

# Chapter 5

## Results and Discussion

### 5.1. Results:

Quantitative log interpretation has been performed on wells localized into the Fula area over Darfur Group, Bentiu Upper Member and Upper Abu Gabra intervals. Two wells have been interpreted (Sharaf-1, Sharaf-2).

From the petrophysical study of wells listed above, it is shown that the Darfur Group, Bentiu and Abu Gabra present highly porous sandstone intervals with variable shale content.

Darfur and Abu Gabra are characterized by a higher shale content compared to Upper Bentiu Member which is composed predominantly of massive sands.

During this study, shale volume ( $V_{sh}$ ) has been interpreted. This is computed preferentially based on GR according to the Clavier Formula, and density neutron cross plot.

Effective porosity has been interpreted. This is preferentially based on the neutron-density cross-plot method. The resulting porosity is generally comprised between 10 and 30%.

Water saturation has been computed using Indonesian equation. Input parameters have been chosen based on standard industry accepted values for tortuosity factor ( $a$ ), saturation exponent ( $n$ ) and cementation exponent ( $m$ ). The formation water resistivity ( $R_w$ ) has been estimated based on apparent water resistivity ( $R_{wa}$ ), and Pickett plot methods.

**As a result, reservoir parameters were averaged after having applied cutoffs and summarized as follow:**

The Gross thickness of the Darfur Group ranges from 16 m (Sharaf-1) to 540m (Sharaf-2), with an average of 278m. The NTG ratio obtained after a cutoff application on shale volume, ranges from 0.127 V/V (Sharaf-1) and 0.21 V/V (Sharaf-2). Reservoir Study of wells drilled on Block 17 show considerable thickness (ranges from 154.5m in Sharaf-1 to 459.5 m in sharaf-2 for Upper Bentiu Member. This reservoir has excellent petrophysical properties.

## Chapter 5: Results and Discussion

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log interpretation shows massive sands characterized by a high porosity with values comprised between 0.267 V/V (Sharaf-1) and 0.143 V/V (Sharaf-2).

The formation is generally homogeneous (high NTG average of 0.497 V/V in sharaf(1) to 0.501 V/V in sharaf(2)) with some thin shaly interbeds. Upper Bentiu sands reservoir is topped by thick shale levels of Aradeiba Formation which act as a seal.

The Gross thickness of the Upper Abu Gabra Formation ranges from 14.5 m (Sharaf-1) to 320.5 m (Sharaf-2), with an average of 167.5 m. This section is composed of medium porosity sandstones between 0.217 and 0.14 V/V (in Sharaf-1 and sharaf-2 respectively) of porosity, with higher shale content than Upper Bentiu Member (NTG about 0.44 V/V). Several shale layers of few to 100 m thick occur typically within the formation and may act as a seal within Abu Gabra Formation.

Over the study areas, these shaly covers involved in the Petroleum System are localized above clean sandstone intervals that have been considered as potential oil bearing reservoir in this resource assessment study.

### 5.2. Conclusions:

1. The data in this study include wire line logs and mud logging data, DST.

and for two wells and only one well with conventional core analysis. Core analysis results was very limited. Therefore its utilization to calibrate the interpretation results was very limited.

2. The idealized type logs were constructed using the gamma ray logs, resistivity logs, density logs, neutron logs and sonic logs for all wells.

The physical properties of stratigraphic column formations were studied where such type of logs help in distinguishing these formations in the area of study.

The logs responses of these formations indicate the response of varying lithologies represented by sandstone, shale and siltstone.

3. The determination of shale volume was achieved using various methods, either single curve shale indicators or two curve shale indicators. Due to the presence of radioactive minerals in sands, gamma ray is not reliable indicator to calculate the shale volume of this area.

The density neutron technique has been the preferred two curve shale indicator method to calculate shale volume, especially where radioactive sand occurs.

## Chapter 5: Results and Discussion

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An important step in well log interpretation is the estimation of shale parameters such as: gamma ray reading in shale (GRsh), shale resistivity (Rsh), shale density ( $\rho_{sh}$ ) and shale neutron porosity ( $\phi_{Nsh}$ ), which have determined either statistically using the frequency crossplots or directly from the well logs. The shale parameters for Darfur Group, Bentiu, and Abugabra formations have been determined statistically using the crossplots and compared with the histograms for the all wells.

4. Porosity can be determined in both cleaned and shaly formations using different methods (sonic, density and neutron) and the combination method (neutron-density).

The porosity obtained from each method excluding shale effect is called the effective porosity. The effective porosity derived from the combination method (neutron density) was used in the calculations because it gives the most optimum porosity.

5. Studied the core analysis data of one well (Sharaf-1), drew a conclusion that the rock mineral constituent in the area is mainly quartz granules and the clay mineral constituent in the area is mainly Kaolinite, and that there is little additive conductivity clay mineral such as Illite/Smectite.

6. Shale volume is the principle factor affecting the reservoir quality as it will decrease the porosity, plug the pore throat and dramatically decrease the permeability and drop both the saturation and porosity exponents.

7. The Indonesian shaly sand equation produced acceptable saturation results for the shaly sand reservoirs that have been part of this study as long as suitable shale parameters are selected.

8. The fluid contact determined in this study using Log response and testing data as no pressure data was available.

9. Only oil down to (ODT) was detected in Sharaf-1 at 2381.0mKB, as no oil zone interpreted in other well.

10. Sharaf structure proved to be oil bearing with Sharaf-1 as an oil well, while the other one well proved to be water wet.

### 5.3. Recommendations:

Currently, open hole logging data are competent for oil/water zone identification. But in order to acquire relatively accurate oil saturation, more works should be carried out, for instance:

## Chapter 5: Results and Discussion

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1. Strengthen the works of shale analysis, core oil/water saturation analysis, in order to acquire the exponent for saturation calculating in conditions of various  $V_{sh}$ .

2. More core analysis data are highly recommended in this area. Particularly special core analysis which will enable us to verify the petrophysical results.

3. Run Log while Drilling (LWD) in a few wells, to compare the LWD resistivity with open hole logging resistivity, in order to analyze the difference between the two resistivities, and how it can affect the reservoir saturation calculation.

4. More advanced logging tools such as nuclear magnetic resonance (NMR), and Elemental Capture Spectroscopy (ECS) are highly recommended to give more accurate results.