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Full Length Research Paper

Facies characterisation of Well A, Field Y, North-Eastern Niger Delta

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The facies characteristics of Well A in the Field Y were studied using wireline log signatures and data derived from them and cores. The lithostratigraphy, facies types which helped in the interpretation of the depositional environments and their characteristics were read from the wireline logs. The logs were environmentally corrected and normalized. The core data analysis helped in confirming the properties of the various facies types and the effective establishment of the facies boundaries.

Key words: Facies, wireline logs, characteristics, depositional environment.

INTRODUCTION

Adequate knowledge and understanding of facies types in sedimentary basin analysis will help in hydrocarbon exploration and exploitation. This study examines some of the basic facies types in a sedimentary basin, using standard electrofacies classification for deltaic environments from “gamma ray logs”. (WEC, 1985) and “gamma ray and SP log basic shapes of facies (Shell, 1982)”. Their appearances or signatures in wireline logs, their characteristics in terms of porosity and permeability which are derived from both the wireline log data and core data, helped in identifying the different facies characteristics of the studied well (Table 1).

Location

The Y field is the field under study and is located within concession OML58 block in the north-eastern Niger Delta (Figure 1). Geographically, the field lies between longitude 6◦ 30’ and 7◦00’E and Latitude 5◦00’ and 5◦30’N. Well A is located within Field Y as indicated in Figure 1. The well was drilled by Elf Petroleum Nigeria limited. Initially, the well was producing at maximum capacity, but the productivity was reduced after sometime. This necessitated this research.

MATERIALS AND METHODS

The materials that were available for this work include: wire line logs and conventional cores. The wire line logs include gamma ray (GR), neutron logs, sonic, density, Self potential (Sp), resistivity l (LLD, LLS and MSFL) and calliper logs. Cores were provided from one meter intervals of 3236 to 3237, 3245 to 3246 and 3253 to 3254. The base map showing location of the Oil field Y, and the position of Well A was drawn to scale of 1:25.00 (Figure 2). These materials were provided by Elf Petroleum Nigeria Limited with the permission of the Department of Petroleum Resources (DPR), Lagos.

INTERPRETATION OF FACIES AND DEPOSITIONAL ENVIRONMENT

The facies and depositional environment of the sequence cross-cut by Well A are discussed in the light of the knowledge of the depositional facies so recognised from gamma ray logs. The gamma ray log is best used for facies delineation because their curves give greater variety of shapes, showing greater detail and have more characteristics than other logs (Schlumberger, 1989). The gamma ray log is complemented by the Sp-log as well as resistivity logs.

Studies of modern depositional environment show that

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Table 1. Evaluation parameters from core analysis.

		Permeability					
Nos	**Depth**	**Horizontal md**	**Vertical md**	**Total k md**	**Porosity helium %**	**Sw**	**Fluid indicated**
ND97065							
1	3236	334	37.9	371.9	17.4	0.27	Hc
2	3236.25	2020	2050	4070	22.3	0.3	Hc
3	336.5	2550	3160	5710	21.3	0.36	Hc
4	3237	8730	3960	12690	21.2	0.35	Hc
Average		3408.5	2301.975	5710.475	20.55	0.32	
ND97067							
5	3253	4950	3780	87309	25	0.66	H20
6	3253.25	5750	5500	11260	23.7	0.5	Hc=H2O
7	3253.5	5000	4110	9110	22.9	0.63	H2O
8	3253.75	6510	9210	15720	24.5	0.25	Hc
9	3254	4580	9160	13740	22.5	0.19	Hc
Average		5358	6352	27427.8	23.72	0.446	

