GEOLOGICAL DESCRIPTION OF THE MAJUEFE-01 WELL, NIGER DELTA, USING CORES AND WIRELINE LOGS DATA.

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Abstract

Cores of MAJUEFE-1 well were analysed within the context of geological core analysis to minimise the risk of interpretation based on the use of inferred data only. Lithofacies intervals were identified, characterized and sedimentologically described. Depositional environments were also reconstructed and delineated. Sandstones, siltstones, heterolithics and mudstones were the lithofacies present. The primary sedimentary structures are beddings, ripples laminations and mud drapes. Much of the sediment is sparsely to intensely burrowed by biogenic activity. Twelve facies were characterized based on gamma –ray response to lithologic variationsin grain size, composition, texture, glauconite content, sedimentary structures and bioturbation as observed on the cores displayed. The main depositional environments represented in the cored interval comprise of marine, tidal channel, tidal flat, tidal inlet and coastal (littoral) shoreface environments. Sandstones in the shoreface and tidal point bar are excellent and good potential reservoirs for hydrocarbon respectively, but very poor in the strongly bioturbated reservoir sands of the trangressive sand Interplay of these encountered environments suggestive that deposition occurred in a marginal marine setting influenced by tidal conditions.

Keywords: Potential reservoirs; Sedimentological; Heterolithic; Depositional; Core analysis; Ichnofossils

Introduction

The nature of subsurface exploration requires obtaining the downhole rock samples that provide a wealth of information, an unweathered and undisturbed, sequence of rock properties. Different authors have presented the advantages of cores over using singular approach in characterizing the subsurface. The work of Andersen et al. (2013) reemphasised that rock samples allow geoscientist to examine firsthand the depositional sequences penetrated by a drill bit. They offer direct evidence of the presence, distribution and can reveal variations in reservoir traits that might not be detected through downhole logging measurements alone. Ezeh et al. (2016) stated that it is costly to obtain core data, the significance of cores to exploration and production cannot be overemphasized especially so in the prolific Niger Delta basin where there is no known outcrop. This study focuses on utilizing geological examination of core and well data to integrate sedimentological, distribution of lithofacies, environments of deposition and reservoir potentiality of the study area. Core photographs supported the exact representation on core slabs.

Location

The area of study is situated within latitude 5° 35' 00" N and longitude 6° 02' 00" E, about 35km East of Warri in Great Ughelli depobelt, onshore Niger Delta Basin (Figure 1). MAJEFE-1 was cored in the interval 8929 to 9154 ft (225 ft) (Table I). Reijers (2011) studied stratigraphic and sedimentology of the Niger Delta and he used wireline log correlations and a number of features from core studies to interpret some activities in the Greater Ughelli depobelt. We now stretch forth this previous work by studying into detail the study area. The history of petroleum exploration has shown that there will always be enough possibility of finding more oil and gas, if more accurate exploration technique is employed in the right place which necessitated this research.

MATERIALS AND METHODS

A total of 225 ft consisting 76 core boxes (Table I), core photographs, Wireline Logs, Core Gamma Logs were made available. Sedimentological study involved the following procedures

1. Detailed characterizarion and desxription of lithofacies intervals
2. Detailed explanation and interpretation of depositional environments
3. Depth shift correction

Table I: Core Box Manifests of MAJUEFE-1 Well

Core No.	Total numbers of Core Boxes	Interval Spanned (ft)	Core Barrel Length (ft)
1	42	8929.00 – 9054.00	125.00
2	34	9054.00 – 9154.00	100
TOTAL	**76**		**225.00**

10% HCl was used to check for presence of carbonate. Comparator chart was employed for estimating sediments texture (Compton, 1962). A binocular stereomicroscope was used to examine core samples. Depth, lithology, grain size, sedimentary structures, bioturbation, ichnofossils, porosity, oil stain, sorting, roundness, rock colour, diagenesis, consolidation, fissility, facies, facies association, depositional environment and depositional complex were determined, logged and recorded SPDC, 1995). Sedimentological core log was generated. Petrel E & P software platform 2014 was used to plot the wireline logs Hettinger, (1995).

