Sedimentological Resolution Of Hydrocarbon Play Elements Of OGE-#1 Well, Greater Ughelli Depo-Belt, Niger Delta Basin.

Ighodaro Ehika J, Lucas F.A, Imasuen O.I, Omodolor Hope E

Abstract: One hundred and thirty six (136) side wall core samples gotten from the well were subjected to lithological description with the aim of determining the various lithofacies and hydrocarbon play elements in the well. Physical characteristics such as colour, texture, hardness, fissility, shapes/roundness of rock were noted. Four major lithofacie were typified by the lithologic model, they include; sandstone, shale, sandy shale and shaly sand respectively. The sedimentary succession penetrated reveals Eighty eight (88) lithozones from bottom to top. Mineralogical assemblages present are iron and mica. The lithologic model of the sedimentary succession penetrated reveals nineteen (19) potential petroleum reservoir rocks, Twenty three (23) potential source rocks and fifteen (15) caprocks. Lithozone - The probable reservoir rocks occupy Lithozones: 2, 3, 7, 9, 10, ,13, 15, 16, 17, 18, 21, 27, 29, 32, 33, 35, 36, 37, 39, 42, 43, 45, 46, 47, 48, 50, 51, 52, 54, 55 56, 58, 62, 72, 86.; and potential source rocks occupy Lithozones: 1, 4, 5, 8, 11, 12, 14, 20, 22, 23, 24, 25, 26, 31, 34, 40, L 49, 53, 57, 59, 60, 63, 65, 67, 71, 73, 76, 77, 78, 79, 80, 83, 85, 87, 88. The environment of deposition penetrated was parallic environment with the intercalation of sand and shale.

Index Terms: depositional environment, hydrocarbon, lithofacies, play element, sedimentology, source rocks.

1 Introduction and background of study

The Niger Delta complex of Southern Nigeria has been the focus of intense exploration since the first discovery of oil in the mid fifties. The delta complex contains a sedimentary thickness of over 12,000m which consists of three diachronous lithostratigraphic units. Exploration activities had been concentrated in the past in the Eocene-Pliocene sequence, but as the delta becomes better understood, exploration efforts are gradually being shifted to both the offshore (Pliocene-Pleistocene sections) and the flanks of the delta where cretaceous prospects are expected. Since the early seventies, stratigraphic analysis of the Pliocene-Eocene series of the Niger Delta has focused mainly on the regional scale depositional history (Murat, 1992).The development of the delta has been dependent on the balance between the rate of sedimentation and the rate of subsidence (Doust and Omatsola, 1990).

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Hydrocarbon exploration and exploitation requires that the spatial and depth distribution and interplay of factors favorable to commercial hydrocarbon accumulation are thoroughly appreciated. These factors include the distribution of source rock, reservoir rock, and migration pathways, sealing mechanisms, and timing which is regarded as hydrocarbon play. The distribution of these elements of the petroleum system is a result of the tectonic history and fill processes occuring in a basin. Studies on the Tertiary Niger Delta have revealed three lithostratigraphic units (Short and Stauable 1967) which from top to bottom are;

Benin Formation:
Consist of coarse grained sand with gravelly admixtures and is also called continental sandstone. Age is Miocene to recent.

Agbada Formation:
A paralic sequence of interbedded sandstones and shales. Age is Eocene to recent

Akata Formation:
Dominantly of overpressured shales. Age is paleocene to recent.

