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Micro paleontological depth palaeoecology of early miocene sequences and systems tracts: A case study of A-60 well in Niger Delta Basin Nigeria

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ABSTRACT

High resolution Biostratigraphic analysis of palaeoecology & systems tract using micro-paleontological data acquired from Early Miocene sediments of A-60 Well drilled to a total depth of 14,616ft was undertaken. The data obtained from the Well which was drilled as an Exploratory Well were divided into three sequences, comprising Transgressive (TST), high stand (HST) and lowstand (LST) systems tracts. The analysis shows a close relationship between the lithofacies and Biofacies changes, in response to relative sea level rise and fall. The high and low abundance/diversity of the micropaleontological data aided in determining the maximum flooding surfaces, sequence boundaries and systems tract, and was also used to determine the paleowater depth and paleoenvironment which spans the entire range of shallow inner neritic (Marginal Marine Environment) in the Continental plain to Bathyal (Deep Marine) in Continental slope ranging in depth from less than 7m to above 200m.

Keywords: Early Miocene; Systems Tract; Micropalaeontology; Palaeowater Depth; Niger Delta.

INTRODUCTION

The Basic aspect of sequence stratigraphy is the role of accommodation & Sediment supply play, defined as the space available for sedimentation generated by the relative Sea Level changes (Posamentier and Vail, 1988; Posamentier et al; 1988; Van wagoner et al; 1988), while Sediment supply refers to the amount (or flux) and type (grian size) of Sediment that is supplied from source areas to depositional areas by various transport agents. This is illustrated by the integration of eustatic Sea level and Subsidence curves, which produces a third curve called the relative Sea-level curve (Jervey, 1988; Naish and Kamp 1997) while the stratigraphic architecture of a sedimentary record is broadly controlled by the generation and loss of accommodation space, the specific lithofacies that accumulate during a relative sea-Level cycle respond more to changes in bathymetry(Naish and Kamp 1997).Bathymetric changes have not been considered explicitly in the concept of accommodation. To model the origin of Sedimentary facies and sequence architecture requires a detailed record of the Paleobathymetric changes within a sequence against which sequence architecture models can be tested (Kamp and Naish, 1997; Naish and Kamp 1997).

Integration of Sequence Stratigraphy and Lithofacies analysis makes it possible to recognize, at the outcrop scale, genetic packages of Sediment, or systems tract, deposited during particular phases of a relative Sea-Level cycle from which broad inferences can be made regarding paleowater-depths(Naish and Kamp 1997). The advantage of working with marine rocks is that details about water depth changes with sequences can be obtained from analysis of the depth paleoecology of the preserved microfossil fauna (Naish and Kamp 1997).

The study area (Fig 1) is the distal part of the Nkali/Omuechum microstructure. It is a horst block defined by two main Faults, the Nkali/Omuechem main antithetic and the Agbada main Synthetic boundary fault. The geologic framework of the area was established with four maximum flooding surfaces identified across Agbada, Agbada main and Nkali fault blocks. All the interpreted horizons/ ie between the maximum flooding surfaces MFS 15.0 ma and MFS 20.7ma. The Stackling pattern of the Sediments shows an alteration of back stepping and forward stepping parasequences within an overall progradational stratigraphic framework.

In this study we examine the micro paleontological content of A-60 Well from Early Miocene Sediments of Niger Delta with the aim to sought (I) high-resolution paleobathymetric detail within Sand/Shale Facies for which Sedimentological Criteria are less depth-diagnostic (II) identify the Key Stratigraphic Surfaces and their palaeodepth.(III) identify the micropalaeontological composition of these Key stratigraphic surfaces, system tracts and their component lithofacies (IV) Examine facies controls on micropaleontological assemblages that might compromise their paleobathymetric meaning.