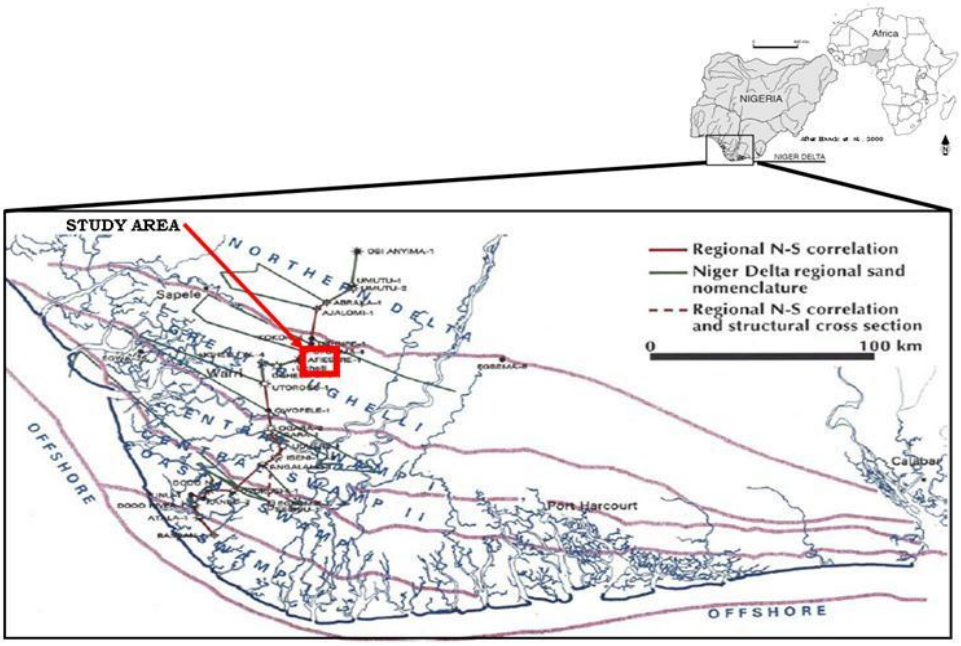


Figure 1: Niger Delta map showing MAJUEFE-1 well location (after Reijers, 2011)

Results

Facies Analysis

Encountered lithofacies, microfacies and electrofacies are precisely mudstones, siltstones, heterolithics and sandstones. Sandstone lithofacies that are most abundant revealed fine grained, medium to fine grained, coarse to medium grained and very coarse to coarse grained sediments deposition at different depths. Very coarse to coarse grained are pebble-bearing, poorly sorted, sub-rounded to sub- angular, generally fining-upward grain size profile with sharp erosive bases. Fine grained sandstone was delineated at 9067 – 9063 ft depths to be well sorted and rounded (Figure II). These sandstone beds are intercalated with moderately sorted, sub-rounded heterolithics siltstone and mudstones (black and grey shale). Coal was observed at 8935-8934 ft capping a coarsening upward sequence in the shoreface. A detailed description and photomicrographs of the derived facies in the entire core used for this study is given in Table II. Core photographs of the identified facies are shown in Figures 3 (Stow, 2010).

Figure 2: Photomicrographs of sandstone lithofacies grain sizes

Interpretation of Depositional Environments

The results were integrated to interpret the environment in which the sediments were deposited. The encountered facies, their facies association and stacking patterns were significant in simplifying and reconstructing the depositional environments. The processes of deposition and formation are controlled by waves, river and tidal current. More of heterolithic intervals were interpreted to be either sandstone dominated or mudrock dominated suggestive of deposition in a subaqueous environment under the influence of tidal currents and are bioturbated. From the bottom of the interval studied, the facies association suggestions are transgressive sands, suspension fallout, back barrier and coastal barrier. Marine, barrier island and nearshore were interpreted as environments within the tidal zone in the study area. Figure 4 shows the intervals, core photographs, facies assemblages, facies association, the, the depositional environments and depositional complex.

