

RESERVOIR DELINIATION USING WELL LOG DATA IN NOLIX OIL FIELD NIGER DELTA

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Abstract: The sand in the Nolix oil field is vertically stacked and can be correlated from well to well. Three oil wells were used for the analysis, Nolix-01, Nolix-02 and Nolix-03. Three sand levels, sand 1, sand 2 and sand 3 are established stratigraphically in each well using gamma ray (GR) logs. Sand 1 in Nolix-01 is the shallowest in Nolix well and appear at 6060ft-6140ft (true vertical depth subsea, TDVSS). The thickness is 80ft (24m). Reservoir analysis was carried out with the use of log motif (shape or pattern) of the GR and resistivity curves in combination. The reservoirs identified were point bars and barrier bar sands. In Nolix-03 well, sand 3 range from 7560ft-7860ft (true vertical depth subsea, TDVSS). The thickness is 300ft (109m), the electric log patterns are serrated blocky and blocky.

Keywords: reservoir delineation, well log data

Introduction

The Niger Delta is one of the sedimentary basins in Nigeria, Figure 1. The Niger Delta is located on the Gulf of Guinea, between longitudes 5° E to 8° E and latitudes 3° N to 5° N. Three important elements are required for hydrocarbon to be produced in an area. These are, the source rocks, the reservoir rocks and the cap rocks. If any of these is lacking, it will result in a general failure, Olisa (2016).

Reservoir rocks are capable of storing hydrocarbons and transmitting them. The target of this research is the reservoir rocks (Nolix oil field) in the Niger Delta. In the Niger Delta, sandstone constitute the lithology of the reservoir. The reservoirs are channel sands, fluvial sands etc.

Aim: The aim of the research is to analyze reservoir sands in Nolix oil field.

Objectives: The objectives are:

1. Carry out lithology analysis
2. Correlate sands and shale in the wells
3. Delineate reservoir sands
4. Geology of Niger Delta

The Niger Delta province is a large, arcuate, wave- and tidal-dominated delta, with deltaic sediments ranging in age from Eocene in the north to Quaternary in the south. The overall regressive sequence of clastic sediments was deposited in a series of offlap cycles that were intermittently interrupted by periods of sea level change, Bouvier et al. (1989). The delta can be divided into three broad lithofacies units. The upper part consists of massive continental sandstones (Benin Formation), which overlie an alternation of paralic sandstones, shales, and clays (Agbada Formation). These, in turn, grade downward into predominantly under compacted, over pressured marine shales, clays, and siltstones with some turbidite sandstones (Akata Formation). The main reservoirs are fairly simple sedimentologic ally and lie in the paralic deposits of the Agbada Formation. These deposits are predominantly stacked shoreface sandstones separated by fieldwide marine and continental shales. Individual sandstones and shales seen in wells are co-relatable.

Sandstone constitute the reservoir. It alternates with shale beds which serves as both source and cap rocks. The Formations found in the Niger Delta are mostly unconsolidated sands and shales, in which it is often not possible to take cores or to make drill stem tests (Ablewhite et al. 1985). Accordingly, Formation evaluation is based mostly on logs, with the help of sidewall samples and wireline formation tests.

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Sedimentation of the Niger Delta is made of sands and shales. The shales are described as being generally fluvio-marine or lagoonal. The sands are fluvial (Channel) or fluvio-marine (Barrier Bar). Channel sands and Barrier Bar sands are often recognized from the GR log shapes, Figure 2 and 3. The funnel shaped GR curve indicates an upward coarsening Barrier Bar sand and the cylindrical shaped GR curve indicates a massive, featureless, non-graded sand normally associated with a channel.

Data base

1. Base map (Figure 4)
2. Lithology logs-gamma ray logs
3. Resistivity logs- deep induction logs (ILD)

Methodology

a. Lithology analysis

This analysis carried out using Spontaneous potential (SP) and gamma ray (GR) logs (Olisa and Oke 2014), Figure 7, 8 and 9.

SP log

The SP log differentiates between permeable and impermeable beds based on the relationships between mud filtrate and formation water. SP curve calibrated in millivolt is a recording of the potential difference between a point in the borehole and the surface (Rider 2002, Ablewhite *et al.* 1985). The salinity of the formation water is greater than that of mud filtrate. This causes the potential opposite the permeable sand bed to be negative with respect to the potential opposite the shale bed.

GR log

The GR log differentiates between sand and shale sequences based on the relative presence of radioactive materials. Generally, the shale has more concentration of radioactive materials than sand. The GR curve calibrated API is a measure the formation natural radioactivity. Sandstone is less radioactive than shale. This causes the GR readings to be lower in sand than in shale, Olisa and Oke 2014, Ablewhite *et al.* 1985).

b. Correlation and Reservoir Analysis

Reservoir analysis of sandstone is carried out via electric log correlation (Ablewhite *et al.* 1985, Tearpock and Bischke, 1991, Olisa and Oke 2014), Figures 3 and 4. Two logs, lithology (SP or GR) and resistivity (short normal) logs are run side by side to each other

Two steps are involved in electric log correlation:

Step 1 (shale correlation): Shale resistivity markers (SRM) are identified on resistivity log which enables adequate correlations from well to well, Figure 5.

Step 2 (sand correlation): Sand reservoirs, identified by sand resistivity marker are subsequently marked, identified and correlated from well to well, Figure 6.

Results

a. Lithology analysis

Sand 1: Sand 1 in Nolix 1 Well has a depth range from 6060ft-6140ft (true vertical depth subsea, TDVSS). The thickness is 80ft (24m). Sand 1 in Nolix 2 Well has a depth range from 6740ft-6860ft (true vertical depth subsea, TDVSS). The thickness is 120ft (36m). Sand 1 in Nolix 3 well has a depth range from 6620ft-6720ft (true vertical depth subsea, TDVSS). The thickness is 100ft (30m), Table 1 and Figure 7, 8, 9.

Sand 2: Sand 2 in Nolix 1 Well has a depth range from 6440ft-6680ft (true vertical depth subsea, TDVSS). The thickness is 240ft (73m). Sand 2 in Nolix 2 Well has a depth range from 7210ft-7460ft (true vertical depth subsea, TDVSS). The thickness is 250ft (76m). Sand 2 in Nolix 3 well has a depth range from 7180ft-7480ft (true vertical depth subsea, TDVSS). The thickness is 300ft (91m), Table 1, Figure 7, 8 and 9.

