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Sequence Stratigraphy Study of UNIABR Field in Northern Delta Depobelt of Niger Delta, Nigeria

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Abstract
Integrated interpretation of wireline logs and high resolution biostratigraphic data has enhanced the subdivision of the stratigraphic column within the Uniabr Field (fictitious) (OML 4) in the Niger Delta of Nigeria into five sequences and different systems tracts. It has also aided the identification of maximum flooding surfaces and type – 1 sequence boundaries.
Lowstand systems tract with basin floor fans, slope fans and prograding wedge complex plus transgressive systems tracts and highstand systems tracts occur in the field. Five maximum flooding surfaces and five sequence boundaries are recognized with their average depths tie to their absolute ages. All except the second sequence boundary are clearly type – 1 sequence boundaries. Lowstand systems tract is missing on top of the second sequence boundary and is directly overlain by transgressive systems tract, hence it cannot convincingly be pass for a type – 1 sequence boundary. Again, five sequences are identified from the base to the top of the stratigraphic column (of the field) with varying average thicknesses and cyclicities. Based on their cyclicities of between 1.0 and 5.0 Ma, all the sequences identified in this field are third order type. They have potential of both serving as excellent source rocks and providing stratigraphic traps. A structural trap is speculated between the second and third sequences at 2417m (7930ft) depth below the mean sea level.
Based on palynological zonation of Uniabr – 1 Well (P450 – P650), the age range of the sediments penetrated in the Uniabr Field is from Late Eocene to Early Miocene, thus placing the field within the northern delta depobelt of the Niger Delta.
Keywords : OML 4, Systems tracts, Maximum flooding surfaces, Type-1 sequence boundaries,Niger Delta.

1. Introduction

The history of petroleum exploration has shown that there will always be a possibility of finding oil and gas deposit if more accurate exploration technique is employed in its search. Sequence stratigraphic approach has turned out to be one of such unique techniques for generating exploration prospects and predicting reservoir and seal qualities in both stratigraphic and structural traps.Sequence stratigraphy evolves as an aspect of stratigraphy that subdivides rock record using a succession of depositional sequences composed of genetically related strata as regional and inter-regional correlative units (Haq et al,1988). It is concerned with the relative rates of change in sea level and sedimentation. Thus, genetically related facies are studied within a frame work of chronostratigraphically significant surfaces (van Wagoner et al, 1990), and rock units that are genetically related are constrained by time lines (Reijers, 1998). Chronostratigraphically significant surfaces are either unconformities or bounding discontinuities or their correlative conformities which form sequence boundaries.
Depositional sequences are made up of series of discrete packages, bounded by either correlative conformities or bounding discontinuities or unconformities.Generally, these packages are arranged in a predictable order in a depositional sequence and are known as systems tracts. They are defined as a linkage of contemporaneous depositional systems (Brown and Fisher, 1977).
Sequence stratigraphy is most successfully achieved using data base that integrates petrophysical, biostratigraphic and seismic data of the study area. This approach offers a predictive model in which a series of systems tracts within a depositional sequence is interpreted to be deposited in response to a cycle of fall and rise of sea level. This is related to a eustatic cycle. It also emphasizes the basic framework for the analysis of the relationship of tectonic subsidence and stratigraphy to eustatic cycles (Sangree et al, 1990); thus enhancing the understanding of the evolution of sedimentary strata.
The overall regressive siliciclastic deposits of the Niger Delta are amenable to the application of sequence stratigraphic concepts. The lithostratigraphic interpretation of the Niger Delta sediments crosses time lines and their lateral linkage turns them into the diachronous continental Benin sands, paralic Agbada sequence of interbedded sands and shales, and prodelta Akata marine undercompacted shales which is an overall product of tectonics and eustacy (Short and Stauble, 1967; Frankl and Cordry, 1967; Weber and Daukoru, 1975; White, 1982). Growth faulting dominates the structural style of the Niger Delta with its complexity increasing seaward (Merki, 1972; Doust and Omatsola, 1990).
Foraminifera are marine creatures and their occurrence in any rock is indicative of marine depositional

environment of such rocks. Typical foraminiferal assemblages are often found in some shale horizons referred to as shale markers. Integrated studies by Bowen et al (1994), Snedden et al (1994), Stacher (1994), Krusi and Idiagbor (1994), Ozumba (1995), Bassey and Ojesina (1998), Bassey and Fagbola (2002) have revealed these shale markers to correspond to major transgression events in the Niger Delta and twenty such intervals are recognized in the Tertiary (Palaeogene-Neogene) Niger Delta using foraminifera alone.

Sequence stratigraphic approach facilitates the subdivision of the Niger Delta lithostratigraphy into packages of sediments that are essentially bounded together by chronostratigraphically significant surfaces. On this basis, the genetic meaning of the Niger Delta lithostratigraphy can be appreciated. Consequently, sequence stratigraphic interpretation of Uniabr Field in the northern depobelt of the Niger Delta using wireline logs and biostratigraphic data of some wells drilled in the field is carried out to delineate sequence boundaries, systems tracts and maximum flooding surfaces in order to isolate hydrocarbon traps.