Depth shifts corrections

Wireline logs data were plotted in Petrel E & P Software Platform 2014, and Gamma ray plot was used as base reference. Core spectral gamma log plot was imported for the depth shift correction. The depth shift for the studied area is presented in Table III below:

Table II: Sedimentological facies and photomicroscopic description of MAJUEFE-01 Well

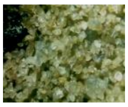
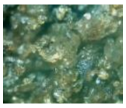
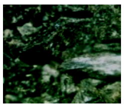
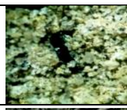
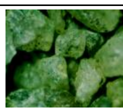
Depth (ft)	Lithology	Sed. structure	Facies	Description	Photomicrograph
8934 – 8929	Shaly sand	Lamination	Bioturbated Sandy heterolithics	Grey, coarse poorly sorted and organic rich, silty clay fossils, calcareous	
8935 – 8934	Coal		Coal	Black with vitreous luster on cleat surfaces	
8947 – 8935	Coarse–Med sandstone	Lamination	Tabular Cross bedded sandstone	blackish or dirty to light brown, well sorted	
8953 – 8947	Coarse sandstone	Cross stratification	Trough Cross bedded sandstone	Light brown, moderately sorted sub-rounded,	
8973 – 8953	Medium sandstone	Swaley laminations	Swaley bedded sandstone	Whitish to light brown, sub-rounded	
8982 – 8973	Shaly sand	Lamination	Bioturbated Sandy heterolithics	Grey, moderately sorted, sub-rounded to rounded, non calcareous	
8994 – 8982	Sandy shale	Flaser, wavy , streaky bedding	Bioturbated Shaly heterolithics	Grey, Silty sand to clay silt	
8997 – 8994	Shale	Lamination, siderite	Bioturbated Mudstone	Dark grey, interbedding, interlamination, well consolidated	
9010– 8997	Coarse–Med sandstone	Cyclic tidal rhythmites	Cross bedded sandstone	Milkish calcareous	
9012 – 9010	Shaly sand	Lamination	Bioturbated Sandy heterolithics	grey, coarse poorly sorted and organic rich, silty clay, calcareous	
9014 – 9012	Shale	Lenticular lamination, burrows	Bioturbated Muddy heterolithics	Dark grey, well consolidated	
9016 – 9014	Sandy shale	Flaser, wavy, streaky bedding, roots	Bioturbated Shaly heterolithics	Grey, Silty sand to clay silt, non calcareous	
9035 – 9016	Coarse-med sandstone	Bioturbation, clay laminae	Bioturbated sandstone	Grey, coarse poorly sorted and organic rich, silty clay	
9045 – 9035	Medium sandstone	Lamination, clay drape	Cross bedded sandstone	Brown moderately sorted, sub-rounded	
9052 – 9045	Coarse sandstone	Lamination	Cross bedded sandstone	Brown moderately, sub-angular to sub-rounded	

Table II: Sedimentological facies and photomicroscopic description of MAJUEFE-01 Well cont'd

