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Application of Gas Ratio Analysis in Reservoir Evaluation – Case Study in Belayim Land Field, Gulf of Suez, Egypt

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Abstract

Knowledge of gas analysis from the extracted drilling formation represents the earliest data while drilling and is performed by mud logging contractors which represent an important stage into the formation evaluation by the wellsite geologists and represent an important stage for the production team especially in exploratory drilling operations. In this paper, we will study Gas Ratio Analysis which can play a role to identify the fluid types and decide which layers have hydrocarbons by using simple ratios of light gases measured by gas chromatograph inside the mud logging unit where it can be calculated in real-time and plotted, both on mud logs together with depth-based data. In this study we selected three wells in belayim land field to application of gas ratio analysis, It was shown that hydrocarbon distributions inside the formation where we can select the best places for perforation and production.

Keywords

Gas Analysis, Real-Time, Gas Ratio

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1. Introduction

The scope of this paper is studying the relation between the mud gases that obtained during drilling which record in real-time and reservoir hydrocarbons types and determine the reservoir extent by using gas ratio analysis.

Gas reading recovered from drilling fluid through gas trap which put in possum belly near flow line as shown in (Figure 1) which its efficiency depending on the design, gel strength of mud and mud flowing. This gas trap connected to ditch line to drawn extracted gases to equipment present in mud logging unit used for gas detection to evaluate total gas and gas chromatograph which carry a sample to columns where it can be characterized the sample into individual components from methane to pentane (C1 To C5) where it transmitted to real-time system in digital form then reported in parts per million for each gas which appear in (Figure 2), so the importance of gas chromatograph appears in pay zones where we can differentiate oil-bearing formation from gas-bearing formation depending on gas analysis results where we should take a consideration any changes from background gases as result of change in lithology, drilling fluid properties or change in ROP that influence the amount of gas detected.

In the interpretation of a gas log, it must be aware of the different mechanisms by which gas can originate from the formation and enter the drilling fluid either it is contamination gas, produced gas, connection gas, liberated gas, recycled gas or trip gas.

In this paper, we selected Belayim Land Field as proposed area of study which located in the eastern part of Gulf of Suez and we selected the available wells (112-124, 112-119 and 112-132) for gas ratio analysis in the reservoirs of the

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study area (Figure 3).

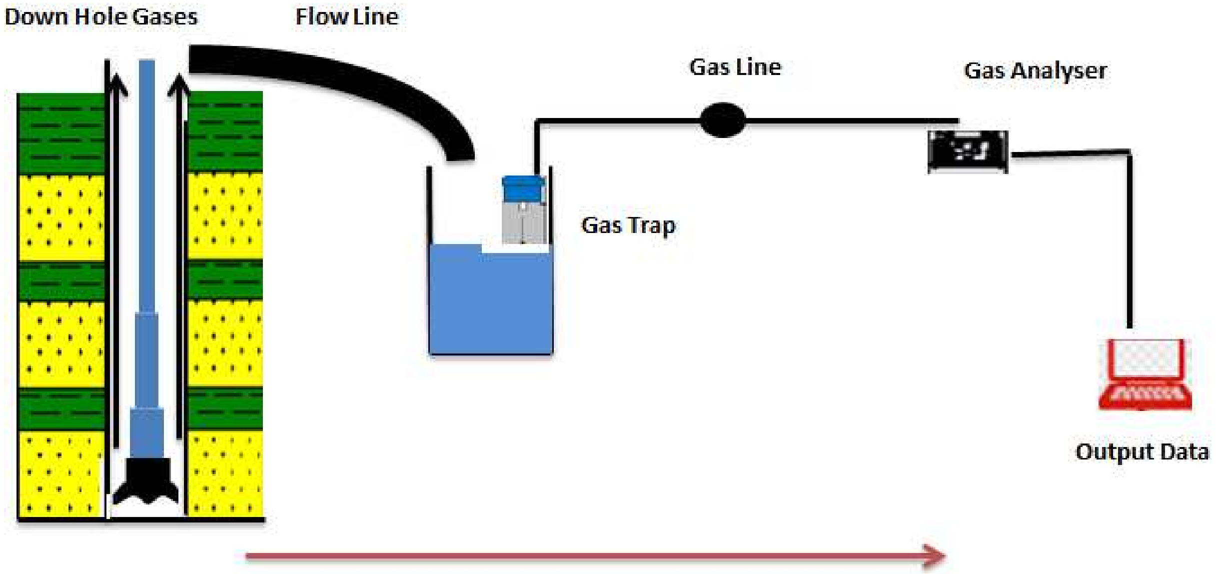

Figure 1. Typical Gas Line for Extracting Drilling Gases.

