RM08

Uncertainty Propagation: The Untold Story - Impact of Fault and Log Uncertainty on Reservoir Assessment

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SUMMARY

Fault position and well logs are two overlooked aspects of subsurface uncertainty which often have a non-negligible impact on in-place volume estimates and production forecasts. Fault uncertainty is seldom considered simply because it is difficult to manage multiple interpretation scenarios and to perturb a structural or reservoir model accordingly, yet it affects compartmentalization and connectivity. Reservoir modeling parameters are generally derived from a single set of well logs, yet considering the uncertainty in how these logs were derived can lead to a completely different picture of the reservoir. This presentation will discuss and illustrate these two fundamental items.

Nowadays, it is commonly acknowledged that uncertainty exists in all aspects of the subsurface and most disciplines are doing a good job at assessing, understanding, and capturing the uncertainty within their own sphere of influence.

However, propagating that uncertainty across the E&P spectrum is still a challenge. Upstream groups still often provide their “best” results because it is supposed that those downstream need only the best possible input either because they cannot deal with uncertainty in their data or it is just what one thinks they expect. Geophysicists have problems transferring velocity uncertainty to the interpreters; interpreters can “see” the uncertainty associated with positioning a fault on a seismic volume but rarely capture it or pick alternative positions for the same fault. Petrophysicists may have looked at uncertainty in well log interpretation for a long time, but more often than not will pass on only one set of logs to their geologists. Reservoir modelers have always claimed to do the best job at assessing uncertainty by generating multiple property models, yet in general, they rely on one set of input logs and one reservoir structure. Engineers have used varied experimental design techniques to quantify the uncertainty in production forecasts, but rarely consider more than one geological model.

A 3D model is the center-piece of any integrated uncertainty study as it numerically combines data from petrophysics, seismic and geologic interpretations with geological concepts. To be complete, it must account for the uncertainty associated with all of these and therefore there cannot be just one or a handful of models, there must be many alternative representations of the subsurface.

Furthermore, a 3D model is built hierarchically, capturing the geological and physical dependencies of the elements that constitute it. It will therefore highlight the compounded effect of the various sources of uncertainty without artificially inflating the overall uncertainty.

This presentation will discuss two often overlooked fundamentally uncertain elements of the construction of a 3D model and their impact on both hydrocarbon in place estimates and production forecasts.

1. We will first look at uncertainty in fault position due to velocity and interpretation uncertainty and its consequences. Accurately determining and positioning faults is of utmost importance in the characterization of oil and gas reservoirs. They often determine the extent of the reservoir and its internal compartmentalization. It is recognized that there is tremendous uncertainty associated with fault interpretation yet little is done to quantify that uncertainty and even less to propagate it through to 3D modeling and flow simulation. Fault uncertainty affects, among other things, hydrocarbon in-place volumes, well positioning, fault seal calculations, and of course reserves. It is seldom considered during history matching. The main reason is that, until now, it has been technically tedious to modify a fault model and the associated reservoir grid once it is computed and still preserve the integrity of the structure. The 3D grid generally has to be reconstructed manually. We will present an approach that enables the stochastic simulation of a complete structural model including multiple horizons and faults, automatically updating the associated geological model. Combined with petrophysical uncertainty, this approach enables to quantify the impact of structure on reservoir volumes and connectivity, as well as on production forecasts.
2. We will then discuss uncertainty in petrophysics analysis and its impact downstream. A typical reservoir model relies on well data to infer all the parameters needed for its construction: quantity of sands, dimension of geological bodies, spread and spatial correlation of porosity and permeability values, calibration with seismic to go beyond well control, etc... By considering only a single set of well logs, the reservoir model is essentially locked in. Yet there is a large uncertainty associated with well log processing, interpretation, and modeling. We will illustrate how considering uncertainty in well log data affects in-place volumes and flow simulation results.

Propagating uncertainty across disciplines, while ensuring that no stone is left unturned, is the key to a robust assessment of uncertainty in hydrocarbon volumes and production forecasts.