The study area is Uniabr Field in OML 4 which is located within the coordinates: 5.23452 Northing and 6.15420 Easting and 221784.40 in northwestern onshore portion of the Niger Delta (Fig. 1). Gamma ray and resistivity logs of Uniabr – 1, Uniabr – 2 and Uniabr – 3 wells and biostratigraphic data comprising foraminiferal diversity and population and foraminiferal environments as well as microfaunal and microfloral zonations were supplied for use in executing this study.

2. Interpretation of Procedures

Interpretation was carried out step by step starting with wireline logs and followed by high resolution biostratigraphic data. The procedures adopted are outlined below:

2.1 Wireline Log Data: Gamma ray and resistivity logs(of Uniabr – 1, 2 and 3 wells) which are available in the composite well logs provided were used to interpret their lithology and thus identify systems tracts, sequences, sequence boundaries and maximum flooding surfaces. The criteria for recognizing these features from gamma ray and resistivity logs as discussed by Mitchum et al (1993) were employed. Log patterns were therefore determined and utilized in defining the different systems tracts, sequences, sequence boundaries and maximum flooding surfaces.

2.2 Biostratigraphic Data: High resolution biostratigraphic data of Unibar – 1 well comprising foraminiferal population, foraminiferal diversity,planktonic population,planktonic diversity and environments provided were plotted (Table 1). Based on relative maximum faunal abundance and diversity peaks maximum flooding surfaces were picked while relative faunal abundance and diversity minima were used to identify sequence boundaries from the biostratigraphic data plots. Also, the microfaunal and microfloral zonation checklists of Uniabr – 1 well (Table 2) were used to date and correlate maximum flooding surfaces and sequence boundaries identified with the Niger Delta Cenozoic chronostratigraphic chart of Reijers (1996). An integration of the two data sets led to a refinement of the interpretation. Biostratigraphic information was annotated on the well logs; initial interpretation of the systems tracts, maximum flooding surfaces and sequence boundaries were refined so that maximum flooding surfaces corresponded to shaly zones while sequence boundaries corresponded to sandy zones on well logs. Iterative interaction of the data sets led to continuous refining of interpreted packages as more information was deduced until interpretation from one data set was verified from the other.

3. Interpretation and Discussion

3.1 Wireline Log Data: Three types of systems tracts are identified from the available well logs. These are lowstand systems tracts, transgressive systems tracts and highstand systems tracts. Each systems tract is deposited at a predictable position in an interpreted base level cycle caused by eustasy, and has recognizable signatures in well logs (Mitchum et al, 1993).

Lowstand Systems Tract (LST) consists of the oldest deposit within a depositional sequence and is bounded at the base by a sequence boundary. It consists of basin floor fan (BFF), slope fan (SF), and prograding wedge complex (PWC). The basin floor fan is characterized on gamma ray and resistivity logs by blocky pattern with relatively few breaks thus indicating massive sand body. The slope fan shows a typical sand – poor facies with overall rounded shape of spiky sand package on gamma ray log. The prograding wedge complex which is the uppermost unit of the lowstand systems tract is characterized by an overall coarsening upward (ie. inverted christmass tree) pattern on gamma ray log. This is interpreted as a gradual overall shallowing upward pattern from marine to non-marine environments.

Transgressive System Tract (TST) is the middle systems tract in an ideal depositional sequence and develops as a result of an increase in the rate of sea level rise. Condense section which is a thin marine facies consisting of pelagic to hemipelagic sediments occurs within transgressive systems tract and represents a time of detrital sediment starvation in the depositional basin. The transgressive systems tract is characterized by a relatively increasing gamma ray and decreasing resistivity readings, marked by fining upward pattern that persists vertically until the maximum flooding surface is reached. The transgressive systems tract is bounded at its base by transgressive surface while maximum flooding surface is characterized by lowest resistivity and highest gamma ray readings.

Highstand Systems Tract (HST) consists of younger strata within a depositional sequence and is widespread on the shelf. It is bounded at its base by maximum flooding surface and at the top by sequence boundary. Highstand systems tract begins with coarsening upward pattern which is predominantly forestepping basinward. It is characterized by a relatively decreasing resistivity readings.

3.2 Biostratigraphic Data: Recognition of criteria for maximum flooding surfaces within condensed sections of the starved transgressive and highstand systems tracts are the major high faunal abundance and diversity peaks that are generated from the plotting of the biostratigraphic data supplied whereas the sequence boundaries correspond to faunal abundance and diversity minima (Mitchum et al,1993). Secondary but minor faunal abundance and diversity peaks are also encountered and are found at the top of individual leveed – channels in the slope fan (Mitchum et al, 1993) which should not be mistaken for major high faunal abundance and diversity peaks that typify maximum flooding surfaces. The latter occurs in basinal shales in distal toes of well developed prograding wedge complex overlying the slope fan.

Integration of biostratigraphic data plots and the well log signatures enables the identification of major faunal abundance and diversity peaks on the biostratigraphic data supplied. Based on the reliability of the biostratigraphic data only four out of the five maximum flooding surfaces are identified while all the five sequence boundaries are clearly established (Fig, 2). Using the foraminiferal (F) and palynological (P) zones of the microfaunal and microfloral zonation check lists (Table 2) , the interpretations obtained from the integrated well logs and biostratigraphic data are dated and correlated within the Niger Delta Cenozoic chronostratigraphic chart (Reijers, 1996). Table 3 therefore presents the ages and summarizes the correlation as well as the inferences obtained for the sequences and their components in the Uniabr Field.

3.3 Sequence Stratigraphy of Uniabr Field

The sequence stratigraphy of Uniabr Field was deciphered after the integration of well log signatures with the biostratigraphic data plots (Fig. 2). Lowstand systems tracts, transgressive systems tracts, and highstand systems tracts were clearly identified; so also the sequences, maximum flooding surfaces and sequence boundaries with their absolute ages (Table3). The five sequences recognized are type – 1 sequences (Posamentier and Vail, 1988)containing lowstand systems tracts that consist of basin floor fan, slope fan and prograding wedge complex and are therefore underlain by type-1 sequence boundaries. The cyclicity of the sequences in this field reveals they are third order sequences (Reijers,1996) ranging from 1.0Ma to 5.0Ma cycles.

The stratigraphic column of the Uniabr Field is therefore subdivided from base to top into sequences 1, 2, 3, 4 and 5 with their details presented below (Table3):

Sequence – 1: At the base of sequence – 1 lies the slope fan of the lowstand systems tract that typifies an interval of late relative sea level fall and subsequent early sea level rise. Fine clastic sediments rich in shale in platform margin to bathyal environments are the characteristic deposits which are succeeded by transgressive systems tract. The transgressive systems tract represents a period of marine flooding across the shelf which progressed to maximum marine flooding, corresponding to maximum relative rise in sea level. Transgressive systems tract is rich in fining upward sediments in platform to bathyal environments. A maximum flooding surface marks the end of the transgressive phase and condensed section develops at this surface. The maximum flooding surface within this sequence is tied in with the Umutu Marker Shale of Niger Delta chronostratigraphic chart (Reijers, 1996)which is found to be 41.0Ma. Highstand systems tract overlies the maximum flooding surface thus representing a time of decelerating rate of relative sea level rise. Highstand systems tract progrades over transgressive systems tract with coarsening upward sands deposited in the platform margin to bathyal environments. The top of this systems tract corresponds to the first sequence boundary which is a type – 1 sequence boundary because it is overlain by slope fan of sequence – 2. This sequence boundary also lies on top of the Umutu Marker Shale and is dated 40.1Ma but the sequence boundary beneath this Umutu Marker Shale is unpenetrated base sequence boundary of sequence – 1 which is dated 42.7Ma. Based on this consideration the sequence is found to have a cyclicity of about 2.6Ma and this makes it a third order sequence.

Sequence – 2: This sequence begins with slope fan sediments deposited on the highstand systems tract of sequence – 1. It is inferred to have formed during the interval between late relative fall in sea level and early relative sea level rise. The sediments were deposited in the platform margin to inner neritic environments and are made up of turbidite – channel – overbank deposits which are poor in sand (Mitchum et al, 1993). Transgressive systems tract overlies the slope fan and represents a period of relative rise in sea level when marine flooding across the shelf took place. During this period, relative sea level rise outpaced deposition, thus resulting in sediment starvation. Fining upward sediments in inner neritic to bathyal environments characterized this deposit with the maximum flooding surface marking the end of this systems tract. This maximum flooding surface corresponds to an unnamed marker shale in the Niger Delta chronostratigraphic chart of Reijers (1996) which is dated 39.4Ma.

The period of maximum flooding as represented by its surface was succeeded by relative fall in sea level which resulted in the deposition of the highstand systems tract that overlies the transgressive systems tract. During this period, progressively coarsening upward sediments in platform to inner neritic environment were deposited. The top of this bounds the sequence and this corresponds to the sequence- 2 boundary. This sequence boundary tops the unnamed marker shale which is dated 38.7Ma and its bottom sequence boundary is found to be 40.1Ma. The cyclicity of this sequence is therefore put at about 1.4Ma which makes it a third order sequence.

Sequence – 3: This sequence begins with transgressive systems tract that overlies the second sequence boundary which can not be convincingly established as a type – 1 sequence boundary because the lowerstand systems tract could be as a result of interruption of the late phase of the relative fall in sea level that deposited the highstand systems tract of sequence – 2 by an abrupt rising of the relative sea level which produced the transgressive systems tract of this sequence. This interruption makes the second sequence boundary a transgressive surface. It could also be explained that the lowstand systems tract was deposited but was subsequently eroded before marine flooding of the shelf that deposited the transgressive systems tract of this sequence took place. If this is the case, then the second sequence boundary is an unconformity. Again, faulting could also have caused its omission.

Maximum flooding surface bounds this transgressive systems tract of progressively fining upward hemipelagic to pelagic shale in platform margin to bathyal environments. This maximum flooding surface is tied in with Uvigerinella – 8 Marker Shale of Niger Delta chronostratigraphic chart (Reijers,1996) which is dated 38.0Ma. The return of relative fall in sea level led to progradation. Coarsening upward sands in middle neritic environment were deposited and the top of this highstand systems tract bounds the sequence and overlies the Uvigerinella – 8 Marker Shale which is dated 37.3Ma. The base of the sequence underlies this marker shale dated 38.7Ma. The sequence is therefore found to have a cyclicity of about 1.4Ma thus making it a third order sequence. The sequence boundary is a type – 1 variety because directly overlying it is the basin floor fan of lowstand systems tract of the overlying sequence – 4.

Sequence – 4: Basin floor fan of the lowstand systems tract underlies sequence – 4. The presence of basin floor fan in this sequence suggests compaction, subsidence, and/or submarine erosion of the underlying sequence – 3. Consequently, space or accommodation was created which was subsequently filled up by the deposit of early relative sea level fall. This deposit is composed of massive, usually well sorted sands in platform margin environment. Relative sea level rise outstripped the rate of sedimentation and the prograding wedge complex was interrupted and bounded by transgressive surface of the overlying transgressive systems tract. The constituent sediments progressively fine upward, culminating in the maximum flooding surface that bounds this systems tract corresponding to an unnamed marker shale of the Niger Delta chronostratigraphic chart which is dated 36.6Ma.

Progressively coarsening upward sands overlie the transgressive systems tract and this is interpreted during period of relative fall in sea level. The top of this systems tract corresponds to the fourth sequence boundary which tops the unnamed marker shale with age put at 36.3Ma and is overlain by basin floor fan of the overlying sequence. The base of this sequence lies beneath the unnamed marker shale dated 37.3Ma. The cyclicity of the sequence is about 1.0Ma which corresponds to a third order sequence. This also makes the fourth sequence boundary of type – 1 sequence boundary variety.

Sequence – 5: The sequence - 5 is underlain by basin floor fan deposited as a result of early relative fall in sea level in accommodation/space created by compaction, subsidence, and/or submarine erosion of underlying sequence. It is composed of well sorted massive sands. Slope fan deposit which overlies this basin floor fan was formed during late relative fall in sea level and subsequent early rise in sea level. It is composed of leveed channels which are rich in shale in platform margin to shallow inner neritic environments. Transgressive systems tract lies on top of the slope fan and was developed as a result of an increase in the rate of relative sea level rise when sedimentation was unable to keep pace with such relative rise in sea level. Fining upward sediments were deposited in shallow inner neritic to deep inner neritic environments until maximum flooding ensued across the shelf as marked by maximum flooding surface. This maximum flooding surface is tied in with the Uvigerinella – 5 Marker Shale of Niger Delta chronostratigraphic chart which is dated 31.1Ma.

Progressive coarsening upward sands in inner neritic to middle neritic environments overlies the maximum flooding surface as a result of relative sea level fall. During this period, the rate of deposition out – paced rate of relative sea level rise leading to progradation with the deposition of highstand systems tract. This phase was interrupted when vertically stacked, hence well sorted sands were deposited during late relative sea level fall to early relative sea level rise, thus giving rise to aggradation. The top of the highstand systems tract corresponds to the period of late relative fall in sea level and forms the fifth sequence boundary with a type – 1 boundary. Thus the sequence boundary that lies beneath this marker shale is dated 36.3Ma and the one above it is dated 29.3Ma. The cyclicity of this sequence is 5Ma which corresponds to a third order sequence.

4. Exploration Implication

The hemipelagic - pelagic shales of the transgressive systems tract in this field are excellent source rock while the levees of the leveed channel of slope fans are potential source rocks. It has also been reported that shales associated with early progradation in the highstand systems tract are often lean gas prone (Sangree et al, 1990), thus all the sequences in Uniabr Field have either potential or excellent source rocks.

The rapid facies changes between successive systems tracts provide potential stratigraphic traps. Again, reservoir stratification and continuity vary greatly between systems tracts and this enhances development of stratigraphic traps in the field. Basin floor fans consist of relatively clean, well sorted sands/sandstones of good reservoir quality. The levees of leveed channels are potential sealing rocks while the prograding toes of the prograding wedge complex also act as seals in a situation where they overlie basin floor fans directly (Posamentier and Vail, 1988). The basin floor fans of sequence – 3 and sequence – 4 are stratigraphically trapped reservoirs.

Reservoir – quality sands are found in transgressive systems tracts and they tend to be best developed in shallow inner neritic water depths (Mitchum et al, 1993). The sands are sealed by the overlain hemipelagic – pelagic shales of the same systems tract. Consequently, transgressive sands of all the sequences in the Uniabr Field exhibit good reservoir quality and are stratigraphically trapped. The highstand systems tracts are potential reservoirs because they consist of progressively coarsening upward sand bodies. They are best sealed by shales of the overlying transgressive systems tracts or levees of leveed channels if overlain by slope fans. Highstand sands of sequence – 1 are potential stratigraphically trapped reservoirs, while the highstand sands of sequence – 3 could pass for either stratigraphically or structurally trapped reservoirs or even both.

5. Conclusions

Several transgressions and regressions occurred during the depositional history of the Tertiary Niger Delta, though the regressive phase exerted more control on the delta progradation. Sea level variations have been used to uncode stratigraphic signals. This has not only led to improved resolution and better understanding of the sedimentary spectrum of the delta but has matched with wireline log signatures and fossil assemblages recorded. Exploration into stratigraphic sequences of the Niger Delta for petroleum is becoming more difficult and frustrating to execute based on conventional methods. A sequence stratigraphic approach is a preferred technique that could lead to a purposeful exploration for hydrocarbon traps especially the stratigraphic types even in the frontier areas with limited well control for enhanced petroleum reserves in the delta.

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Table 1: Biostratigraphic Data of Uniabr – 1 Well

UNIABR -- 1 WELL BIOFACIES INTERPRETATION							
S/N	DEPTH (ft)	SEQ. TYPE	ENVIRONMENT	FORAM. DIVERS.	FORAM. POPULAT.	PLANKTIC DIVERS.	PLANKTIC POPULAT.
1	1550	2	B	0	0	0	0
2	1640	2	B	0	0	0	0
3	2063	2	B	0	0	0	0
4	2281	2	B	0	0	0	0
5	2519	2	B	0	0	0	0
6	2637	2	B	0	0	0	0
7	2713	2	B	0	0	0	0
8	2800	2	B	0	0	0	0
9	2863	2	B	0	0	0	0
10	2890	3	MN	9	295	1	18
11	2935	3	B	0	0	0	0
12	2988	2	IN	3	3	1	1
13	3081	2	B	0	0	0	0
14	3085	3	B	0	0	0	0
15	3130	3	B	0	0	0	0
16	3164	2	B	0	0	0	0
17	3190	3	B	0	0	0	0
18	3280	3	B	0	0	0	0
19	3325	3	B	0	0	0	0
20	3355	3	B	0	0	0	0
21	3385	3	B	0	0	0	0
22	3445	3	B	0	0	0	0
23	3505	3	SH.IN	2	36	0	0
24	3640	3	SH.IN	1	3	0	0
25	3700	3	IN	4	152	0	0
26	3730	3	SH.IN	2	58	0	0
27	3775	3	B	0	0	0	0
28	3835	3	B	0	0	0	0
29	3910	3	B	0	0	0	0
30	3955	3	PFM	2	300	0	0
31	4012	2	B	0	0	0	0

32	4060	3	PFM	3	120	0	0
33	4121	2	PFM	4	346	0	0
34	4240	3	B	0	0	0	0
35	4300	3	B	0	0	0	0
36	4322	2	B	0	0	0	0
37	4392	2	B	0	0	0	0
38	4435	3	PFM	2	30	0	0
39	4522	2	B	0	0	0	0
40	4570	3	PFM	2	192	0	0
41	4637	2	B	0	0	0	0
42	4675	3	B	0	0	0	0
43	4744	2	B	0	0	0	0
44	4819	2	B	0	0	0	0
45	4885	3	B	0	0	0	0
46	4935	2	B	0	0	0	0
47	5005	3	B	0	0	0	0
48	5080	3	B	0	0	0	0
49	5110	3	B	0	0	0	0
50	5193	2	B	0	0	0	0
51	5362	2	B	0	0	0	0
52	5432	2	B	0	0	0	0
53	5650	3	B	0	0	0	0
54	5740	3	B	0	0	0	0
55	5860	3	B	0	0	0	0
56	6025	3	B	0	0	0	0
57	6060	2	B	0	0	0	0
58	6115	3	B	0	0	0	0
59	6175	3	B	0	0	0	0
60	6265	3	B	0	0	0	0
61	6337	2	B	0	0	0	0
62	6490	3	B	0	0	0	0
63	6655	3	B	0	0	0	0
64	6734	2	B	0	0	0	0
65	6790	3	B	0	0	0	0
66	6838	2	B	0	0	0	0
67	6895	3	B	0	0	0	0
68	6955	3	B	0	0	0	0
69	7105	3	PFM	2	105	0	0
70	7140	2	B	0	0	0	0
71	7209	2	B	0	0	0	0
72	7280	2	PFM	2	30	0	0
73	7385	2	ON-BA	17	235	4	34
74	7480	3	B	0	0	0	0
75	7518	2	B	0	0	0	0
76	7604	2	MN	9	526	0	0
77	7675	3	MN	10	200	0	0
78	7700	2	MN	9	189	2	16
79	7740	2	B	0	0	0	0
80	7780	3	IN	3	58	0	0
81	7836	2	PFM	2	116	0	0
82	7875	2	B	0	0	0	0
83	7946	2	B	0	0	0	0
84	7990	3	SH,IN	2	105	0	0
85	8032	2	B	0	0	0	0
86	8086	2	B	0	0	0	0
87	8158	2	IN	4	124	0	0
88	8200	3	IN	8	362	0	0
89	8245	3	IN-PFM	7	76	0	0

90	8265	2	B	0	0	0	0
91	8305	3	ON-BA	17	630	3	204
92	8342	2	B	0	0	0	0
93	8365	3	ON-BA	12	1183	3	204
94	8424	2	IN	3	13	0	0
95	8450	2	B	0	0	0	0
96	8520	2	B	0	0	0	0
97	8545	3	ON-BA	10	940	2	132
98	8636	2	PFM	1	4	0	0
99	8712	2	MN	9	379	2	24
100	8755	3	MN	10	344	1	14
101	8808	2	PFM	2	12	0	0
102	8845	3	MN-ON	10	1340	1	84
103	8875	3	MN-ON	9	1147	0	0
104	8912	2	B	0	0	0	0
105	8915	2	MN	1	28	0	0
106	8980	3	MN-ON	12	461	2	52
107	9032	2	IN	4	206	0	0
108	9130	3	IN	5	126	0	0
109	9156	2	PFM	2	8	0	0
110	9220	3	MN-ON	10	1181	2	52
111	9240	2	PFM	7	501	1	11
112	9280	3	MN-ON	13	1504	2	44
113	9310	2	MN	7	255	1	21
114	9330	2	IN	4	224	0	0
115	9335	2	B	0	0	0	0
116	9346	2	B	0	0	0	0
117	9380	2	MN-ON	13	1764	2	28
118	9445	3	MN-ON	9	1567	1	30
119	9505	3	ON-BA	16	2583	2	72
120	9535	2	ON-BA	16	1393	1	30
121	9595	3	ON-BA	12	976	1	31
122	9620	2	B	0	0	0	0
123	9626	2	B	0	0	0	0
124	9630	2	PFM	5	96	0	0
125	9646	2	B	0	0	0	0
126	9652	2	IN	4	52	0	0
127	9655	2	B	0	0	0	0
128	9685	3	ON-BA	15	1956	2	93
129	9664	2	B	0	0	0	0
130	9713	2	B	0	0	0	0
131	9735	2	B	0	0	0	0
132	9756	2	B	0	0	0	0
133	9805	3	MN	7	214	0	0
134	9865	3	ON-BA	16	1099	1	18
135	9910	3	ON-BA	13	792	1	19
136	9934	2	B	0	0	0	0
137	9939	2	B	0	0	0	0
138	9943	2	B	0	0	0	0
139	10015	3	ON-BA	14	570	1	19
140	10017	2	B	0	0	0	0
141	10061	2	B	0	0	0	0
142	10064	2	B	0	0	0	0
143	10084	2	B	0	0	0	0
144	10087	2	B	0	0	0	0
145	10141	2	B	0	0	0	0
146	10210	3	MN-ON	9	732	0	0
147	10279	2	PFM	2	88	0	0

148	10345	3	MN-ON	12	778	1	27
149	10405	3	MN-ON	8	375	0	0
150	10450	3	MN-ON	10	634	0	0
151	10525	3	MN-ON	12	1323	2	56
152	10577	2	B	0	0	0	0
153	10600	3	MN-ON	15	737	1	13
154	10660	3	MN-ON	11	809	1	22
155	10724	2	B	0	0	0	0
156	10780	3	ON-BA	14	1084	2	36
157	10840	3	ON-BA	13	951	2	54
158	10893	2	IN	4	272	0	0
159	10960	3	MN	8	671	0	0
160	10982	2	SH.IN	2	7	0	0
161	11061	2	B	0	0	0	0
162	11125	3	MN-ON	9	947	0	0
163	11185	3	ON-BA	13	778	3	132
164	11260	3	ON-BA	12	644	1	24
165	11316	2	B	0	0	0	0
166	11340	2	B	0	0	0	0
167	11427	2	B	0	0	0	0
168	11455	3	MN	6	742	0	0
169	11544	2	B	0	0	0	0
170	11590	3	MN	8	381	0	0
171	11650	3	IN	5	104	0	0
172	11687	2	B	0	0	0	0
173	11740	3	MN	7	302	0	0
174	11800	3	IN	5	271	0	0
175	11860	3	MN	10	1410	1	31
176	11900	2	B	0	0	0	0
177	11950	3	MN	5	200	0	0
178	11995	3	PFM	2	110	0	0
179	12030	3	ON-BA	11	1815	1	25

KEY: B=Barren **;** PFM = Platform margin; SH.IN= Shallow inner neritic; IN= Inner neritic;
MN= Middle neritic; ON=Outer neritic and BA= Bathyal.

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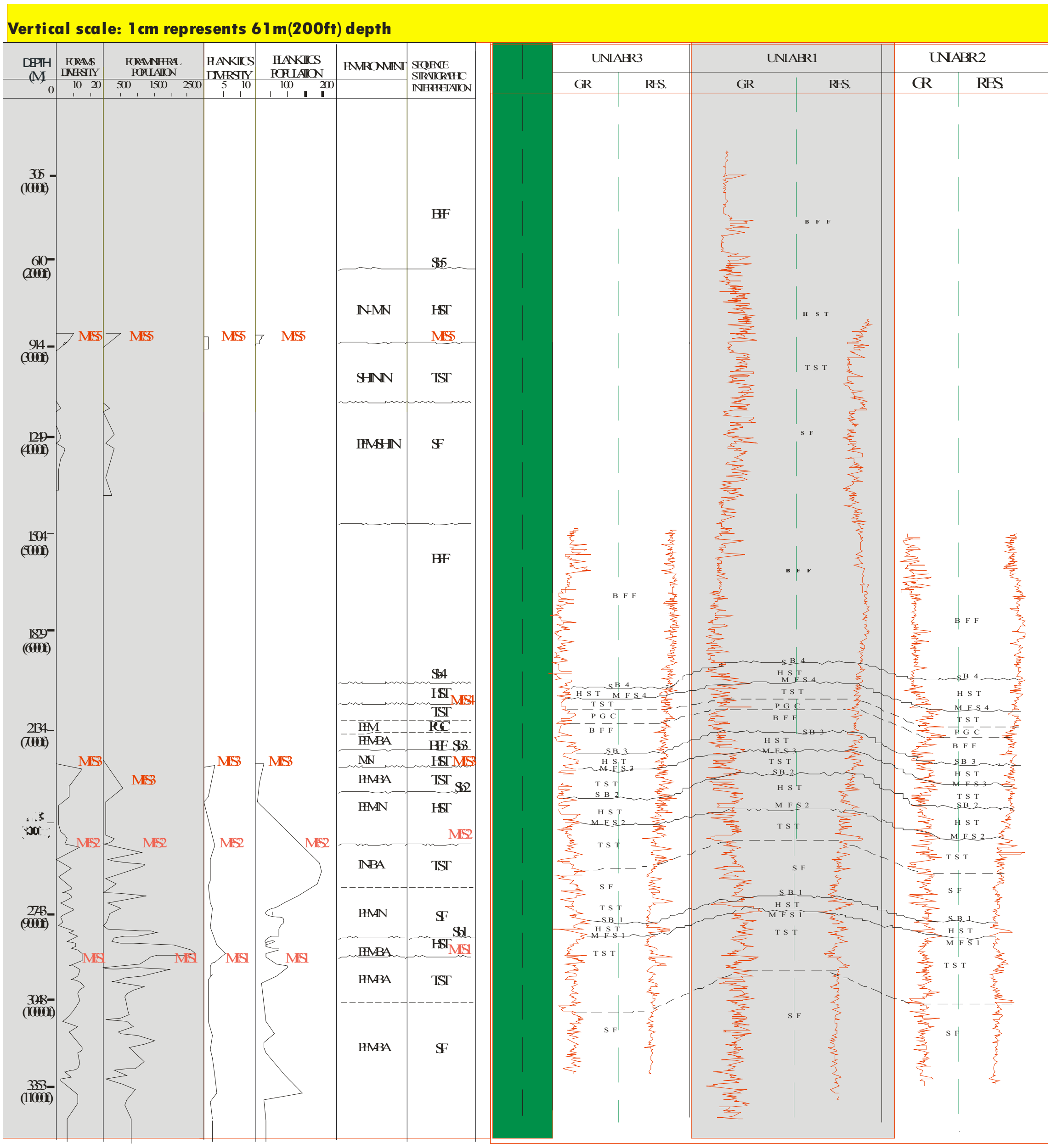
Table 2: Microfaunal and microfloral zonations for Uniabr – 1 Well

MICROFAUAL ZONATION				
F. ZONE	**TOP DEPTH (ft)**	**BOTTOM DEPTH (ft)**	**RELIABILITY GRADIENT**	**REMARKS**
	0	1500		No data
	1550	2863		Barren
	2890	4121		Undiagnostic (poor fauna)
	4240	7280		Practically barren
F5700	7385	12030	1	
MICROFLORAL ZONATION				
P. ZONE	**TOP DEPTH (ft)**	**BOTTOM DEPTH (ft)**	**RELIABILITY GRADIENT**	**REMARKS**
	0	1540		No data
P650	1550	2281	1	
P620	2394	2519	1	
P580	2713	2988	3	
P560-P540	3081	4322	2	
	4392	4522		
P520	4637	4819	1	
P470-P480	5088	8086	1	
P450	8246	11340		

Table 3: Summary of interpretations based on the integrated biostratigraphic – well log parameters of Uniabr Field.

SEQUENCES	Sequence- 1	Sequence - 2	Sequence - 3	Sequence - 4	Sequence- 5
Bottom SB (Average)	Unpenetrated	2813m (9230ft)	2417m (7930ft)	2265m (7430ft)	2021m (6630ft)
Top SB (Average)	2813m (9230ft)	2417m (7930ft)	2265m (7430ft)	2021m (6630ft)	628m (2060ft)
Thickness	640m (2100ft)	396m (1300ft)	152m (500ft)	244m (800ft)	1393m (4570ft)
MFS (Average)	2865m (9400ft)	2521m (8270ft)	2323m (7620ft)	2085m (6840ft)	933m (3060ft)
Corresponding F. Zone	F5700	F5700	F5700		
Corresponding P. Zone	P450	P450	P470-P480	P470-P480	P560-P580
Marker Shale	Umutu	Unnamed	Uvigerinella-8	Unnamed	Uvigerinella-5
MFS Epoch	Late Eocene	Late Eocene	Late Eocene	Latest Eocene	Early Oligocene
Bottom SB Epoch	Late-Middle Eocene	Late Eocene	Late Eocene	Late Eocene	Latest Eocene
Top SB Epoch	Late Eocene	Late Eocene	Late Eocene	Latest Eocene	Middle Oligocene
MFS Age (Ma)	41.0	39.4	38.0	36.6	31.1
Bottom SB Age (Ma)	42.7	40.1	38.7	37.3	36.3
Top SB Age (Ma)	40.1	38.7	37.3	36.3	29.3
Cyclicity (Ma)	2.6	1.4	1.4	1.0	5.0
Order	3rd	3rd	3rd	3rd	3rd
KEY: BS=Sequence Boundary F. Zone = Foraminiferal Zone MFS = Maximum Flooding Surface P. Zone = Palynological Zone					



LEGEND
HST - HIGHSTAND SYSTEM TRACT
TST - TRANSGRESSIVE SYSTEM TRACT
PGC - PROGRADING WEDGE COMPLEX
SF - SLOPE FAN
BFF - BASIN FLOOR FAN
MFS - MAXIMUM FLOODING SURFACE

SB - SEQUENCE BOUNDARY
PFM - PLATFORM MARGIN
SH. IN - SHALLOW INNER NERITIC
IN - INNER NERITIC
MN - MIDDLE NERITIC
ON - OUTER NERITIC

BA - BATHYAL
GR - GAMMA RAY LOG
RES - RESISTIVITY LOG

Fig.2 : integrated wireline logs and biostratigraphic correlations

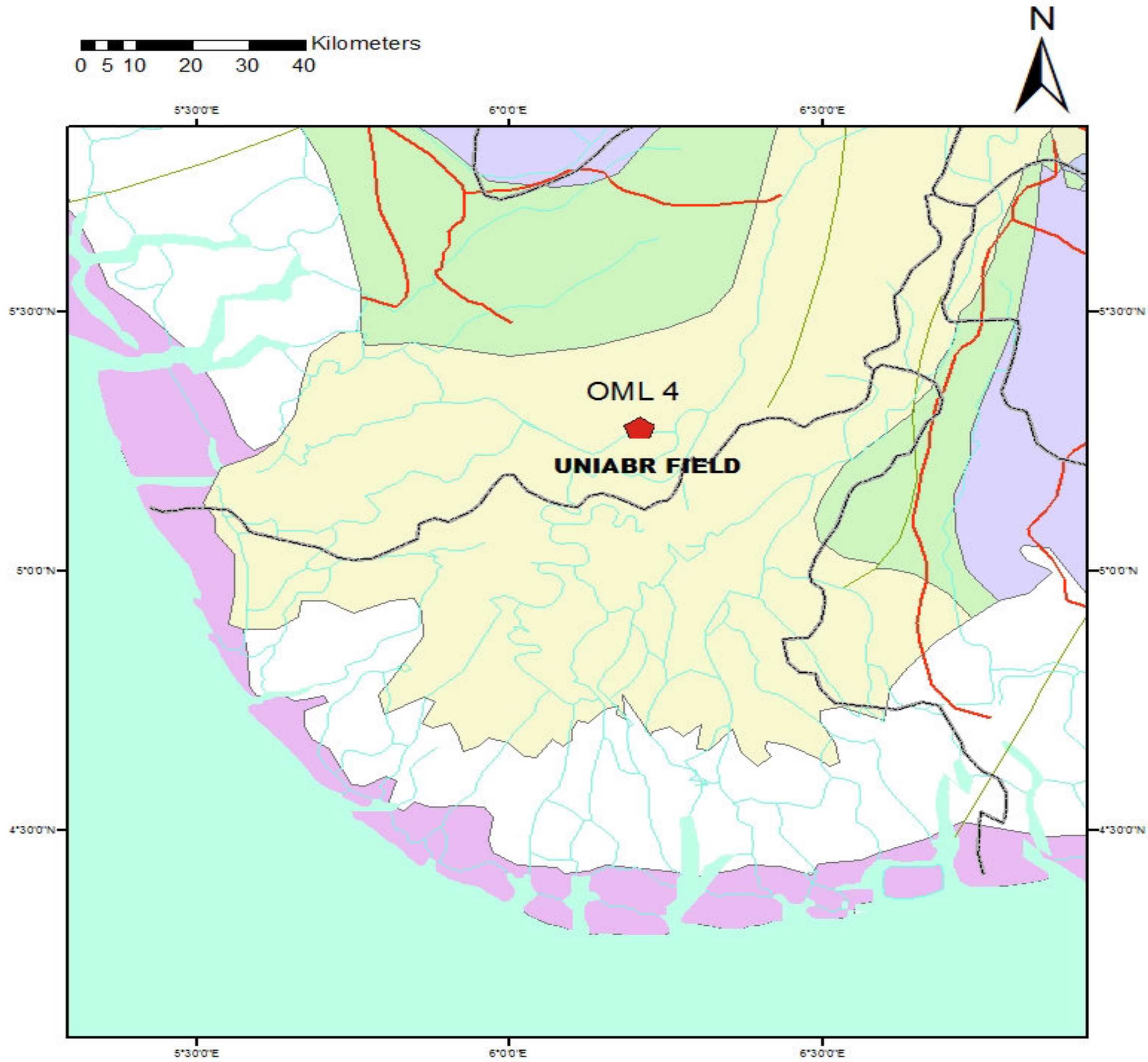


Fig. 1. Map of Niger Delta Province Showing Study Location (UNIABR FIELD)