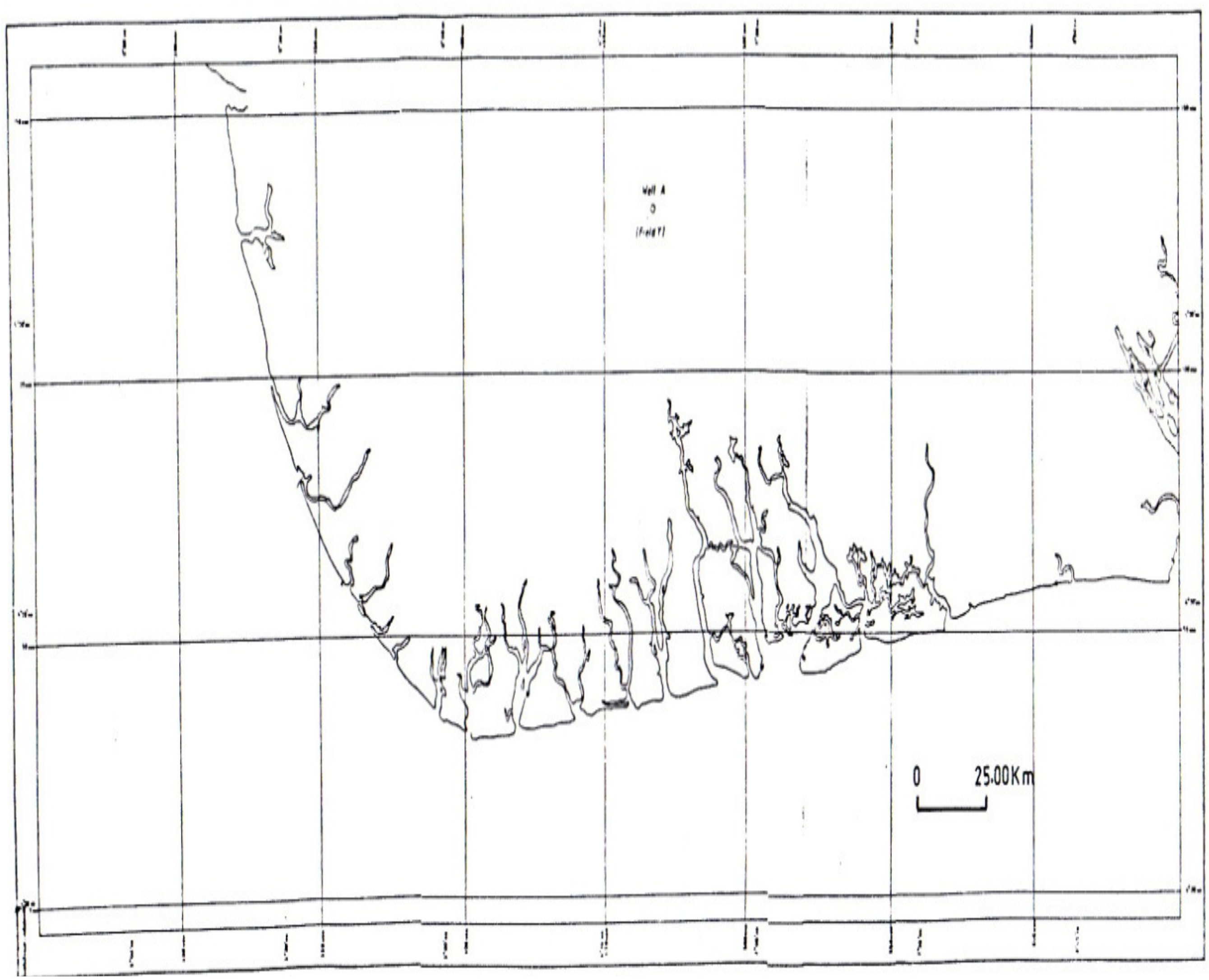

Figure 1. The Geographical Location of the study well relative to the coastline of Niger Delta (Elf, 1997).

