Tibor-1 – Formation Evaluation

The Tibor-1 exploration well was a vertical drilled to a total depth (TD) of 1723.5 mMDRT targeting the Hutton Sandstone as the primary objective and the Namur and Adori formations as secondary objectives.

A 9-$^{5}/_{8}$" casing string was set at 750.9 mMDRT and the prospective sequences were drilled in 8-½" hole to TD where wireline logging was carried out as described below. LWD logs were not acquired in the Tibor-1 well.

Wireline logging was carried out using Schlumberger wireline services. Tibor-1 wireline logs were analysed over the 8-½" hole section.

The Tibor-1 well has been plugged and abandoned.

In addition to the available wireline log responses, data which may be available from gas chromatograph readings and cuttings descriptions have been integrated into the formation evaluation.

Unless otherwise specified all depths mentioned below are wireline depths referenced to the drill floor.

Discussion

Wireline log interpretation of Tibor-1 was carried out using a probabilistic interpretation (Minsolver module) within the Interactive Petrophysics (IP) software application. An explanation of the interpretive procedure has been included as **Appendix-2**. Petrophysical analysis was performed across the Toolebuc formation and from the Murta Member to TD (1290.0 – 1723.5 mMDRT).

The petrophysical model was constructed based on offset wells in the ATP 539 exploration block. Offset wells within the area include Triclops-1, Curalle-1, Planet Downs-1, Cook-1, Inland-1 and Inland-3 (core across the Hutton). Formation salinities were estimated using water analysis recovered from DST's and Pickett plots in offset wells. Water saturation parameters and coefficients were computed using Modified Simandoux. Saturation equations and parameters are detailed in the Interpretation Parameters section.

A separate petrophysical model was created for the Toolebuc Fm. Elevated gas was observed across the Toolebuc Fm. Cuttings descriptions indicate the Toolebuc is predominantly a calcareous siltstone. Spectral Gamma Ray across the Toolebuc indicate elevated Uranium content which is likely associated with elevated total organic carbon (TOC). TOC estimations were conducted using the deltalogR technique; however quantities cannot be calibrated because core data is not available.

The dielectric scanner (ADT) tool was deployed in the Tibor-1 well to reduce uncertainty in the water saturation calculation by measuring the total water volume in the flushed zone.

The porosities which have been interpreted across the Tibor-1 well are believed to be within the accuracy of measurement error inherent in the tools. The gas chromatograph readings taken from the drilling fluids do not display responses which would normally be associated with hydrocarbon accumulations. The Hutton, Namur and Adori Sandstones of the Tibor-1 well are interpreted as being wet.

Logs Acquired and Drilling Fluid Parameters

The following table itemises the logs acquired in the Tibor-1 well and the drilling fluid parameters at the time of the logging runs.