Depth (ft)	Lithology	Sed. structure	Facies	Description	Photomicrograph
9057 - 9052	Shale	Lenticular Lamination, Pyrite noddles	Pyritic Mudstone	Black, well consolidated	
9060 - 9057	Shaly sand	Bioturbation, clay laminae, roots	Bioturbated Sandy heterolithics	Grey, coarse poorly sorted and organic rich, silty clay	
9063 - 9060	Very,coarse sandstone	Cross bedding, bioturbation	Glauconitic Cross bedded sandstone	Whitish, poorly sorted, sub-angular,	
9067 - 9063	Fine sandstone	Sparsely burrowed	Glauconitic Cross bedded sandstone	Whitish rounded,	
9076 - 9067	Very coarse	Sparsely burrowed	Glauconitic Cross bedded sandstone	Whitish, poorly sorted, sub-angular	
9091 - 9076	Coarse–Med sandstone	Mud drape and cross lamination	Glauconitic Cross bedded sandstone	Dark milkish, moderately sorted,	
9095 - 9091	Medium sandstone	Swaley laminations	Swaley bedded sandstone	Milkish to creamy, moderately sorted	
9097 - 9095	Shaly sand	Cross lamination	Bioturbated Sandy heterolithics	Grey, moderately sorted and organic rich, silty clay	
9101 - 9097	Sandy shale	Flaser, wavy, streaky bedding, roots	Bioturbated Shaly heterolithics	Grey, Silty sand to clay silt, non calcareous	
9103 - 9101	Shaly sand	Lamination	Bioturbated Sandy heterolithics	Grey, moderately sorted and organic rich, silty clay	
9105 - 9103	Shale	Lamination	Bioturbated Muddy heterolithics	Black, well consolidated	
9114 - 9105	Siltstone	Lamination	Heterolithic Siltstone	Light grey, well consolidated, silty sand	
9119 - 9114	Shale	Lamination	Bioturbated Muddy heterolithics	Dark grey, well consolidated	
9120 - 9119	Shaly sand	Lamination	Bioturbated Sandy heterolithics	Grey, moderately sorted and organic rich, silty clay	
9129 - 9120	Coarse–Med sandstone	Bioturbation	Bioturbated sandstone	Light grey to whitish, poorly sorted, sub-angular	
9154 - 9129	Coarse sandstone	Bioturbation	Bioturbated sandstone	Light grey to whitish, poorly sorted,	

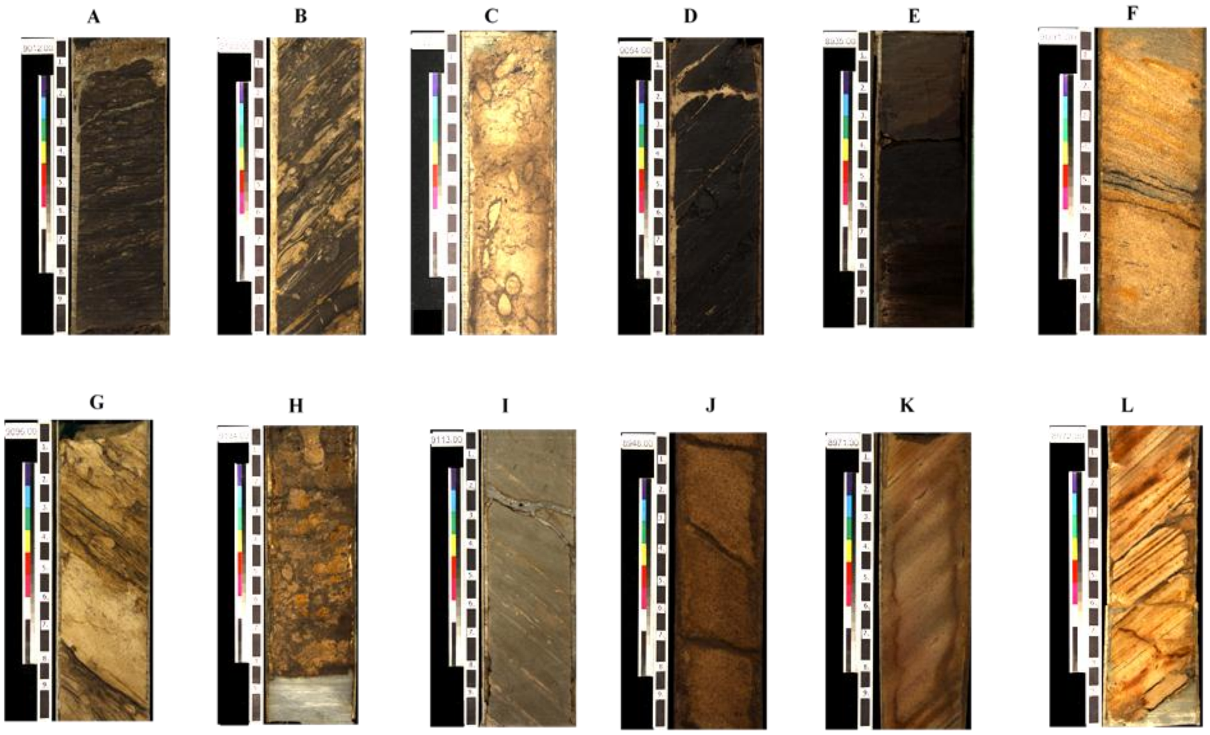


Figure 3: (A) Lenticular bedded muddy heterolith at 9101 – 9097 ft, 9016 – 9014 ft and 8997 – 8982 ft depths interval, (B) Bioturbated muddy heterolith at 9119 – 9114 ft, 9105 – 9103 ft and 9014 – 9012 ft and 8994 – 8982 ft depths interval, (C) Bioturbated sandstone at 9035 – 9016 ft depths interval, (D) Pyritic silty clay at 9057 – 9052 ft depths interval, (E) Coal at 8935 – 8934 ft depths interval, (F) Laminated sandstone at 9095 – 9091 ft and 8969 - 8963 ft depths interval. (G) Bioturbated sandy heterolith at 9120 – 9119 ft, 9103 – 9101 ft, 9097 – 9095 ft, 9060 – 9057 ft, 9012 – 9010 ft, 8982 – 8973 ft and 8934 – 8929 ft depths interval, (H) Glauconitic bioturbated sandstone at 9154 – 9120 ft depths interval, (I) Heterolithic Siltstone at 9114 – 9105 ft depths interval, (J) Cross bedded sandstone at 9091 – 9060 ft, 9052 – 9035 ft, 9010– 8997 ft and 8963 – 8935 ft depths interval, (K) Swaley bedded sandstone at 8973 – 8953 ft depths interval and (L) Heterolithic sandstone at 8972 – 8969 ft depths interval..

Table III: MAJUEFE-01 Well Depth Shift

Core	INTERVAL SPANNED (ft)	GAMMA RAY	CORE GAMMA RAY	SHIFTS (ft)
		Top: 4900		
#7 - #8	8929.00 – 9154.00		9156.00	- 2.00
		Bottom: 10010		

