence fluid flow.

Another common scenario where flow simulation dynamic responses (e.g. temporal changes in modelled saturations and pressure) are linked with rock physics modelling is the case of seismic history-matching, where reservoir engineers attempt to optimize reservoir performance based on assimilating both the production data as well as time-lapse seismic data. Time-lapse seismic data can help identify temporal changes in the reservoir related to production. These changes in seismic signatures depend not only on the production scheme but also on the rock and fluid properties of the reservoir. Because joint assimilation of production and time-lapse seismic data can be computationally expensive, it is essential to perform sensitivity studies to eliminate some of the insensitive parameters (Suman & Mukerji, 2013). Such sensitivity analyses can help to identify which rock physics model parameters need to be better constrained for interpretation of time-lapse seismic data.

References

Grana, D., Pirrone, M., and Mukerji, T., 2012, Quantitative log interpretation and uncertainty propagation of petrophysical properties and facies classification from rock-physics modeling and formation evaluation analysis, Geophysics, 77, WA45-WA63

Suman, A., and Mukerji, T., 2013, Sensitivity study of rock-physics parameters for modeling time-lapse seismic response of Norne field, Geophysics, 78, D511-D523