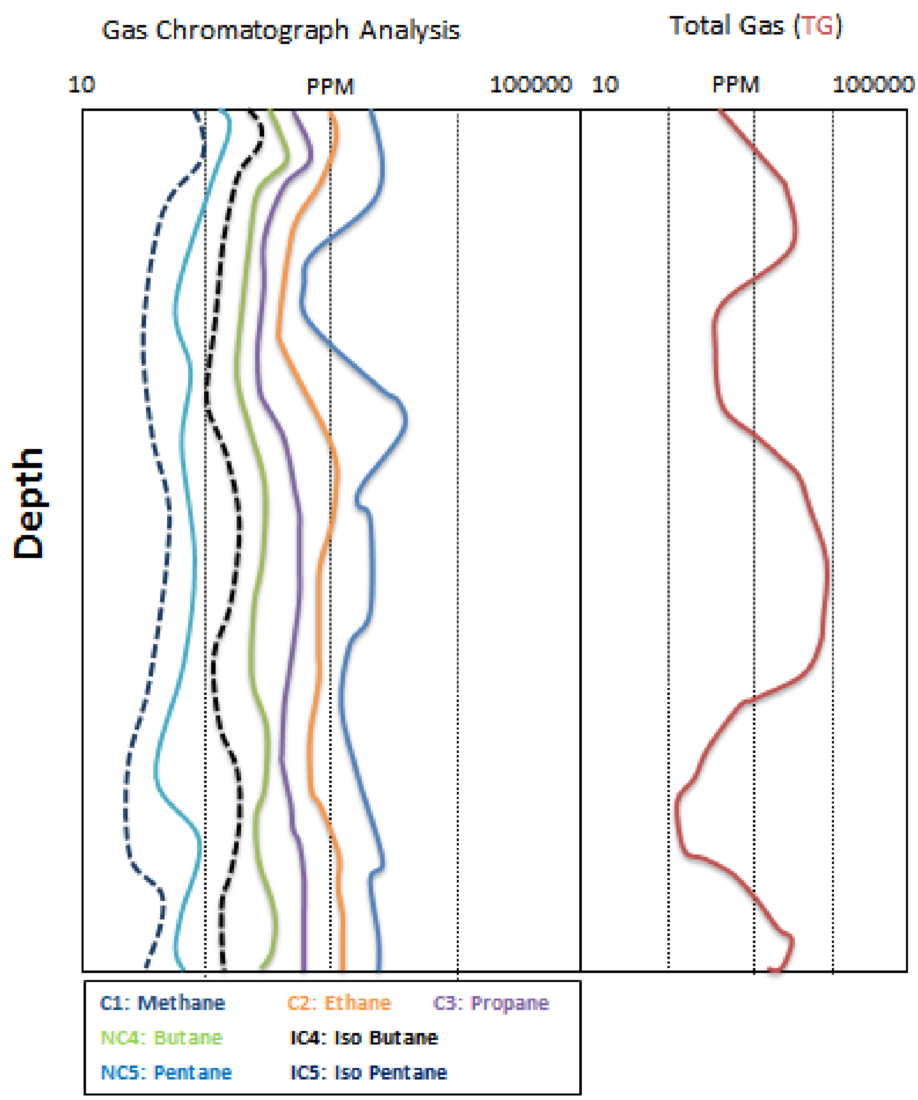

Figure 2. Chromatograph Analysis and Total Gas.

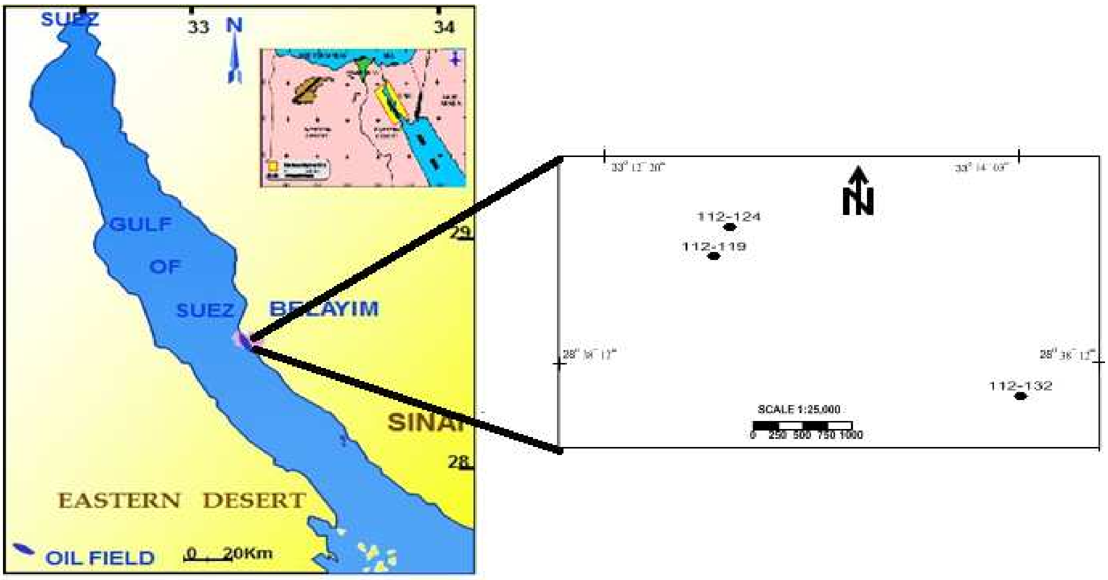

Figure 3. Location Map of Belayim Land Field.

2. Geological Setting of Study Area

The study area present in Gulf of Suez which located in Egypt at the junction of the African and Arabian plates where it separates the northeast African continent from the Sinai Peninsula. The Gulf of Suez is among the most important hydrocarbon provinces in Egypt. The petroleum exploration in Gulf of Suez began since more than 100 years ago at Ras Gemsa field.