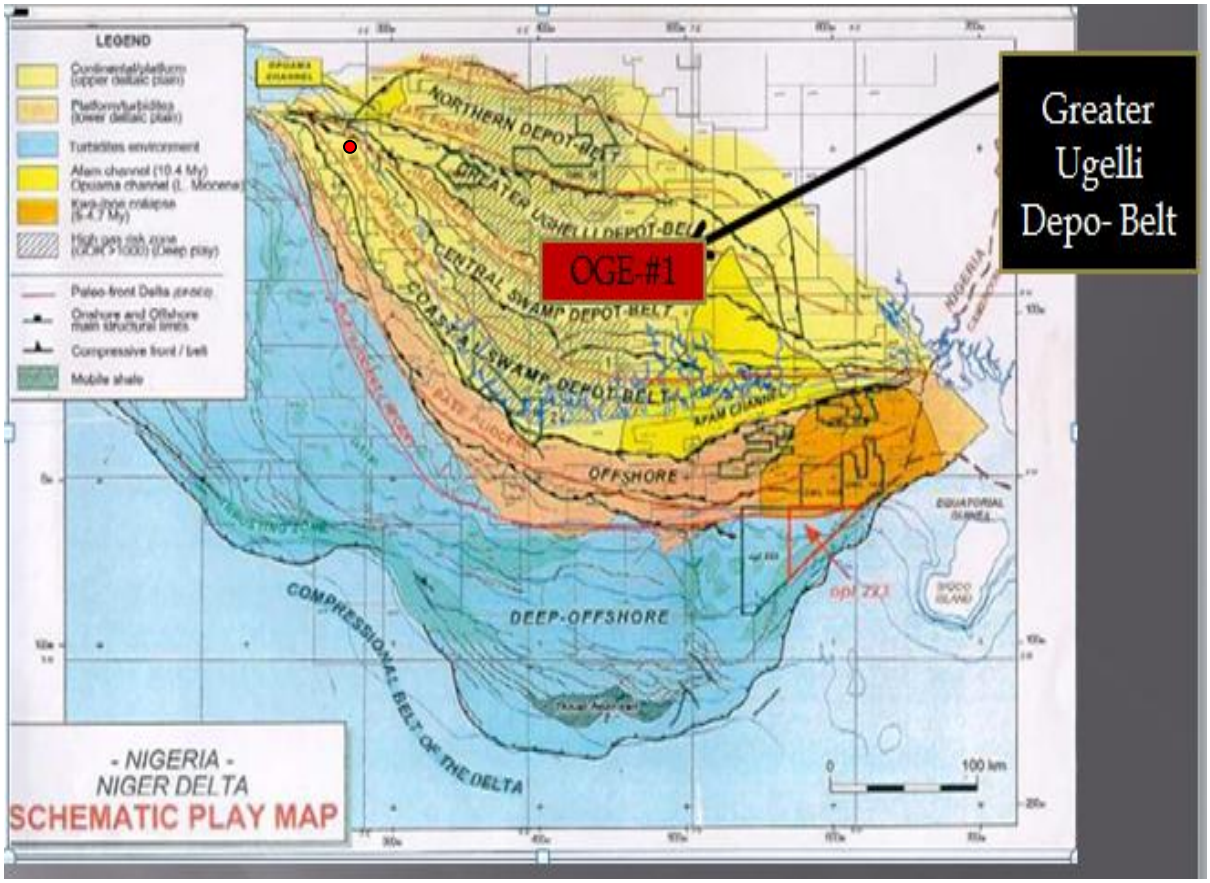


Fig. 1: *Map showing Depo Belt of Niger Delta (Nwozor et al, 2013)*

2 Methodology

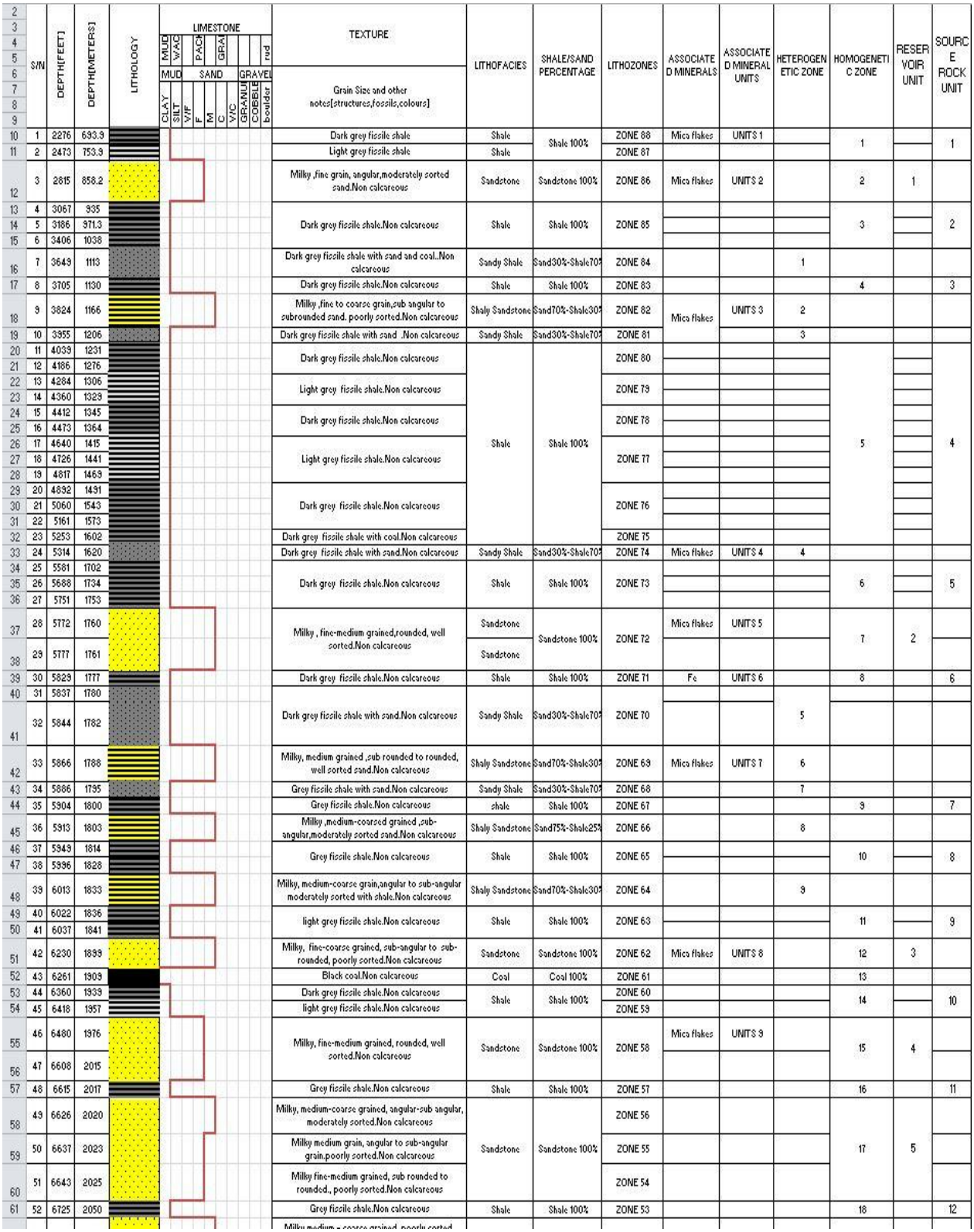
Two broad methods were employed in this study.

1. Lithostratigraphy:Lithologic descriptions and grain size interpretations.
2. Sedimentology:study of Physical characteristics such as colour, texture, hardness, fissility, rock type ,shapes/roundness, mineral composition, and post depositional diagenetic effect.

A Binocular microscope was used to describe the 136 (One hundred and thirty six) samples (ditch – cutting samples) in terms of lithology, textural characteristics, accessory minerals and fossil content. Subsequently, a grain size log was generated on the basis of the dominant grain sizes in each lithologic unit and dilute HCl was used to test for calcareous material Materials used for the analysis include

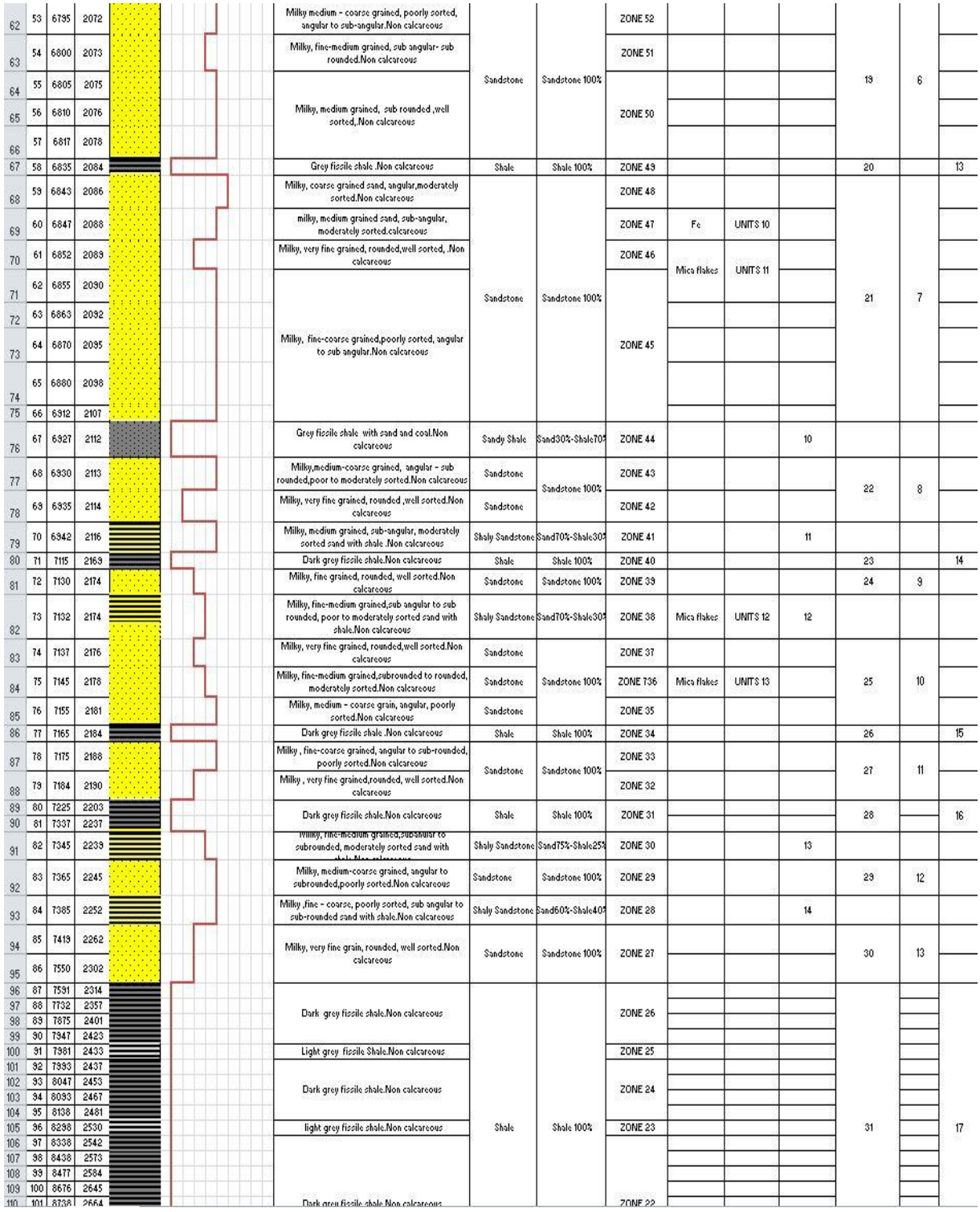
1. HCL
2. Binocular microscope
3. Sample scale
4. Conical flask
5. Filter paper
6. sample plate

