Petrophysical Uncertainty in Geolog

Introduction

Well logs are used to infer many of the parameters needed to construct reservoir models, yet their inherent uncertainty and the impact of that uncertainty on reservoir volumes and connectivity is seldom considered. A novel and comprehensive model-based uncertainty 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.

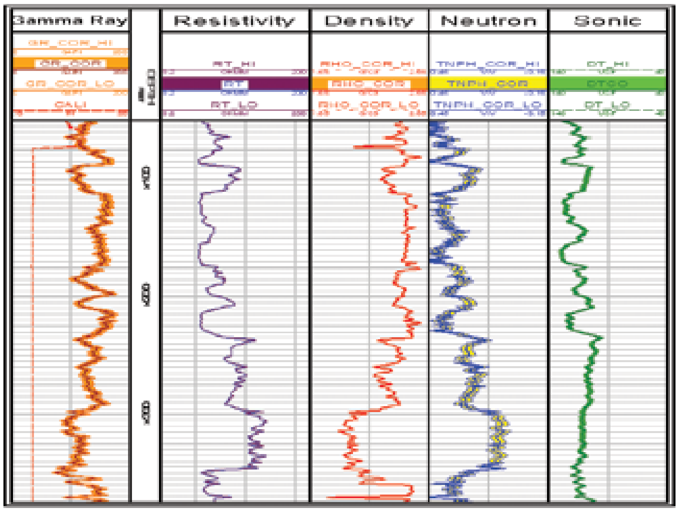

Figure 1: Input logs after environmental corrections with the base case, low and high case scenario

Deterministic Monte Carlo

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

Full parameter inter-dependencies are used; parameters selected from logs and crossplots are automatically adjusted to account for changing input logs. Applying inter-dependency ensures uncertainties are correctly carried through the analysis. Distributions of petro-physical curves are output on a frame-by-frame basis for an understanding of where uncertainty is greatest.

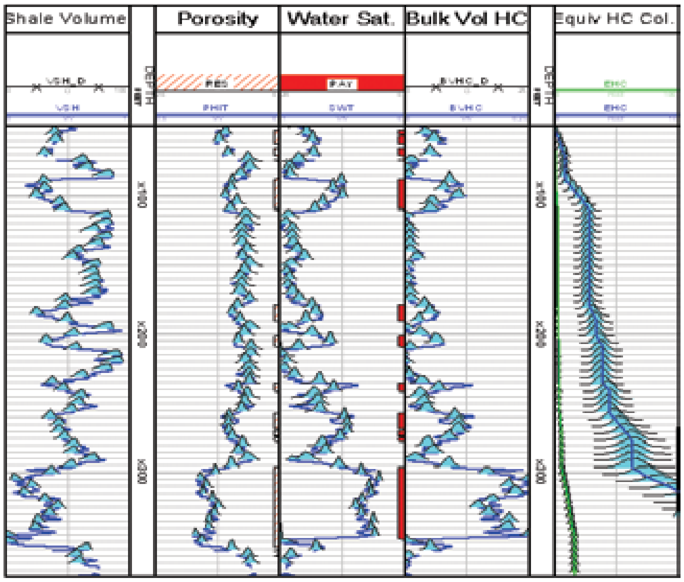

Figure 2: Output log showing distributions for each main petrophysics output on a frame-by-frame basis

Outputs from all iterations are sorted on an equivalent hydrocarbon column (EHC) in the well or by zone to give a probability distribution function (PDF) from which EHC 1P, 2P, 3P can be determined.

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

Figure 3: Table showing 1P, 2P, 3P results

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

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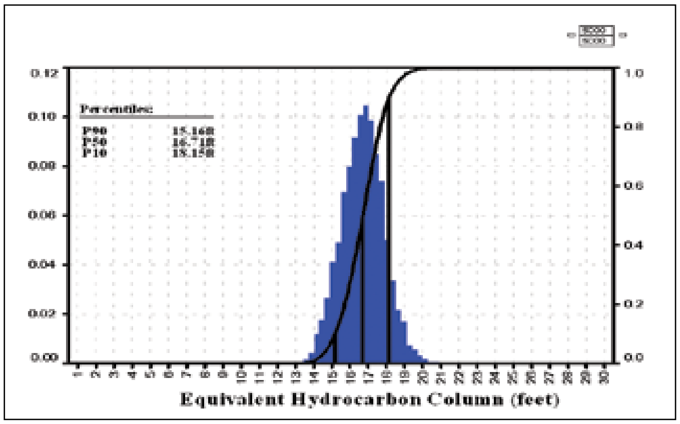

Figure 4: Distribution of EHC from all iterations

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.

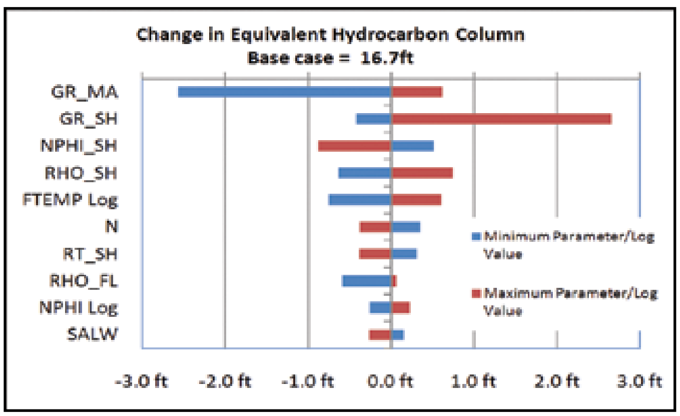

Figure 5: Tornado chart showing the change in EHC for the uncertainty range of the most influential inputs

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.

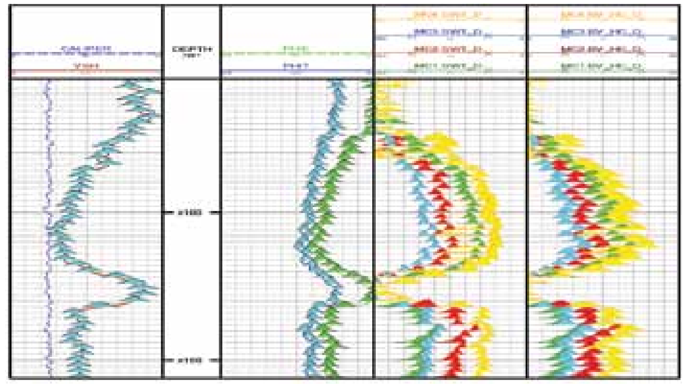

Figure 6: Log plot showing the results of water saturation and bulk volume hydrocarbon from different saturation models

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).

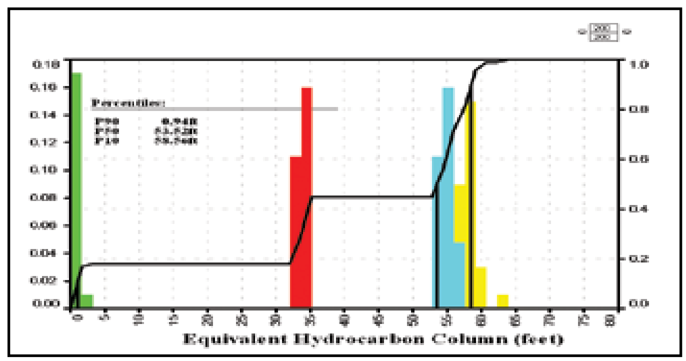

Figure 7: Histogram depicting the EHC computed from 4 different saturation models, showing that saturation model uncertainty can significantly affect hydrocarbons-in-place

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. For further details, contact info@pdgm.com.

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.

A D V A N C E D   S U B S U R F A C E   S O L U T I O N S

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