The general structure of the study area is consists of north-south trending anticline. This anticline is cut by two main faulting system, one parallel to the coast represents a normal step faulting connected with Suez graben, The second is represented by a series of transcurrent faults subdivide the structure into different blocks (Figure 4).

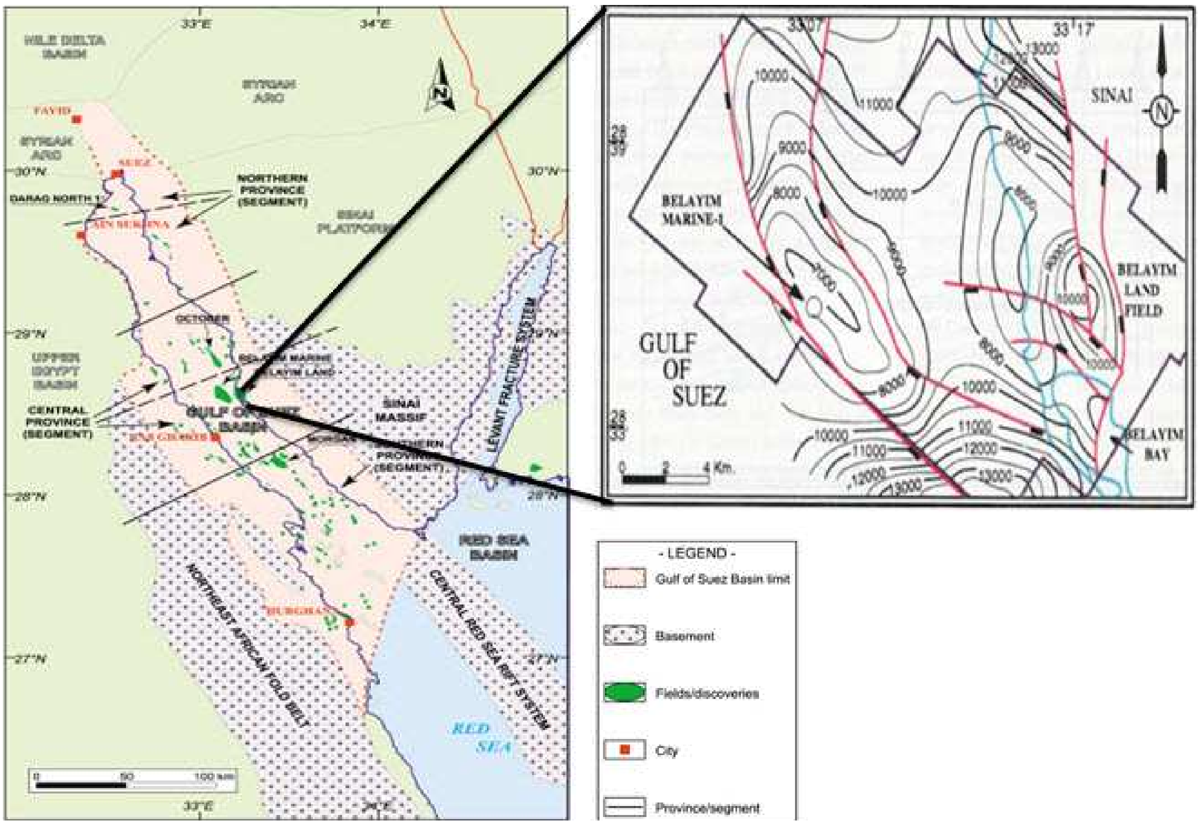

Figure 4. Structure Provinces of Gulf of Suez, The Map also Shows Structural Frameworks of Study Area [After EGPC].

3. Methodology

3.1. Data Preparation

This methodology is based on the computation and analysis of several gas ratios obtained from the different gas Components (C1-C5) continuously extracted from the circulating mud and monitored at the rig site in real-time by the mud logging company.

In the first step of this methodology started with pre-analysis with quality control check of the dataset which include total gas (TG), Methane (C1), Ethane (C2), Propane (C3), Butane (NC4), Iso Butane (IC4), Pentane (NC5), Iso Pentane (IC5) with other data of ROP and lithology to review any of erroneous data influence on data quality.

The second step is gas ratio analysis application to determine hydrocarbon gases in the drilling fluid which comes from the reservoir to determine gas zone, oil zone or it is a non-productive zone.

In this study, we will use hydrocarbon Wetness (Wh), hydrocarbon Balance (Bh) and hydrocarbon Character (Ch) ratios calculated from lagged gases and plotted against depth to give a picture for reservoir evaluation. The beauty of this method, it can be immediately calculated during drilling and penetration the reservoir with graphical representation in real-time on the plot to give an immediate view on reservoir evaluation.

3.2. Application of Wetness (Wh)/ Balance (Bh)/ Character (Ch) ratios

3.2.1. Wetness Ratio (Wh)

Wetness Ratio shows an increasing trend as gas and oil density increases where the amount of heavy gas increases proportionally against the lighter gases

$$Wh = \left(\frac{C2 + C3 + C4 + C5}{C1 + C2 + C3 + C4 + C5} \right) \times 100$$

Also, Wetness Ratio increases, dry gas (methane) through to wet gas (higher concentration of heavy gases) is being indicated, increasing gradually from light, through medium and high density to, finally, a residual oil deposit as shown in (Figure 5).