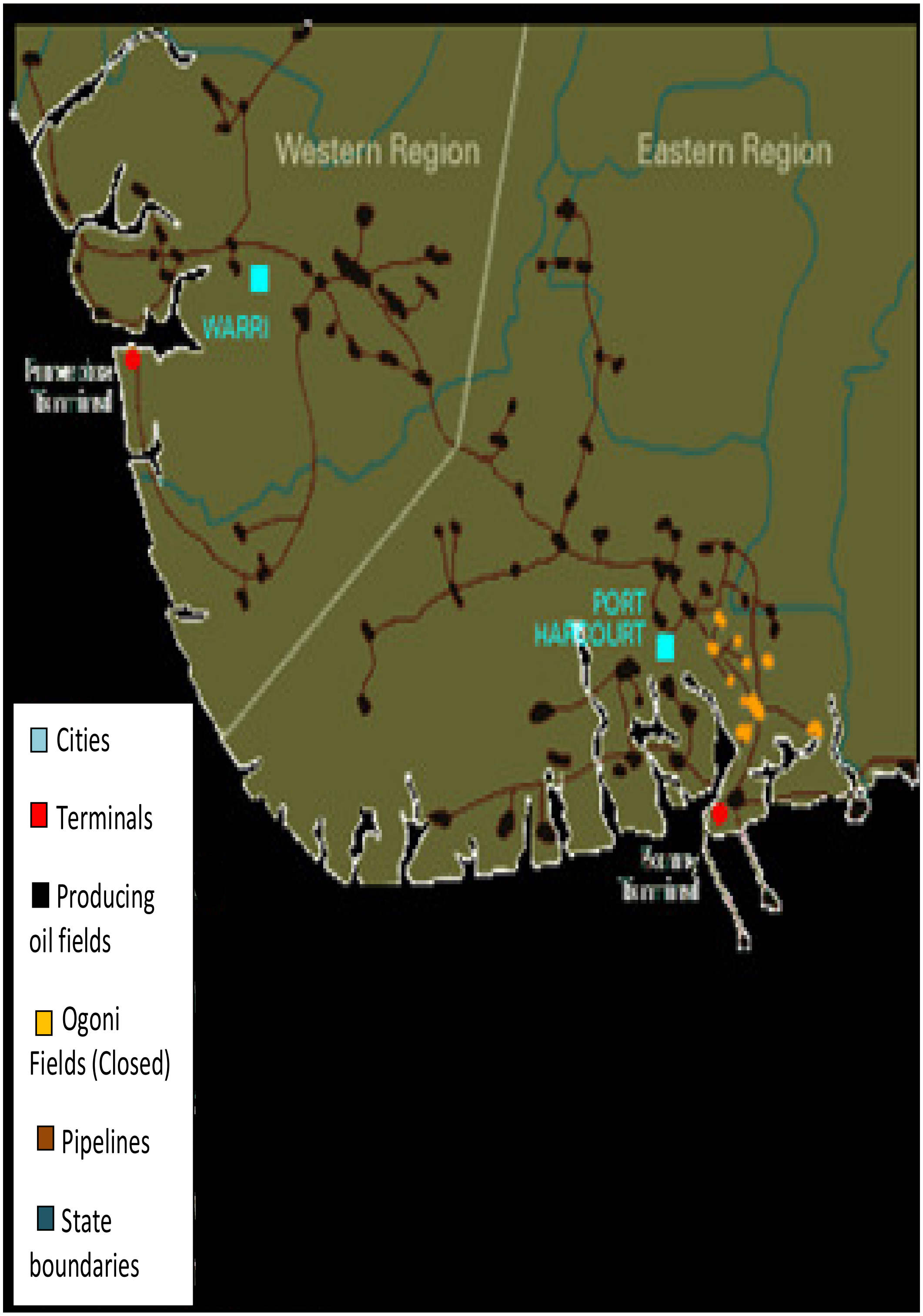

Figure 2. A Map of Niger Delta showing oil fields and pipelines (Source; Urhobo historical society, 2008).

they deposit sediment with characteristic vertical profile of grain size. Gamma and Sp-logs often show 3-basic motifs, bell, funnel, boxcar or blocky motifs (Figure 3). No log motif is specific to a particular sedimentary environment but by combining an analysis of log profiles with the composition of well samples, and interpretation of the of the environment can be attempted as well as prediction of the reservoir geometry and trend (Selley, 1998).

Moore (1949) described facies as "any restricted part of a designated stratigraphical unit which exhibit

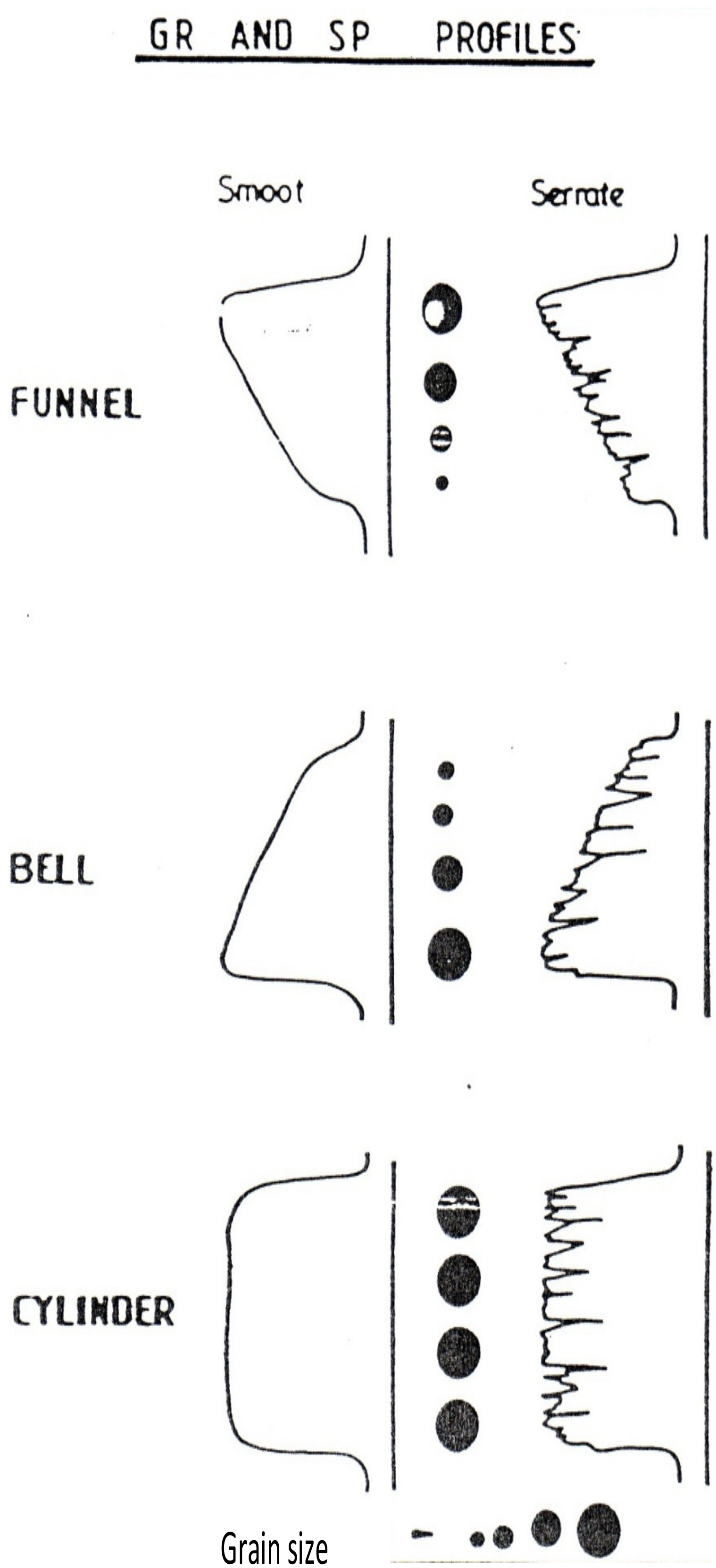

Figure 3. Gamma ray and SP log profiles showing the basic shapes of facies (After Shell, 1982).

