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Determination and Evaluation of Hydrocarbon Depositional Environments for Well Planning Using Wireline Logs: a case study of niger delta

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***Abstract*— The knowledge of the geometrical shape of Gamma ray log helped to establish the depositional environments; because the architectural profile showed the lithology and grain size distributions of the deposits. The understanding of depositional environment of a reservoir rock gave an idea of nature, variation and distribution of its porosity and permeability which are very important during well planning. In Niger Delta, the progradational, retrogradational and aggradational stacking patterns formed the architecture of the depositional facies that reflected changes in relative sea level and the distribution of accumulated sediments as shown by wireline log signatures of the case study wells (figures 1-5) .**

Microsoft excel was used to estimate the gross thickness of the individual reservoir sand bodies across the 'X" Case Study Field. Standard log shape identification and classification schemes were used to infer the depositional environments of the reservoirs rocks. Sequence stratigraphic concept was applied to identify sub-environments of deposition of the reservoir sand units to interpret stratigraphic sequences and their stacking patterns.

Four logs facies were used in this study, they are; Irregular log trends representing deep marine, Funnel shaped succession representing crevasse splay; Cylindrical shaped succession representing slope channel fills and Bell shaped succession representing transgressive Marine shelf.

The results showed that, the cylindrical shaped succession was dominant across the Case Study Wells in the Niger Delta which had serrated sand, silt and clay lithologies. The Deltaic system, Marine setting and deep Marine setting were the most common depositional environments recognized in this study with the aid of the wireline logs. These further identified the reservoir sand facies/ facies architecture showing the sand thickness, continuity and connectivity of the sand bodies.

Keywords—Hydrocarbon reserve; wireline logs; Niger Delta; Well planning; Depositional environment

I. INTRODUCTION

Depositional environment describes the combination of physical, chemical and biological processes associated with the deposition of sediments and the rock types that were formed after lithification, The types of deposition depends on three main types of depositional environments, which are,: Continental Environment: Transitional Environment and Marine Environment: In the Niger Delta most of the hydrocarbons were found in the transitional environment, which branches out into Deltas, Lagoons, Beaches and Estuarine.

Determination of depositional environments is of great importance in Well Planning for exploration and development of reservoir systems. The depositional processes associated with sedimentary environments impart variation and heterogeneity. This strongly influence reservoir distribution, continuity, connectivity, stacking patterns, as well as the vertical and horizontal arrangement of reservoir facies, which controls fluid flow and production performance.

Wireline logs provide a strong mechanism for interpretation and determination of depositional environments, facies stacking pattern and identification of reservoir units (Galloway and Hobday, 1983). This is essential for Well Planning necessary for subsequent and effective Well Drilling and Field Development. The processes associated with a particular environment for sedimentary facies are recognizable on outcrops and wireline logs. Wireline logs measure the electrical, radioactive, and acoustic properties of rocks which are used to derive information on lithology, grain-size, density, porosity and pore-fluids . The observation of wireline logs help to define and identify log sequences in order to determine depositional environments and delineate the stacking patterns of the reservoir sand.

II. METHODOLOGY

In the 'X' Field of the Niger Delta, five (5) Oil Wells: WELL 1, WELL 2, WELL 3,WELL 4 and WELL 5, provided the Wireline Logs and Well Header information data used for this research, to determine and evaluate the depositional environment. Petrel Application was used to process the log data and produced the wireline logs signatures. The wireline logs were first subjected to qualitative analysis and later followed by quantitative analysis. The qualitative interpretation involved visual analysis of the log shapes and trends for the identification of lithology, reservoir tops and bases, correlation of the reservoir facies, delineation of stacking pattern, geometry and predicting probable environments of deposition. Quantitative analysis involved the estimation of reservoir thickness, which was used to produce isopach map for each reservoir sand body. The procedure followed in this work involved recognition of stacking patterns (stratigraphic sequences) that may reflect changing relative sea level and the distribution of accumulated sediments within depositional cycles, as displayed by the wireline log signatures.

Depositional sequences are stratigraphic units composed of relatively conformable strata deposited during one cycle of rise and fall of relative sea level. Within the depositional sequence, progradational, retrogradational and aggradational stacking patterns were identified.