Sand 3: Sand 3 in Nolix 1 Well has a depth range from 6760ft-7120ft (true vertical depth subsea, TDVSS). The thickness is 360ft (109m). Sand 3 in Nolix 2 Well has a depth range from 7540ft-7800ft (true vertical depth subsea, TDVSS). The thickness is 260ft

(79m). Sand 3 in Nolix 3 well has a depth range from 7560ft-7860ft (true vertical depth subsea, TDVSS). The thickness is 300ft (109m), Table 1, Figure 7, 8 and 9.

The depth range of sand 1 intervals range from 80ft (24m) to 360ft (109m). The sand intervals are vertically stacked. A sand body should range from 40ft (12m)-60ft (18m) Figure 3. These sand intervals is therefore subjected to reservoir analysis, Table 2.

The depth range of sand 2 intervals range from 240ft (73m) to 250ft (76m) to 300ft (91m). The sand intervals are vertically stacked. A sand body should range from 40ft (12m)-60ft (18m) Figure 3. These sand intervals is therefore subjected to reservoir analysis, Table 2.

The depth range of sand 3 intervals range from 260ft (79m) to 300ft (91m) to 360ft (109m) The sand intervals are vertically stacked. A sand body should range from 40ft (12m)-60ft (18m) Figure 3. These sand intervals is therefore subjected to reservoir analysis, Table 2.

b. Reservoir analysis and correlation.

Sand 1 (reservoir): The sand thicknesses vary from 80ft (24m) in Nolix-01 to 120ft (37m) in Nolix-02 to 100ft (30m) in Nolix-03. The electric log patterns are serrated blocky and blocky. The reservoir is interpreted as barrier bar and point bar, Table 2, Figures 10, 11, 12, and 13.

Sand 2 (reservoir): The sand thicknesses vary from 240ft (73m) in Nolix-01 to 250ft (76m) in Nolix-02 to 300ft (91m) in Nolix-03. The electric log patterns are serrated blocky and blocky. The reservoir is interpreted as barrier bar and point bar, Table 2, Figures 10, 11, 12, and 13.

Sand 3 (reservoir): The sand thicknesses vary from 360ft (109m) in Nolix-01 to 260ft (79m) in Nolix-02 to 300ft (91m) in Nolix-03. The electric log patterns are serrated blocky and blocky. The reservoir is interpreted as barrier bar and point bar, Table 2, Figures 10, 11, 12, and 13.

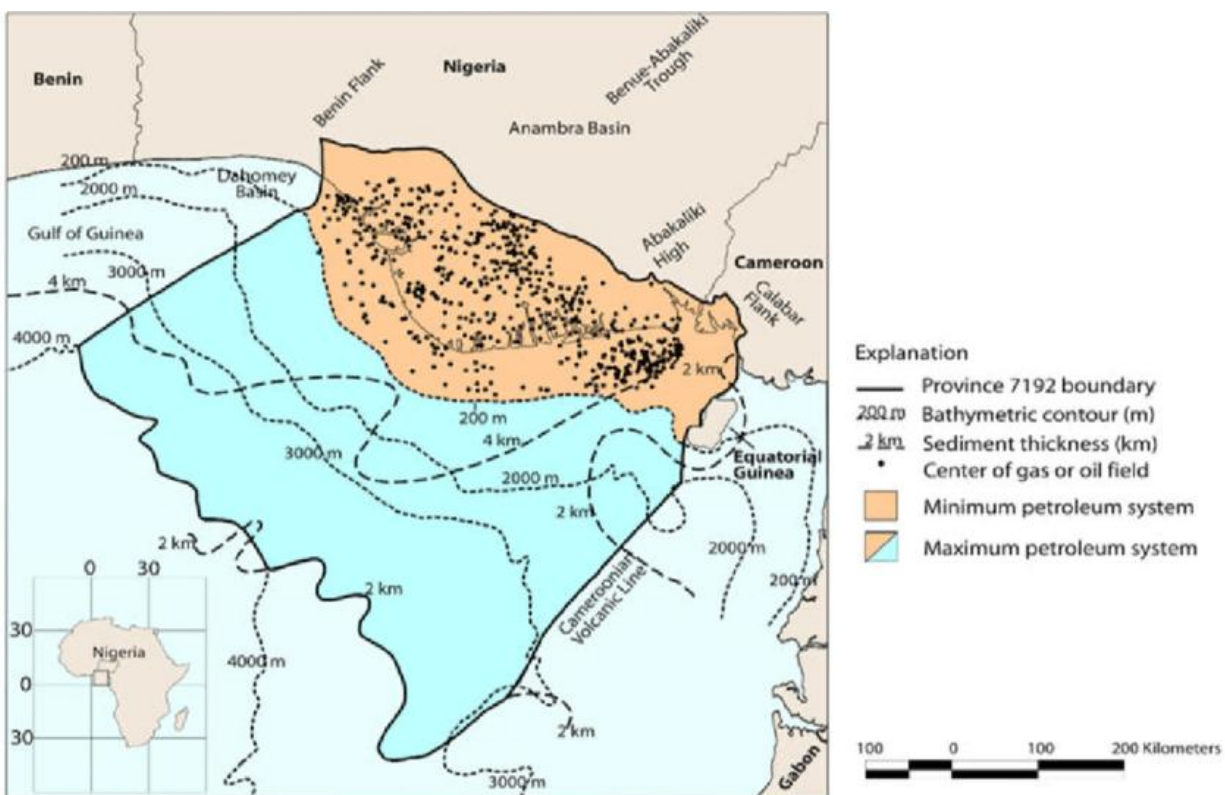


Fig 1: Map of Niger Delta Showing the Province and the key Structural Features (Tuttle *et al*, 1999).