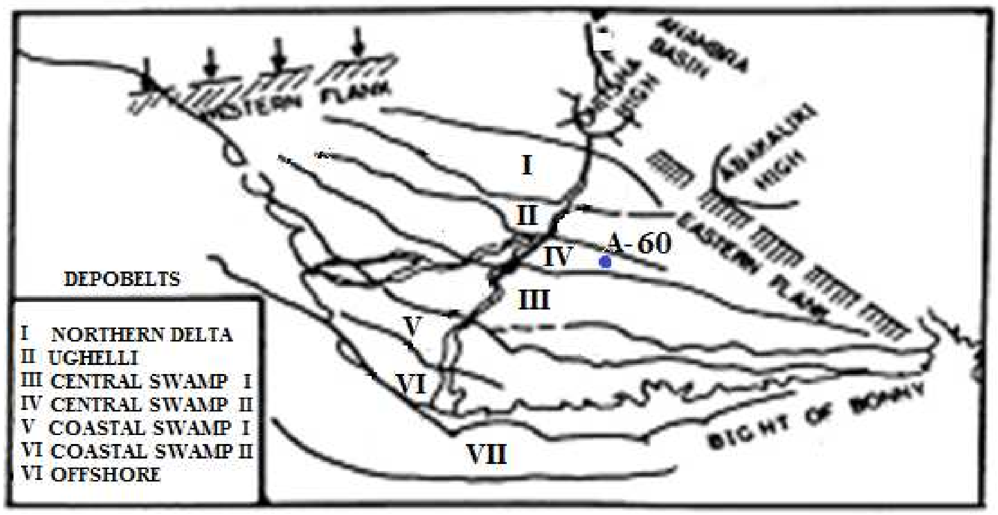

Fig. 1: Location Map of the Study Area

MATERIALS AND METHODS

The interpretation was done in steps, with the aim to optimize stratigraphic controls of the Well. The log suite was displayed at a consistent scale, chosen to enhance the log trend. Intervals of progradation, retogradationand aggradation from stacking patterns where determined, and Key stratigraphic surfaces identified. System tracts were interpreted using parasequence stacking patterns and the nature of the systems tract boundaries. The Foram sample were prepared using white spirit method which involves hand breaking of samples, soarking in fume cupboard, and immersing in a boiling water containing 10ml of sodium bicarbonate; detailed investigation was taken using microscope utilizing the wild Heerbrugg M8 with magnifications 250,400 and 450 while Palynological preparation was done using the conventional acid digestion and maceration technique which involves weighing & crushing of the sample to facilitate reactions with the mineral acids. The resultant aliquot were dispersed with polyvinyl alcohol and mounted for microscopic observation.

RESULTS AND DISCUSSION

Based on Mitchum(1977); the studied Well was divided in 3 sequence. Each biofacies in the sequence is characterized by a distinctive lithofacies and dominant depth significant taxa (Fig 2). These compositional variations may reflect palaeoecological changes other than water depth. Given the constraints imposed by the fact that most of the micro-palaeontological species inhabit a range of water-depths it is not possible to attribute absolute depths to any of the biofacies.(Naish & Kamp 1977). The Biofacies report are viewed as closely reflecting the palaeowater-depths, which ranges from shallow inner neritic(less than 7m) in the marginal marine to Bathyal (200m) in the continental slope of Deep marine (Table I). The Biofacies report confirm the relationship between the lithofacies, paleobathymetric changes and abundance/diversity of the micropaleontological species which are basically forams and planktonics (Fig 3). A stratigraphic summary sheet which tie the logs, paleobathymetry, lithofacies, abundance and diversity of forams / planktonics and systems tract of the Well was used in the interpretations (fig 4).

Sequence I

The sequence ranges from below 14010ft to 10800ft. within the sequence is a maximum flooding surface dated 19.4ma (Ogara shale) by the Niger Delta Chronogratigraphic Chart (fig 5). The MFS marks the pick of the transgressive systems tracts which reached its highest point at 12,000ft, with Bolivian 25a (*Bolivina Mandoroveensis*), Bolivina Spp, Uvigerina Spp, Textularia-3 (*Spiroplectammina Wrightii*),Textularia Spp, Planktonic-Spp, Ostracoda, Glogiberinaoides Spp, and Globigeria Spp as the dominant species. The presence of Uvigerina suggests a Depth Paleoecology of middle to outer neritic (distal offshore continental shelf). The high stands systems tract which stopped at 10,700ft before sequence boundary 17.7ma, has its dominant species as Uvigerina, Globigerina -Spp, Eponides-12(*Cibicorbis Inflata*) and Bolivina 25a(*Bolivina Mandoroveensis*), which suggest a paleowater Depth of middle neritic(60m) which lies within continental shelf environment to outer-neritic (200m) in the Continental slope (Allen, 1965 and 1970).