III. PREPARE YOUR PAPER BEFORE STYLING

A. Cylinder shaped succession

The cylinder-shaped gamma ray logs observed in the Case Study Wells were serrated and the trend was dominant in the reservoir units in the Well logs (Fig. 1-Fig. 5). The thickness ranged from 6 m to 54 m for all the Wells and the reservoir sands were seen to be deposited in a slope channel environment with irregular trends above them.

WELL 1; The gamma ray trend occurred between the depth of 2450 m - 2480 m and 2423m - 2439 m with the thickness of 16 m and 30 m respectively.

WELL 2: The trend occurred between the depth of 2325 m - 2336 m, 2345 m - 2373m, 2374 m - 2387 m, and 2484 m - 2587 m with the thickness of 11m, 11m, 8m, 13m, and 54m respectively.

WELL 3: The trend occurred between the depth of 2331 m – 2342 m, 2348 m -2359m, 2379 m - 2388 m, 2444 m - 2455 m, 2475 m - 2493 m, 2495 m - 2526 m and 2528 m - 2534 m with thickness of 11m, 11m, 40m, 11m, 18m, 31m, and 6m respectively.

WELL 4: The trend occurred between the depth of 2373 m - 2381 m, 2383 m - 2394m, 2401 m – 2407 m, 2533 m -2566 m, 2582 m -2592 m, and 2656 m – 2662m with thickness of 8m, 11m, 16m, 38m, 10m, and 6m respectively.

WELL 5: The trend occurred between 2390 m - 2400 m, 2402 m -2416 m, 2422 m – 2433 m, 2450 m – 2459 m, 2521 m -2541 m, 2559 m – 2594 m, 2600 m – 2615 m, 2690 m – 2711m with thickness of 10m, 14m, 11m, 9m, 20m, 35m, 15m, and 21m respectively.

B. Funnel shaped succession

The funnel shaped trend occurred in WELL 1, WELL 2 and WELL 4 (Fig.1,Fig.2 & Fig.4), at depths between , 2323 m - 2337 m, 2289 m- 2299 m and 2497 m-2516 m with a thickness of about, 14 m, 10 m and 19 m respectively. This showed a deposition of cleaning upward sediment and also an increase in the sand content of the turbidite bodies to indicate deep Marine setting.

C. Bell shaped succession

The bell-shaped occurred between, depth 2449 m - 2479m with thickness of 30m and2426 m -2442 m with thickness of 16m in WELLS 1 and 4 respectively. It can also be seen multiple times in WELL 2 at depths 2311m - 2323 m, 2449 m - 2468 m, and 2619 m – 2629 m with thickness 12m, 19m and 10m respectively. The bell-shaped successions are thin, which indicated that the sands were deposited in environment of transgresive shelf.

D. Irregular log trends

Well 1 (Fig.1) showed that the irregular log trends, indicated shale and silts and also similar occurrences in Well 3 and Well 4. These were at depths of 2295 m to 2336 m with thickness of 41m, at depths of 2591 m -2604 m with thickness of 13m; and at depth 2316 m – 2328 m with thickness of 12m respectively. However Well 4 had dual occurrences as shown at, depth of 2373 m - 2381 m and 2570 m - 2580 m with thickness of 8m and 10m respectively.

IV. CONCLUSION

The X field is located in the Niger delta basin of Nigeria. The interpretation of the facies and environment of deposition was carried out using a wireline log in which gamma ray log responses were useful in generating a series of log facies and to interpret the environment of deposition as shown in the Tables 1-4 below.

Table .1 Log Description of WELL 1

Depth (m)	Thickness (m)	Log Signature	Interpretation	Depositional Environment
2423 – 2439 2480 – 2450	16 30	Cylinder shaped	Thick and serrated	Turbidite channels Or Slope channel
2323 – 2337	14	Funnel shaped	Coarsening upward sequence	Crevasse splay Or Deltas
2449 – 2479	30	Bell shaped	Fining upward sequence	Transgressive marine shelf
2295 – 2336 2591 – 2604	41 13	Irregular pattern		Basin plain Or Deep marine