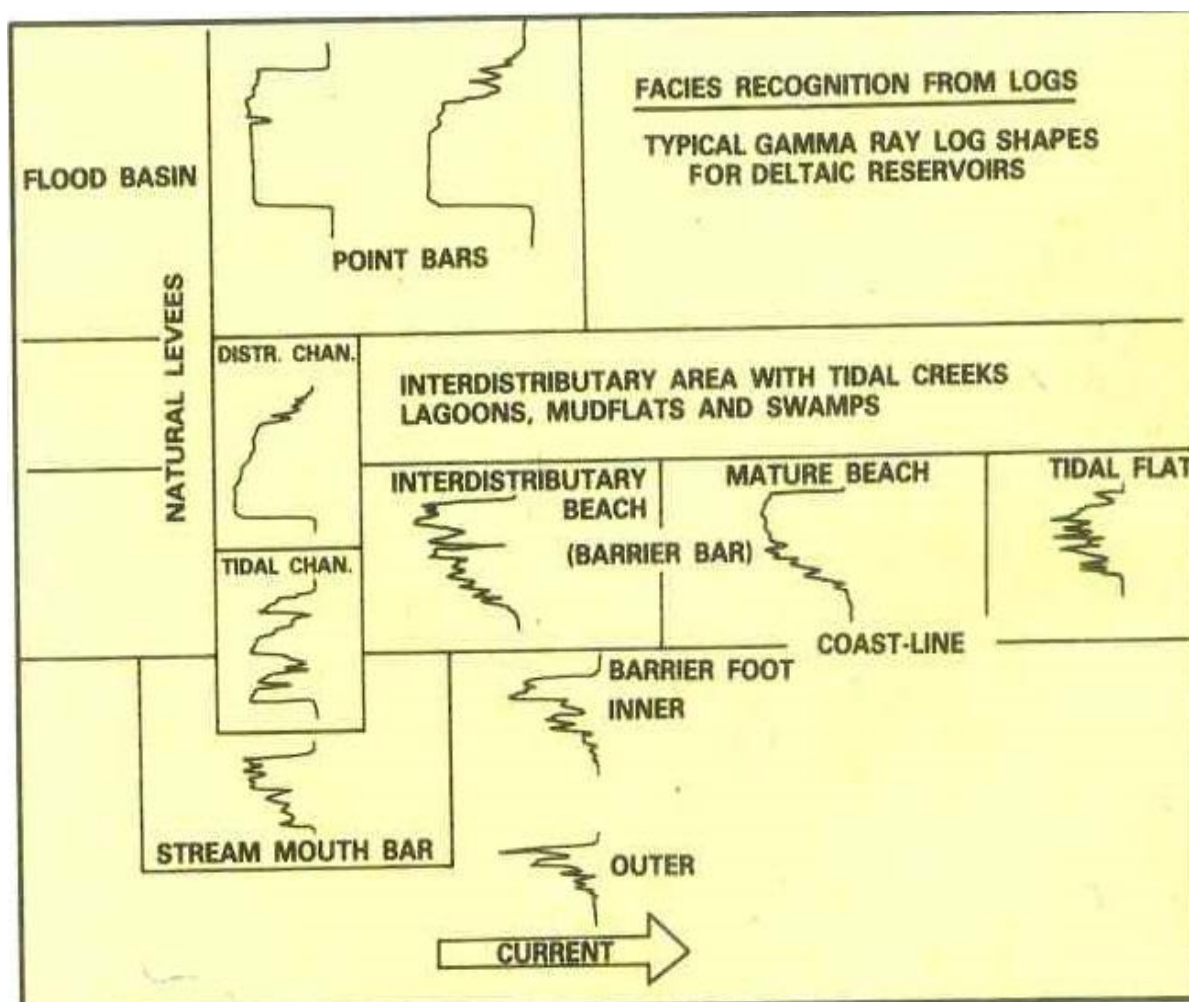


Figure 2: Electropacies classification for deltaic environments from gamma Ray logs (Ablewhite *et al*. 1985).

Name	Log Pattern	Lithology	Sand-Body Geometry	Associated Facies	Example	Interpretation
BLOCKY		•sand, 40-60' thick •abrupt contact with overlying and underlying shales		•tapered spike electrofacies (i) along basinward edge •simple spike electrofacies (i) along landward edge	Atkinson Field	BARRIER BEACH, BARRIER BAR OR BARRIER ISLAND
		•sand, 40-60' thick •abrupt contact with overlying and underlying shales		•pinches out into shales along depositional strike	Hysaw Field	AXIS OF PROGRADING BAR-FINGER SAND
		•sand, 40-60' thick •abrupt contact with overlying and underlying shales		•surrounded by funnel-shaped electrofacies (ii)	Hondo Creek Area	BAR-FINGER SANDS THROUGH DELTA-FRONT SHEET SAND
MARGINAL BLOCKY		•interbedded sand and shale •abrupt contact with overlying and underlying shales		•on the margins of isopach thicks defined by blocky (b,c) electrofacies	Hysaw Field	MARGINS OF BAR-FINGER SANDS