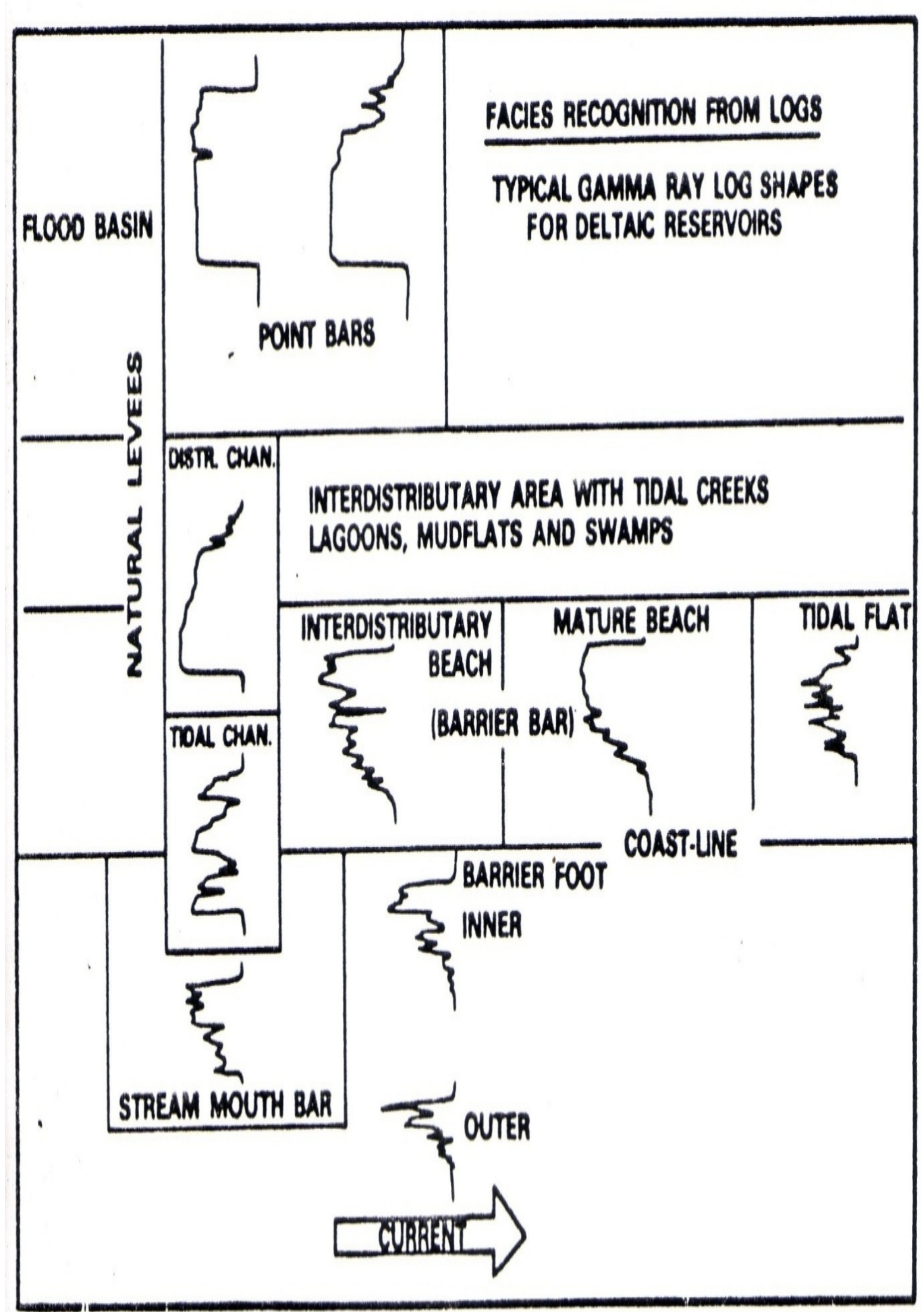

Figure 4. Electrofacies classification for deltaic environments from Gamma Ray logs. (After WEC, 1985).

characters significantly different from those of other part of the unit". Moore's definition summarized every other meaning of facies, (Selley, 1998).

The Well Evaluation Conference, WEC (1985) show that the funnel shaped gamma ray curve indicate an upward coarsening barrier bar sand, the cylindrical shaped gamma ray curve indicate a massive, featureless, non-graded sand normally associated with channel fills and the bell shaped gamma ray signature indicates an upward finning fluvial deposited sand (Figure 4). This in combination with the Sp log responses enabled the delineation of the different facies types (Figure 5).