Table .2 Log Description of WELL 2

Depth (m)	Thickness (m)	Log Signature	Interpretation	Depositional Environment
2325 – 2336 2345 – 2373 2374 – 2387 2484 – 2336	11 11 8 13	Cylinder shaped	Thick and serrated	Turbidite channels Or Slope channels
2289 – 2299	10	Funnel shaped	Coarsening upward sequence	Prograding marine shelf Or Deltas
2311 – 2323 2619 – 2629	12 10	Bell shaped	Fining upward sequence	Transgressive marine shelf

Table.3 Log Description of WELL 3

Depth (m)	Thickness (m)	Log Signature	Interpretation	Depositional Environment
2331 – 2342 2348 – 2359 2379 – 2388 2444 – 2455 2475 – 2493 2495 – 2526 2528 – 2534	11 11 40 11 18 31 6	Cylinder shaped	Thick and serrated	Turbidite channels Or slope channel
2316 – 2328	12	Irregular pattern		Basin plain

Table.4 Log Description of WELL 4

Depth (m)	Thickness (m)	Log Signature	Interpretation	Depositional Environment
2373 – 2381 2383 – 2394 2401 – 2407 2533 – 2566 2582 – 2592 2656 – 2662	8 11 16 38 10 6	Cylinder shaped	Thick and serrated	Turbidite channels Or Slope channel
2497 – 2516	19	Funnel shaped	Coarsening upward sequence	Prograding marine shelf Or Delta
2426 – 2442	16	Bell shaped	Fining upward sequence	Transgressive marine shelf
2419 – 2423 2570 - 2580	4 10	Irregular pattern		Basin plain

Table .5 Log Description of WELL 5

Depth (m)	Thickness (m)	Log Signature	Interpretation	Depositional Environment
2390 – 2400 2402 – 2416 2422 – 2433 2450 – 2459 2521 – 2541 2559 – 2594 2600 – 2615 2690 - 2711	10 14 11 9 20 35 15 21	Cylinder shaped	Thick and serrated	Turbidite channel Or Slope channel

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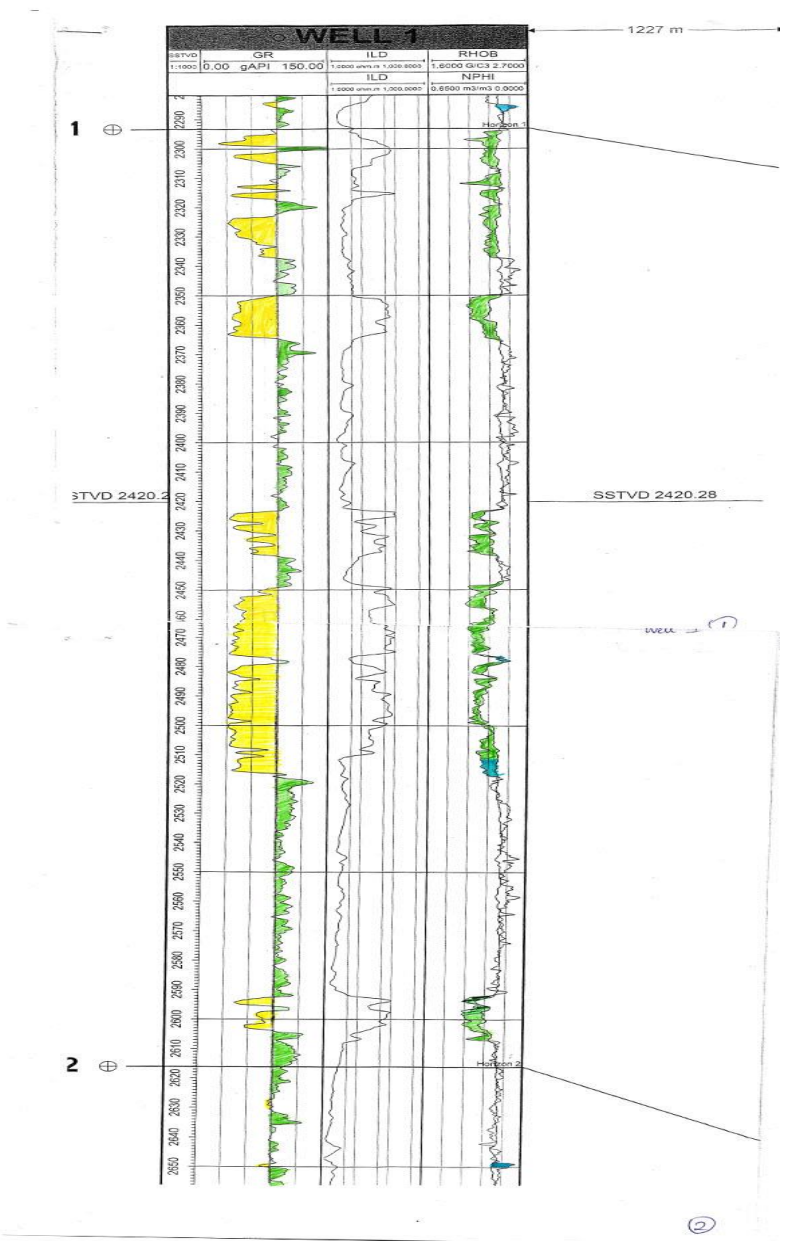