3 Discussion of Results



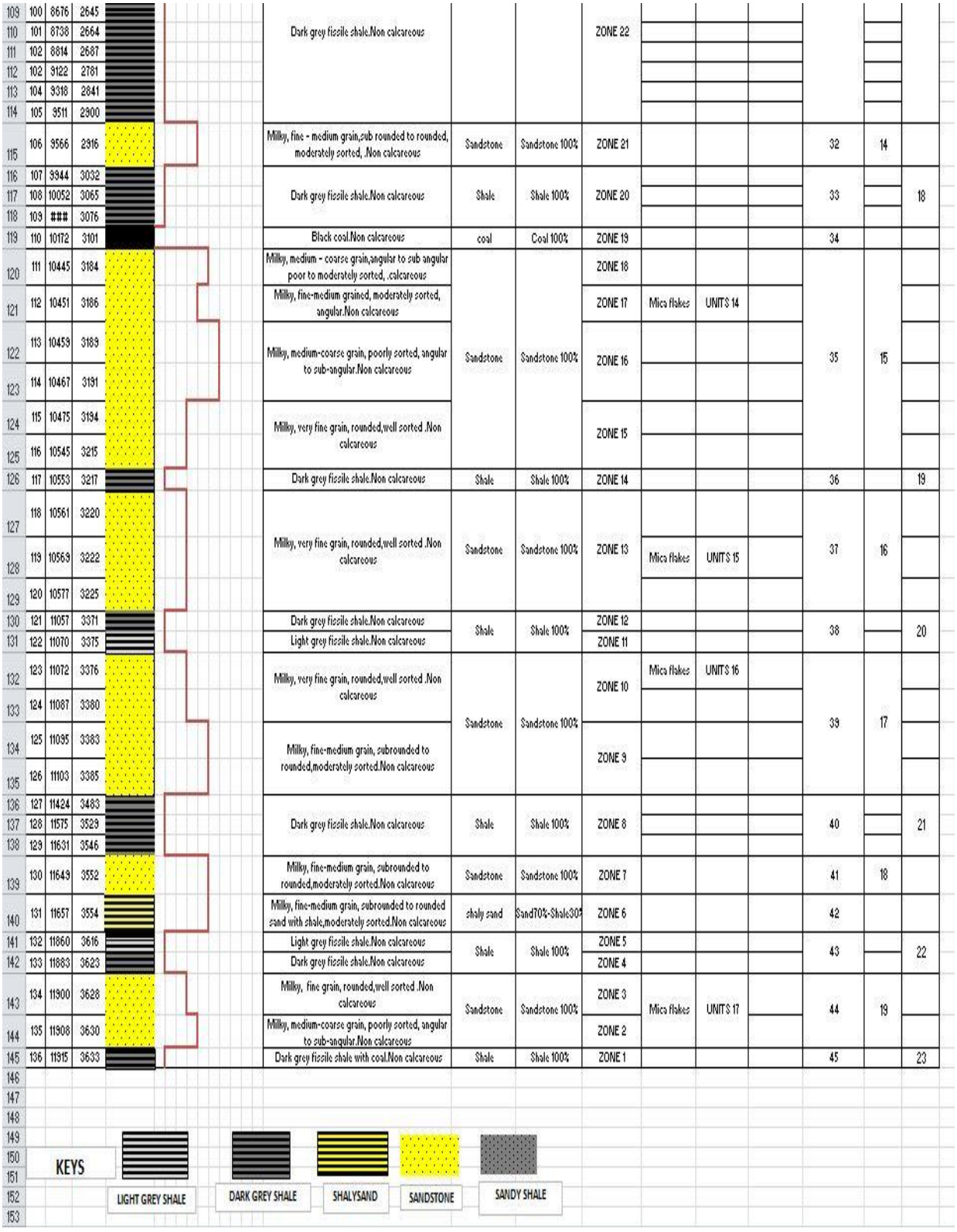
S/N	DEPTH[FEET]	DEPTH[METERS]	LITHOLOGY	LIMESTONE: MUD	WAC	PACK	GRA	TEXTURE: MUD	SAND	GRAVEL	Grain Size and other notes[structures,fossils,colours]	LITHOFACIES	SHALE/SAND PERCENTAGE	LITHOZONES	ASSOCIATED MINERALS	ASSOCIATED MINERAL UNITS	HETEROGENETIC ZONE	HOMOGENETIC ZONE	RESERVOIR UNIT	SOURCE ROCK UNIT
								CLAY	SILT	VF	F	M	C	VC	GRANULE	COBBLE	boulder	rud								
1	2276	693.9																			Dark grey fissile shale	Shale	Shale 100%	ZONE 88	Mica flakes	UNITS 1		1		1
2	2473	753.9																			Light grey fissile shale	Shale		ZONE 87						
3	2815	858.2																			Milky ,fine grain, angular,moderately sorted sand.Non calcareous	Sandstone	Sandstone 100%	ZONE 86	Mica flakes	UNITS 2		2	1	
4	3067	935																			Dark grey fissile shale.Non calcareous	Shale	Shale 100%	ZONE 85				3		2
5	3186	971.3																												
6	3406	1038																												
7	3643	1113																			Dark grey fissile shale with sand and coal..Non calcareous	Sandy Shale	Sand30%-Shale70%	ZONE 84			1			
8	3705	1130																			Dark grey fissile shale.Non calcareous	Shale	Shale 100%	ZONE 83				4		3
9	3824	1166																			Milky ,fine to coarse grain,sub angular to subrounded sand, poorly sorted.Non calcareous	Shaly Sandstone	Sand70%-Shale30%	ZONE 82	Mica flakes	UNITS 3	2			
10	3955	1206																			Dark grey fissile shale with sand .Non calcareous	Sandy Shale	Sand30%-Shale70%	ZONE 81			3			
11	4039	1231																			Dark grey fissile shale.Non calcareous	Shale	Shale 100%	ZONE 80				5		4
12	4186	1276																												
13	4284	1306																			Light grey fissile shale.Non calcareous			ZONE 79						
14	4360	1329																												
15	4412	1345																			Dark grey fissile shale.Non calcareous			ZONE 78						
16	4473	1364																												
17	4640	1415																			Light grey fissile shale.Non calcareous			ZONE 77						
18	4726	1441																												
19	4817	1469																												
20	4892	1491																			Dark grey fissile shale.Non calcareous			ZONE 76						
21	5060	1543																												
22	5161	1573																												
23	5253	1602																			Dark grey fissile shale with coal.Non calcareous			ZONE 75						
24	5314	1620																			Dark grey fissile shale with sand.Non calcareous	Sandy Shale	Sand30%-Shale70%	ZONE 74	Mica flakes	UNITS 4	4			
25	5581	1702																			Dark grey fissile shale.Non calcareous	Shale	Shale 100%	ZONE 73				6		5
26	5688	1734																												
27	5751	1753																												
28	5772	1760																			Milky , fine-medium grained,rounded, well sorted.Non calcareous	Sandstone	Sandstone 100%	ZONE 72	Mica flakes	UNITS 5		7	2	
29	5777	1761																				Sandstone								
30	5829	1777																			Dark grey fissile shale.Non calcareous	Shale	Shale 100%	ZONE 71	Fe	UNITS 6		8		6
31	5837	1780																			Dark grey fissile shale with sand.Non calcareous	Sandy Shale	Sand30%-Shale70%	ZONE 70			5			
32	5844	1782																												
33	5866	1788																			Milky, medium grained ,sub rounded to rounded, well sorted sand.Non calcareous	Shaly Sandstone	Sand70%-Shale30%	ZONE 69	Mica flakes	UNITS 7	6			
34	5886	1795																			Grey fissile shale with sand.Non calcareous	Sandy Shale	Sand30%-Shale70%	ZONE 68			7			
35	5904	1800																			Grey fissile shale.Non calcareous	shale	Shale 100%	ZONE 67				9		7
36	5913	1803																			Milky ,medium-coarsed grained ,sub-angular,moderately sorted sand.Non calcareous	Shaly Sandstone	Sand75%-Shale25%	ZONE 66			8			
37	5943	1814																			Grey fissile shale.Non calcareous	Shale	Shale 100%	ZONE 65				10		8
38	5996	1828																												
39	6013	1833																			Milky, medium-coarse grain,angular to sub-angular moderately sorted with shale.Non calcareous	Shaly Sandstone	Sand70%-Shale30%	ZONE 64			9			
40	6022	1836																			light grey fissile shale.Non calcareous	Shale	Shale 100%	ZONE 63				11		9
41	6037	1841																												
42	6230	1899																			Milky, fine-coarse grained, sub-angular to sub-rounded, poorly sorted.Non calcareous	Sandstone	Sandstone 100%	ZONE 62	Mica flakes	UNITS 8		12	3	
43	6261	1909																			Black coal.Non calcareous	Coal	Coal 100%	ZONE 61				13		
44	6360	1939																			Dark grey fissile shale.Non calcareous	Shale	Shale 100%	ZONE 60				14		10
45	6418	1957																			light grey fissile shale.Non calcareous			ZONE 59						
46	6480	1976																			Milky, fine-medium grained, rounded, well sorted.Non calcareous	Sandstone	Sandstone 100%	ZONE 58	Mica flakes	UNITS 9		15	4	
47	6608	2015																												
48	6615	2017																			Grey fissile shale.Non calcareous	Shale	Shale 100%	ZONE 57				16		11
49	6626	2020																			Milky, medium-coarse grained, angular-sub angular, moderately sorted.Non calcareous	Sandstone	Sandstone 100%	ZONE 56				17	5	
50	6637	2023																			Milky medium grain, angular to sub-angular grain,poorly sorted.Non calcareous			ZONE 55						
51	6643	2025																			Milky fine-medium grained, sub rounded to rounded., poorly sorted.Non calcareous			ZONE 54						
52	6725	2050																			Grey fissile shale.Non calcareous	Shale	Shale 100%	ZONE 53				18		12
																					Milky medium - coarse grained, poorly sorted									