The gamma ray log signatures complimented with those of Sp-log as well as resistivity readings were also used to establish the lithology. The observed sequence in Well A, consists of sand bodies with shale breaks on the upper part and intercalation of sand and shale bodies suggesting that logging started from the transition zone

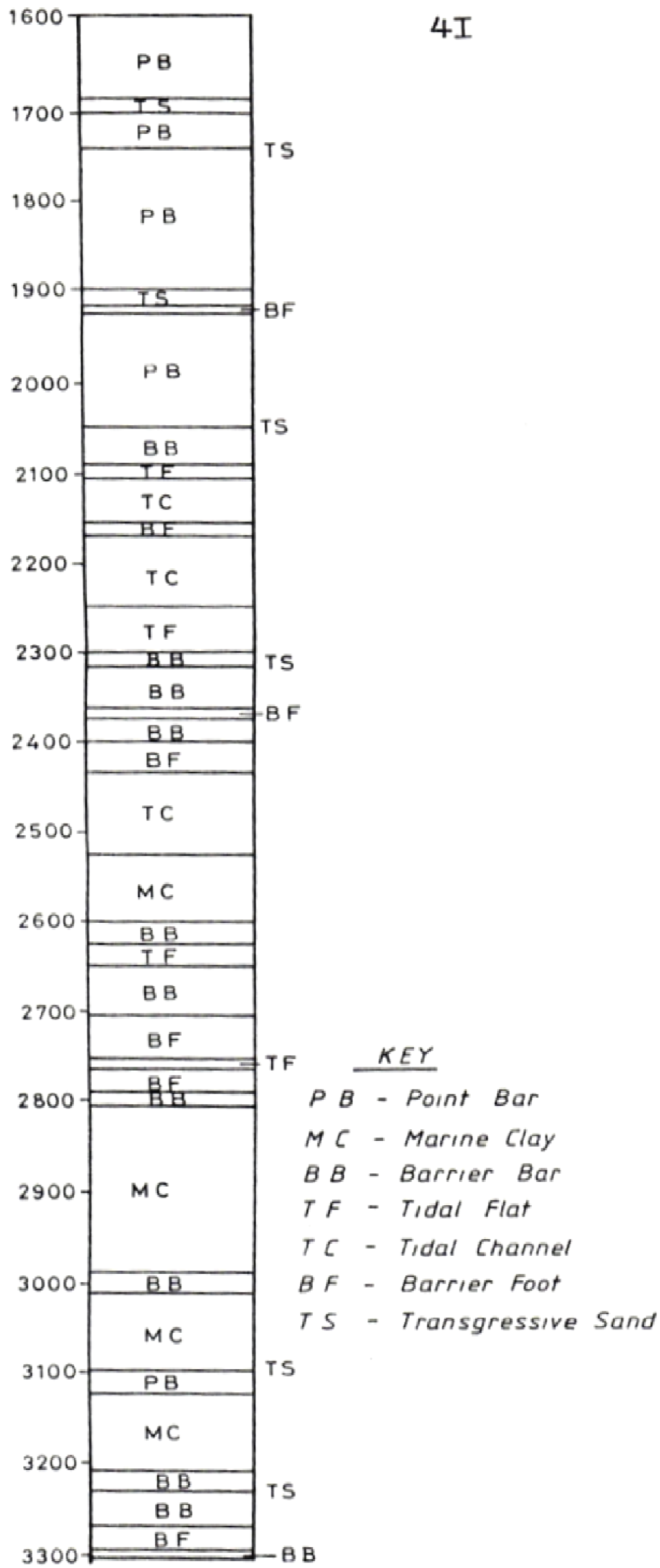

Figure 5. The Different Types of Facies Interpreted from Gamma Ray Logs of Well-A