Figure 1: WELL 1

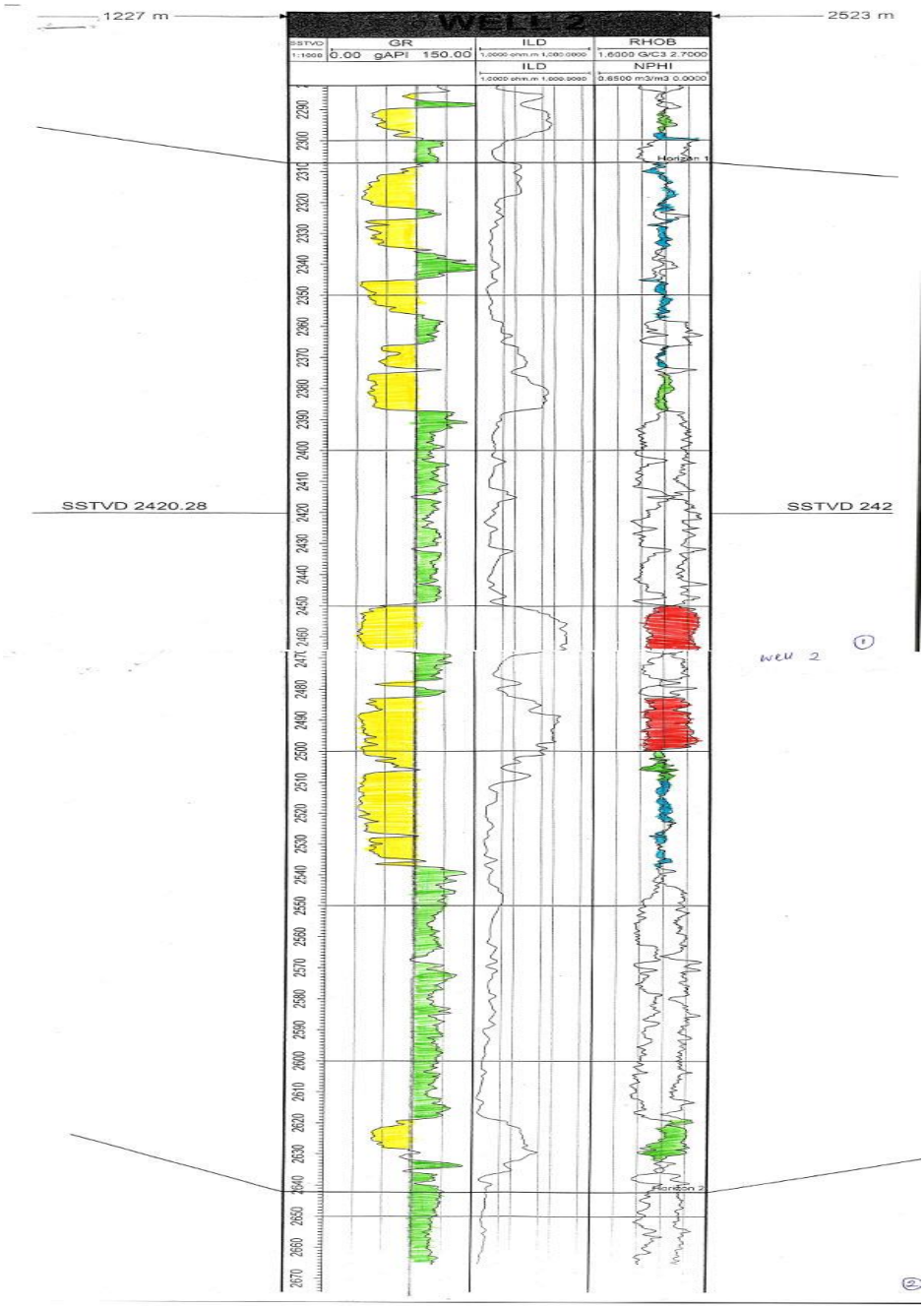

Figure 2: WELL 2