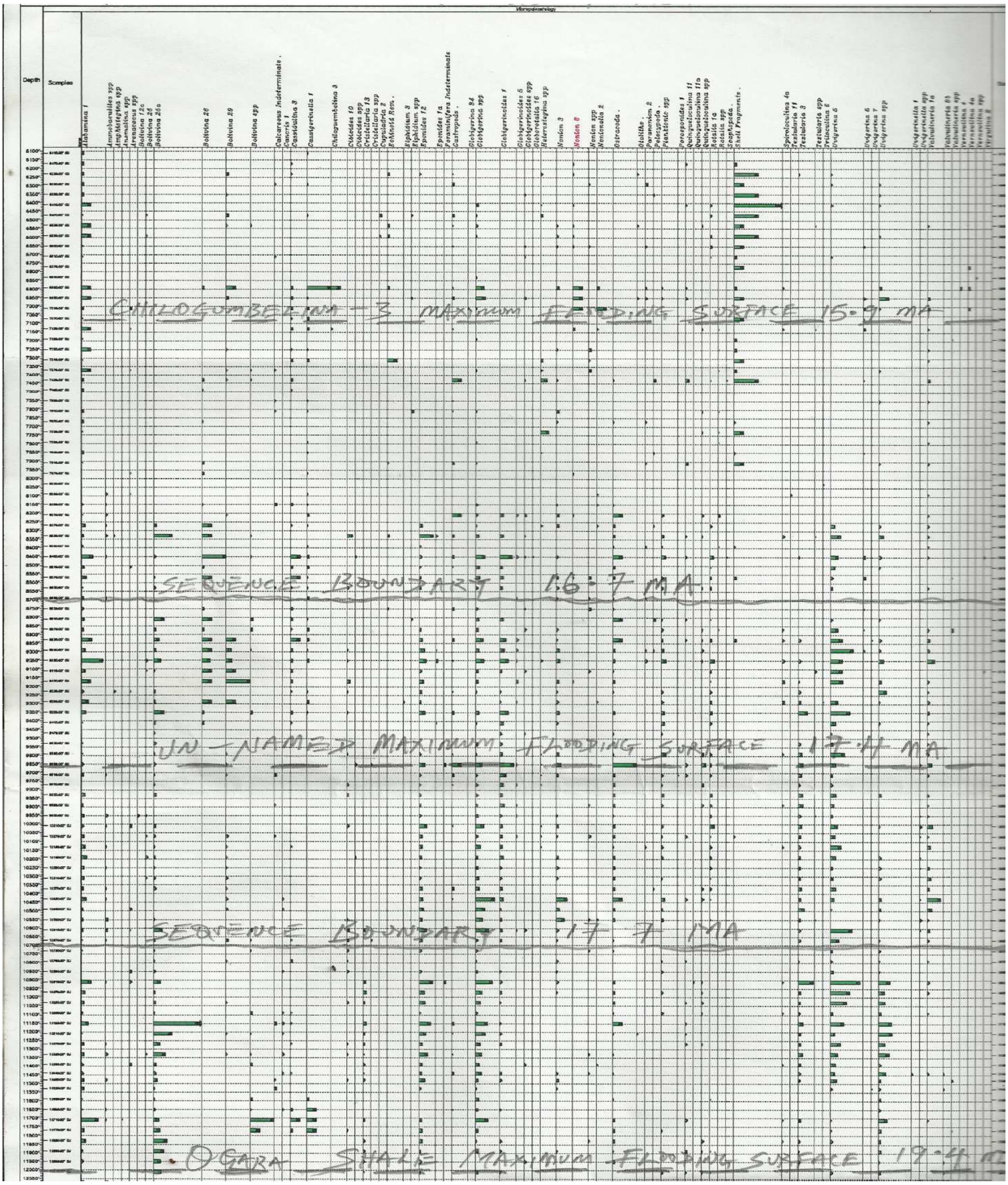

Fig 2: Micro paleontological analysis of Well A-60

Sequence II

The sequence ranges from the base of sequence Boundary 17.7ma at 10,700ft to sequence Boundary 16.7ma at 8,700ft. The lowstand systems tract interval which was identified at the depth range of 10,100ft to 10, 700ft marks a considerable rise in Sea-level as shown by high abundance and diversity of forams and planktonics. The dominant species within the lowstand systems tract are Globigerina Spp, Nonion-3(*pseudonoion atlanticum*), Ostracoda, Uvigerina-5(*uvigerina sparsicostata*) and Valvulineria-1a(*hanzawaia strattoni*), which suggest a paleowater depth of 30m to 100m, corresponding to proximal offshore to Distal offshore within the continental shelf environment (Allen 1965 and 1970).