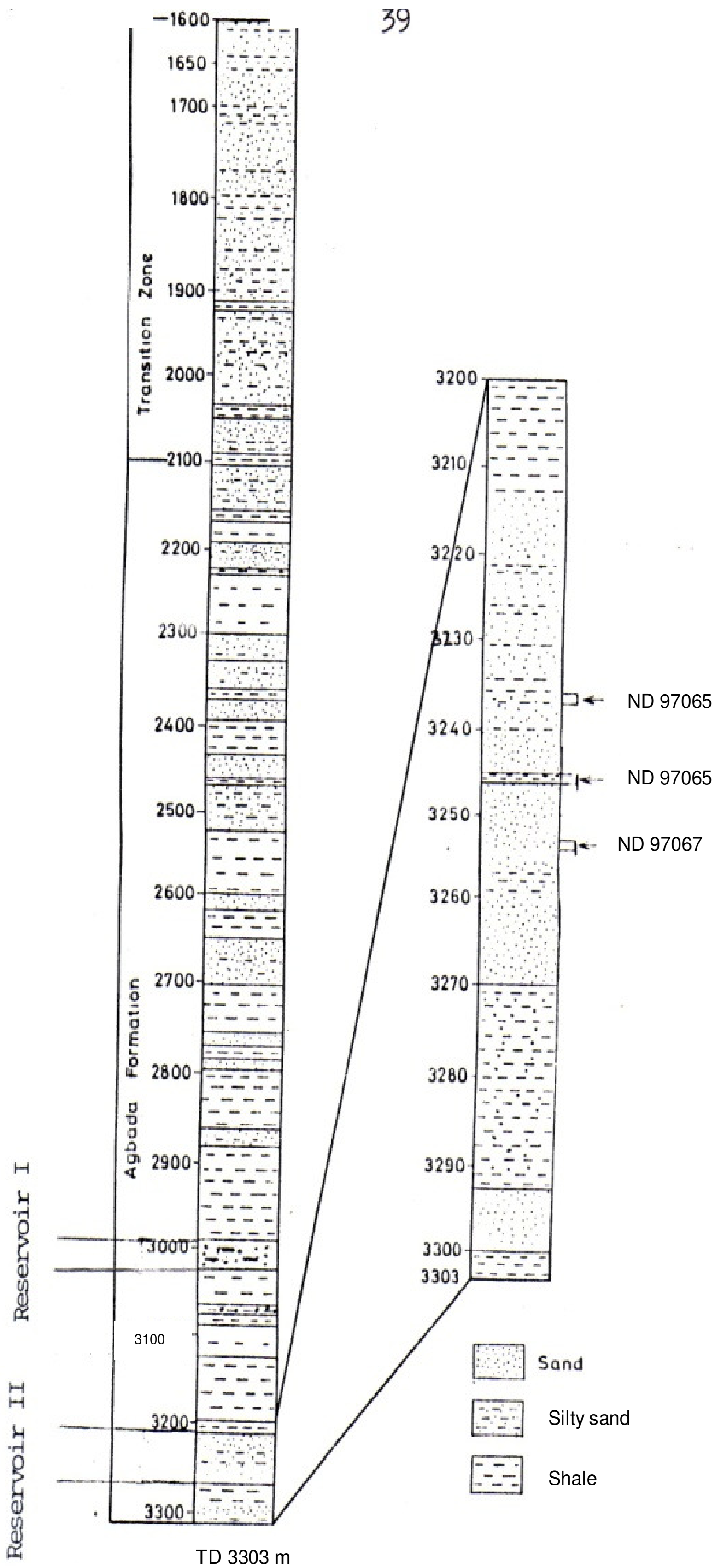

Figure 6. Depth profile of Well-A. Showing the sampled intervals.