Fig. 2: *lithostratigraphy analysis of samples from Oge-#1 Well, Greater Ughelli Depo-Belt.*



62	53	6795	2072	Milky medium - coarse grained, poorly sorted, angular to sub-angular.Non calcareous	Sandstone	Sandstone 100%	ZONE 52				19	6	
63	54	6800	2073	Milky, fine-medium grained, sub angular- sub rounded.Non calcareous			ZONE 51						
64	55	6805	2075	Milky, medium grained, sub rounded ,well sorted,.Non calcareous			ZONE 50						
65	56	6810	2076										
66	57	6817	2078										
67	58	6835	2084	Grey fissile shale .Non calcareous	Shale	Shale 100%	ZONE 49				20		13
68	59	6843	2086	Milky, coarse grained sand, angular,moderately sorted.Non calcareous	Sandstone	Sandstone 100%	ZONE 48				21	7	
69	60	6847	2088	milky, medium grained sand, sub-angular, moderately sorted.calcareous			ZONE 47	Fe	UNITS 10				
70	61	6852	2089	Milky, very fine grained, rounded,well sorted, .Non calcareous			ZONE 46	Mica flakes	UNITS 11				
71	62	6855	2090	Milky, fine-coarse grained,poorly sorted, angular to sub angular.Non calcareous			ZONE 45						
72	63	6863	2092										
73	64	6870	2095										
74	65	6880	2098										
75	66	6312	2107										
76	67	6327	2112	Grey fissile shale with sand and coal.Non calcareous	Sandy Shale	Sand30%-Shale70%	ZONE 44			10			
77	68	6330	2113	Milky,medium-coarse grained, angular - sub rounded,poor to moderately sorted.Non calcareous	Sandstone	Sandstone 100%	ZONE 43				22	8	
78	69	6335	2114	Milky, very fine grained, rounded ,well sorted.Non calcareous	Sandstone		ZONE 42						
79	70	6342	2116	Milky, medium grained, sub-angular, moderately sorted sand with shale .Non calcareous	Shaly Sandstone	Sand70%-Shale30%	ZONE 41			11			
80	71	7115	2163	Dark grey fissile shale.Non calcareous	Shale	Shale 100%	ZONE 40				23		14
81	72	7130	2174	Milky, fine grained, rounded, well sorted.Non calcareous	Sandstone	Sandstone 100%	ZONE 39				24	9	
82	73	7132	2174	Milky, fine-medium grained,sub angular to sub rounded, poor to moderately sorted sand with shale.Non calcareous	Shaly Sandstone	Sand70%-Shale30%	ZONE 38	Mica flakes	UNITS 12	12			
83	74	7137	2176	Milky, very fine grained, rounded,well sorted.Non calcareous	Sandstone	Sandstone 100%	ZONE 37				25	10	
84	75	7145	2178	Milky, fine-medium grained,subrounded to rounded, moderately sorted.Non calcareous	Sandstone		ZONE 736	Mica flakes	UNITS 13				
85	76	7155	2181	Milky, medium - coarse grain, angular, poorly sorted.Non calcareous	Sandstone		ZONE 35						
86	77	7165	2184	Dark grey fissile shale .Non calcareous	Shale	Shale 100%	ZONE 34				26		15
87	78	7175	2188	Milky , fine-coarse grained, angular to sub-rounded, poorly sorted.Non calcareous	Sandstone	Sandstone 100%	ZONE 33				27	11	
88	79	7184	2190	Milky , very fine grained,rounded, well sorted.Non calcareous			ZONE 32						
89	80	7225	2203	Dark grey fissile shale.Non calcareous	Shale	Shale 100%	ZONE 31				28		16
90	81	7337	2237										
91	82	7345	2239	Milky, fine-medium grained,subangular to subrounded, moderately sorted sand with shale.Non calcareous	Shaly Sandstone	Sand75%-Shale25%	ZONE 30			13			
92	83	7365	2245	Milky, medium-coarse grained, angular to subrounded,poorly sorted.Non calcareous	Sandstone	Sandstone 100%	ZONE 29				29	12	
93	84	7385	2252	Milky ,fine - coarse, poorly sorted, sub angular to sub-rounded sand with shale.Non calcareous	Shaly Sandstone	Sand60%-Shale40%	ZONE 28			14			
94	85	7419	2262	Milky, very fine grain, rounded, well sorted.Non calcareous	Sandstone	Sandstone 100%	ZONE 27				30	13	
95	86	7550	2302										
96	87	7591	2314	Dark grey fissile shale.Non calcareous	Shale	Shale 100%	ZONE 26				31		17
97	88	7732	2357										
98	89	7875	2401										
99	90	7947	2423										
100	91	7981	2433	Light grey fissile Shale.Non calcareous			ZONE 25						
101	92	7993	2437	Dark grey fissile shale.Non calcareous			ZONE 24						
102	93	8047	2453										
103	94	8093	2467										
104	95	8138	2481										
105	96	8298	2530	light grey fissile shale.Non calcareous			ZONE 23						
106	97	8338	2542	Dark grey fissile shale.Non calcareous			ZONE 22						
107	98	8438	2573										
108	99	8477	2584										
109	100	8676	2645										
110	101	8738	2664										

