ESTIMATION OF PROSFECTIVE HYDROCARBON ZONE BASED ON LOG INTERPRETATION IN "Z" AREA SOUTH SUMATERA BASIN

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Abstract

Log analysis is one way to estimate hydrocarbon zone and evaluate the reservoir formation, it applied to get the physical characteristics consist of porosity (¤*)*, resistivity *(R),* water saturation *(Sw),* and permeability *(K).* The main object of this study is performing petrophysical analysis to estimate hydrocarbon zone of Well-K1, located in South Sumatera basin.

The methods are log interpretation and core analysis. First, well logging interpretation using Interactive Petrophysics (IP) software. Secondly, determining productive zone using Petrophysical properties, include permeability by gamma ray (GR) log, porosity by Schlumberger method, water saturation by Archie's equation which a factor and cementation exponent were derived from the core analysis in laboratory. Then, analyze fluid rock type using Electric logs, with resistivity values of oil is 60-100Ωm, and gas >100Ωm.

As a result, there is one prosfective hydrocarbon zone in well-K1, located in 2295-2397ft below surface in Air Benakat Formation. Average petrophysical parameter values of these hydrocarbon zone are ¤=31%, Sw=30%, R=96Ωm. Based on resistivity values, this productive zone is contained oil (LLD=60-100Ωm). The lithology of this zone is dominated by sandstone with Gamma Ray logs values around 21-46 API, indicating excellent reservoir quality. The petrophysical properties of the reservoirs in Well-K1 are enough to permit hydrocarbon production.

Keyword: Petrophysical properties, Hydrocarbon, Log analysis

Introduction

The South Sumatra Basin received a great deal of attention in the early days of petroleum exploration because of the numerous oil seeps in the area.

Well log analysis and interpretation are the most important tasks to detect reservoir petrophysical parameters, such as locating hydrocarbon zones, determine depth and thickness of zones, and distinguish between oil, gas and water.

Different types of gamma ray (GR), spontaneous potential (SP), resistivity, neutron and density log are helped to define physical characteristics of the reservoirs such as porosity, saturation, hydrocarbon moveability and permeability. These data are used to identify permeable zones for hydrocarbon with depth and thickness of the zones and to distinguish interfaces of oil, gas or water in a reservoir. All these are essential for estimation of hydrocarbon reserves.

The purpose of this research was to determine the lithology of the formation and predict position and thickness of hydrocarbon production based on petrophysica properties include shale volume (Vsh), porosity (Φ), permeability (K), resistivity and water saturation (Sw) on well K1 in South Sumatera basin.

Geology and stratigraphy

The geology and tectonic evolution of the basin have been described by Adiwidjaja and de Coster (1973), de Coster (1974), Pulunggono et al. (1992), Darman and Sidi (2000) and Barber et al. (2005). The geology of South Sumatra is dominated by the Holocene-Pleistocene and Pliocene-Miocene sediments, pre-Tertiary Volcanic and intrusive igneous as well as metamorphic rocks (Figure 2). Stratigraphically, four phases of tectono-stratigraphic evolution are recognised.

Sediments representing the Cratonic Stage are absent in the South Sumatra Basin. Tertiary sediments overlie Mesozoic limestones, various metasediments and igneous rocks of the basement directly. The Lahat Formation represents the earliest Rifting Stage. This formation has been penetrated in the Palembang Sub-basin, but has not so far been encountered in the Jambi Sub-Basin, probably due to its greater depth in that area.

The Lahat Formation is absent on basement highs, and some grabens have not been drilled below the 'overlying' Talang Akar Formation. The Lahat Formation represents the initial rift valley sediments, which overlie the Kikim Tufts, erupted as the rifts opened. Thus, the Lahat consists of alluvial fans, basal conglomerates, lacustrine and fluvial sediments. It is likely that these late Eocene lacustrine facies provide one of the sources of oil for the basin(Barber et al,2005) (Figure 3).