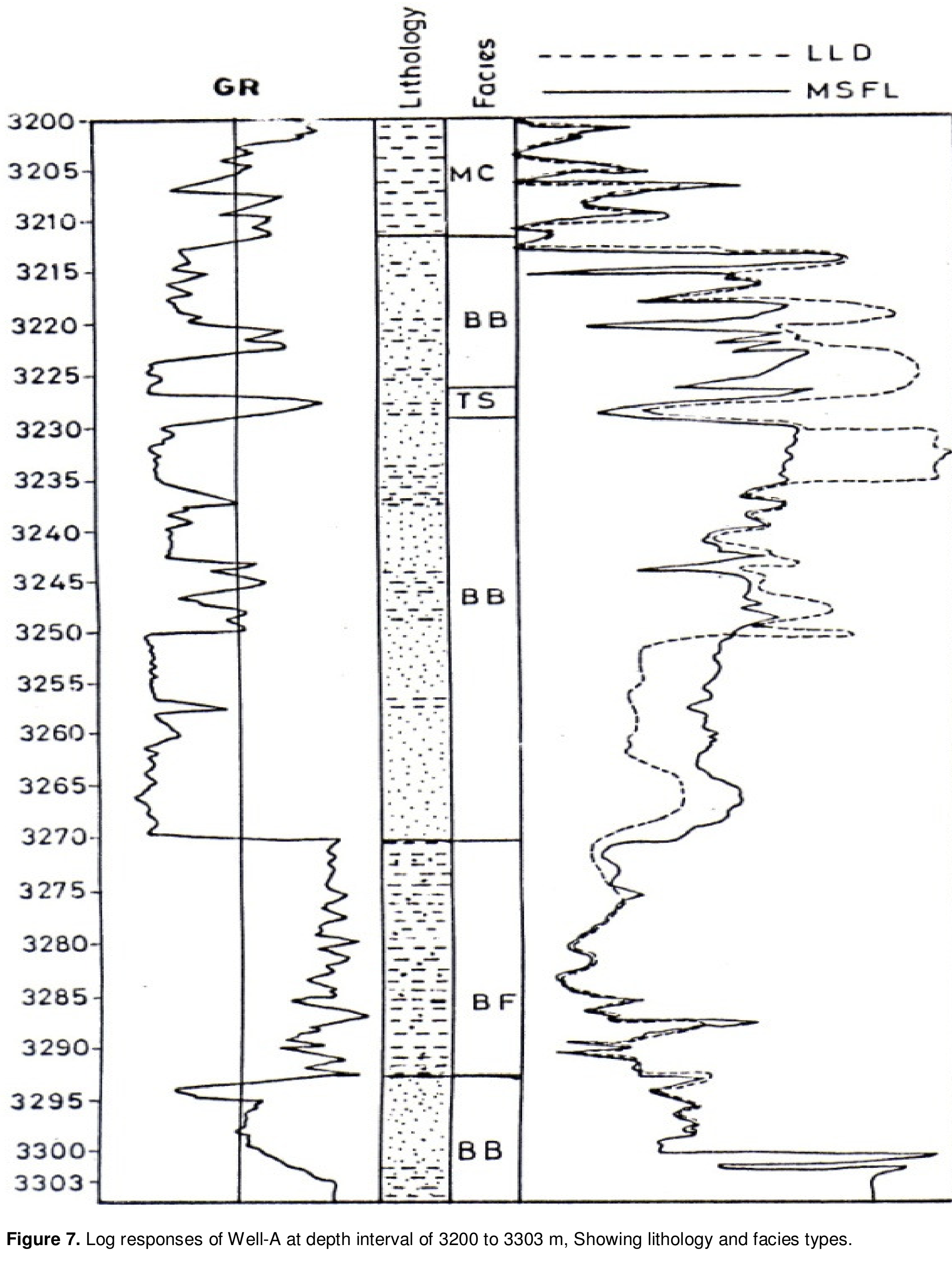

Figure 7. Log responses of Well-A at depth interval of 3200 to 3303 m, Showing lithology and facies types.

between the Benin and the Agbada Formation (Figure 6). This stratigraphic sequence is typical of Agbada Formation in the Niger Delta, which is the productive zone and has been the target of all drillings in the Niger Delta.

Based on the Wireline log signatures 7 basic facies types were delineated; they are point bar, barrier bar,

Table 2. Evaluation parameters from wireline logs (corresponding to ND97350 and ND97065 respectively).

Depth	ӨN	ӨN corrected	ӨD	ӨN-D	F	Swirr	k	Rt	Rwa	Sw	Fluid Indicated	Sp-Log values
ND97350												
3236	21	24	23.97	23.99	13.3	8.2	2388.1	45	3.45	0.27	Hc	-1
3236.25	22	25	22.2	23.61	13.8	8.3	2168.7	40	2.96	0.31	Hc	-1
3236..50	23	26	24	25.03	12.2	7.8	3164.4	55	4.57	0.36	Hc	-1
3236.75	22	25	26.3	25.6	11.6	7.6	3699.75	80	6.99	0.34	Hc	-1
3237	21	24	26.9	25.44	11.6	7.6	3237	100	8.53	0.35	Hc	-1
Average				24.7			2931.6					
ND97065												
3263	16	19	26.32	22.95	14.7	8.6	1786.4	10	0.5	0.68	H_2O	0
3253.25	14	18	26.3	22.5	15.3	8.7	1599.9	11	0.7	0.5	Hc=H_2O	0
3253.5	18	21	26.9	24.1	13.2	8.1	2497.1	12	0.9	0.63	H_2O	0
3253.75	17	20	26.9	23.7	13.7	8.3	2209.4	12	0.9	0.25	Hc	0
3254	17.6	20.5	29.9	23.7	13.7	8.3	2209.4	12	0.93	0.56	H_2O	0
Average				23.4			2060.4					

barrier foot, marine clay, tidal channel, tidal flat and transgressive sand facies (Figure 6). These facies types are deposited in different depositional environment. Depositional environments are characterised by the facies types they contain. Thus, facies could be defined as a geographical unit with a particular set of physical, chemical and biological variables (Shell, 1982).

Depositional systems are divided into 3 major types which are;

1. Deltaic-fluvial environment.
2. Marine environment.
3. Deep sea environment.

The seven facies types found in this environment cut across these 3 major depositional systems. Point bar, Tidal channel and Tidal flats are found in Deltaic fluvial environment. Transgressive sand facies which are found in the Transgressive marine shelf are part of the marine environment. While barrier bar, barrier foot, and marine clay facies are found in the deep sea environments.

Characteristics of the facies

In Well A, two commercially viable reservoir horizons were selected for study. This was judged from the wireline logs such as gamma ray, resisitivity and calliper logs which indicated invaded zones and the length of these zones extends from 2988 to 3025 m for Reservoir I and 3212.55 to 5270 m for Reservoir II (Figure 6).

The Fluviatile channel which is a subdivision of the Deltaic-Fluvial environment commonly consists of well sorted sands and thus obvious potential reservoirs for hydrocarbon. They result from meandering streams that create Point bar facies.

For effective characterisation of the marine and deep sea environment facies depositional facies, the work was concentrated on two horizons where sidewall cores of 1 m which is the standard were available. These are Horizons I and II corresponding to depth intervals of 3236 to 3237 (ND95065) (Table 2) and 3253 to 3254 (ND95067) respectively (Figure 6). Well log responses of Reservoir II are depicted in Figure 7, in which we have Marine clay (MC), Barrier bar (BB), Transgressive sand (TS), and Barrier foot (BF) facies.