Fig. 3: *lithostratigraphy analysis of samples from Oge-#1 Well, Greater Ughelli Depo-Belt*



109	100	8676	2645	Dark grey fissile shale.Non calcareous			ZONE 22								
110	101	8738	2664												
111	102	8814	2687												
112	102	9122	2781												
113	104	9318	2841												
114	105	9511	2900												
115	106	9566	2916	Milky, fine - medium grain,sub rounded to rounded, moderately sorted, .Non calcareous	Sandstone	Sandstone 100%	ZONE 21				32	14			
116	107	9944	3032	Dark grey fissile shale.Non calcareous	Shale	Shale 100%	ZONE 20				33		18		
117	108	10052	3065												
118	109	###	3076												
119	110	10172	3101	Black coal.Non calcareous	coal	Coal 100%	ZONE 19				34				
120	111	10445	3184	Milky, medium - coarse grain,angular to sub angular poor to moderately sorted, .calcareous	Sandstone	Sandstone 100%	ZONE 18				35	15			
121	112	10451	3186	Milky, fine-medium grained, moderately sorted, angular.Non calcareous			ZONE 17	Mica flakes	UNITS 14						
122	113	10459	3189	Milky, medium-coarse grain, poorly sorted, angular to sub-angular.Non calcareous			ZONE 16								
123	114	10467	3191												
124	115	10475	3194	Milky, very fine grain, rounded,well sorted .Non calcareous			ZONE 15								
125	116	10545	3215												
126	117	10553	3217	Dark grey fissile shale.Non calcareous	Shale	Shale 100%	ZONE 14				36		19		
127	118	10561	3220	Milky, very fine grain, rounded,well sorted .Non calcareous	Sandstone	Sandstone 100%	ZONE 13				37	16			
128	119	10569	3222					Mica flakes	UNITS 15						
129	120	10577	3225												
130	121	11057	3371	Dark grey fissile shale.Non calcareous	Shale	Shale 100%	ZONE 12				38		20		
131	122	11070	3375	Light grey fissile shale.Non calcareous			ZONE 11								
132	123	11072	3376	Milky, very fine grain, rounded,well sorted .Non calcareous	Sandstone	Sandstone 100%	ZONE 10	Mica flakes	UNITS 16		39	17			
133	124	11087	3380												
134	125	11095	3383	Milky, fine-medium grain, subrounded to rounded,moderately sorted.Non calcareous			ZONE 9								
135	126	11103	3385												
136	127	11424	3483	Dark grey fissile shale.Non calcareous	Shale	Shale 100%	ZONE 8				40		21		
137	128	11575	3529												
138	129	11631	3546												
139	130	11643	3552	Milky, fine-medium grain, subrounded to rounded,moderately sorted.Non calcareous	Sandstone	Sandstone 100%	ZONE 7				41	18			
140	131	11657	3554	Milky, fine-medium grain, subrounded to rounded sand with shale,moderately sorted.Non calcareous	shaly sand	Sand70%-Shale30%	ZONE 6				42				
141	132	11860	3616	Light grey fissile shale.Non calcareous	Shale	Shale 100%	ZONE 5				43		22		
142	133	11883	3623	Dark grey fissile shale.Non calcareous			ZONE 4								
143	134	11900	3628	Milky, fine grain, rounded,well sorted .Non calcareous	Sandstone	Sandstone 100%	ZONE 3	Mica flakes	UNITS 17		44	19			
144	135	11908	3630	Milky, medium-coarse grain, poorly sorted, angular to sub-angular.Non calcareous			ZONE 2								
145	136	11915	3633	Dark grey fissile shale with coal.Non calcareous	Shale	Shale 100%	ZONE 1				45		23		

Fig. 4: *lithostratigraphy analysis of samples from Oge-#1 Well, Greater Ughelli Depo-Belt*

4 INTERPRETATION AND DISCUSSION OF RESULT

4.1 SEDIMENTOLOGICAL ANALYSIS

A total of One hundred and thirty six (136) side wall samples collected from the well were lithologically described using a reflected light microscope in order to obtain Physical characteristics such as colour, texture, hardness, fissility, rock type etc were noted., shapes/roundness, mineral composition, and post depositional diagenetic effect. Chemical tests to determine the presence of calcareous materials was also carried out using 10% dilute Hcl These properties are vital for the analysis of lithofacies. Consequently a Geological model embracing Lithofacies, mineral associated, Heterogenetic and Homogenetic zones were generated for the Well's sedimentary succession. One lithostratigraphic unit Agbada Formations was penetrated by the drill, with lithofacies units ranging from Sand, Shale, Shaly sand and Sandy Shale respectively.

4.2 LITHOLOGICAL DESCRIPTION

The lithologies penetrated by the drill as observed under the microscope are sandstone and shale intervals, with sand having Milky colour and shale comprising of light and dark grey colour. Minerals found were basically iron and mica. The lithostratigraphic succession penetrated has a total number of 88 lithozones. The lithostratigraphic model was analyzed from bottom to the top.

4.3 LITHOFACIES UNITS

The concept of lithofacies as applied to sediments is a means of classifying and grouping sedimentary deposits in such a way that objective differences, usually with genetic significance are highlighted. A total of 88 lithofacies zones which include: Sandstone ,Shale, Sandy Shale and Shaly Sand facies were defined and established on the basis of the lithological types and mineralogical contents. The zones are discussed from bottom to top on the basis of probable reservoir and source rock characteristics as follows:

Lithofacies Zone 1 (3630.4-3632.6m)
This zone is characterized by a Dark grey fissile shale with coal and its non calcareous. Its thickness is 2.2m

Lithofacies Zone 2 (3628m-3630.4m)
This zone is characterized by Milky coloured, medium to coarse grain, poorly sorted sand, angular to sub-angular. Non calcareous . Its thickness is 2.4m,minerals present is mica.

Lithofacies Zone 3 (3628- 3622.8m)
This zone is characterized by Milky coloured, fine grain, rounded,well sorted sand .Non calcareous. Its thickness is 5.2m,minerals present is mica.

Lithofacies Zone 4 (3628m-3622.8m)
This zone is characterized by a Dark grey fissile shale. its non-calcareous With a thickness of 5.2m

Lithofacies Zone 5 (3622.8m-3615.8m)
This zone is characterized by a Light grey fissile shale. its non-calcareous With a thickness of 7m.