Figure 3: Electric log patterns for reservoir identification

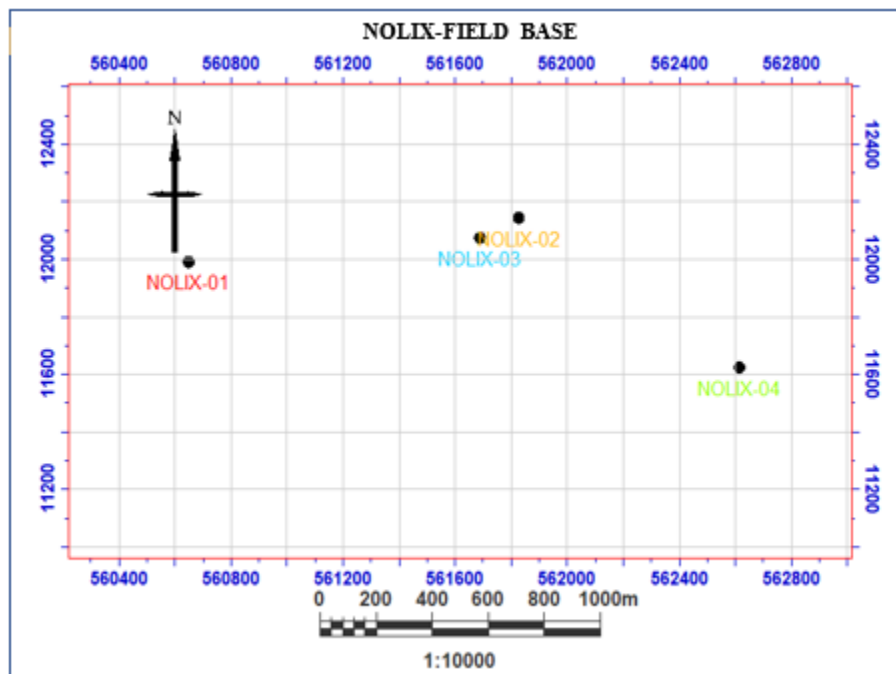
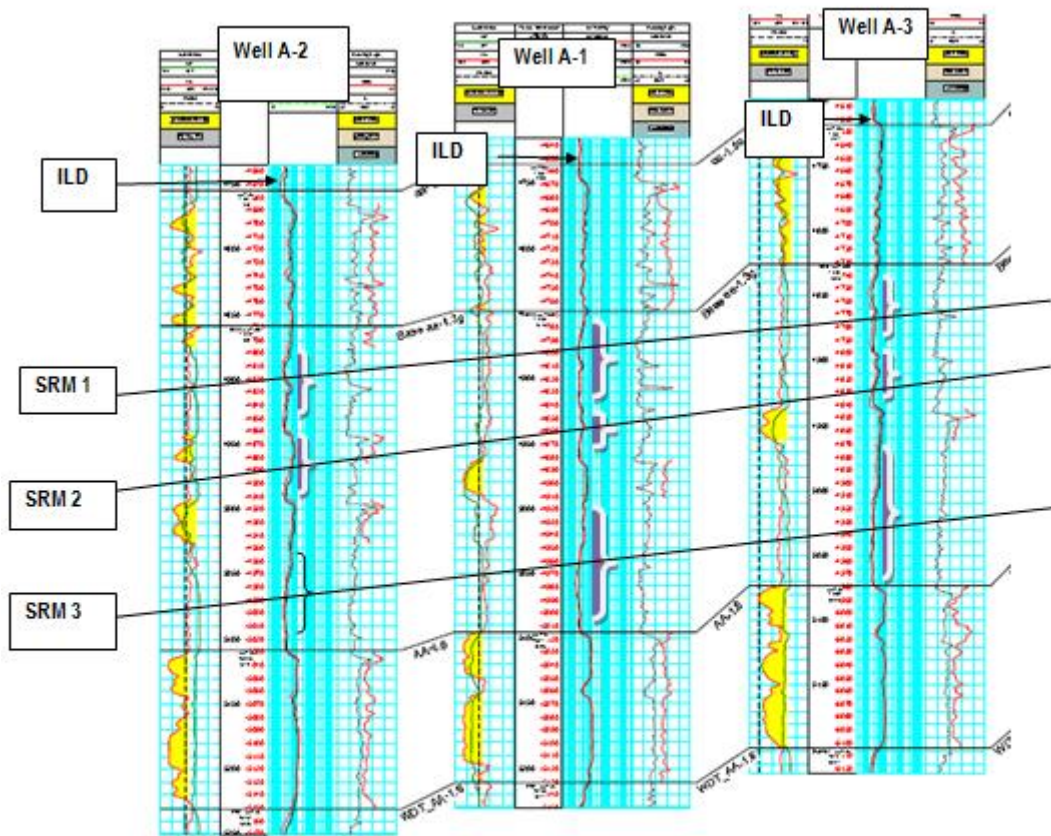


Figure 4: Location of the study area.



SRM 1 is Shale Resistivity Marker number 1

SRM 2 is Shale Resistivity Marker number 2

SRM 3 is Shale Resistivity Marker number 3

Figure 5: Shale Correlation (Olisa and Oke 2014).

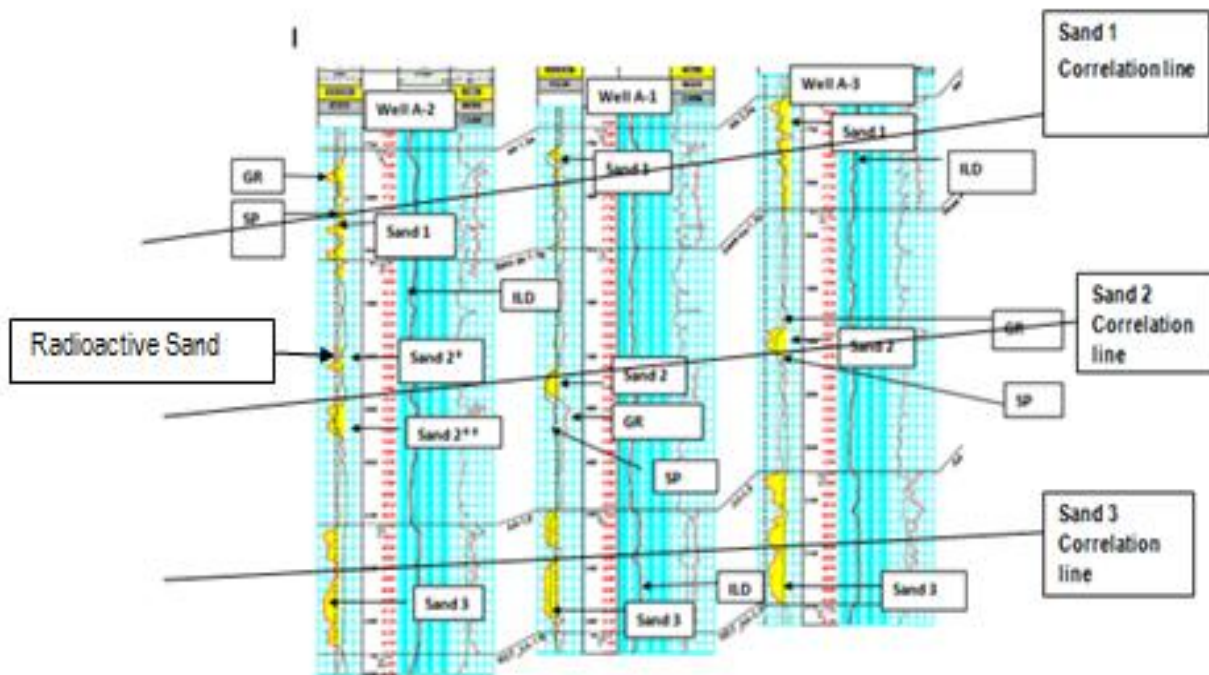


Figure 6: Sand Analysis and Sand Correlation (Olisa and Oke 2014).

