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New Petrophysical Uncertainty Handling, Deconvolution Routines

New software adds value to determining viable prospects by quantifying uncertainty.

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The goal of formation evaluation is to identify the nature and volume of fluids contained in a given formation. If the uncertainty associated with evaluations can be quantified, the evaluations become more valuable in the process of deciding whether a field contains viable prospects. Following a research effort involving close cooperation with several clients, the latest edition of Paradigm's Geolog petrophysical analysis software, Geolog 6.7.1p2, features a new model-based petrophysical uncertainty analysis module that allows users to systematically quantify uncertainties within the hydrocarbon columns. Petrophysical uncertainties can be classified according to their source and can belong to one of three types:

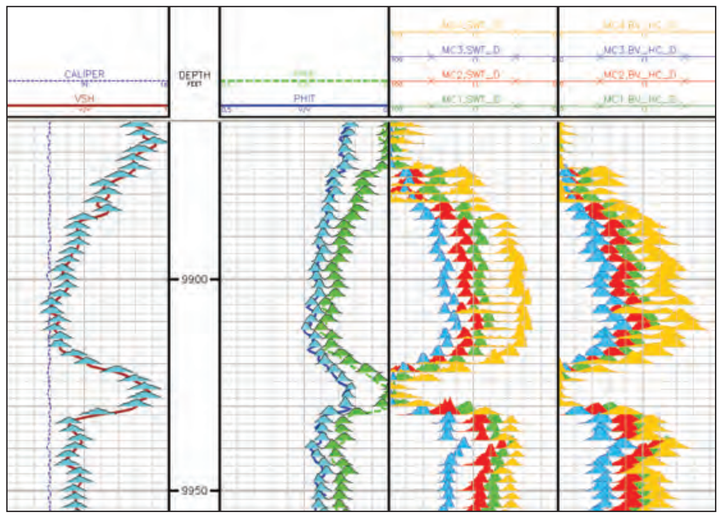
- *Random uncertainty* that equates to measurement noise where, for example, measuring the same formation multiple times with the same tool yields a range of values. In formation evaluation, this generally is accounted for by zone averaging;
- *Systematic uncertainty* that represents a systematic shift between a measurement and the true value. In logging, this is due to calibration errors and environmental effects. For petrophysical parameters, this usually is due to insufficient knowledge of the formation or a lack of representative data; or
- *Model-based uncertainty* that occurs when the interpretation model being used deviates significantly from the evaluated formation. Model-based uncertainty generally has the greatest impact on results but is the hardest to quantify and usually is the least analyzed.

To provide an effective solution, software must be capable of considering all three types of petrophysical uncertainty.

Uncertainty analysis

At the heart of most uncertainty analysis is Monte Carlo processing, in which input values are selected randomly from a user-defined range, resulting in a probability density function for each calculated value at each depth. By incorporating Monte Carlo processing at each step of the deterministic workflow, from environmental correction to reservoir summation, Geolog's petrophysical uncertainty analysis workflow enables uncertainty to be quantified at each stage of the analysis.

Output uncertainties on the results from multiple petrophysical models can be evaluated and compared, and sensitivity analysis functionality enables individual contribution of each input variable to uncertainty to be ranked. These new tools will allow users to quantify uncertainties in their formation evaluations, providing greater confidence in output results.



Quantified uncertainty on output bulk volume hydrocarbon column has resulted from four different petrophysical modules.

The outputs of this next generation technology are designed to feed into the Paradigm SKUA/GOCAD Reservoir Risk Assessment (JACTA) module, Paradigm's existing solution for 3-D uncertainty analysis.

Performing pressure deconvolution

Interpret 2010, Paradigm's pressure transient analysis software, features the results of a second research initiative undertaken to address specific requirements from clients and completed with the cooperation of OCCAM, the University of Oxford, and the Knowledge Transfer Network for Industrial Mathematics. This project developed a new iterative method for performing pressure deconvolution where the deconvolution is transferred into a nonlinear total least square (TLS) problem using the maximum *a posterior* method under a Bayesian framework. The method is formulated to take advantage of the special features of the TLS cost function and introduces a cumulative production constraint to ensure more realistic results.

Introduction of this method, which effectively provides an additional curvature control factor, results in better results achieved from a variety of test data and provides the engineer with additional flexibility to obtain the best possible solution.

These projects illustrate Paradigm's ongoing commitment to new research endeavors to provide software solutions to E&P challenges. ■