Table 1: Logging Acquisition Parameters

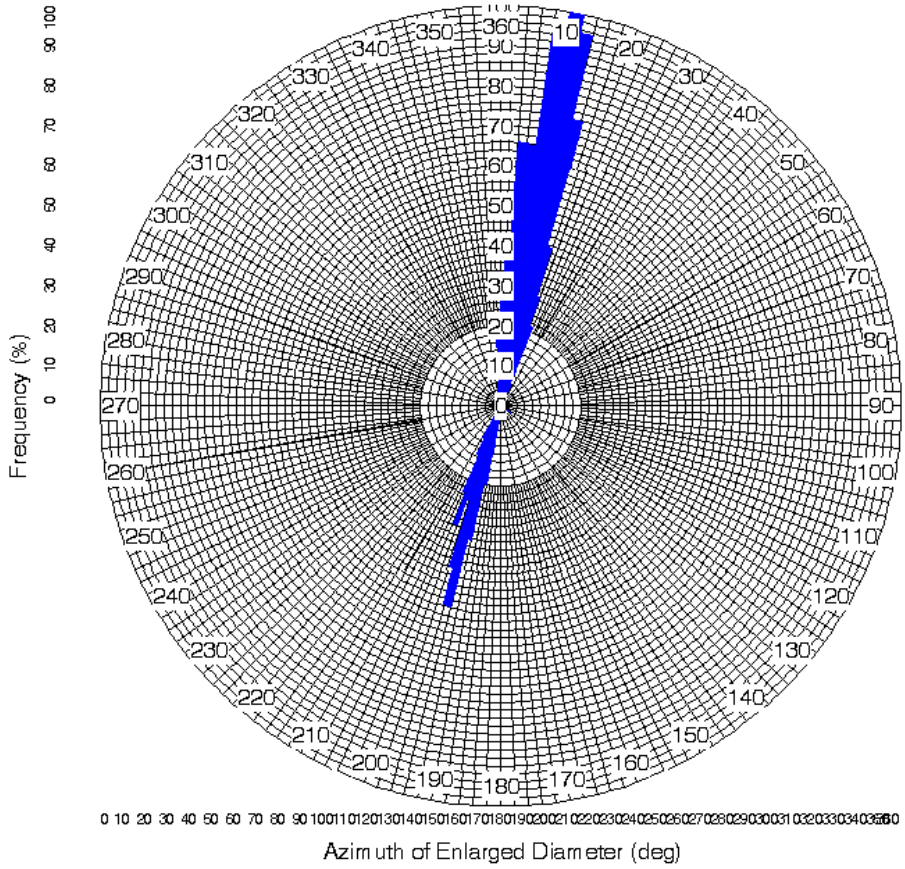
Well Name	Tibor-1	Tibor-1	Tibor-1
Logging Company	Schlumberger	Schlumberger	Schlumberger
Logging Date	19-Feb-2013	19-Feb-2013	20-Feb-2013
Suite No.	1	1	1
Run No.	1	2	3
	HRLA-PEX-HNGS-ADT	MSIP-GPIT-GR-PPC	VSP (Zero Offset)
Bottom Log Interval	1723.5	1723.5	1723.5
Top Log Interval	750.0	Surface	750.0
Casing Size @ Depth	750.9	750.9	750.9
Bit Size	8.5 inch	8.5 inch	8.5 inch
Drilling Fluid Type	KCL Polymer	KCL Polymer	KCL Polymer
Drilling Fluid Density	9.3 lb/gal	9.3 lb/gal	9.3 lb/gal
Drilling Fluid Viscosity	46 s	46 s	46 s
Drilling Fluid Loss	4.0 cm3	4.0 cm3	4.0 cm3
Drilling Fluid pH	9.5	9.5	9.5
R_M @ Temp degC	0.13 @ 33.4	0.13 @ 33.4	0.13 @ 33.4
R_{MF} @ Temp degC	0.13 @ 33.4	0.13 @ 33.4	0.13 @ 33.4
R_{MC} @ Temp degC	0.51 @ 33.4	0.51 @ 33.4	0.51 @ 33.4
Maximum Recorded Temp	108	113.8	Not recorded
Circulation Stopped	19-Feb-2013 @ 04:20	19-Feb-2013 @ 04:20	19-Feb-2013 @ 04:20
Logger on Bottom	19-Feb-2013 @ 15:34	20-Feb-2013 @ 00:54	Not recorded

Remarks

Caliper responses from the previous Triclops-1 well indicate preferential borehole breakout in the NNE-SSW plane. Based on the results from Triclops-1 well, a powered position caliper (PPC) and swivel head adapter was run in the Tibor-1 well in an attempt to align the density and ADT tool in the short axis of the wellbore by applying caliper pressure in the long axis (Calipers 2 & 4). Overall, breakout was not large enough to keep the tool in the short axis; however log quality was better than in Triclops-1. The density tool did a reasonable job of correcting for poor hole condition; however log responses indicate porosity readings are still higher than expected.

The X-Y caliper (PPC) in Run 1 indicates that the orientation of breakout occurs predominantly in the NNE-SSW plane. **Figure 1** below displays an azimuthal frequency plot of the X-Y caliper from the PPC log in Run 1.