TABLE 1: Biofacies Report of Well A-60

Smpl Nr	Smpl type	Depth Ft BDF	Env Code	Fauna Div.	Fauna Popln	plankt Div	plankt Popln
1	3	6110	SH.IN	2	3	1	1
2	3	6170	IN	4	6	0	0
3	3	6230	IN-MN	8	13	0	0
4	3	6290	IN-MN	7	12	1	1
5	3	6350	IN	4	6	1	1
6	3	6410	IN-MN	8	17	1	2
7	3	6470	IN-MN	8	12	2	2
8	3	6530	IN-MN	9	19	1	2
9	3	6590	IN-MN	7	18	1	1
10	3	6650	IN-MN	8	13	1	1
11	3	6710	IN	5	5	1	1
12	3	6770	CD	1	2	0	0
13	3	6830	SH.IN	2	2	1	1
14	3	6890	ON-BA	17	97	4	48
15	3	6950	MN	14	56	4	13
16	3	7010	MN	15	73	4	16
17	3	7070	IN	4	5	1	2
18	3	7130	MN	13	28	2	3
19	3	7190	IN	3	3	1	1
20	3	7250	MN	8	31	1	2
21	3	7310	IN-MN	6	24	1	4
22	3	7370	IN-MN	10	21	1	1
23	3	7430	MN-ON	12	82	1	2
24	3	7490	IN	3	4	0	0
25	3	7550	IN	4	4	1	1
26	3	7610	IN-MN	8	12	2	2
27	3	7670	IN	5	6	0	0
28	3	7730	MN	4	21	0	0
29	3	7790	IN	4	4	2	2
30	3	7850	IN	4	5	1	1
31	3	7910	MN	7	20	1	2
32	3	7970	IN	4	5	1	1
33	3	8030	SH.IN	1	1	0	0
34	3	8090	IN	6	7	1	1
35	3	8150	IN-MN	9	15	2	4
36	3	8210	IN-MN	14	78	6	40
37	3	8270	MN-ON	15	53	2	2
38	3	8330	ON-BA	20	310	4	44
39	3	8390	IN	7	8	2	2
40	3	8450	ON-BA	24	327	7	124
41	3	8510	MN-ON	11	68	3	22
42	3	8570	ON-BA	16	124	4	26
43	3	8630	MN-ON	15	35	4	11
44	3	8690	MN	9	11	2	3
45	3	8750	MN	8	18	2	4
46	3	8810	ON-BA	14	70	4	16
47	3	8870	ON-BA	18	78	4	16
48	3	8930	ON-BA	21	428	5	90
49	3	8990	ON-BA	21	280	5	52
50	3	9050	ON-BA	24	558	5	90
51	3	9110	ON-BA	15	102	3	10
52	3	9170	ON-BA	16	366	2	20
53	3	9230	ON-BA	16	46	4	5
54	3	9290	ON-BA	19	184	4	18
55	3	9350	ON-BA	16	464	4	97
56	3	9410	ON-BA	13	155	3	57
57	3	9470	MN	6	7	3	4
58	3	9530	MN	8	21	2	7
59	3	9590	ON-BA	16	150	3	34
60	3	9650	ON-BA	19	492	3	173
61	3	9710	MN-ON	17	106	3	34
62	3	9770	MN	11	26	4	12
63	3	9830	MN	12	138	3	30
64	3	9890	MN	14	94	4	27
65	3	9950	MN	15	37	3	8
66	3	10010	MN-ON	17	407	3	94
67	3	10070	MN-ON	19	106	4	20
68	3	10130	ON-BA	16	144	3	36
69	3	10190	ON-BA	15	244	3	52
70	3	10250	MN-ON	14	75	2	14
71	3	10310	MN	14	47	3	10
72	3	10370	MN-ON	12	111	2	23
73	3	10430	MN-ON	17	300	3	108
74	3	10490	MN-ON	13	244	3	70
75	3	10550	MN-ON	17	131	3	40
76	3	10610	ON BA	18	435	4	106
77	3	10670	ON BA	16	153	2	21
78	3	10730	MN	9	18	1	3

78	3	10730 MN	9	18	1	3
79	3	10790 IN-MN	12	15	2	2
80	3	10850 MN	11	25	3	7
81	3	10910 ON-BA	17	704	2	114
82	3	10970 ON-BA	13	432	3	77
83	3	11030 ON-BA	13	279	2	32
84	3	11090 MN	14	46	2	10
85	3	11150 ON-BA	13	1024	2	130
86	3	11210 ON-BA	13	496	2	92
87	3	11270 ON-BA	14	179	2	28
88	3	11330 ON-BA	15	232	1	25
89	3	11390 ON-BA	13	102	2	20
90	3	11440 ON-BA	16	122	2	30
91	3	11480 MN-ON	14	132	2	16
92	3	11530 MN	10	21	1	1
93	3	11590 MN	7	18	2	9
94	3	11650 MN	10	24	3	12
95	3	11710 ON-BA	16	229	2	55
96	3	11770 MN-ON	12	96	3	19
97	3	11830 MN-ON	12	192	2	9
98	3	11890 MN-ON	12	106	2	16
99	3	11950 MN	8	60	1	6
100	3	12010 MN-ON	13	42	3	9
101	3	12070 ON-BA	19	327	5	117
102	3	12130 IN	4	5	2	3
103	3	12190 SH.IN	1	1	1	1
104	3	12250 SH.IN	2	2	1	1
105	3	12310 SH.IN	2	2	1	1
106	3	12370 IN	3	3	1	1
107	3	12430 SH.IN	2	4	0	0
108	3	12490 SH.IN	2	4	0	0
109	3	12550 SH.IN	2	2	0	0
110	3	12610 SH.IN	2	2	1	1
111	3	12670 SH.IN	2	2	0	0
112	3	12730 SH.IN	1	1	0	0
113	3	12790 SH.IN	3	3	0	0
114	3	12850 SH.IN	2	2	0	0
115	3	12910 B	0	0	0	0
116	3	12970 B	0	0	0	0
117	3	13030 SH.IN	2	2	0	0
118	3	13090 SH.IN	0	0	0	0
119	3	13150 SH.IN	0	0	0	0
120	3	13210 SH.IN	2	2	0	0
121	3	13270 SH.IN	0	0	0	0
122	3	13330 SH.IN	3	3	0	0
123	3	13390 SH.IN	3	6	1	2
124	3	13450 B	0	0	0	0
125	3	13510 B	0	0	0	0
126	3	13570 SH.IN	2	3	1	1
127	3	13600 SH.IN	2	2	1	1
128	3	13690 B	0	0	0	0
129	3	13750 B	0	0	0	0
130	3	13820 SH.IN	3	3	0	0
131	3	13880 SH.IN	2	2	0	0
132	3	13940 SH.IN	2	3	0	0
133	3	14000 B	0	0	0	0
134	3	14060 B	0	0	0	0
135	3	14120 B	0	0	0	0
136	3	14180 B	0	0	0	0
137	3	14240 B	0	0	0	0
138	3	14300 B	0	0	0	0
139	3	14360 B	0	0	0	0
140	3	14420 B	0	0	0	0
141	3	14470 B	0	0	0	0
142	3	14520 B	0	0	0	0
143	3	14570 B	0	0	0	0
144	3	14610 B	0	0	0	0