Theory

Porosity

Porosity can be calculated using the

$$\emptyset_T = \frac{\rho_{ma} - \rho_B}{\rho_{ma} - \rho_f}$$

following mathematical relationship:

Where: *ρma* is density log reading in 100% matrix rock, default 2.65, *ρf* is fluid density, and *ρB* is density log reading in zone of interest.

Shale Volume

Shale volume computation determines the amount of shale in percentage using Gamma ray log. This computation is important because it gives an idea of how much shale presence can affect the effective porosity, fill the porous space and decrease space for hydrocarbons. Shale volume can be calculated using this equation:

$$Igr = \frac{GR_{log} - GR_{min}}{GR_{max} - GR_{min}}$$

$$V_{sh} = 0.083x2\ 2^{3.7(vsh)} - 1.0$$

GRlog is GR of formation measured from log, GRmin is Least GR in zone of interest, Grmax is Maximum GR reading in formation of interest, Igr is Gamma Ray Index, and Vsh is Volume of Shale. Where GRmatriks is gamma ray log reading in 100% matrix rock, Grshale is gamma ray log reading in 100% shale, and GR is gamma ray at specific depth.

Water Saturation

Archie Equation was used to calculate the water saturation as shown in this equation:

$$S_w = \left(\frac{aR_w}{\phi^m R_t} \right)^{\frac{1}{n}}$$

Where Rt is Deep Resistivity, Rw is Down hole water resistivity, Φ is Effective porosity, and Sw is water saturation (Thomas, 1992).

Method

The Interactive Petrophysics V3.5 was used to integrate all the available wellbore data in order to interpret and compute the input of the different petrophysical properties to deliver a more realistic and accurate prosfective hydrocarbon zone detection. With the following log data: Gamma ray (GR), Density (RHOB), Neutron (NPHI), Deep Resitivity(LLD).

The Gamma Ray log is used to determine permeable zone, reservoir and non reservoir zones. Electric logs analyze fluid rock type such as hydrocarbon or formation water. Porosity is calculated by both density and neutron log. Cross plot between density and neutron log is used to determine lithology.

Results and Discussion

Lithology Determination

The lithology of the well K1 was determined using the neutron versus density cross -plots.

Figure 4 shows the cross-plot neutron versus density of the well K1 which displays the lithology present in the entire well. Most cloud point is populated on the shale and limestone region and minor in sandstone region, which possibly indicates the presence of calcareous shale. When plotted only the prosfective hydrocarbon section points, it clearly indicates a predominance of clean sandstone (Figure 5).

Zonation

The zonation determination allowed a division of the logs into different zones. The gamma-ray log was used as a permeability indicator, density and neutron log as porosity, indicators and resistivity log as a fluid indicator. The gamma-ray log was used to define the formation thickness of each well.

The well-K1 presented in this work, are described below, where, are divided into four zones: Potential zone, Productive zone, clay zone and Sandstone zone (Figure 6).

Potential zone: This zone was classified lithologically as shale zone. It is permeable zone, because have low Gamma Ray values. But there are no separasi in this zone. This zone located 2400-2600ft below surface in well K1.

Productive zone: this zone was classified lithologically as shaly sand because of the evidence of shale intercalated with sand in some reservoirs. This zone was also characterized by its high resistivity and low gamma ray values, implying the presence of less clay mineral. This zone 2295-2397ft below surface in well K1. Based on resistivity values, this productive zone is contained oil (LLD=60-100Ωm) (figure 7).

Clay zone: The first zone is also called gas-bearing reservoir zone. In this zone the density-neutron cross-over shows mirror effect that provides conclusive evidence of gas indication, while, the second zone is filled dominantly with water, though, some gas content is present as evidenced by very low resistivity in this zone.

The thickness of the clay zone is about 500ft.it is located at 1800-2300ft. From 2270ft gamma-ray value started gradually decreasing, indicating a transition from shale to reservoir zone.

Sandstone zone: this zone at 2600-2290 ft. this zone dominated by sandstone rock. It is permeable zone because the Gamma Ray values is low.