Figure 1: Caliper Orientation and Breakout of X-Caliper



		# Points Total:	18777
Start Depth:	1703.82 m	**# Points Plotted:**	4315
Stop Depth:	749.999 m	**# Points Absent:**	0
Sampling Rate:	0.0508 m	**# Points Cut:**	14461
X Max Value:	359.998 deg	**# > X Scale Max:**	1
X Min Value:	0.0205994 deg	**# < X Scale Min:**	0

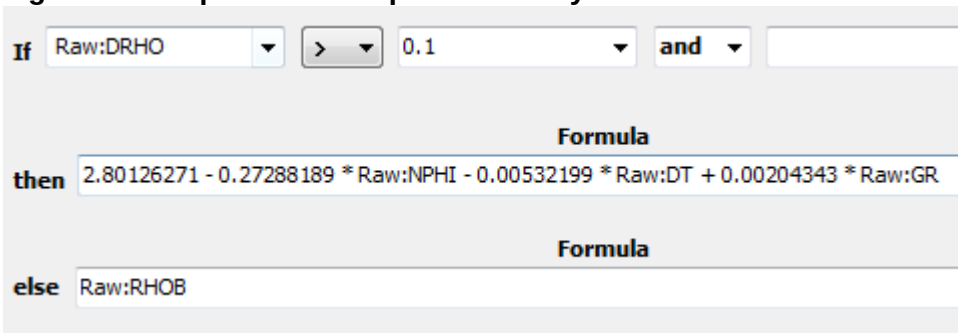
All tool responses indicate that the tools are within the calibration limits.

Log Processing

All recorded wireline log responses were corrected for borehole and environment effects utilising algorithms which emulate the published corrections charts for each of the individual tools.

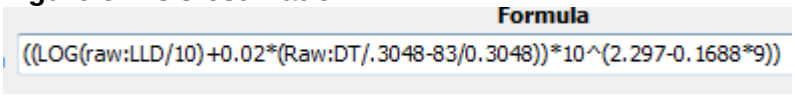
Density data affected by poor hole condition was corrected utilising GR, Neutron and Sonic logs in a multi-linear regression based on offset wells. The regression was then applied to zones where density data was of poor quality where DRHO > 0.10 g/cc. Figure 2 below displays the multi-linear regression used to apply the 'best' density across the well:

Figure 2: Computation for optimal density



Across the Toolebuc Fm total organic carbon (TOC) was estimated using the deltalogR technique. Core data is not available to calibrate TOC quantities within the Toolebuc; therefore elevated uncertainty exists within the petrophysical model. Estimated TOC across the Toolebuc Fm is displayed in **Figure 3** below:

Figure 3: TOC estimation

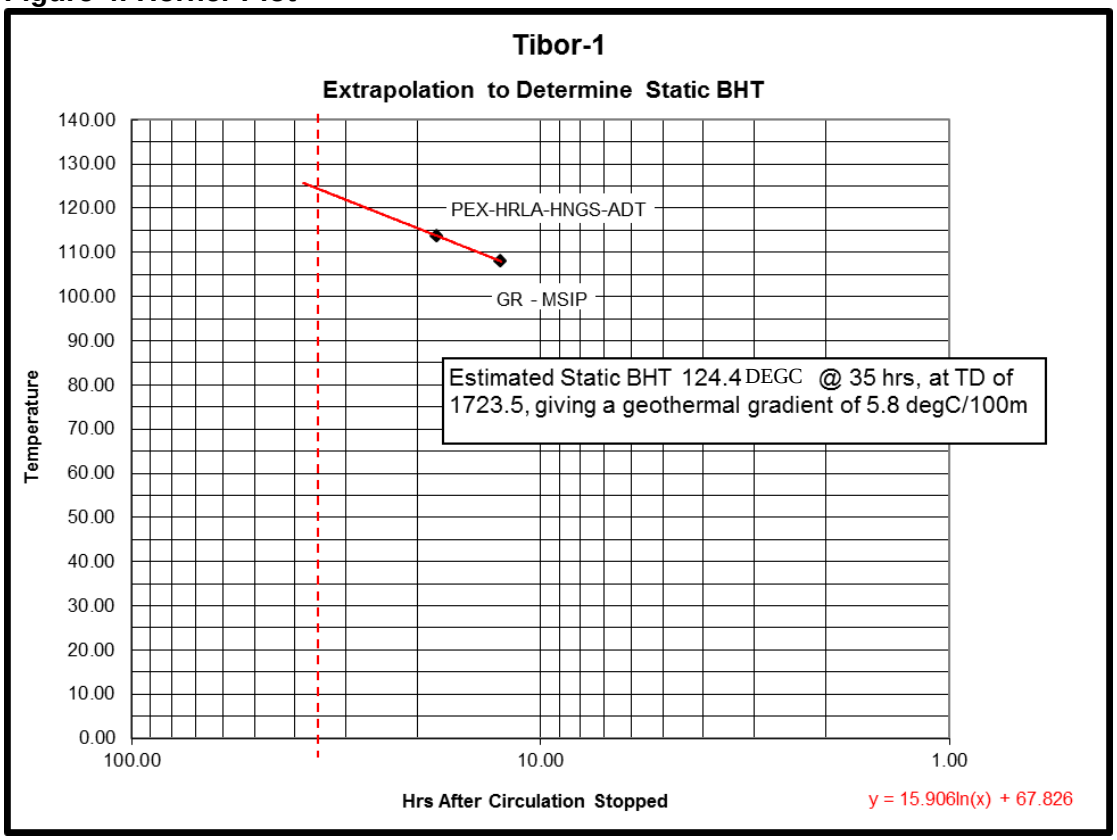


ADT data was processed by Schlumberger Data Consulting Services (DCS) team.

Sonic compressional and shear data were acquired from TD to surface. DLIS files were sent to Schlumberger DCS for processing and relabelling. Full waveforms were obtained in the event future processing is required.

A bottom hole reservoir temperature of 124.4^{0}C at 1723.5 mMDRT was extrapolated using a Horner plot. Temperatures were taken from logging runs 1 and 2 for the extrapolation resulting in a geothermal gradient of 5.77 degC/100m (3.17 degF/100ft). **Figure 4** below displays the resultant temperatures on a Horner plot.

Figure 4: Horner Plot



Interpretation Parameters

The following are tabulations of the analysis parameters utilised in each of the interpreted intervals in the Tibor-1 well.

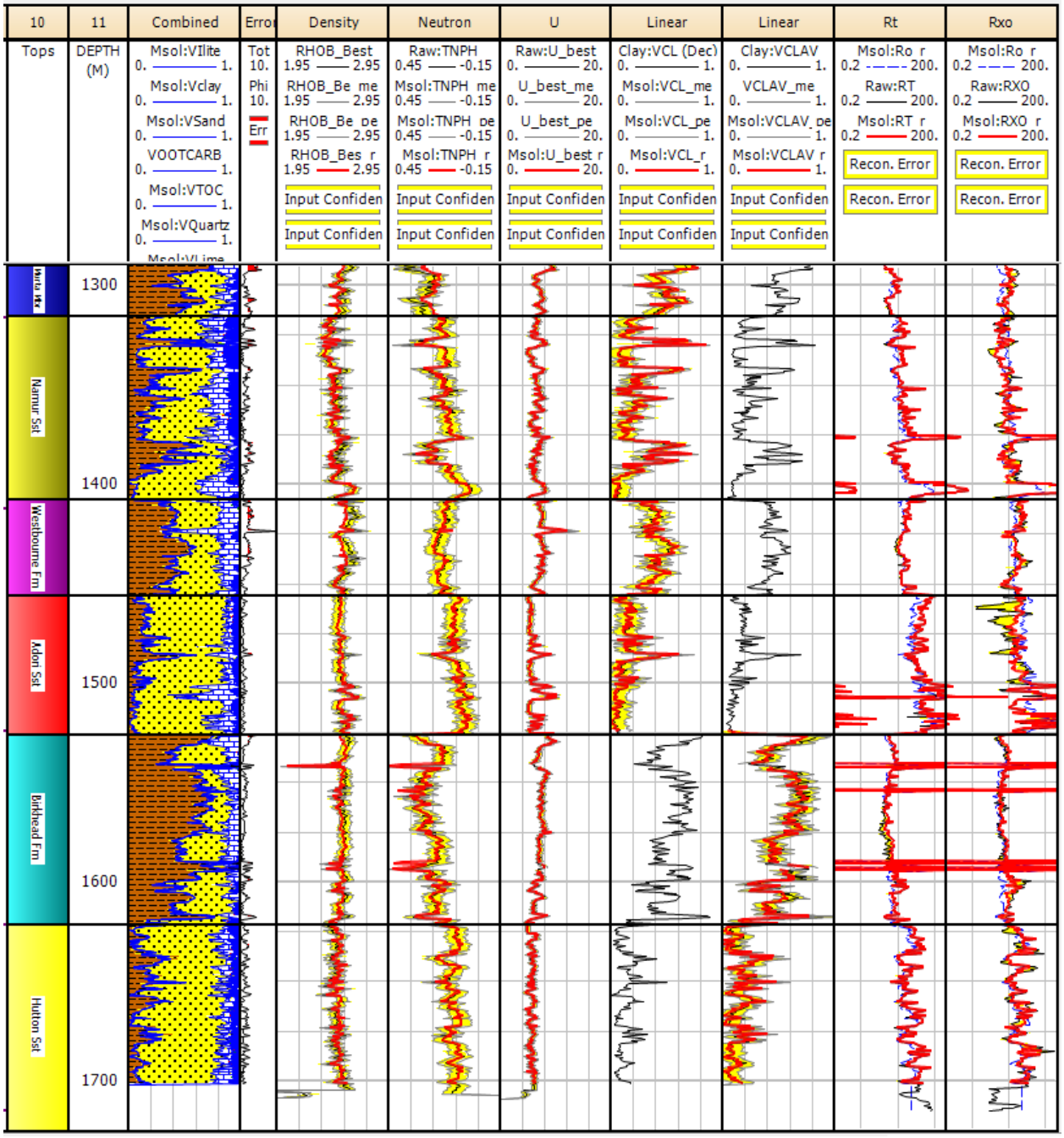
Table 2: Formational Interpretation Parameters