Note-B,barren;SH-IN,shallow inner neritic;MN,middle neritic;IN,inner neritic;ON,outer neritic;BA,bathyal

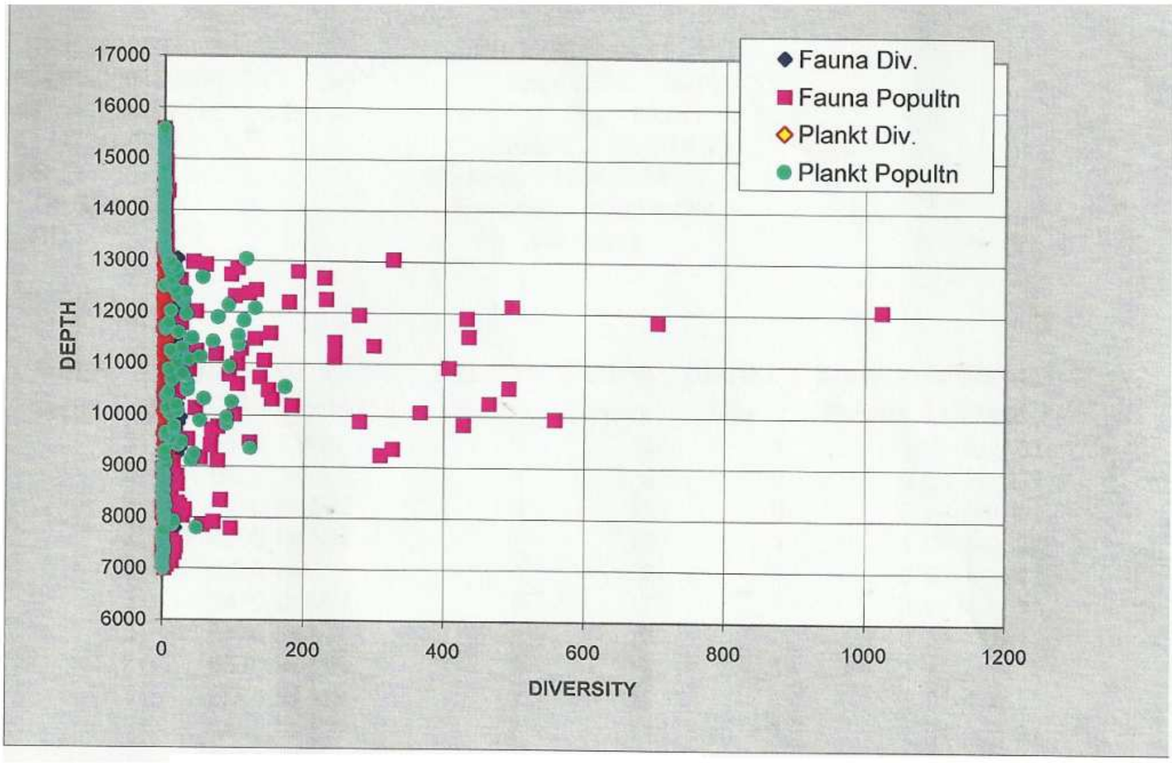

Figure 3 : Biofacies Interpretation plot of well A - 60

The transgressive systems tract with the depth range of 9,600ft to 10,100ft marks a steady rise in Sea level with high abundance and diversity of forams and planktonics. The dominant species identified are Ostracod, Globigerinoides-1(*praeglobulimina ovata*), Nonion-3(*pseudonoion atlanticum*), Uvigerina-5(*uvigerina sparsicostata*), Globigerina-Spp and Eponides-12(*cibicorbis inflata*), which suggest a paleowater Depth of 30m to 100m, corresponding to proximal offshore to Distal offshore within the continental shelf environment (Allen 1965 and 1970). The maximum flooding surface dated 17.4ma was at 9,600ft marked with high aboundance of forams and planktonics, with an estimated paleowater depth of 200m and above, which corresponds to a Distal offshore continental shelf/continental slope environment. An estimated highstand systems tract depth range of 8700ft to 9600ft with a gradual fall in sea level was observed, the dominant species are Uvigerina-5(*uvigerina sparsicostata*), Bolivina-26(*bolivina beyrichi*),Bolivina-29(*bolivina miocenica*) and alabamina-1,(*epistominella vitrea*) thereby suggesting a paleowater depth of middle neritic (60m) which lies within continental shelf environment to outer neritic (200m) in the continental slope (Allen, 1996 and 1970).

Sequence III

The sequence ranges from the base of sequence boundary 16.7ma at 8700ft to an unknown sequence boundary. The lowstand systems tract which was identified at the depth range of 7300ft to 8700ft marks show a gradual fall in Sea level. The dominant species identified within the lowstand systems tract range are Bolivina 25(*brazilina interjuncta*), Bolivina 26(*bolivina beyrichi*), Cassidolina-3(*cassidulina norcrossi*), Eponides 12(*cibicorbis inflata*), Globigerina-Spp, Globigerinoides-1(*globigerinoides immaturus*), Ostracoda and Uvigerina-5(*uvigeria sparsicostata),* which suggest a paleowater depth range of inner neritic (7m) to middle neritic (100m).