Wh Fluid Type

< 0.5 Indicates to non-productive Zone.

0.5 – 17.5 Indicates to gas reservoir as increasing gradually in Wh.

17.5 – 40 Indicates to oil reservoir with continue increasing in Wh.

> 40 Indicates to residual oil.

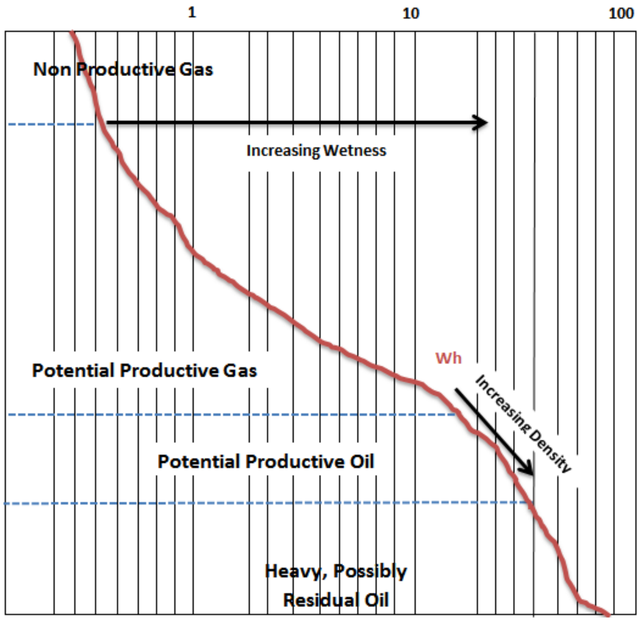

Figure 5. Reservoir Evaluation based on wetness ratio.

3.2.2. Balance Ratio (Bh)

$$Bh = \frac{C1 + C2}{C3 + C4 + C5}$$

This ratio (Bh) is a direct comparison of light to heavy hydrocarbons and with the wetness ratio for interpretative purposes and give immediately prediction for reservoir evaluation.

Bh reacts inversely to Wh and decreases with increasing in fluid density. So with increasing in wetness ratio followed with decreases in balance ratio to show it will pass all phases from gas phase to oil phase as shown in (Figure 6).

Balance Ratio Wetness Ratio Reservoir Fluid

> 100 Dry gas typically non-associated and non-productive.

< 100 < 0.5 Possible, light or dry gas.

Wh < Bh < 100 0.5 – 17.5 Productive gas, the curves are closer together.

< Wh 0.5 – 17.5 Productive, wet gas or condensate or high gravity oil.

< Wh 17.5 – 40 Productive oil and decreasing gravity.

<< Wh 17.5 – 40 Lower production of low gravity oil.

> 40 Very low gravity or residual oil.

Representation of react of two ratios to each other show that nature of reservoir (gas or oil) and with determine top of reservoir with fluid contacts (Gas Oil contact or Oil Water contact), furthermore with identification every fluid zone in the reservoir during drilling and this ratio (Bh) is a direct comparison of light to heavy hydrocarbons and with the wetness ratio for interpretative purposes and give immediately prediction for reservoir evaluation.

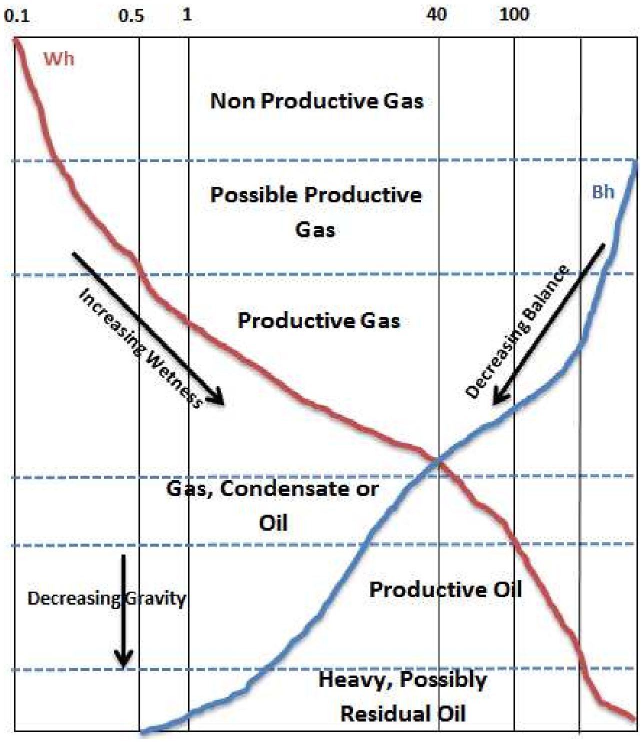

Figure 6. Identification Reservoir Fluid type using Wetness and Balance Ratios.

In (Figure 7) illustrates that Wh/Bh cross-over as fluid-based where top of the reservoir is identified when Bh drops to show a more productive gas then gas-oil contact is seen when Wh/Bh curves come together to be cross to each other, then Wh/Bh curves still close together with lower Wh to indicate condensate fluid or light oil and with appearing separation and the curves quite close together between Wh/Bh curves as oil zone is approached. Then the oil-water contact is determined when there is a greater degree of separation between Wh/Bh curves resulting from heavier, residual oil.