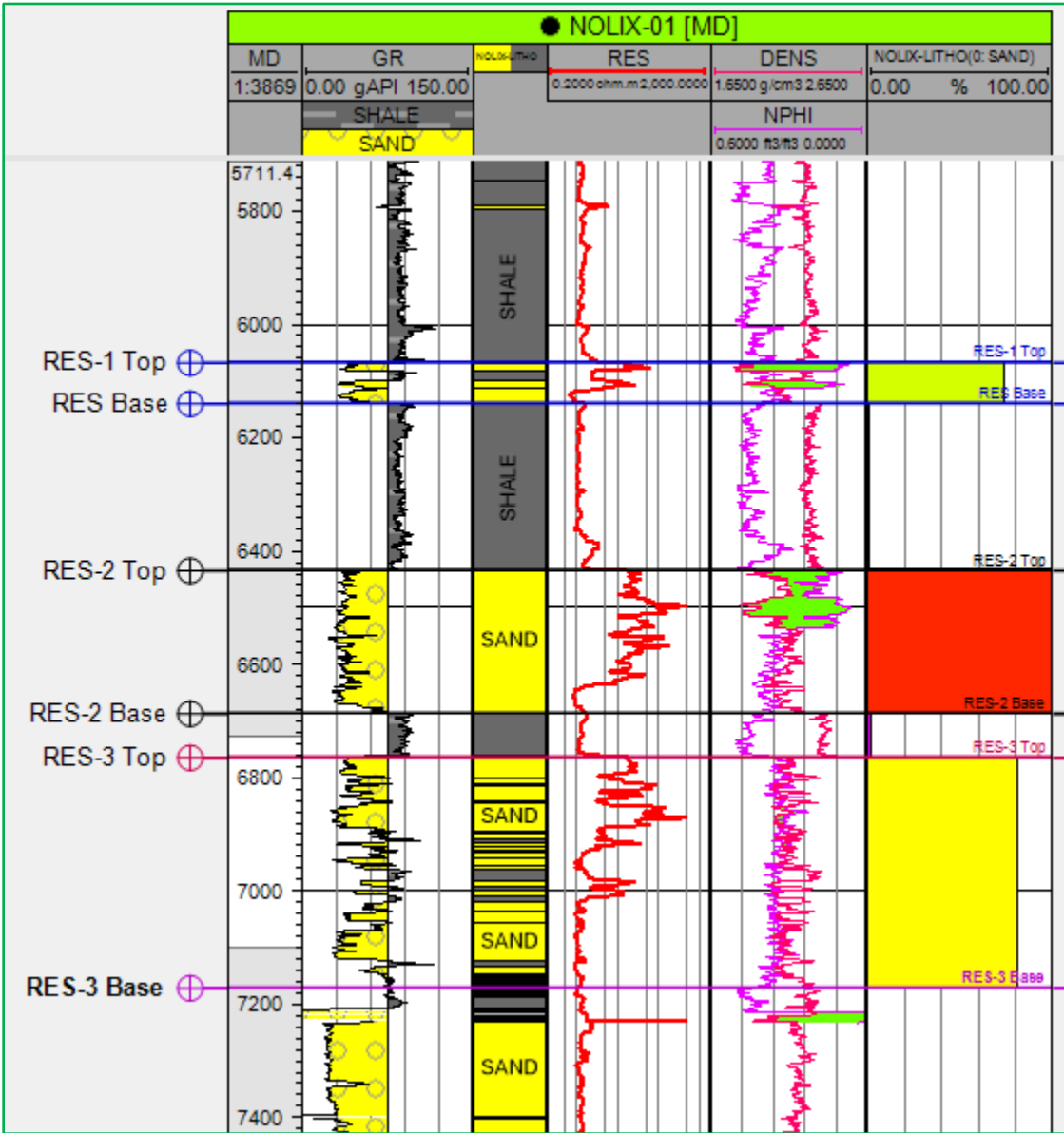


Figure 7: Lithology analysis, Nolix-01

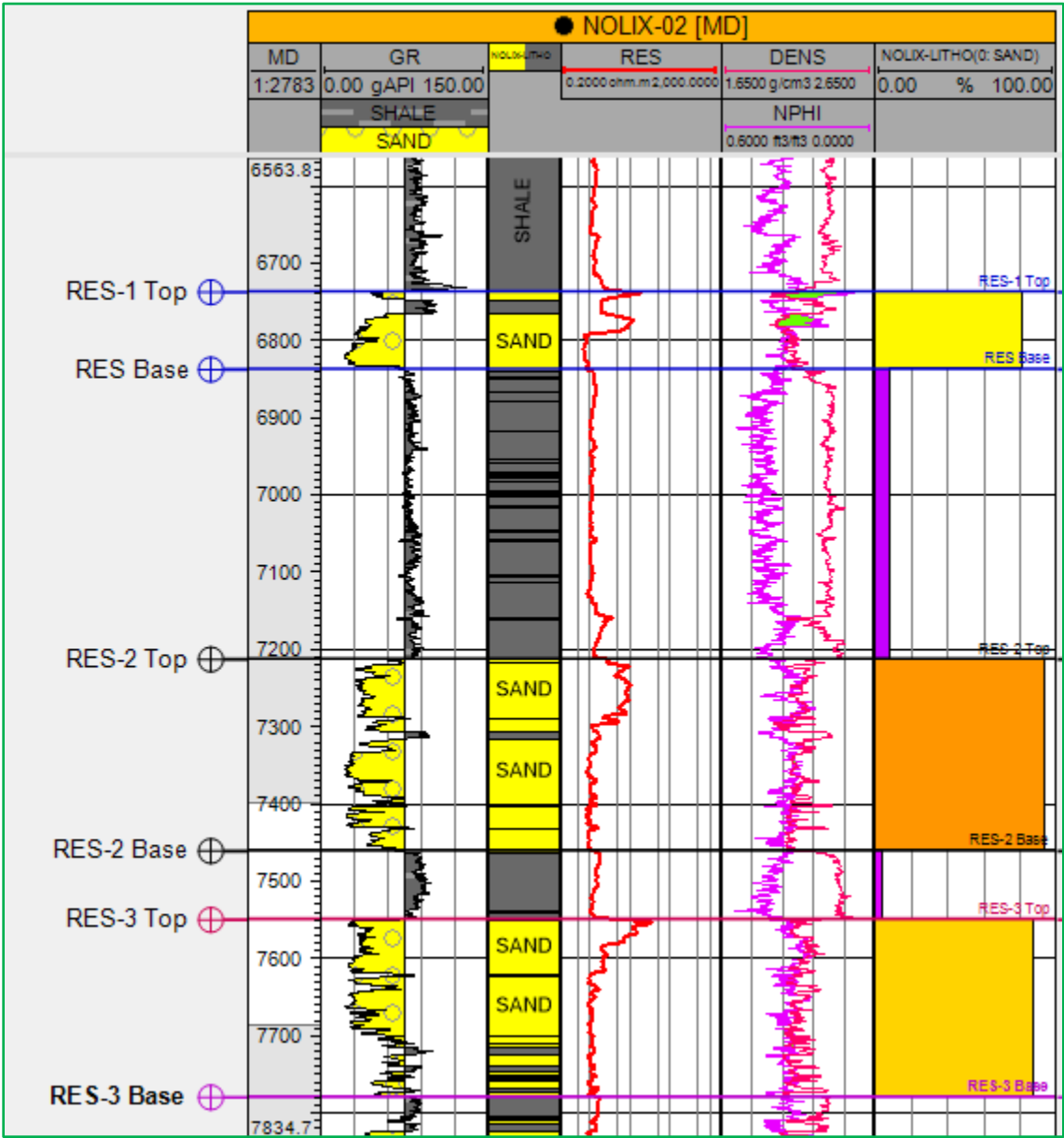