Lithofacies Zone 6 (3615.8m- 3553.9m)
This zone is characterized by Milky, fine-medium grain, subrounded to rounded sand with shale, moderately sorted. Non calcareous.(shaly sand). With a thickness of 61.9m

Lithofacies Zone 7 (3553.9m- 3551.5m)
This zone is characterized by Milky, fine-medium grain, subrounded to rounded sand,moderately sorted sand With a thickness of With a thickness of 2.4m. Non calcareous

Lithofacies Zone 8 (3546m- 3482.9m)
This zone is characterized by Dark grey fissile shale With a thickness of 63.1m.Non calcareous

Lithofacies Zone 9 (3385m- 3382.6m)
This zone is characterized by Milky, fine-medium grain, subrounded to rounded,moderately sorted sand With a thickness of 2.4m.Non calcareous

Lithofacies Zone 10 (3380.1m- 3375.6m)
This zone is characterized by Milky, very fine grain, rounded,well sorted sand with a thickness of 4.5m . mineral present is mica, Non calcareous

Lithofacies Zone 11 (3375m- 3371m)
This zone is characterized by Light grey fissile shale with a thickness of 4m. minerals present is mica. Non calcareous

Lithofacies Zone 12 (3371m- 3224.6m)
This zone is characterized by dark grey fissile shale with a thickness of 146.4m. minerals present is mica. Non calcareous

Lithofacies Zone 13 (3224.6m- 3217.3m)
This zone is characterized by Milky, very fine grain, rounded,well sorted sand with a thickness of 7.3m ,minerals present is mica. Non calcareous

Lithofacies Zone 14 (3219.8m- 3217.3m)
This zone is characterized by Dark grey fissile shale with a thickness of 2.5m.Non calcareous

Lithofacies Zone 15 (3214.9m- 3191.1m)
This zone is characterized by Milky, very fine grain, rounded,well sorted sand with a thickness of 23.8m.Non calcareous

Lithofacies Zone 16 (3191.1m- 3186.2m)
This zone is characterized by Milky, medium-coarse grain, poorly sorted, angular to sub-angular sand with a thickness of 4.9m .Non calcareous

Lithofacies Zone 17 (3186.2m- 3184.4m)
This zone is characterized by Milky, fine-medium grained, moderately sorted, angular sand with a thickness of 1.8m. Minerals present is mica. Non calcareous

Lithofacies Zone 18 (3184.4m- 3101.2m)
This zone is characterized by Milky, medium – coarse grain,angular to sub angular poor to moderately sorted sand with a thickness of 83.2m .calcareous

Lithofacies Zone 19 (3101.2m- 3075.9m)
This zone is characterized by coal with a thickness of 25.3m. Non calcareous

Lithofacies Zone 20 (3101.2m- 3031.7m)
This zone is characterized by Dark grey fissile shale with a thickness of 69.5m.Non calcareous

Lithofacies Zone 21 (3031.7m- 2916.4m)
This zone is characterized by Milky, fine – medium grain,sub rounded to rounded, moderately sorted sand with a thickness of 115.3m .Non calcareous

Lithofacies Zone 22 (2916.4m- 2529.8m)
This zone is characterized by Dark grey fissile shale with a thickness of 386.6m. Non calcareous

Lithofacies Zone 23 (2529.8m- 2481m)
This zone is characterized by light grey fissile shale with a thickness of 48.8m. Non calcareous

Lithofacies Zone 24 (2529.8m- 2433.2m)
This zone is characterized by Dark grey fissile shale with a thickness of 96.6m. Non calcareous

Lithofacies Zone 25 (2433.2m- 2422.8m)
This zone is characterized by light grey fissile shale with a thickness of 10.4m. Non calcareous

Lithofacies Zone 26 (2422.8m- 2314.3m)
This zone is characterized by Dark grey fissile shale with a thickness of 108.5m. Non calcareous.

Lithofacies Zone 27 (2314.3m- 2251.5m)
This zone is characterized by Milky, very fine grain, rounded, well sorted sand with a thickness of 62.8m .Non calcareous

Lithofacies Zone 28 (2251.5m- 2245.4m)
This zone is characterized by Milky ,fine – coarse, poorly sorted, sub angular to sub-rounded sand with shale and has a thickness of 6.1m .Non calcareous

Lithofacies Zone 29 (2245.4m- 2239.3m)
This zone is characterized by Milky, medium-coarse grained, sub angular to subrounded ,poorly sorted sand with a thickness of 6.1m.Non calcareous.

Lithofacies Zone 30 (2239.3m- 2236.8m)
This zone is characterized by Milky, fine-medium grained, subangular to subrounded, moderately sorted sand with shale and has a thickness of 2.5m. Non calcareous.

Lithofacies Zone 31 (2236.8m- 2190.2m)
This zone is characterized by Dark grey fissile shale with a thickness of 46.6m Non calcareous.

Lithofacies Zone 32 (2190.2m- 2187.5m)
This zone is characterized by Milky , very fine grained,rounded, well sorted sand with a thickness of 2.7m .Non calcareous.

Lithofacies Zone 33 (2187.5m- 2184.4m)
This zone is characterized by Milky , fine-coarse grained, angular to sub-rounded, poorly sorted sand with a thickness of 3.1m.Non calcareous.

Lithofacies Zone 34 (2184.4 m-2181.4m)
This zone is characterized by Dark grey fissile shale with a thickness of 3m. Non calcareous.

Lithofacies Zone 35 (2181.4m- 2178.3m)
This zone is characterized by Milky, medium – coarse grain, angular, poorly sorted sand with a thickness of 3.1m .Non calcareous

Lithofacies Zone 36 (2181.4m- 2178.3m)
This zone is characterized by Milky, fine-medium grained, subrounded to rounded, moderately sorted sand with a thickness of 3m. mineral present is mica .Non calcareous

Lithofacies Zone 37 (2175.9m- 2174.3m)
This zone is characterized by Milky, very fine grained, rounded,well sorted sand with a thickness of 1.6m .Non calcareous

Lithofacies Zone 38 (2174.3m-2171.5m)
This zone is characterized by Milky, fine-medium grained, sub rounded-rounded, moderately sorted sand with shales.it has a thickness of 2.8m . mineral present is mica .Non calcareous

Lithofacies Zone 39 (2174.3m-2173.7m)
This zone is characterized by Milky, fine grained, rounded, well sorted sand with a thickness of 0.6m.Non calcareous

Lithofacies Zone 40 (2173.7m- 2169.2m)
This zone is characterized by Dark grey fissile shale with a thickness of 4.5m. Non calcareous

Lithofacies Zone 41 (2169.2m- 2116.4m)
This zone is characterized by Milky, medium grained, sub-angular, moderately sorted sand with shale .it has a thickness of 52.8m .Non calcareous

Lithofacies Zone 42 (2116.4m- 2114.3m)
This zone is characterized by Milky, very fine grained, rounded ,well sorted sand with a thickness of 2.1m.Non calcareous

Lithofacies Zone 43 (2114.3m- 2112.8m)
This zone is characterized by Milky, medium-coarse grained, angular – sub rounded, poor to moderately sorted sand with a thickness of 1.5m. Non calcareous

Lithofacies Zone 44 (2112.8m- 2111.8m)
This zone is characterized by Grey fissile shale with sand and coal . it has a thickness of 1m.Non calcareous

Lithofacies Zone 45 (2111.8m-2089m)
This zone is characterized by Milky, fine-coarse grained,poorly sorted, angular to sub angular sand with a thickness of 22.8m. Non calcareous

Lithofacies Zone 46 (2089m-2087.5m)
This zone is characterized by Milky, very fine grained, rounded,well sorted sand with a thickness of 1.5m, .mineral present is mica.Non calcareous

Lithofacies Zone 47 (2087.5m-2086.2m)
This zone is characterized by milky, medium grained sand, sub-angular, moderately sorted sand with a thickness of 1.3m . mineral present is iron.calcareous