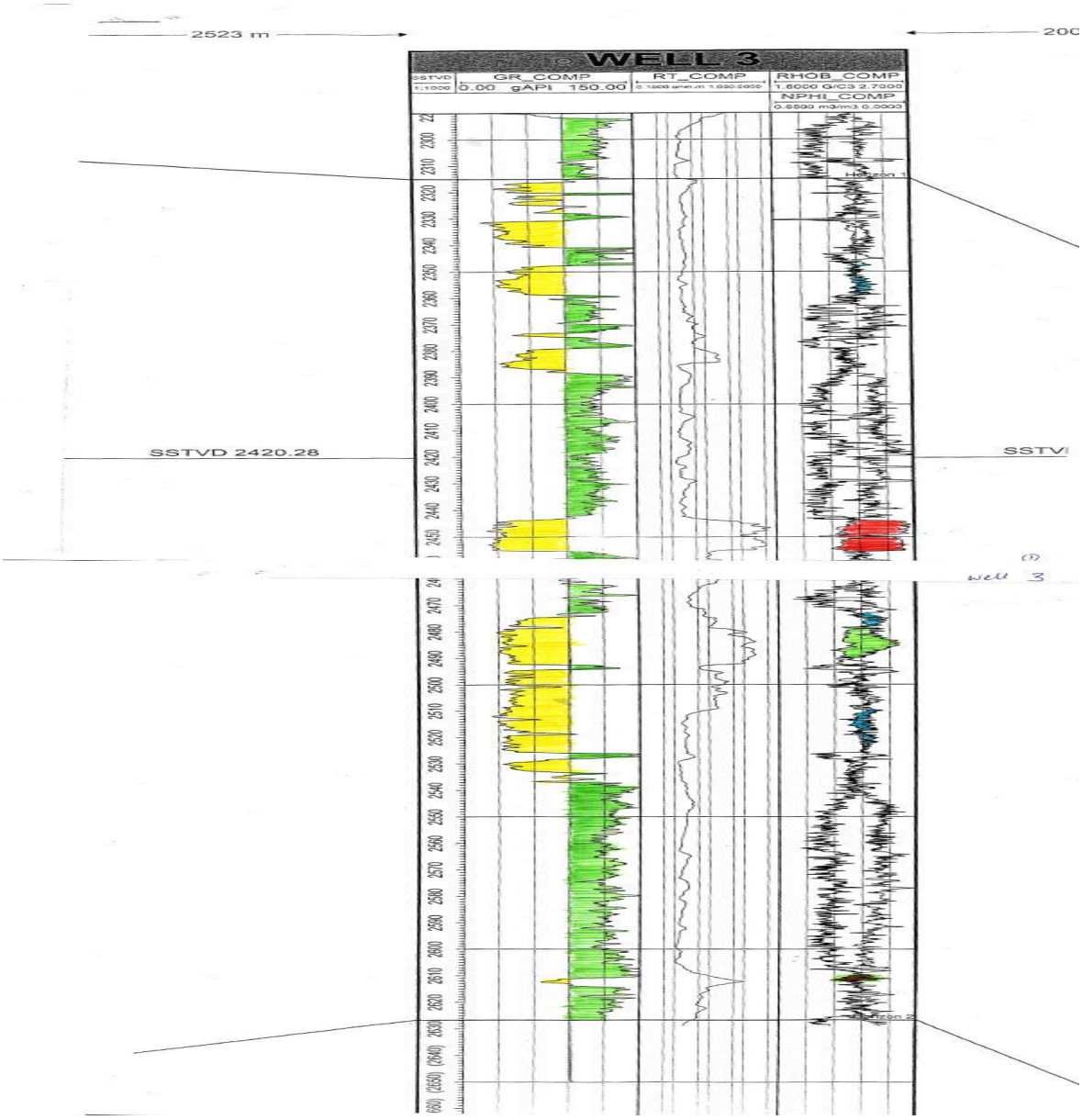

Figure 3: WELL 3