In (Figure 8) shows that in this case enters directly into an oil-bearing reservoir where Wh/Bh cross-over as fluid-based where top of the reservoir is identified without gas-oil contact, then Wh/Bh curves close together with appearing separation between Wh/Bh curves as oil zone which suggests low gravity oil. Then the oil-water contact is determined when there is a greater degree of separation between Wh/Bh curves resulting from heavier, residual oil.

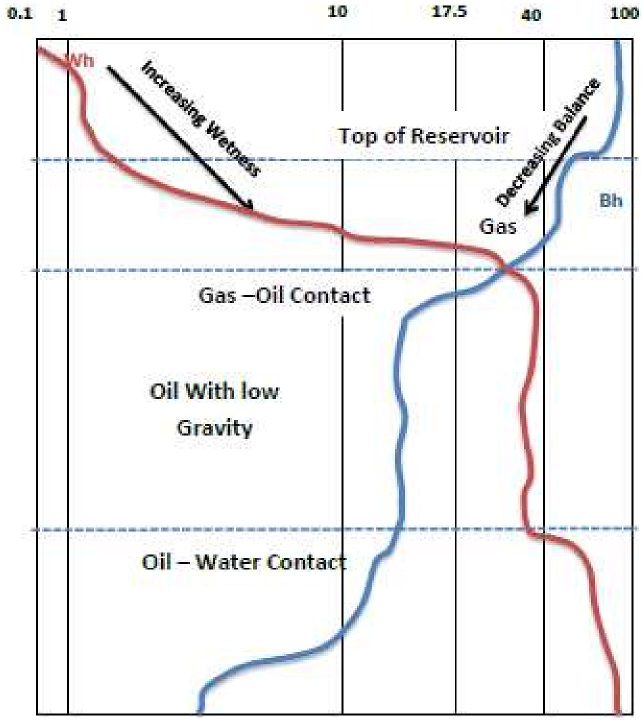

Figure 7. Reservoir Evaluation Using the Wetness and Balance ratios.

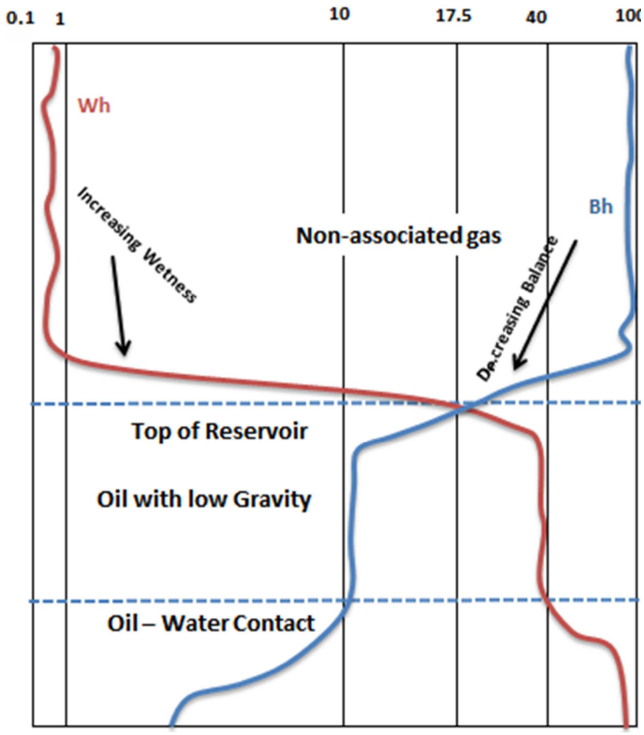

Figure 8. Reservoir Evaluation Using the Wetness and Balance ratios in Case of Oil Bearing.

3.2.3. Character Ratio (Ch)

Character ratio just comparing the heavier compounds where we can characterize a very wet gas from very high gravity oil. The comparing of three compounds show that C3 typically be more predominant in gas reservoir with traces amounts of C4/C5 and with increasing in heavier components will be with increases in the fluid density but C4 and C5 will increase proportionally in the case of light oil, (Figure 9).

$$Ch = \frac{C4 + C5}{C3}$$

If Ch < 0.5 Where C3 is the major component, the presence of a productive gas phase is confirmed and it may be wet gas or gas condensate.

If Ch > 0.5, Indicating productive liquid phase, gas indicated by wetness ratio and associated with light oil.

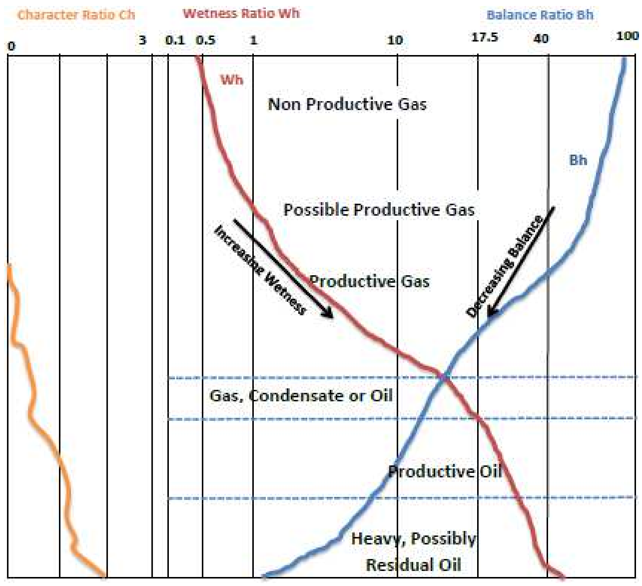

Figure 9. Reservoir Evaluation using Wetness, Balance and Character ratios.