Permeability

Gamma ray, neutron, and density logs were used as indirect indicators of permeability of the Well K1 reservoirs because core is generally of limited extent and could not be relied on to define all net reservoir zones, hence, reliance was placed on the wire line log data due to the fact that it indicated the presence of fluid invasion by mud filtrate. Low gamma ray reading indicated low clay content and higher permeability, while high neutron density porosity indicated high permeability (Tixier, 1949).

Water Saturation

The average water saturation revealed the proportion of void space occupied by water in the Well K1 reservoirs based on the calculations made, and it showed that water saturation of the reservoirs are low, thus, high hydrocarbon saturation and high hydrocarbon production (Timur, 1969). The average valuse of water saturation in prosfective hydrocarbon is 30%.

The formation resistivity factors (a, m) and water saturation exponent (n) have been derived from Pickett plot and formation water salinity.

Shale Volume

Shale volume calculated determines the amount of shale in percentage using Gamma ray log.

This calculation is important because it gives an idea of how much shale presence can effect the effective porosity, fill the porous space and decrease space for hydrocarbons. Based on calculation, the average of shale volume at prosfective hydrocarbon zone is 8%.

Porosity

Porosity is the key parameter in petrophysical evaluation, because of allowing the amount of hydrocarbons to be stored in the porous space of the rock (Theodoor, 2000). Density and neutron log is used to calculate porosity at prosfective hydrocarbon zone. Based on calculation, the average of porosity at prosfective hydrocarbon zone is 31%, indicating excellent reservoir quality.

Petrophysical Properties computation

It is important to identify properly the lithology and the reservoir to allow an accurate petrophysical calculation of porosity, water saturation and permeability. Therefore, in this section it was possible to discriminate and understand the reservoir zone. The reservoir is between 2295-2397ft, it presents partially a clean and thick sand reservoir with 8% water saturation average. The presence of low clay content seems to affect insignificantly the effective porosity and permeability values. Therefore, analyzing the average effective porosity (31%) and permeability of around 73-100mD, is concluded that this well presents a clean reservoir with a good permeability. The reservoir thickness matches with the pay zones. Average petrophysical values for each reservoir are shown in table 1.

Conclusion

The Prosfective hydrocarbon zone analysis done on well K1 at South Sumatra basin, enabled to come up with the following conclusions:

1. Prosfective hydrocarbon zone of well K1 located in 2295-2397ft below surface.
2. Both log interpretations and Neutron-Density cross-plots confirmed that the reservoir consists of sand mixed with shale lithology. However, the cross-plot snapshot shows some dispersed points in the limestone field
3. The average porosity and water saturation of the reservoirs was about 31% and 30% respectively, indicating a very good reservoir quality.
4. The log analysis performed shows that colony sand contains significant accumulations of oil.

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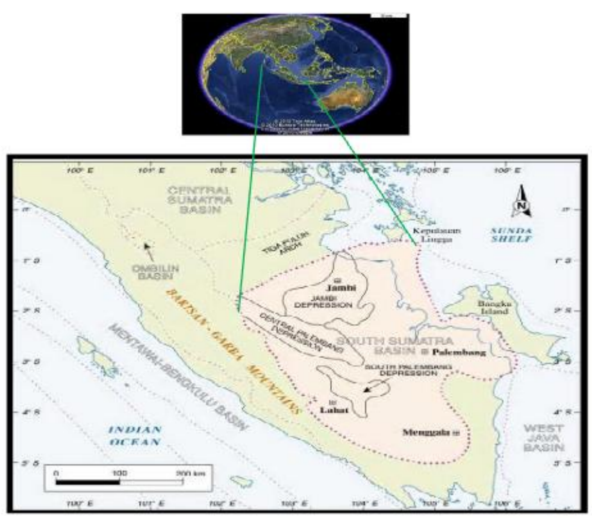

Figure 1. Location map of the South Sumatra Basin (After Petroconsultants, 1996)