Figure 8: Lithology analysis Nolix-02.

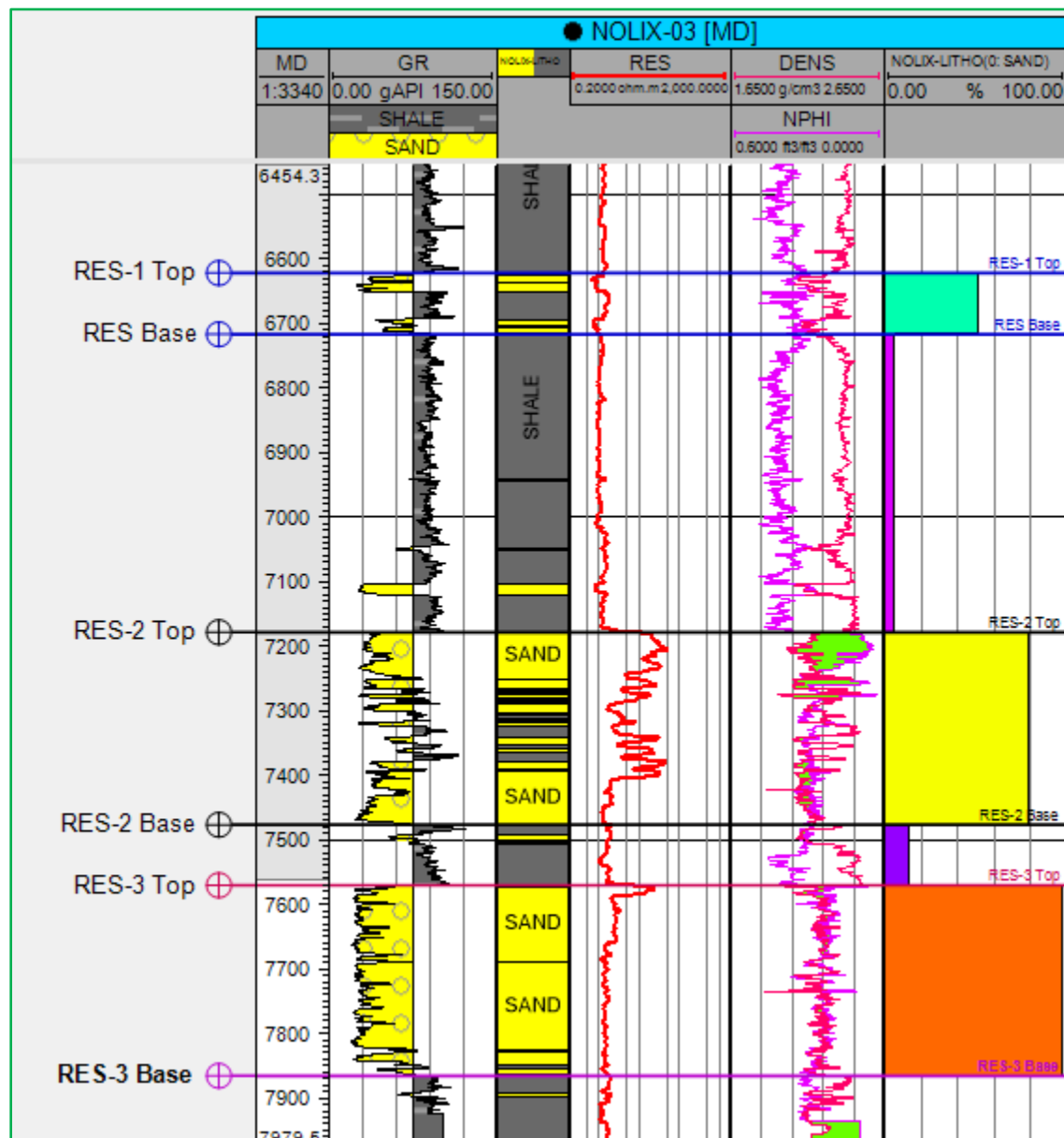


Figure 9: Lithology analysis, Nolix-03.