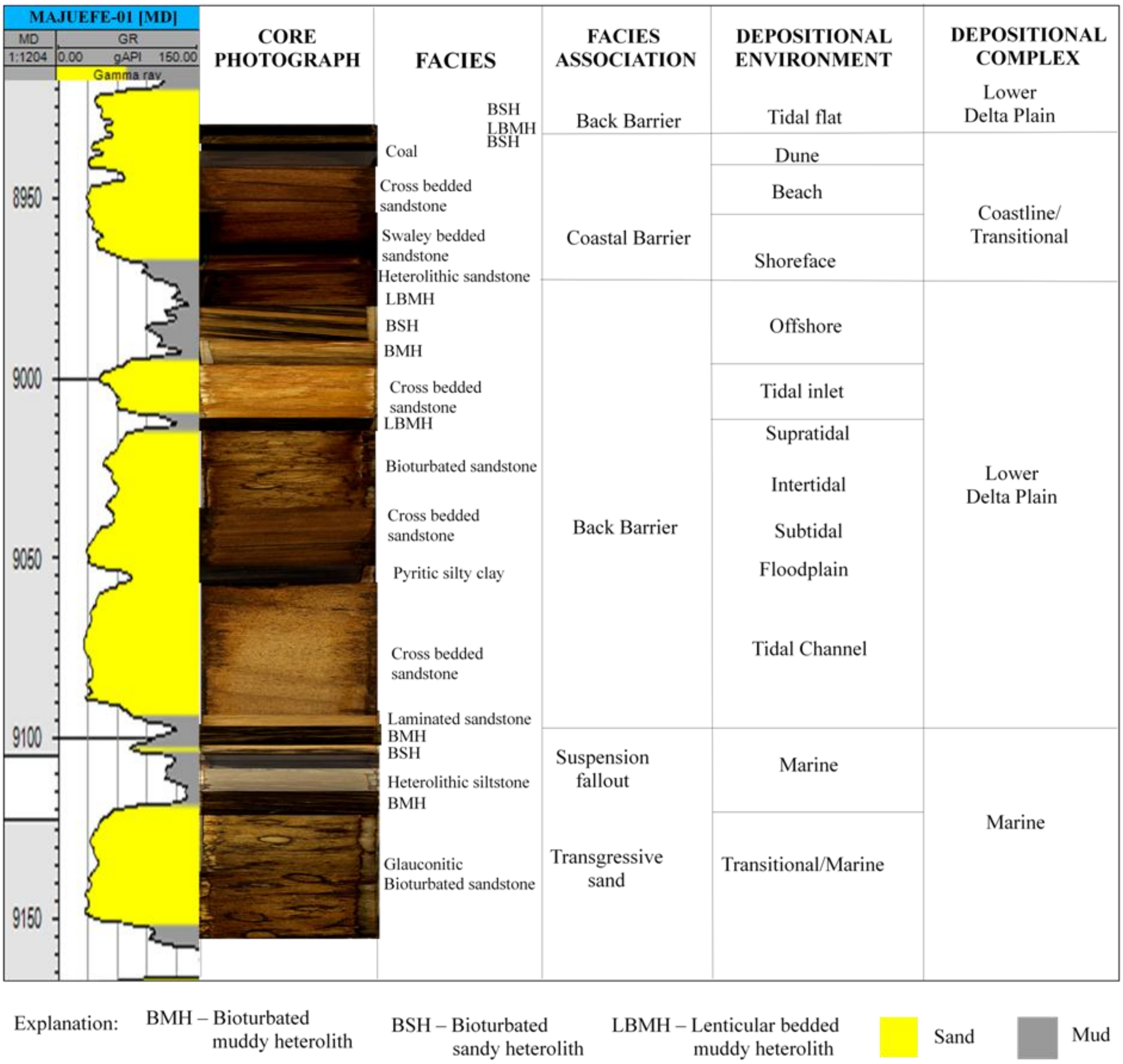


Figure 4: depositional environments in MAJUEFE-1 well.

Discussion

Characterization of the facies revealed marine, tidal channel, tidal flat, tidal inlet and coastal (littoral) shoreface environments belonging to marine, coastaline and lower delta plain depositional complexes. These deposits were gradational from underline marine upward through transitional under the influence of tidal currents. Abundant of *Ophiomorpha* burrows, clay draped foreset beds and rare pebble, fining upward grain size trend from erosive basal contact sandstones of the bay-fill delta appears to define the inshore limit of marine sandstones facies (Carter, 1965), which were overlain by heterolithic siltstone, and laminated dark grey to black shale abhorring pyrites nodules that indicate that the mudrocks were deposited in shallow marine transgressive settings. This was overlain by tidally influenced deposists in tidal delta systems (Pettijohn *et al*., 1972), capped by dark grey carbonaceous shales indicate deposition in floodplain of lower delta plain environments. Thereafter sediment input from the rivers were temporarily stored in the estuaries through tidal inlets (Elias *et al*., 2006), and then pass into the ocean. Tidal inlet is associated with ebb tidal delta. The tidal flat were overlain by tide and wave influenced shallow marine deposits as offshore, shoreface and foreshore sands and silts. Walker 1984 stated that they were deposited during a relative slack in rates of sea level rise and shoreline standstill as coastal barrier bars and beach complexes.

Conclusion

The cored interval of MAJUEFE-01 Well (8929 – 9154 ft) was examined, described and interpreted. Characterisation has shown mudstones, siltstones, heteroliths and sandstones lithofacies belonging to four facies associations were deposited in an estuarine tidal/fluvial delta to shallow marine depositional settings. The black to dark and grey grey shale facies were deposited in shallow marine shelf environment and coastal floodplain environments respectively. The sandstones were deposited within estuarine delta as fluvial point bar (meandering) and tidal channels in a bay delta and within coastal (littoral) shoreface environments. The barrier islands was characterized by low wave and tide but cut by a tidal inlet due to high tidal current. Tide dominated estuary exhibits dominant upward fining pattern of the lithofacies with abundant *Ophiomopha* burrows and clay draped foreset beds but poor reservoir potential while tidal flat show sandy, grading upward and landward into clay and excellent reservoir potential.

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