4. Results and Discussion

Gas ratio analysis represents hydrocarbon distribution through the reservoir with determination whether it corresponds to a gas or oil reservoir. In this study, we will use gas ratio in available wells (112-119, 112-124 & 112-132) in belayim land field.

In the first as previously described in the methodology, we can extract gas ratio parameters (hydrocarbon Wetness (Wh), hydrocarbon Balance (Bh) and hydrocarbon Character (Ch) to represent gas or oil zone through the reservoir.

Gas ratio analysis for every well was calculated and plotted against depth through the reservoir to show the relation between three gases ratio curves, also with plotting total gas, drilling rate and lithology to improve reliability in evaluating gas ratio characterization.

Gas ratio analysis for 112-119 well (Figure 10) shows gradually increase in background gases at depth 2728 m (MD) while drilling through the sediments with fast break where top of reservoir is identified without gas-oil contact when Wh and Bh gradually come together with cross-over of Wh and Bh which identifies zone of oil where 17.5 < Wh < 40 and Bh < Wh which reflect productive oil with oil gravity decreasing density where the degree of curve separation will indicate the oil density. Also by using Character ratio (Ch) values to more reliability where it serves to resolve ambiguities between oil or gas which confirmed the zone of oil. Oil-water contact is identified with more degree of separation between Wh and Bh resulting from heavier, residual oil.

Gas ratio analysis for 112-124 well (Figure 11) shows a gradual increase in a gas response above background gases at depth 2983 m (MD) while drilling in the formation with good drilling break. Top of reservoir is identified without true gas-oil contact, at this time Wh and Bh gradually come together with cross-over of Wh and Bh which identifies zone of oil where 17.5 < Wh < 40 and Bh < Wh which refers to productive zone with oil gravity decreasing density and by using (Ch) as an extra indicator which confirms that the main zone is oil. Oil-water contact will be evident with more degree of separation between Wh and Bh.

Gas ratio analysis for 112-132 well (Figure 12) shows fast drilling break and gas level start to increase with crossing over of Wh and Bh at 2923 m (MD) which represent top of reservoir, then appearing good separation of Wh and Bh curves to show the entry into oil-bearing sand or (sweet spot) and with degree of separation showing the medium gravity oil where 17.5 < Wh < 40 and Bh < Wh. The higher (Ch) ratio value would tend to predict this zone is oil. Oil-water contact illustrated by the wide separation or divergence of Wh and Bh curves (indicating water).

5. Conclusion

This study carried out on available wells spread in Belayim Land which lies between longitudes 33°12̀ and 33°15̀ east and latitudes 28°35̀ and 28°40̀ north where we used application of gas ratio analysis for reservoir evaluation in the study area during drilling and with calculation of hydrocarbon Wetness (Wh), hydrocarbon Balance (Bh) and hydrocarbon Character (Ch) ratios we determined the reservoir extent, top of reservoir, hydrocarbon-bearing formation and oil-water contact for every well.

Basics of interpretation in the paper depending on studying the relation and relative position between hydrocarbon Wetness (Wh) and hydrocarbon Balance (Bh) with consideration of hydrocarbon Character (Ch) during drilling for evaluating gas ratio characterization and it must integrate with lithology and drilling rate to make more confirmation.

With application of plotting of Wh, Bh and Ch against depth, the plot shows crossing over between Wh and Bh which represent top of reservoir, when Wh values located between

17.5 and 40 and Bh < Wh which represent separation between Wh and Bh curves, it will indicate the oil density where the narrower of separation, the lighter the oil. With using Ch to more reliability and resolving ambiguities between oil or gas. Also, oil-water contact is identified with more degree of separation between Wh and Bh which indicating water.

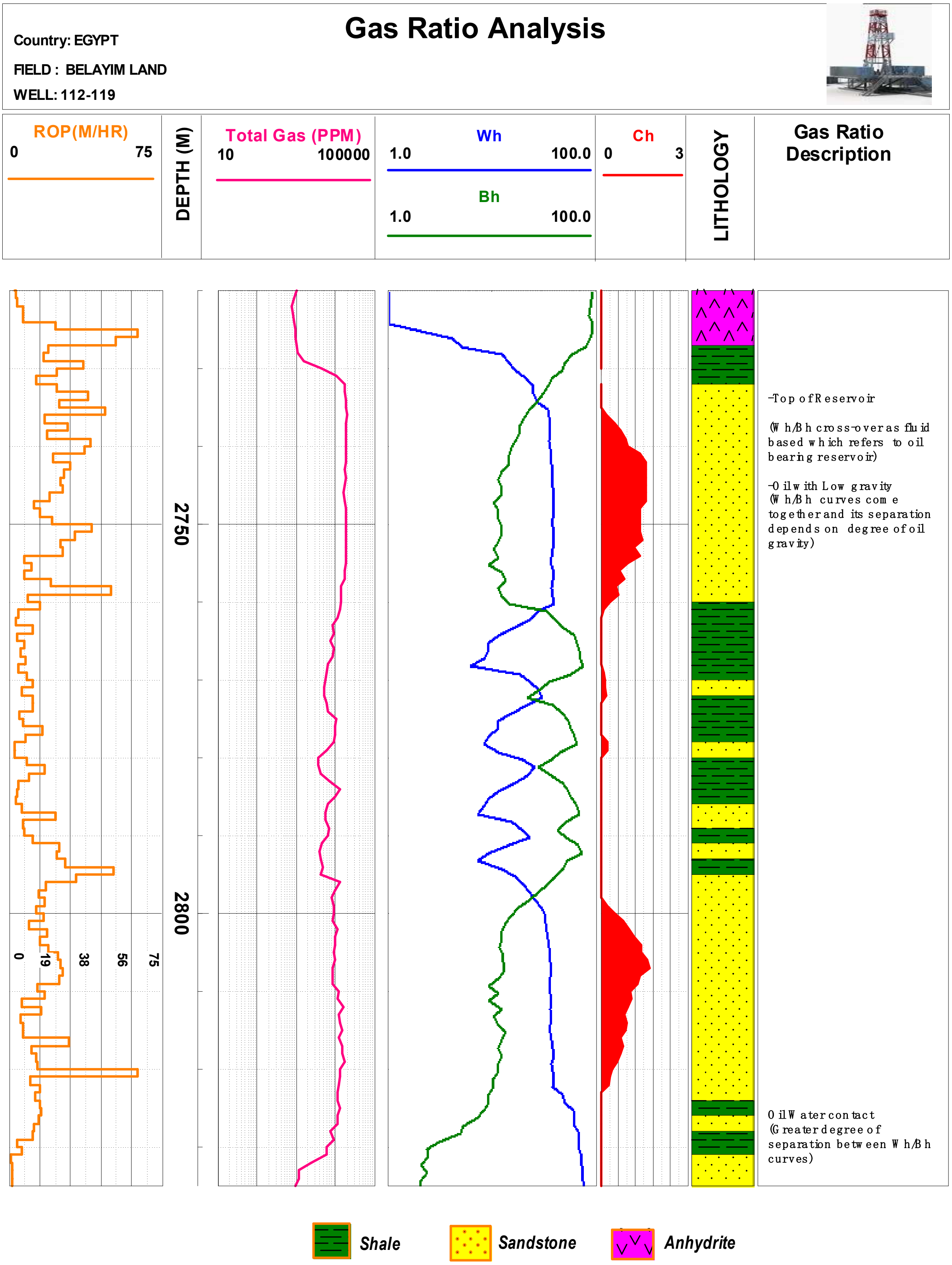

Figure 10. Gas Ratio Analysis for 112-119 Well.