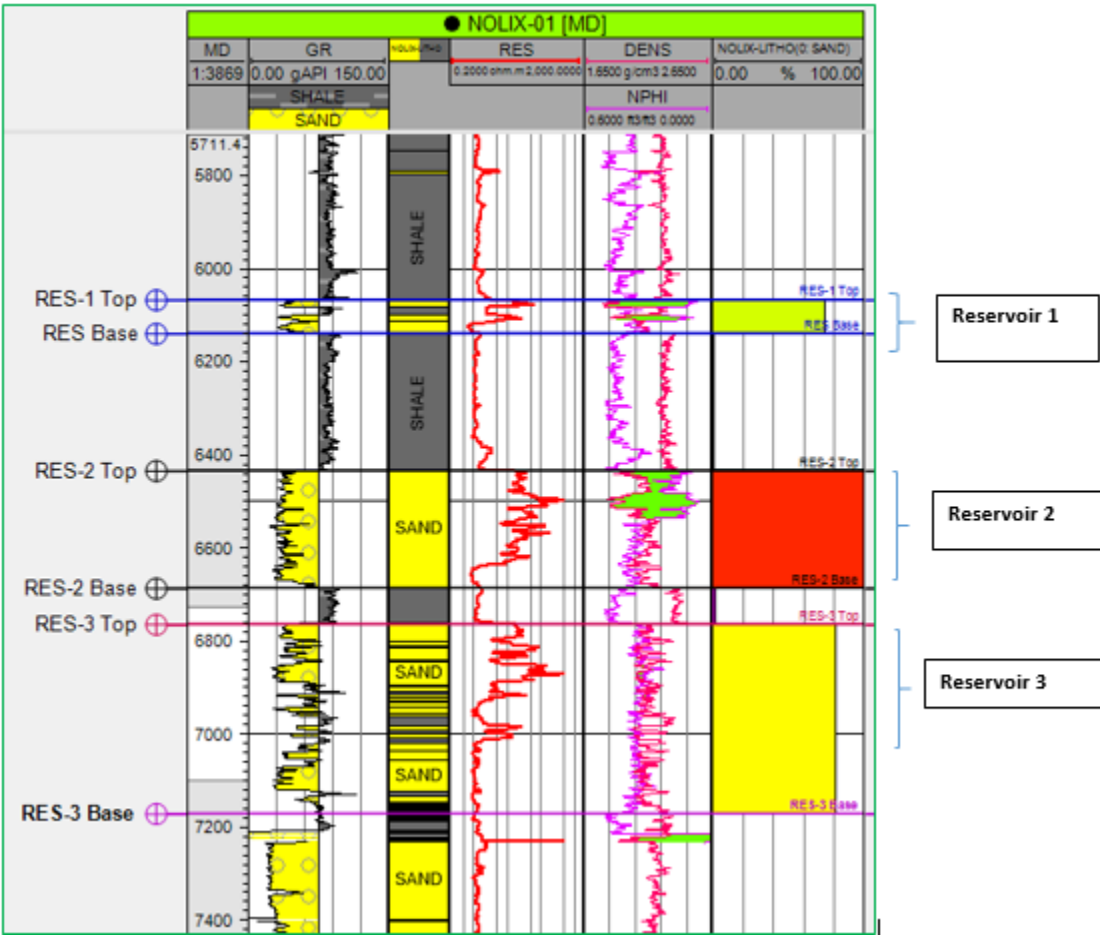


Figure 10: Reservoirs Nolix-01.

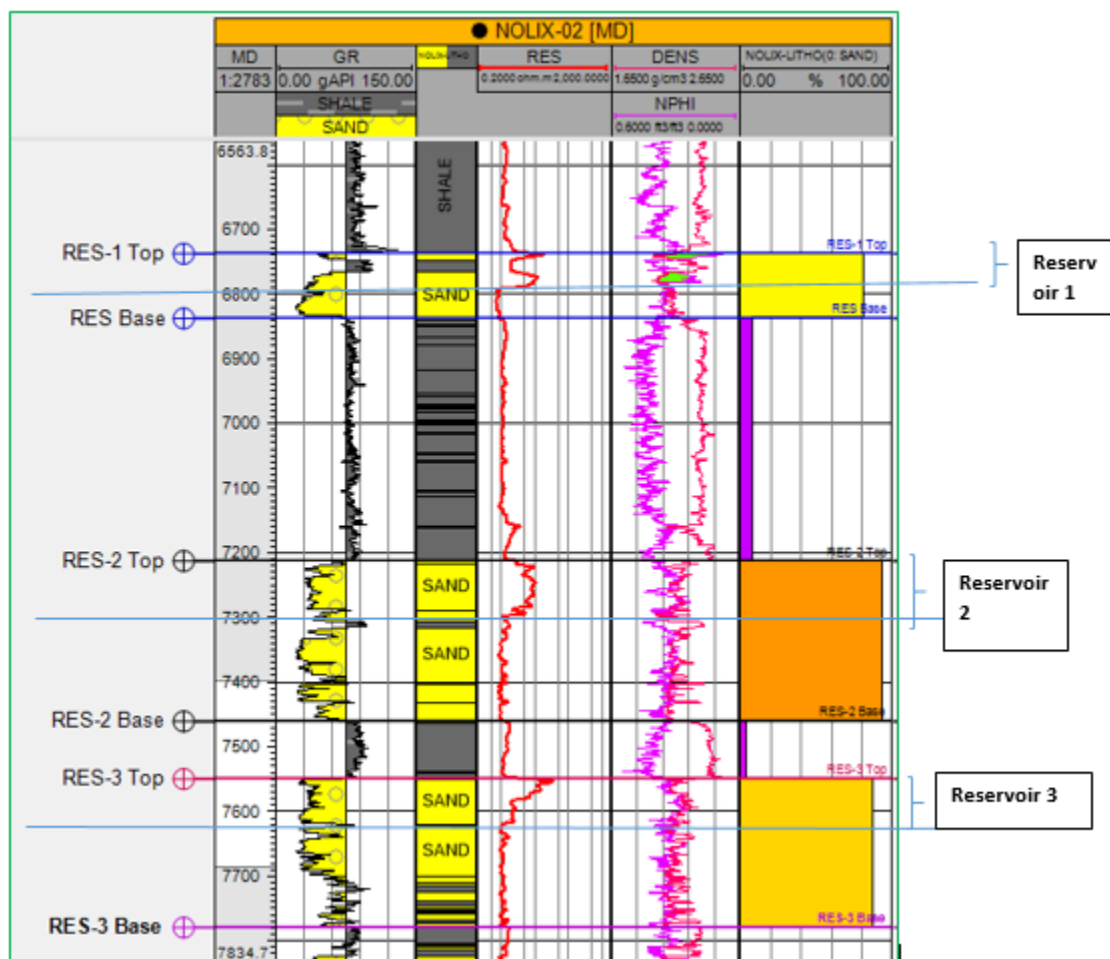


Figure 11: Reservoirs Nolix-02.