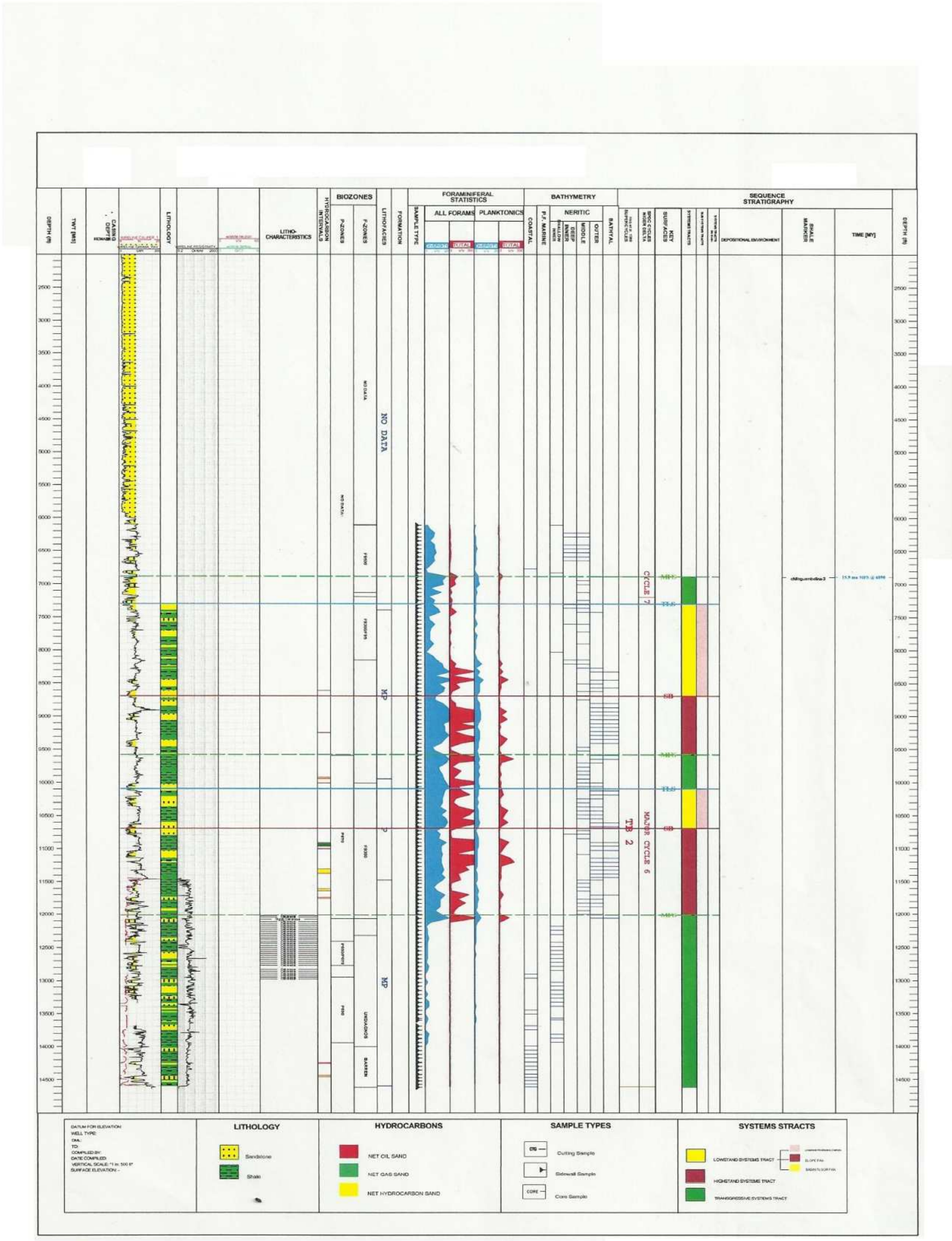

Figure 4 : Stratigraphic summary sheet of well A - 60

This indicates a gradual fall in Sea level as the paleowater depth moves gradually into shoreface part of the Continental shelf. Between the depth range of 6900ft to 7400ft, High stand systems tract was identified with its dominant species as Castropoda and shell fragment, which signifies a gradual but steady fall in Sea level, and the paleowater depth was estimated to be about 20m, which is within the shore face. At the depth of 6900ft marks a rapid increase in Sea level with high abundance and diversity of Forams and planktonics, which signifies the maximum flooding surface (Chilogumbeline-3) dated 15.9ma. After the maximum flooding surface, marks a steady fall in Sea level with shell fragments as the dominant species which signifies a low paleowater depth of less than 7m, meaning a transition into a Non-Marine/Marginal Marine environment (Allen, 1996 & 1970).