Marine clays are usually found in the Basin plain unit of the Deep Sea Environment. They are usually silty and sandy indicating the quiet nature of this environment. Marine clay facies are of great importance with respect to hydrocarbon accumulation because they form the seal over the top of reservoirs as in Figure 5.

Barrier bars are characterisitics of the Inner Fan Channel environment which is also a subunit of the Deep Sea Environment. This form the sedimentary offlap cycle in the Niger Delta complex. They are characterised by upward coarsening sequence which is an indication of increasing grain size upward (Figure 7). The environment is formed by processes such as long shore currents and wave action. Deposits in the Inner Fan Environment are coarse and clean enough to be regarded as potential reservoir beds (Coleman and Prior, 1980).

The Transgressive marine shelf environment subunit which is a part of the Deltaic-Fluvial environment is characterised b the recognition of this facies type will enhance the success of petroleum exploration efforts. Transgressive sand facies and is inferred by the high gamma ray radiation emitted due to high percentage of potassium rich glauconite (Schlumberger, 1985). The sands in this type of environment are derived from

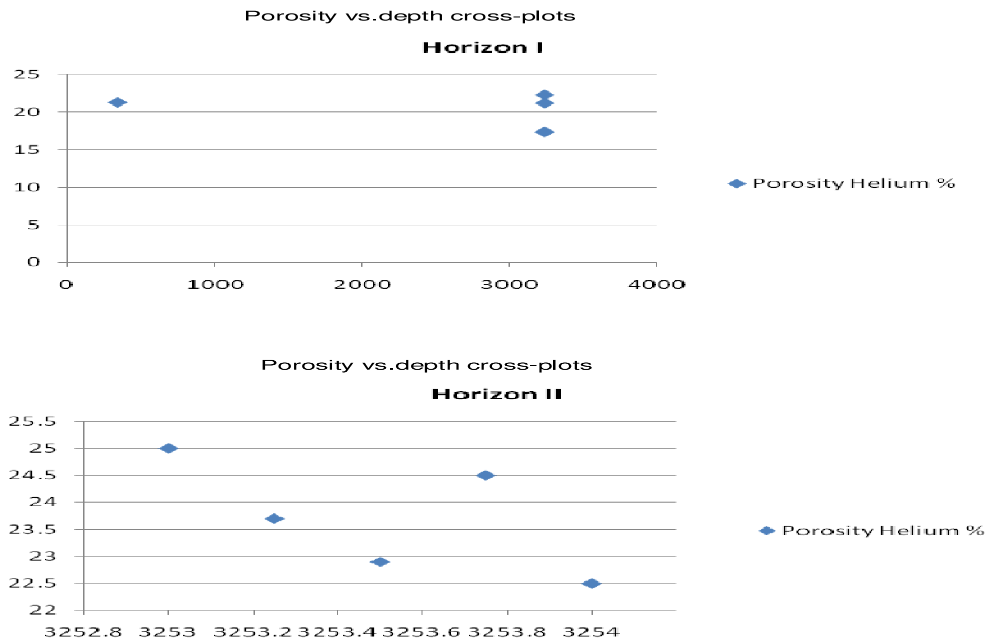

Figure 8. Porosity vs. depth cross-plots.

reworking and winnowing of eroded beds.

The Basin floor fan system as recognised in the well is a relatively small, sand rich submarine fan depositional system at or near the base of a slope. On an irregular continental margin, it is restricted to the vicinity of intraslope basins or to the mouths of submarine canyons. The sand-rich sediment is eroded from non-marine, shelf-edge deposit during the early phase of relative sea-level fall (Hallam, 1981).

The clean well sorted nature of the Barrier bars is evidenced in the good porosity values from both the wireline logs and core data as depicted by the porosity vs. depth cross-plots for both horizons (Figure 8).

GOCON (1988) states that a porosity of one percent is equivalent to a total volume of 77.58 barrels of void space per acre foot of bulk volume. They also indicate that the minimum porosity for a hydrocarbon bearing rock to be of commercial and economic importance is 10 to 20%. The average porosities from both the wireline logs and core data for the barrier bar within the depth interval of 3236 to 3237 m and 3253 to 3254 m is 20.5 and 23.7% respectively while the average porosities for the two horizons from the wireline logs data is 24.7 and 23.4% which is within a barrier bar facies confirming that barrier bars are very important to hydrocarbon exploration and the recognition of this facies type will enhance the success of petroleum exploration efforts.

Conclusion

Facies is a Latin word meaning face, figure, appearance, aspect, look or condition and thus signify an abstract idea. Primary goal of facies analysis is to produce a facies model which is in effect a hypothesis about the environment signified by the rocks and fossils under study. In this work we have tried to characterize some of the basic facies types that are very important to petroleum exploration using Well A in the Y field, in North-Eastern Niger Delta as a case, invariably this will help to enrich the understanding of facies characterisation for the purpose of petroleum exploration.

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