Lithofacies Zone 48 (2086.2m-2083.8m)
This zone is characterized by milky Milky, coarse grained sand, angular,moderately sorted sand with a thickness of 2.4m.Non calcareous

Lithofacies Zone 49 (2083.8m- 2078.3m)
This zone is characterized by Grey fissile shale with a thickness of 5.5m .Non calcareous

Lithofacies Zone 50 (2078.3m-2074.6m)
This zone is characterized by Milky, medium grained, sub rounded ,well sorted sand with a thickness of 3.7m.Non calcareous

Lithofacies Zone 51 (2074.6m-2073.1m)
This zone is characterized by Milky, fine-medium grained, sub angular- sub rounded moderately sorted sand with a thickness of 1.5m .Non calcareous

Lithofacies Zone 52 (2073.1m-2050.3m)
This zone is characterized by Milky medium – coarse grained, poorly sorted, angular to sub-angular sand with a thickness of 22.8m.Non calcareous

Lithofacies Zone 53 (2050.3m-2025.3m)
This zone is characterized by Grey fissile shale with a thickness of 25m.Non calcareous

Lithofacies Zone 54 (2025.3m-2023.4m)
This zone is characterized by Milky fine-medium grained, sub rounded to rounded sand., moderately to well sorted with a thickness of 1.9m.Non calcareous

Lithofacies Zone 55 (2023.4m-2020.1m)
This zone is characterized by Milky medium grain, angular to sub-angular grain. Poor to moderately sorted 3.3m.Non calcareous

Lithofacies Zone 56 (2020.1m-2016.7m)
This zone is characterized by Milky, medium-coarse grained, angular-sub angular, moderately sorted sand with a thickness of 3.4m.Non calcareous

Lithofacies Zone 57 (2016.7m -2014.6m)
This zone is characterized by Grey fissile shale with a thickness of 2.1m.Non calcareous

Lithofacies Zone 58 (2014.6m-1956.7m)
This zone is characterized by Milky, fine-medium grained, rounded, well sorted sand with a thickness of 57.9m .minerals present is mica.Non calcareous

Lithofacies Zone 59 (1956.7m-1939m)
This zone is characterized by light grey fissile shale with a thickness of 17.7m .Non calcareous

Lithofacies Zone 60 (1939m-1908.8m)
This zone is characterized by Dark grey fissile shale with a thickness of 30.2m .Non calcareous

Lithofacies Zone 61 (1908.8m-1899.3m)
This zone is characterized by Black coal with a thickness of 9.5m.Non calcareous

Lithofacies Zone 62 (1899.3m-1840.5m)
This zone is characterized by Milky, fine-coarse grained, sub-angular to sub-rounded, poorly sorted with a thickness of 58.8m. mineral present is mica Non calcareous

Lithofacies Zone 63 (1840.5m-1833.2m)
This zone is characterized by light grey fissile shale with a thickness of 7.3m .Non calcareous

Lithofacies Zone 64 (1833.2m-1828m)
This zone is characterized by Milky, medium-coarse grain,angular to sub-angular ,moderately sorted sand with shale.has a thickness of 5.2m Non calcareous

Lithofacies Zone 65 (1828m-1802.7m)
This zone is characterized by grey fissile shale with a thickness of 25.3m .Non calcareous

Lithofacies Zone 66 (1802.7m-1800m)
This zone is characterized by Milky ,medium-coarsed grained ,sub-angular,moderately sorted sand with a thickness of 2.7m.Non calcareous

Lithofacies Zone 67 (1800m-1794.5m)
This zone is characterized by grey fissile shale with a thickness of 5.5m .Non calcareous

Lithofacies Zone 68 (1794.5m-1788.4m)
This zone is characterized by grey fissile shale with sand and has a thickness of 6.1m .Non calcareous

Lithofacies Zone 69 (1788.4m-1781.7m)
This zone is characterized by Milky, medium grained ,sub rounded to rounded, well sorted sand with a thickness of 6.7m. mineral present is mica, Non calcareous

Lithofacies Zone 70 (1781.7m-1779.5m)
This zone is characterized by Dark grey fissile shale with sand and has a thickness of 2.2 m .Non calcareous

Lithofacies Zone 71 (1779.5m-1777.1m)
This zone is characterized by Dark grey fissile shale with a thickness of 2.4 m . mineral present is iron .Non calcareous

Lithofacies Zone 72 (1777.1m-1753.3m)
This zone is characterized by Milky , fine-medium grained,rounded, well sorted sand with a thickness of 23.8m. mineral present is mica Non calcareous

Lithofacies Zone 73 (1753.3m-1620.1m)
This zone is characterized by Dark grey fissile shale with a thickness of 133.2 m .Non calcareous

Lithofacies Zone 74 (1620.1m-1601.5m)
This zone is characterized by Dark grey fissile shale with sand and has a thickness of 18.6 m mineral present is mica.Non calcareous

Lithofacies Zone 75 (1601.5m-1573.4m)
This zone is characterized by Dark grey fissile shale with coal and has a thickness of 28.1 m .Non calcareous

Lithofacies Zone 76 (1573.4m-1468.5m)
This zone is characterized by Dark grey fissile shale with a thickness of 104.9 m .Non calcareous

Lithofacies Zone 77 (1468.5m-1363.7m)
This zone is characterized by light grey fissile shale and has a thickness of 104.8 m .Non calcareous

Lithofacies Zone 78 (1363.7m-1329.2m)
This zone is characterized by Drak grey fissile shale and has a thickness of 34.5 m .Non calcareous

Lithofacies Zone 79 (1329.2m-1278.2m)
This zone is characterized by Light grey fissile shale and has a thickness of 51 m .Non calcareous

Lithofacies Zone 80 (1278.2m-1205.7m)
This zone is characterized by Dark grey fissile shale and has a thickness of 72.5 m .Non calcareous

Lithofacies Zone 81 (1205.7m-1165.8m)
This zone is characterized by Dark grey fissile shale with sand and has a thickness of 39.9 m mineral present is mica .Non calcareous

Lithofacies Zone 82 (1165.8m-1129.5m)
This zone is characterized by Milky ,fine to coarse grain,sub angular to subrounded sand . poorly sorted, has a thickness of 36.3m. mineral present is mica Non calcareous

Lithofacies Zone 83 (1129.5m-1112.5m)
This zone is characterized by Dark grey fissile shale with a thickness of 17 m .Non calcareous

Lithofacies Zone 84 (1129.5m-1038m)
This zone is characterized by Dark grey fissile shale with sand and coal, has a thickness of 91.5 m .Non calcareous

Lithofacies Zone 85 (1038m-858.2m)
This zone is characterized by Dark grey fissile shale with a thickness of 179.8 m .Non calcareous

Lithofacies Zone 86 (858.2m-753.9m)
This zone is characterized by Milky ,fine grain, angular,moderately sorted sand with a thickness of 104.3m.mineral present is mica.Non calcareous

Lithofacies Zone 87 (753.9m-693.9m)
This zone is characterized by light grey fissile shale with a thickness of 60m .Non calcareous

Lithofacies Zone 88 (693.9m)
This zone is characterized by Dark grey fissile shale . mineral present is mica Non calcareous

4.4 Hydrocarbon Play Element in the WELL

In petroleum geology, the sands are potential reservoir while Shale is regarded as Source rocks or Seal & Cap. It is known that the condition for hydrocarbon depends on factors such as the presence of the Seal & Cap, Reservoir and Source Rocks. All these determine the Play Elements in Petroleum Geology. For easy comprehension, the lithozones would be used to depict the various Play elements.

