Petrophysical Uncertainty in Geolog®

Well logs and interpretation parameters are used to derive many of the values needed to construct reservoir models, yet their inherent uncertainty and the impact of that uncertainty on reservoir volumes and connectivity is seldom considered. A thorough and comprehensive uncertainty modeling procedure is now available to Geolog® users to scientifically quantify petrophysical uncertainties within a hydrocarbon column.

Environmental Corrections

Input logs undergo Monte Carlo environmental corrections, incorporating input log accuracy and uncertainty on correction parameters, and output base, low and high case environmentally corrected logs, ready for input to log analysis.

Deterministic Monte Carlo

The base, low and high case logs, along with interpretation parameters with user-defined error ranges and distributions, are passed to a full Monte Carlo deterministic log analysis module, which allows the user to choose between standard petrophysical models and relationships.

All types of parameter dependencies are addressed. Parameters selected from logs and crossplots are automatically adjusted to account for changing input logs, while the Monte Carlo method chosen for Geolog ensures that the effects of the other types of parameter dependency are eliminated.

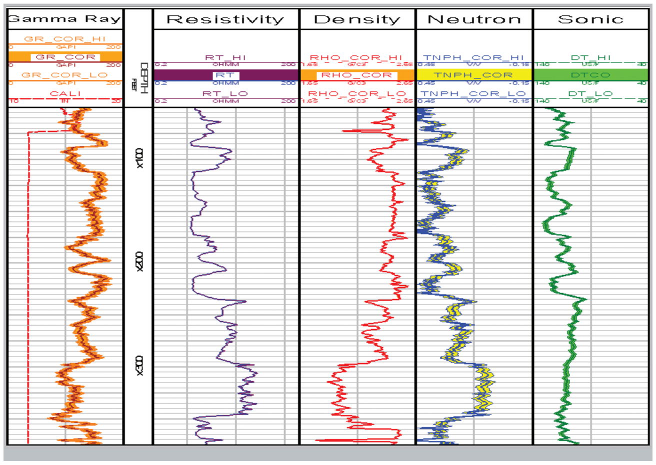
Distributions of petrophysical values are output on a frame-by-frame basis for an understanding of where uncertainty is greatest.

Outputs from all iterations are sorted on an equivalent hydrocarbon column (EHC) in the well or by zone to give a cumulative distribution function (CDF) from which 1P, 2P, 3P values for each output parameter can be determined.

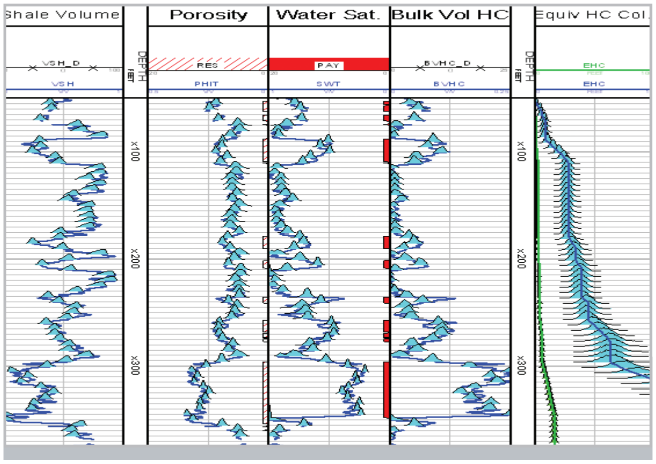
The full distribution of the petrophysical curves can be transferred from Geolog to Paradigm® SKUA-GOCAD™ for integration into a reservoir uncertainty analysis using the Reservoir Uncertainty (Jacta®) module.

Log and Parameter Sensitivity

The impact of uncertainty on individual interpretation parameters and input logs can be analyzed through tornado charts. The range of possible values for all inputs is plotted against their effect on EHC. This allows the petrophysicist to target future work and future data acquisition on the study of big impact uncertainties.



▲ Input logs after environmental corrections with the base case, low and high case scenario



▲ Output log showing distributions for each main petrophysics output on a frame-by-frame basis

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Petrophysical Uncertainty in Geolog

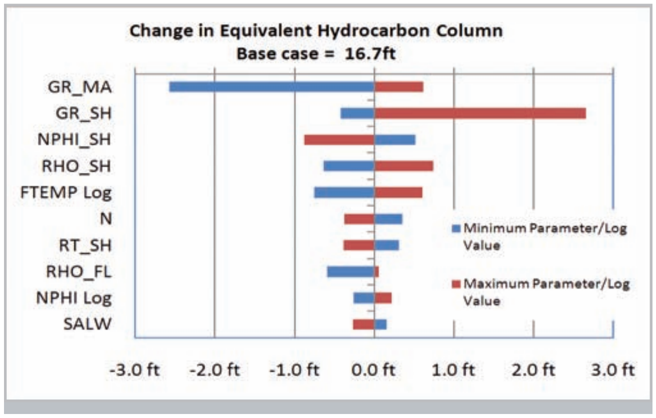
Model-Based Uncertainty

The biggest uncertainty in petrophysics is often model-based uncertainty - the impact of the chosen petrophysical model on the computed hydrocarbons in place when compared with other possible models. The Geolog Determin Uncertainty Module allows different petrophysical models to be run and compared quickly and efficiently, and permits the petrophysicist to quantify the impact of these assumptions on the calculation of hydrocarbons in place.

This knowledge can be input into a cost-benefit analysis to determine the true value of additional data acquisition, to confirm or eliminate the initial assumptions on each of the petrophysical models. For a case study of how this process has been used, refer to Kennedy et al 2010 (1).

Conclusion

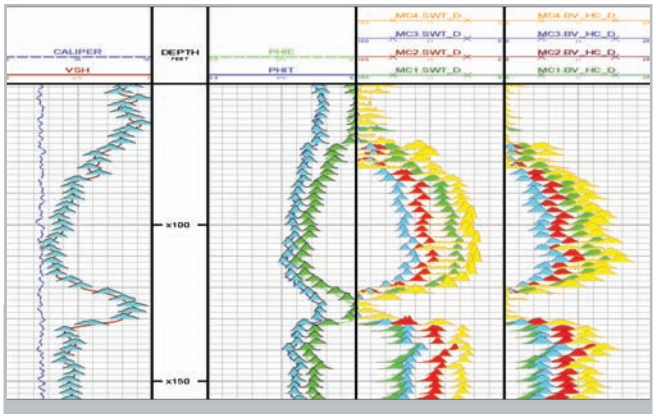
A holistic approach to petrophysical uncertainty is required to ensure that the true range of unknowns is considered for the hydrocarbon-in-place computation. Geolog provides this through the Determin Uncertainty module, an add-on to the Determin module for Geolog.



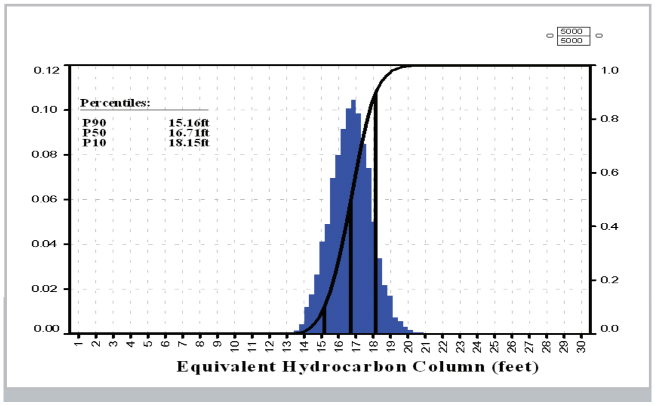
▲ Tornado chart showing the change in EHC for the uncertainty range of the most influential inputs

ZONE ONE					
	BASE CASE	MEAN	1P (90)	2P (50)	3P (10)
Net Reservoir - ft	141.5	151.0	132.5	148.0	154.0
Net Res:Gross	0.38	0.40	0.35	0.39	0.41
Net Pay - ft	133.5	139.5	123.0	138.5	145.0
Net Pay:Gross	0.36	0.37	0.33	0.37	0.39
Equivalent HC Column - ft	16.68	16.70	15.18	16.74	18.16
Averages for net pay interval:					
Ave Total Porosity	0.24	0.24	0.23	0.23	0.25
Ave Eff Porosity	0.20	0.19	0.20	0.19	0.20
Ave Total Sw	0.50	0.51	0.49	0.50	0.50
Ave Eff Sw	0.39	0.39	0.39	0.39	0.38

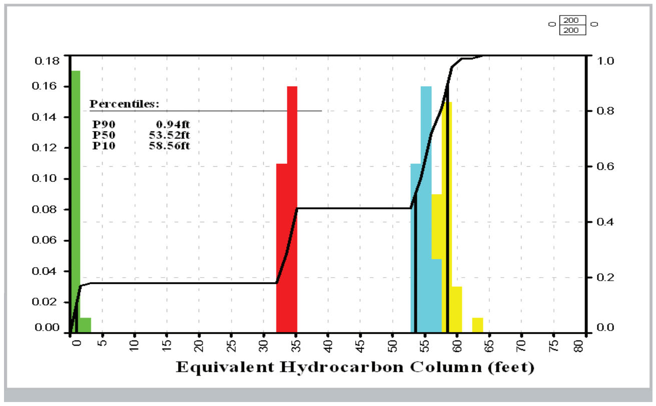
▲ Table showing 1P, 2P, 3P results



▲ Log plot showing the results of water saturation and bulk volume hydrocarbon from different saturation models



▲ Distribution of EHC from all iterations



▲ Histogram depicting the EHC computed from 4 different saturation models, showing that saturation model uncertainty can significantly affect hydrocarbons-in-place

1) Kennedy J., Pujiyono, Cox A. and Aldred R., 2010, Using quantified model based petrophysical uncertainty to aid in conflict resolution, SPWLA 38th Annual Logging Symposium, Paper AA.

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