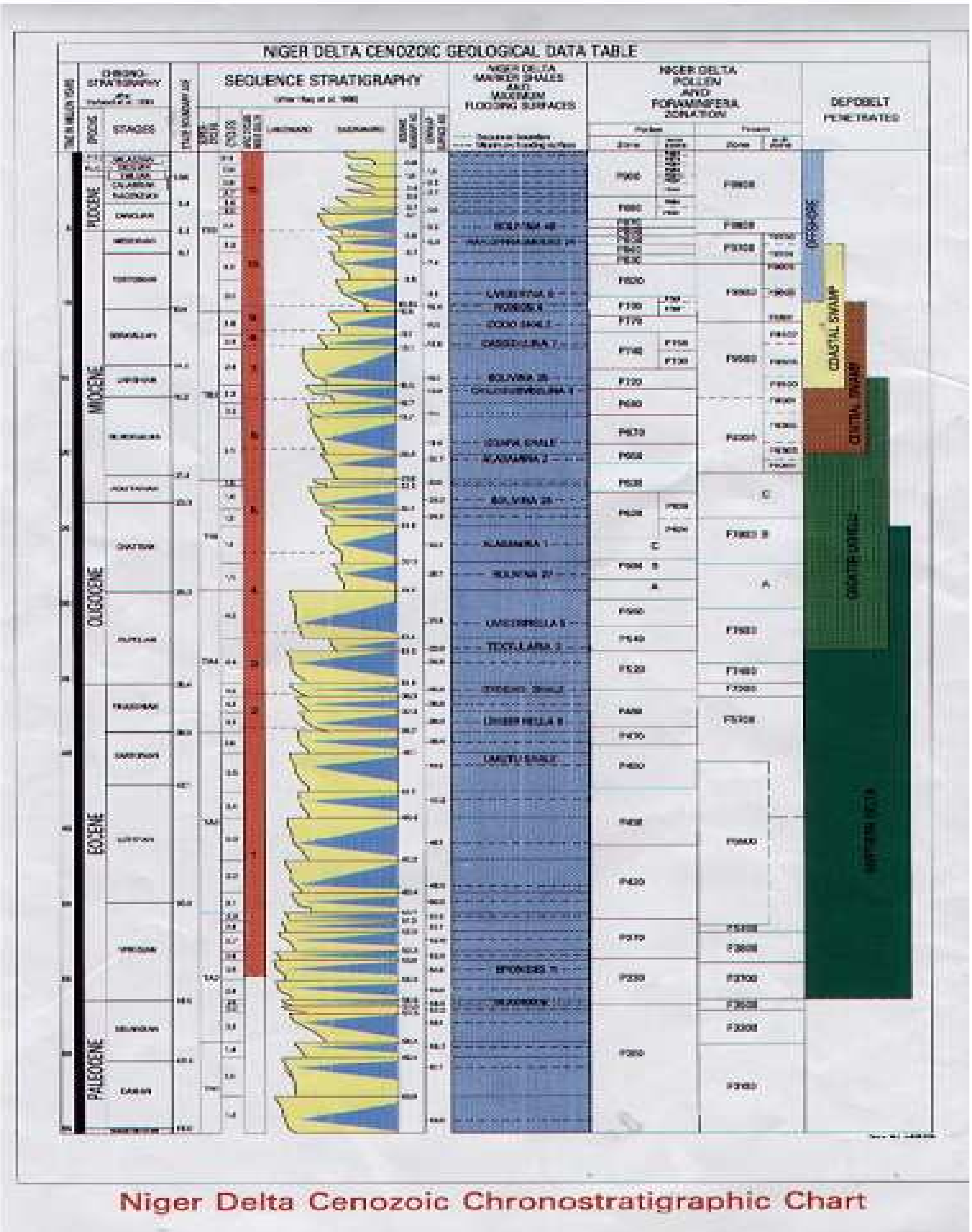

Fig 5: Niger Delta Cenozoic Chronostratigraphic Chart

CONCLUSION

High-resolution Biostraigraphic analysis has revealed micropaleontological associations spanning the entire range of outer neritic/Bathyal (Continental slope) to Non Marine/Marginal Marine (Continental plain) paleoenvironments. The paleobathymetric changes indicate a high paleowater depth within the Transgressive Systems tract which shows fining upward sequence. The high paleowater depths (middle neritic-Bathyal) is always associated with high abundance and diversity of micropalaeontological species, while the low palaeowater depth of low stand systems tract, shows coarsening upwards sequence. The low palaeowater depth inner neritic-shallow inner neritic) has low abundance and diversity of micropalaeontological species. The micropalaeontological and Biofacies data shows a strong affinity with the lithofacies and the systems tract. Non-Marine/Marginal Marine sediments was observed between associations of shallow water affinity with sand-dominated lithofacies, which corresponds to early lowstand system tract and late highstandsystems tract, while marine sedimentswhere observed within deep water affinity of shale dominated lithofacies, which corresponds to transgressive systems tract.

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REFERENCES

[1] Allen, J.R.L., **1965**, *Sedimentology*, 5, 98 – 191.
[2] Allen, J.R.L., **1970,** Physical processes of Sedimentation. Allen and Unwin, London. pp. 248.
[3] Jervey, M.T., **1988**, Quantitative geological modelling of Siliciclastic rock sequences and their Seismic expression, In: C.K. Wilgos, B.S. Hastings,