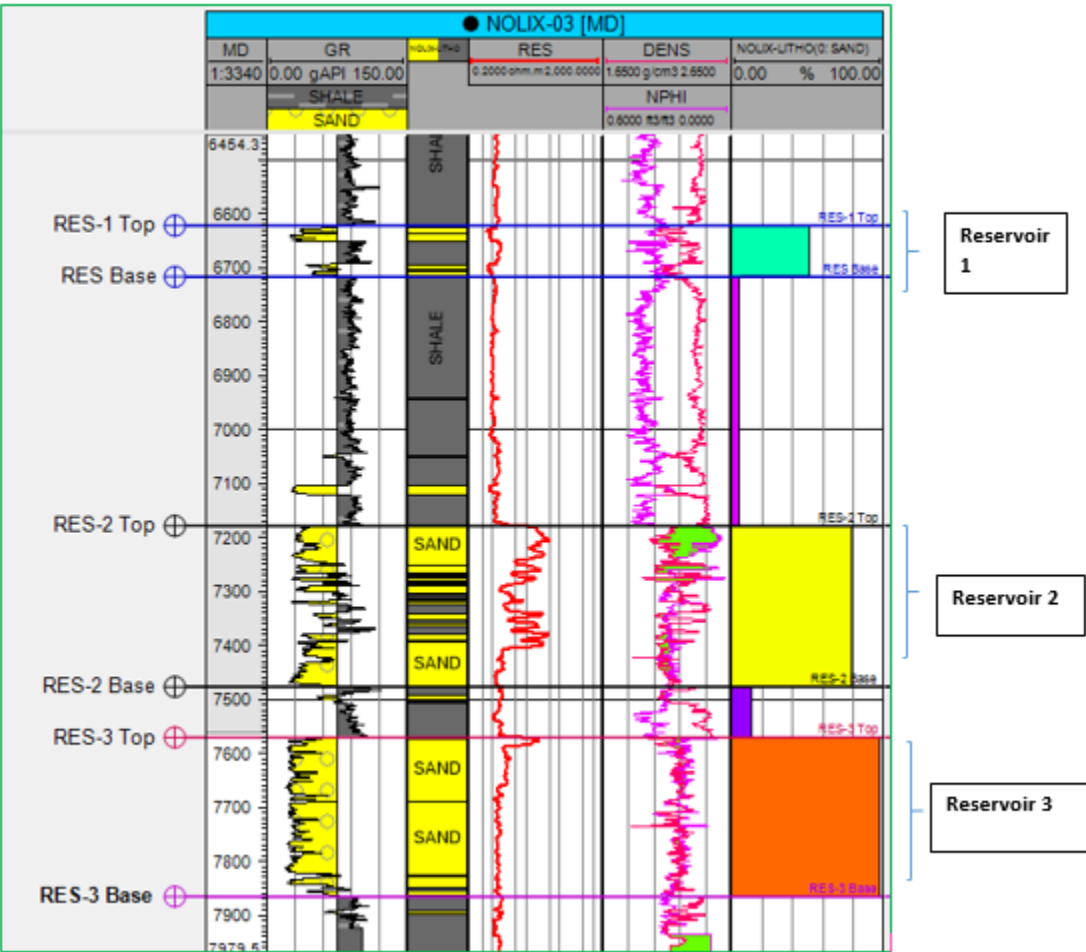


Figure 12: Reservoirs in Nolix-03.

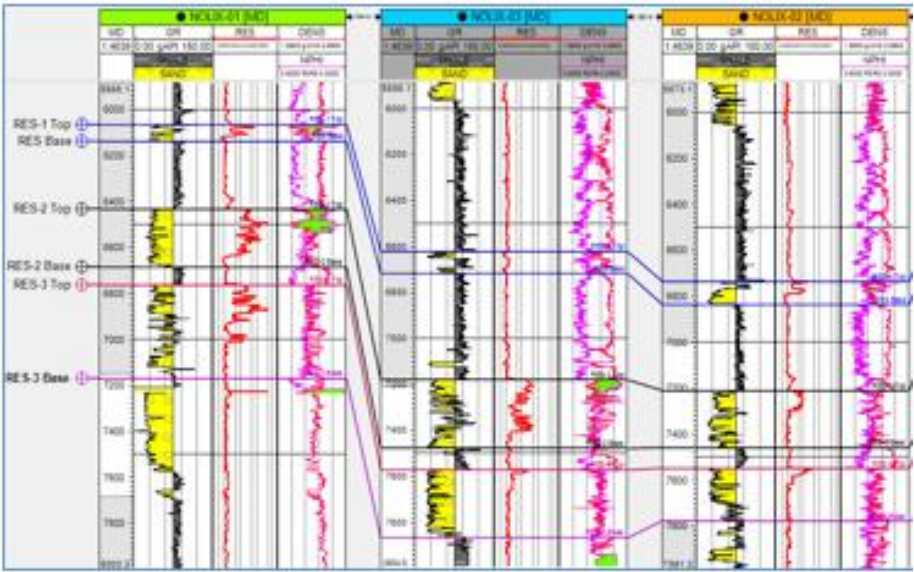


Figure 13: Correlation of reservoirs, Nolix-01, Nolix-02 and Nolix-03.

Table 1: lithology analysis and sands correlation

Sand name	Nolix 1 Well				Nolix 2 Well				Nolix 3 Well			
	Top (ft)	Base (ft)	Thick. (ft)	Thick (m)	Top (ft)	Base (ft)	Thick. (ft)	Thick (m)	Top (ft)	Base (ft)	Thick. (ft)	Thick (m)
Sand 1	6060	6140	80	24	6740	6860	120	36	6620	6720	100	30
Sand 2	6440	6680	240	73	7210	7460	250	76	7180	7480	300	91
Sand 3	6760	7120	360	109	7540	7800	260	79	7560	7860	300	91

Table 2: Reservoir analysis and correlation

	Nolix 1 Well			Nolix 2 Well			Nolix 3 Well		
	Thickness	Log shape	Reservoir	Thick	Log shape	Reservoir	Thick	Log shape	Reservoir
Sand 1	80ft(24m)	Serrate-blokk	Barrier bar	120ft(37m)	blokk	Point bar	100ft(30m)	blokk	Point bar
Sand 2	240ft(73m)	Serrate-blokk	Barrier bar	250ft(76m)	blokk	Point bar	300ft(91m)	blokk	Barrier bar
Sand 3	360ft(109m)	Serrate-blokk	Barrier bar	260ft(110m)	blokk	Point bar	300ft(91m)	blokk	Point bar

Conclusion

Three sand levels were established in Nolix oil field using gamma ray (GR) log. The thickest sand is in Nolix-03 with thickness of 360ft (109m). The thinnest sand is 80ft (24m) in Nolix-01.

The reservoir sand are point bars and barrier bars sand established with GR and resistivity curves deep induction resistivity, (ILD) used in combination.

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