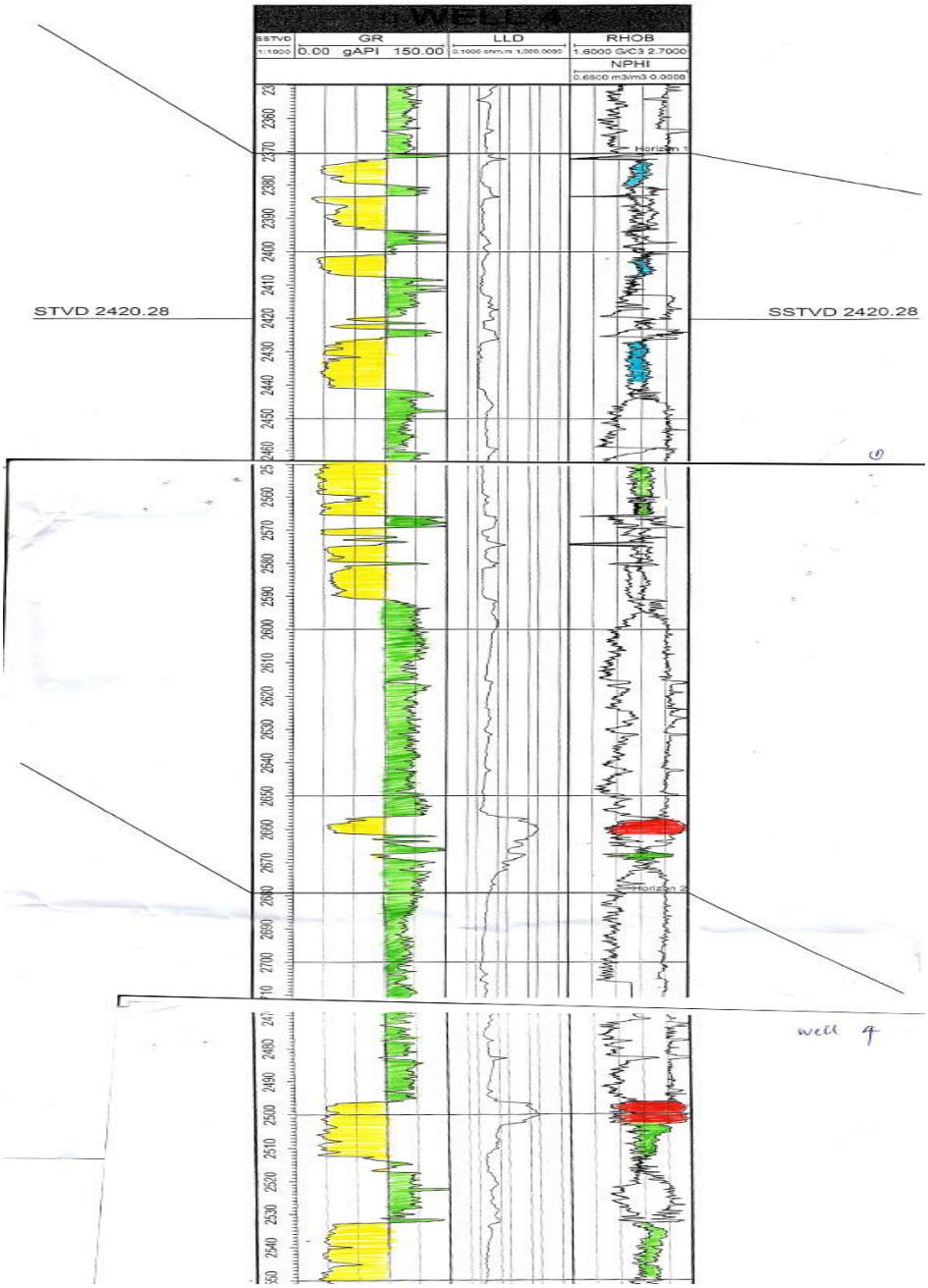

Figure 4: WELL 4

Figure 5: WELL 5