4.4.1 Reservoir Rocks

Reservoir rocks are rocks that have sufficient porosity and permeability to store and transmit hydrocarbon. From the lithostratigraphic model established 19 major reservoir rock units were established and were categorized into 35 lithozones .

The lithozones are as follow:
Lithozones2, Lithozones 3, Lithozones 7, Lithozones 9, Lithozones 10, Lithozones,13, Lithozones 15, Lithozones16, Lithozones 17, Lithozones 18, Lithozones 21, Lithozones 27, Lithozones 29, Lithozones 32, Lithozones33, Lithozones 35, Lithozones 36, Lithozones 37, Lithozones 39, Lithozones 42, Lithozones 43, Lithozones 45, Lithozones 46, Lithozones 47, Lithozones 48, Lithozones 50, Lithozones 51, Lithozones 52, Lithozones 54, Lithozones 55 Lithozones 56, Lithozones 58, Lithozones 62, Lithozones 72, Lithozones 86.

4.4.2 Potential Source Rock

A source rock is a rock that contains organic matter and has generated or is capable of generating hydrocarbon. The nature/ Type of organic matter contained in the source rock, time length and temperature are some factors that control petroleum generation from source rock. From the lithostratigraphic model established, 23 major source rock units were present which are categorized into 35 lithozones.

The lithozones are as follows:
Lithozones 1, Lithozones 4, Lithozones 5, Lithozones 8, Lithozones 11, Lithozones 12, Lithozones 14, Lithozones 20, Lithozones 22, Lithozones 23, Lithozones 24, Lithozones 25, Lithozones 26, Lithozones 31, Lithozones 34, Lithozones 40, Lithozones 49, Lithozones 53, Lithozones 57, Lithozones 59, Lithozones 60, Lithozones 63, Lithozones 65, Lithozones 67, Lithozones 71, Lithozones 73, Lithozones 76, Lithozones 77, Lithozones 78, Lithozones 79, Lithozones 80, Lithozones 83, Lithozones 85, Lithozones 87, Lithozones 88

4.4.3 Cap and Seal Rock

They are impermeable rock that acts as a barrier to stop the migration of hydrocarbon fluid. Rocks that form the Seal/Cap rocks are basically shale, Evapourites and carbonates. Shale rocks that acts as seal/cap rocks in the well are 15 in numbers ,they are as follow:

Reservoir Rock UNIT 1 (858.2ft)
The probable cap rock for reservoir unit 1 is source rock unit 1 which is categorizes as **lithozone 87 and 88** and it is composed of 100% shale.

Reservoir Rock UNIT 2 (1759.7-1761.2ft)
The probable cap rock for reservoir unit 2 is source rock unit 5 which is categorizes as **lithozone 73** and it is composed of 100% shale.

Reservoir Rock UNIT 3 (1899.3ft)
The probable cap rock for reservoir unit 3 is source rock unit 9 which is categorizes as **lithozone 62,** and it is composed of 100% shale.

Reservoir Rock UNIT 4 (1975.6-2014.6ft)
The probable cap rock for reservoir unit 4 is source rock unit 10 which is categorizes as **lithozone 59 and 60,** and it is composed of 100% shale.

Reservoir Rock UNIT 5 (2020.1-2025.3ft)
The probable cap rock for reservoir unit 5 is source rock unit 11 which is categorizes as **lithozone 57,** and it is composed of 100% shale.

Reservoir Rock UNIT 6 (2017.6-2078.3ft)
The probable cap rock for reservoir unit 6 is source rock unit 12 which is categorizes as **lithozone 53,** and it is composed of 100% shale.

Reservoir Rock UNIT 7 (2086.2-2107.3ft)
The probable cap rock for reservoir unit 7 is source rock unit 13 which is categorizes as **lithozone 49,** and it is composed of 100% shale.

Reservoir Rock UNIT 9 (2173.7ft)
The probable cap rock for reservoir unit 9 is source rock unit 14 which is categorizes as **lithozone 40,** and it is composed of 100% shale.

Reservoir Rock UNIT 11 (2187.5-2190.2ft)
The probable cap rock for reservoir unit 11 is source rock unit 15 which is categorizes as **lithozone 34,** and it is composed of 100% shale.

Reservoir Rock UNIT 12 (2245.4ft)
The probable cap rock for reservoir unit 12 is source rock unit 16 which is categorizes as **lithozone 31,** and it is composed of 100% shale.

Reservoir Rock UNIT 14 (2916.4ft)
The probable cap rock for reservoir unit 14 is source rock unit 17 which is categorizes as **lithozone 22,** and it is composed of 100% shale.

Reservoir Rock UNIT 16 (3219.8-3224.6ft)
The probable cap rock for reservoir unit 16 is source rock unit 19 which is categorizes as **lithozone 14,** and it is composed of 100% shale.

Reservoir Rock UNIT 17 (3375.6-3385ft)
The probable cap rock for reservoir unit 17 is source rock unit 20 which is categorizes as **lithozone 11 and 12,** and it is composed of 100% shale.

Reservoir Rock UNIT 18 (3551.5ft)
The probable cap rock for reservoir unit 18 is source rock unit 21 which is categorizes as **lithozone 8,** and it is composed of 100% shale.

Reservoir Rock UNIT 19 (3628-3630.4ft)
The probable cap rock for reservoir unit 19 is source rock unit 22 which is categorizes as **lithozone 4 and 5,** and it is composed of 100% shale.

4.5 ENVIRONMENT OF DEPOSITION

Base on the various lithofacies gotten from the well, parallic environment was suggested, which is the intercalation of sand and shale.

5 Conclusion

The Hydrocarbon play elements of the well are estimated on the basis of lithostratigraphic analysis. The information obtained from the observation and analysis of the various strata aided in understanding of the play element, which gives insight of economic potential of the sedimentary basin. The sedimentary succession penetrated reveals about eighty eight (88) lithozones from bottom to top. The lithologic model of the sedimentary succession penetrated reveals nineteen (19) potential petroleum reservoir rocks, twenty three (23) potential source rocks and fifteen (15) caprocks. The probable reservoir rocks occupy ,Lithozones2, Lithozones 3, Lithozones 7, Lithozones 9, Lithozones 10, Lithozones,13, Lithozones 15, Lithozones16, Lithozones 17, Lithozones 18, Lithozones 21, Lithozones 27, Lithozones 29, Lithozones 32, Lithozones33, Lithozones 35, Lithozones 36, Lithozones 37, Lithozones 39, Lithozones 42, Lithozones 43, Lithozones 45, Lithozones 46, Lithozones 47, Lithozones 48, Lithozones 50, Lithozones 51, Lithozones 52, Lithozones 54, Lithozones 55 Lithozones 56, Lithozones 58, Lithozones 62, Lithozones 72, Lithozones 86. The probable source rocks occupy :Lithozones 1, Lithozones 4, Lithozones 5, Lithozones 8, Lithozones 11, Lithozones 12, Lithozones 14, Lithozones 20, Lithozones 22, Lithozones 23, Lithozones 24, Lithozones 25, Lithozones 26, Lithozones 31, Lithozones 34, Lithozones 40, Lithozones 49, Lithozones 53, Lithozones 57, Lithozones 59, Lithozones 60, Lithozones 63, Lithozones 65, Lithozones 67, