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Gaining Insight from Integrated Petrophysical Uncertainty

Formation evaluation software can lead to valid petrophysical property uncertainty ranges.

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Petrophysical interpretation plays a key role in the estimation of hydrocarbon resources, and the quantification of uncertainty is central in the definition of proven, probable, and possible resources. Every geoscientist understands the above statement, yet petrophysical analysis is still too often carried out without any consideration of uncertainty; or, when petrophysical results are delivered with uncertainty ranges, these are usually improperly calculated.

Monte Carlo processing is becoming the most popular method for quantifying petrophysical uncertainty, but what is often overlooked is there are a number of different ways in which Monte Carlo processing can be applied to a petrophysical interpretation. The Monte Carlo technique chosen determines which of the different types of dependencies can be accounted for. If any of the dependencies are ignored, the final uncertainties are too great, leading to a possible downgrading of the proven resources for a project.

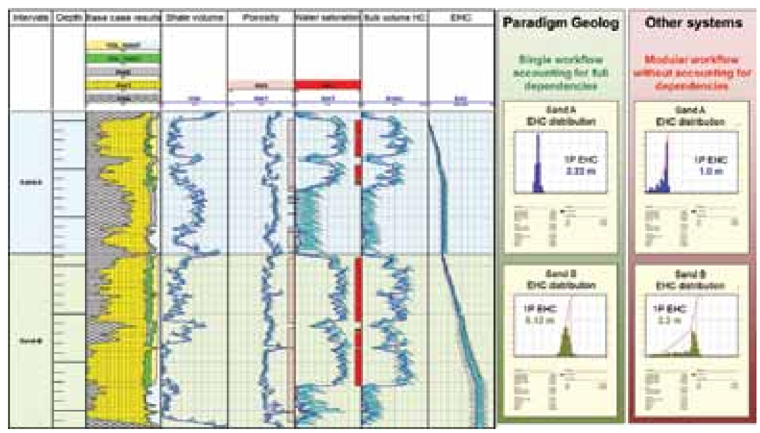
Most petrophysical uncertainty systems offer a modular workflow implementation of Monte Carlo processing, where each step of the petrophysical interpretation is treated as an independent step. Simple zone averages using spreadsheet and add-ins such as Crystal Ball are also commonly used when a petrophysical uncertainty system is unavailable.

These methods produce hydrocarbon-in-place distributions generated by a combination of petrophysical curve distributions that are created independently. Therefore, such methods fail to account for functional and parameter dependencies, which are inherent to a petrophysical interpretation.

A close examination of the different types of dependencies present in petrophysical interpretations is essential for understanding how they affect resource estimates. Awareness of the impact of dependencies on uncertainty estimates should prevent the petrophysicist from using inappropriate uncertainty assessment methodologies and help to avoid common pitfalls and shortcuts.

Paradigm Geolog provides a single workflow implementation of Monte Carlo processing that accounts for all dependencies, leading to valid petrophysical property uncertainty ranges.

In Geolog, input logs undergo Monte Carlo environmental corrections, incorporating input log accuracy and correction parameter uncertainty. Outputted base and low- and high-case environmentally corrected logs as well as interpretation parameters with user-defined error bars and error distributions are inputted into a full Monte Carlo deterministic log analysis module.



Shown are petrophysical analysis results with their uncertainties and EHC distributions differences when using Geolog or modular workflow with no account for dependencies. (Image courtesy of Paradigm)

Full-parameter interdependencies are accounted for. Parameters selected from logs and cross-plots are automatically adjusted to account for changing input logs. Accounting for interdependency ensures uncertainties are correctly carried through the analysis. Distributions of petrophysical curves are outputted on a depth-by-depth basis, providing an understanding of where uncertainty is greatest.

Outputs from all Monte Carlo iterations are sorted on an equivalent hydrocarbon column (EHC) per well or per zone to give a probability distribution function from which proven, probable, and possible (1P, 2P, and 3P) EHC can be determined.

The full distribution of the petrophysical curves can be input to the SKUA subsurface modeling system and associated with other uncertainties such as facies and gross rock volume in an integrated reservoir uncertainty analysis using the Jacta Reservoir Risk Assessment module.

To learn more about Geolog 7 visit Paradigm at booth 1230 during EAGE 2013. ■