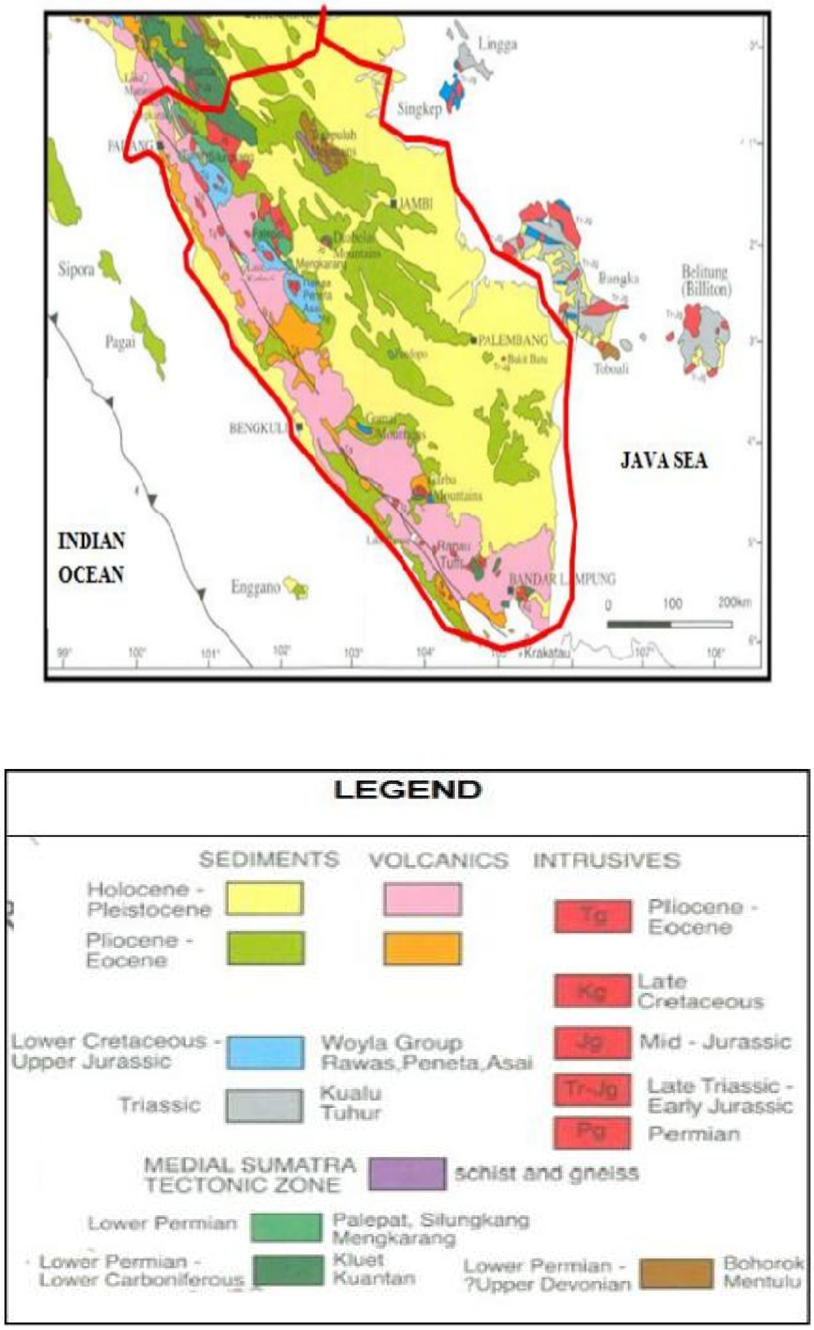

Figure 2. Simplified Geological Map of the South Sumatra Basin (modified from J. Armstrong et al, 2015)