[4] Kamp, P.J.J. and Naish, T.R., **1997**, Forward modelling of the sequence architecture of shelf cyclothems: Application to Wanganvi Basin (New Zealand). (in review).
[5] Mitchum, R.M., **1977**, Seismic Stratigraphy and global changes of Sea level, part 1: Glossary of terms used in seismic stratigraphy, in C.E. Payton, ed., Seismic Stratigraphy - applications to hydrocarbon exploration: AAPG Memoir 26, P. 205 -212.
[6] Naish, T.R. and Kamp, P.J.J., **1997**, High-resolution sequence stratigraphy of 6^{th} Order (41 ka) Plio-pleistocene cyclothems, Wanganvi Basin, New Zealand: A case for the regressive systems tract. Bull. Geol. Soc. Am. (in review).
[7] Posamentier, H.W. and Vail, P.R., **1988**, Eustatic controls on classic deposition II sequence and systems tracts model. In : C.K. wilgus, B.S. Hastings, C.G.St, C. Kendall, H. Posamentier, C.A. Ross and J. Van Wagoner (Editors), Sea-level changes: An Integrated Approach Soc. Eon. Paleontol. Mineral., *Spec. publ*., 42: 109 – 124.
[8] Posamentier, H.W., Jervey, M.T. and Vail, P.R., **1988**, Eustatic controls on clastic deposition I conceptual framework. In: C.K. Wilgus, B.S. Hastings, C.G.St.C. Kendall, H. Posamentier, C.A. Ross and J. Van Wagoner (Editors), Sea-level changes: An Integrated Approach. Soc. *Econ. Paleontol. Mineral., spec. Publ*., 42: 125-154.
[9] Van Wagoner, J.C., Posamentier, H.W., Mitchum, R.M., Vail, P.R., SArg, J.F., Loutit, T.S. and HArdenbol, J., **1988**, An overview of sequence stratigraphy and key definitions. In: C.K. Wilgus, B.S. Hastings, C.G.St. C. Kendall, H. Posamentier, C.A. Ross and J. Van Wagoner (Editors), Sea level changes: An integrated Approach. *Soc. Eon. Paleontol. Mineral., spec. publ*., 42: 39-40.