Formation Name	Toolebuc	Murta	Namur	Adori	Birkhead	Hutton
Top (m)	950	1290	1315.8	1456.0	1526.0	1622.0
Base (m)	978	1315.8	1408.0	1526.0	1622.0	1725.0
GR-Clean (GAPI)	10	15	15	15	15	12
GR-Clay (GAPI)	125	150	150	210	125	205
RHO-Matrix (g/cc)	2.79	2.60	2.60	2.59	2.59	2.58
RHOB-Clay (g/cc)	2.70	2.65	2.65	2.65	2.65	2.65
NPHI-Matrix (v/v)	0.000	-0.030	-0.030	-0.030	-0.030	-0.030
NPHI-Clay (v/v)	0.470	0.430	0.430	0.350	0.340	0.350
dT-Matrix (us/ft)	47	52	52	52	52	52
dT-Clay (us/ft)	120	100	100	96	100	100
Resistivity Clay (ohmm)	1.41	3.4	4.3	6.1	3.3	3.3
Rxo Clay (ohmm)	2.8	6.6	8.1	8.7	4.1	4.1
a	1.0	1.0	1.0	1.0	1.0	1.0
m	2.1	2.2	2.0	2.2	2.0	2.2
n	2.1	2.2	2.0	2.2	2.0	2.2
R_W-Salinity (ppm NaCl eq)	18135	8730	8730	10360	14025	11240
R_W(ohm) @ 25^{0}F (23.9^{0}C)	0.325	0.641	0.641	0.546	0.412	0.506
Saturation Eqn	Mod Sim	Mod Sim	Mod Sim	Mod Sim	Mod Sim	Mod Sim

Interpretation Parameters – Plots

As an interpretive quality control, the software back calculates pseudo logs for each of the inputs. By comparing the pseudo log with the actual this quantifies the error and uncertainty within the model. **Figure 5** below displays the uncertainty of each of the predicted inputs along with the overall error of the probabilistic model.

Figure 5: Probabilistic Error and Uncertainty



Pressure Data, Testing, Sampling and Analysis

Formation pressure data was not acquired in the Tibor-1 well.

Image Log Data and Analysis

Image data was not acquired in the Tibor-1 well.

Petrophysical Summary

The definitions of ‘Reservoir’ and ‘Pay’ as utilised in this interpretation are as follows;

- Net reservoir is defined as any interval where PHI_E > 8% and V_{CL} < 35%, and,
- Pay is defined as any interval where PHI_E > 8%, V_{CL} < 35% and S_W < 60%.

Further work is required to define net reservoir and net pay.

The following are petrophysical parameter tabulations of intervals interpreted in the Tibor-1 well.

Table 3: Net Reservoir Petrophysical Summary by Formation

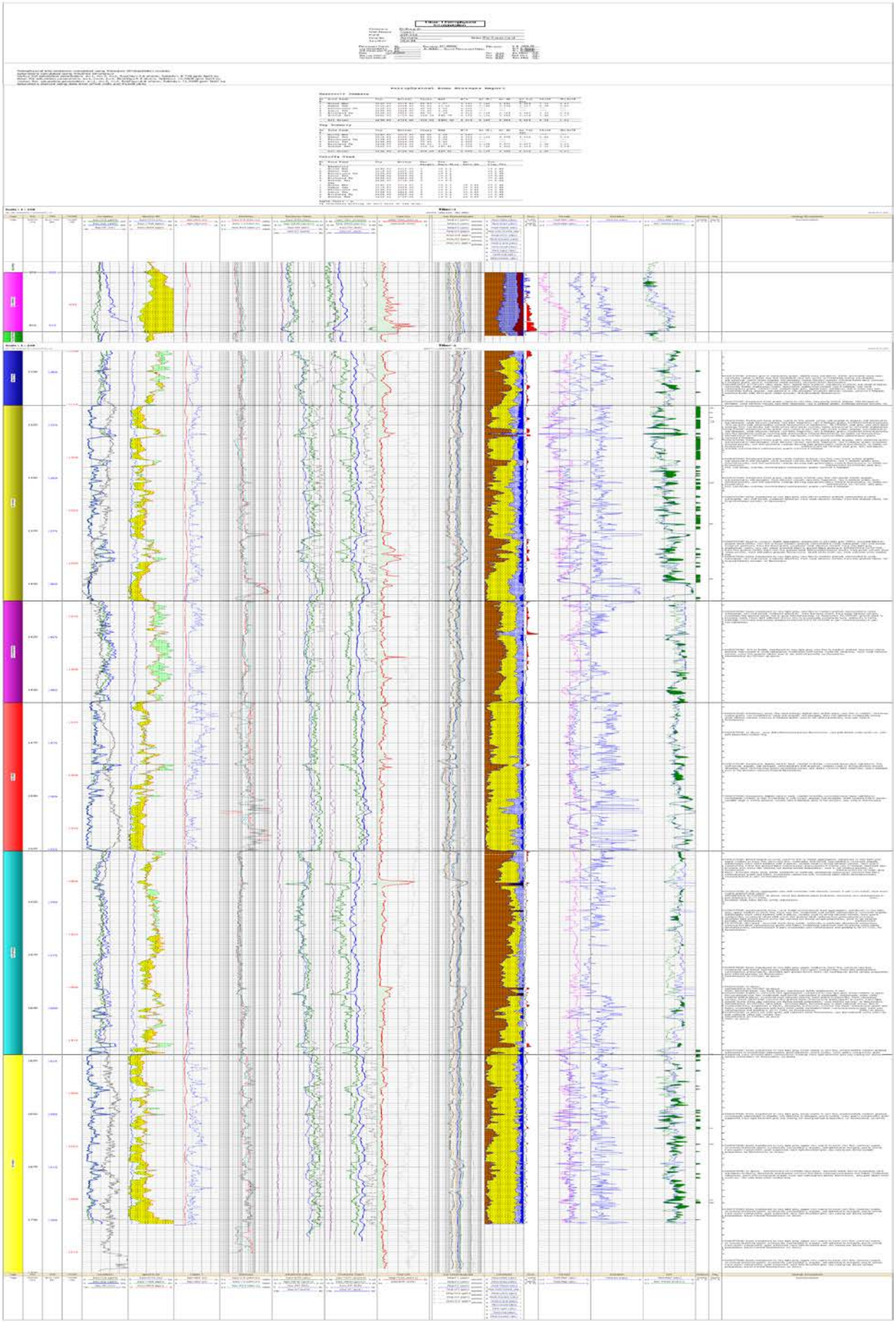
Zone Name	Top	Bottom	Gross	Net	N/G	Av Phi	Av Sw	Av Vcl	Phi*H	PhiSo*H
Murta Mbr	1290	1315.8	25.8	1.07	0.041	0.122	0.961	0.266	0.13	0.01
Namur Sst	1315.8	1408	92.2	40.39	0.438	0.126	0.823	0.127	5.08	0.9
Westbourne Fm	1408	1456	48	0	0	---	---	---	---	---
Adori Sst	1456	1526	70	0	0	---	---	---	---	---
Birkhead Fm	1526	1622	96	1.15	0.012	0.116	0.723	0.162	0.13	0.04
Hutton Sst	1622	1725.02	103.02	8.76	0.085	0.113	0.825	0.114	0.99	0.17

Table 4: Net Pay Petrophysical Summary by Formation

Zone Name	Top	Bottom	Gross	Net	N/G	Av Phi	Av Sw	Av Vcl	Phi*H	PhiSo*H
Murta Mbr	1290	1315.8	25.8	0	0	---	---	---	---	---
Namur Sst *	1315.8	1408	92.2	2.44	0.026	0.116	0.579	0.142	0.28	0.12
Westbourne Fm	1408	1456	48	0	0	---	---	---	---	---
Adori Sst	1456	1526	70	0	0	---	---	---	---	---
Birkhead Fm *	1526	1622	96	0.15	0.002	0.102	0.607	0.23	0.02	0.01
Hutton Sst *	1622	1725.02	103.02	0.91	0.009	0.115	0.601	0.103	0.11	0.04

* Artificial Net pay interpreted due to borehole breakout and rugosity issues.

Appendix 1
Petrophysical Interpretation



Appendix 2

Interpretation Procedures

Data received from the logging contractor is loaded into the IP software application and the relevant log header information is entered in the appropriate fields. In cases where there has been more than one logging run in any programmed logging suite the response curves are added to the file and depth matched to ensure that the acquired log responses from each of the individual runs are on depth. In cases where there have been multiple logging suites run in the borehole the acquired responses are edited to remove both the initial tool pick-up and the final casing responses from the data before the curves are merged to allow display of a complete data-set.

Borehole and environment corrections are applied to all recorded tool responses using algorithms which emulate the correction charts published by the appropriate logging contractor company and using the parameters which have been supplied from the wellsite, or entered upon the contractors well log headers.

A BADHOLE flag is created, using standard cross-plotting techniques, to disallow certain input logs so as to avoid computing erroneous results. When the BADHOLE conditions are met neither the Density nor the Neutron log responses are used in the computations for the affected depth interval.

Calculation of R_T (true formational resistivity), R_{XO} (flushed zone resistivity and DI (the diameter of invasion) is calculated using the appropriate butterfly charts as supplied by the various logging companies.

Where R_{XO} is unable to be calculated due to borehole quality, or acquisition problems, then R_{XO} is deemed to be equal to R_T. In this case it is not possible to calculate the flushed zone water saturation (S_{XO}) which is usually presented as the movable hydrocarbon on the final presentation plots.

In situations where appropriate butterfly charts are not available to assist in the calculation of R_T the invasion corrected R_T is calculated using the following relationship;

$$R_T = 1.7 * R_D – 0.7 * R_S$$

Where:

R_T = true formational resistivity,
R_D = corrected deep resistivity log, and,
R_S = shallow resistivity log.

The volume of clay (V_{CL}) is able to be computed using any of the following indicators;

- Gamma Ray (GR),
- Spontaneous Potential (SP),
- Sonic (DT),
- Neutron (NPHI),
- True formational resistivity (R_T),
- Density and Neutron (RHOB & NPHI),
- Sonic and Density (DT & RHOB),
- Neutron & Sonic (NPHI & DT), and,
- M / N (log derived M factor & N factor).

Not all indicators are always used. If a resultant V_{CL} curve is not deemed to be reasonable, or if a particular indicator has insufficient resolution to be meaningful, that indicator is not used in the final calculation of V_{CL}.

As individual clay indicators tend to be pessimistic the final V_{CL} is deemed to be the minimum of the values calculated using the utilised clay indicators.

Deterministic Interpretation Procedures

Total porosity (PHI_T) is calculated utilising standard cross plotting techniques and using the corrected log response curves. The log response curves which are used in the calculation of total porosity are dependent upon the quality of the individual response curves and the borehole conditions over the zone which is being interpreted.

The hierarchal use of log response curves for the calculation of the total porosity is as follows;

- RHOB & NPHI if good hole conditions are met,
- RHOB if good hole conditions are met and NPHI is unavailable, and,
- DT if good hole conditions are not met.

Effective porosity is computed as follows;

$PHI_E = PHI_T * (1 – V_{CL})$

Within this petrophysical interpretation water saturation has been determined by utilisation of the Modified Simandoux equation.

The Modified Simandoux equation can be written as follows;

S_W = (((V_{CL} /ResClay)^2 + 4* PHI_E ^m/(a* R_W *(1- V_{CL})* R_T))^(1/n) - VcL/ResClay)/(2* PHI_E ^m/(a* R_W *(1- V_{CL})))

Where:

S_W = calculated water saturation (fraction),
R_T = true formational resistivity (ohmm),
V_{CL} = calculated volume of clay (fraction),
R_{CL} = resistivity of the clay (ohmm),
PHI_E = calculated effective porosity (fraction),
R_W = formation water resistivity,
ResClay = Resistivity of Clay
a = empirical factor (tortuosity factor),
m = cementation exponent, and,
n = saturation exponent.

When hydrocarbons are computed as being present in the interpreted section hydrocarbon corrections are applied immediately after computing the water saturations. This is an iterative process which corrects the density and neutron log responses due to the presence of hydrocarbons. The hydrocarbon corrected density and neutron logs are then used to recompute PHI_T, PHI_E and thus S_W once again. Since the iteration process is a converging process, where changes to the calculated log values become smaller and smaller, there is no point continuing past a certain point. For this reason the iterative process is terminated once certain conditions are met. For the process utilised in this interpretive procedure the iterative loop continues for as long as the difference in value between of two successive calculations of PHI_E is greater than 0.001 (0.1%). Once the difference in two successive calculations of PHI_E is less than 0.001 (0.1%) the iterative loop is terminated.

Lithology is computed using standard cross plotting techniques. Where all of the required log responses curves (RHOB, NPHI and PE) are available a RHOMAA (apparent matrix density from the Density/Neutron cross-plot) vs. UMATA (apparent photo electric matrix cross section) plot is constructed with a ternary diagram based upon the pure mineral endpoints for quartz, calcite and dolomite overlain on the cross plot. The position of any given point within the ternary diagram defines the volumes of individual minerals which will comprise the lithology for the given depth interval. Where the requisite curves which make up the RHOMAA vs UMATA cross plot are either missing, or have been disallowed due to BADHOLE conditions, the matrix is deemed to be constituted of the mineral corresponding to the value entered for either the RHO_{MA} (matrix density) or DT_{MA} (sonic matrix).

Probabilistic Interpretation Procedure

In this method the user defines the mineral inputs and fluid phases present in each zone. The user also defines which logs will be used that is most representative to define the zone of interest. According to these inputs (minerals and logs) the software calculates the most probable distribution of minerals and fluids. As a quality control, the software back calculates pseudo logs of each of the inputs. By doing so it quantifies the error within the model.

The resultant petrophysical interpretation can be adjusted by changing the input logs or minerals (usually clay). Inputs can also be given different weighting factors (trust) to rely more heavily on certain logs. In order for the probabilistic model to compute a unique solution the model must satisfy the following requirement:

(# of minerals) + (# of fluid phases) <= (# of input curves) + 1

This method of interpretation can provide excellent results provided the minerals and log inputs are representative of the downhole lithology.