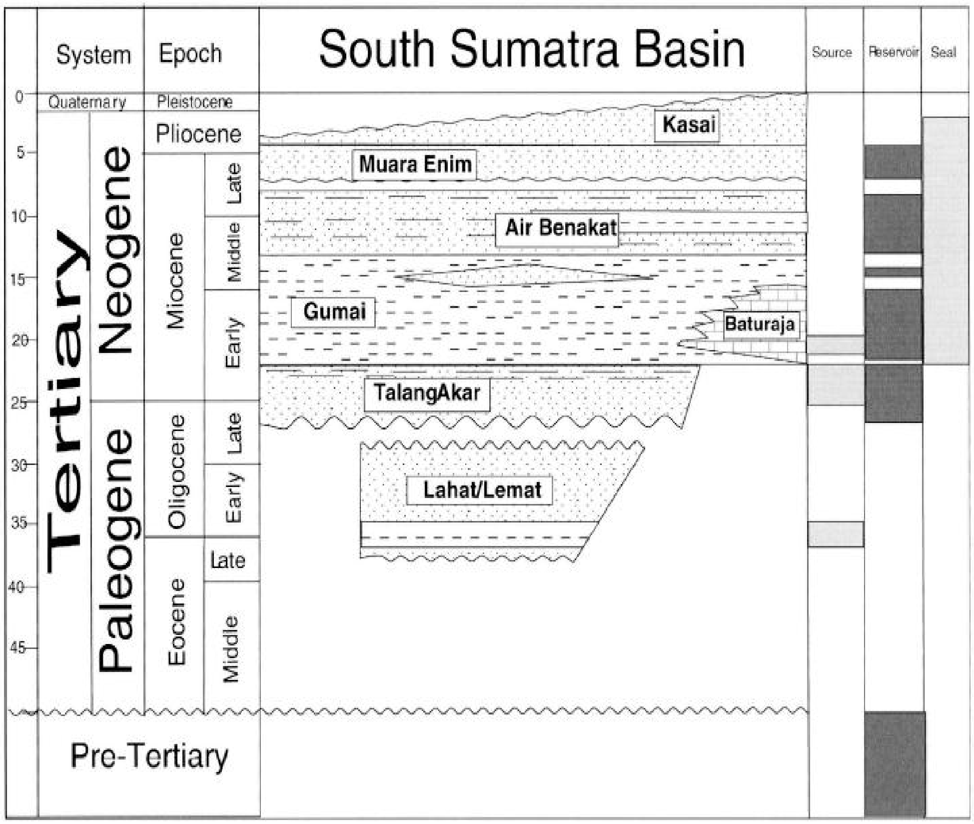

Figure 3. The stratigraphy of the South Sumatra Basin showing the positions of source rocks, reservoirs and seals.(modified from Barber et al., 2005

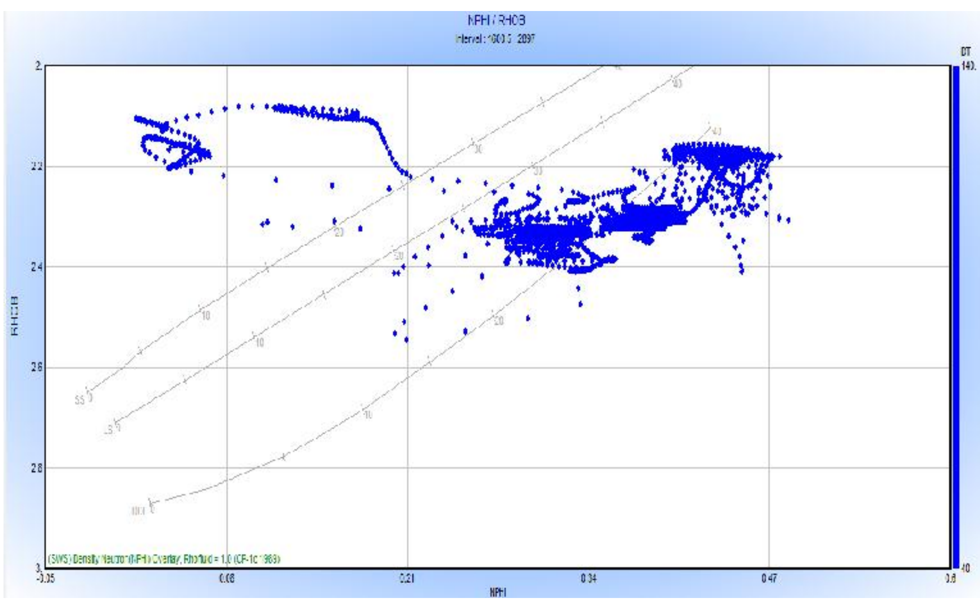

Figure 4. Cross plot Neutron Porosity vs Bulk Density for well K1

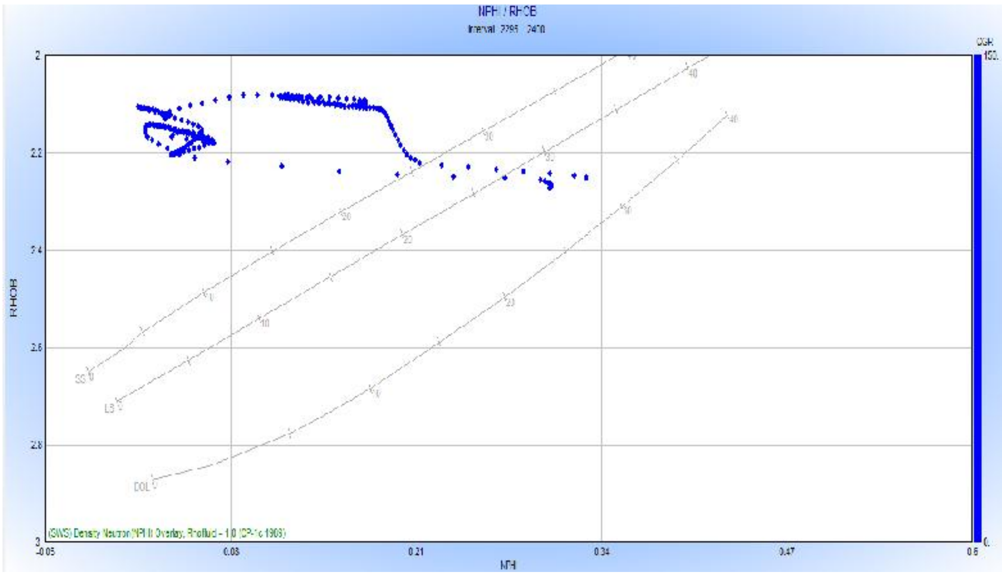

Figure 5. Cross plot Neutron Porosity vs Bulk Density for prosfective hydrocarbon zone in well K1

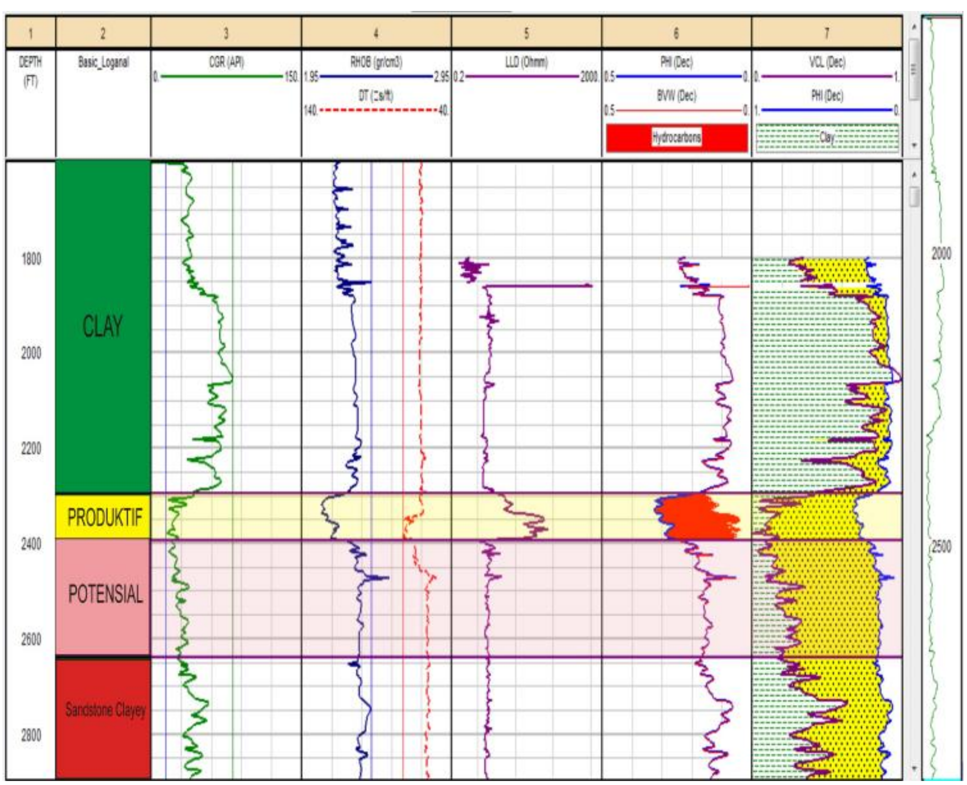

Figure 6. Well zone description for well K1

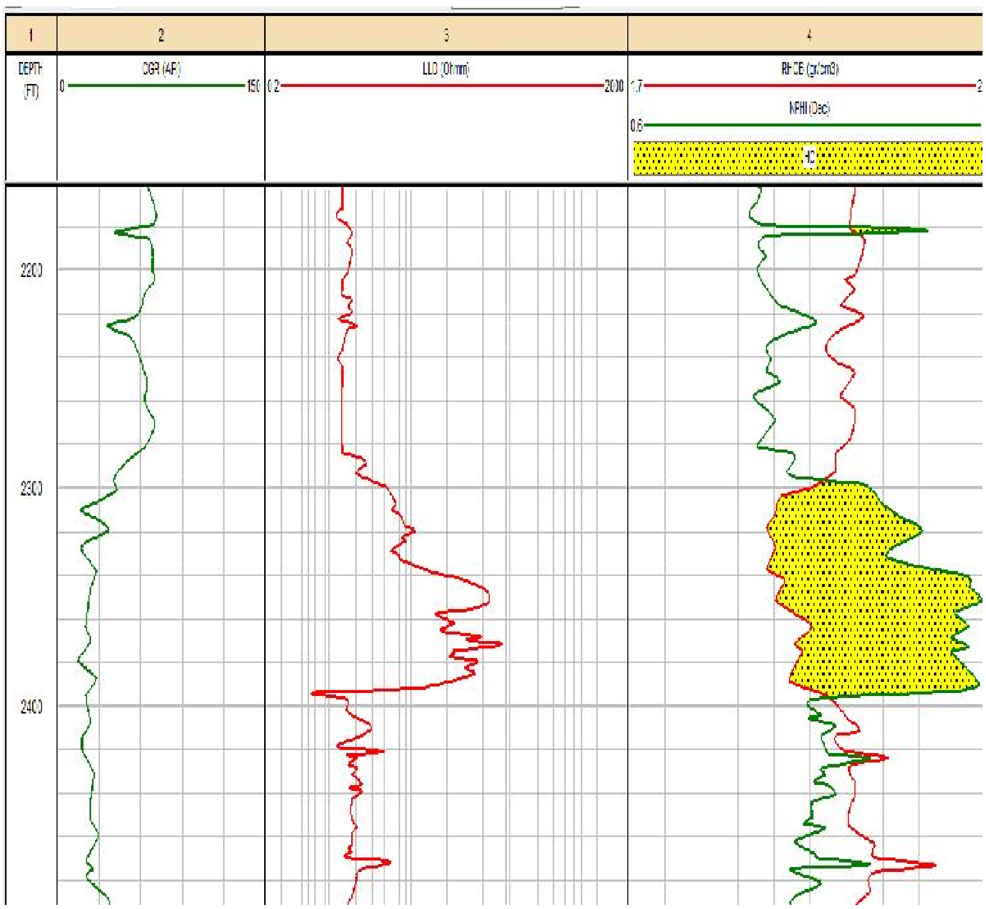

Figure 7. Productive zone at well K1