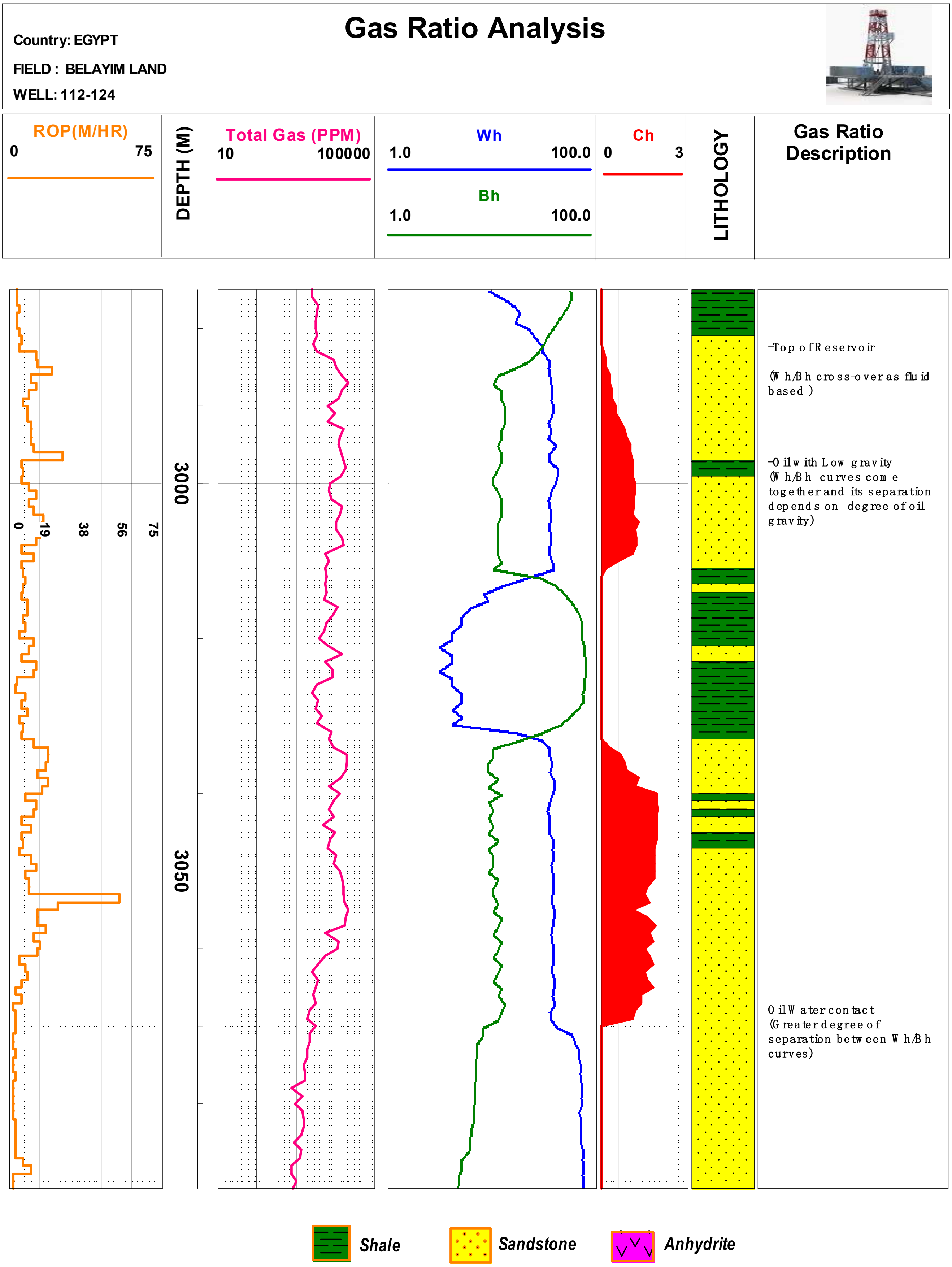

Figure 11. Gas Ratio Analysis for 112-124 Well.

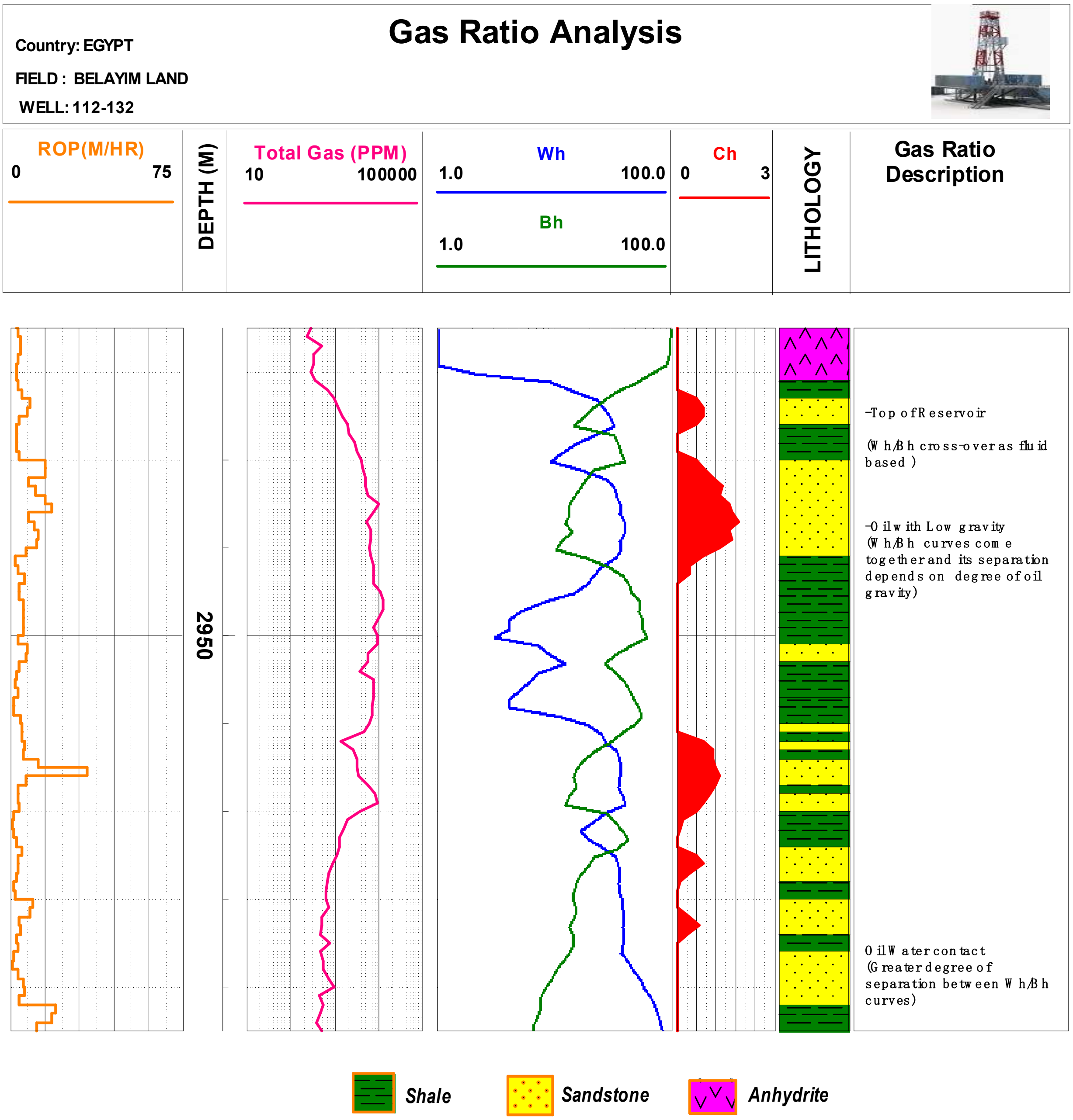

Figure 12. Gas Ratio Analysis for 112-132 Well.

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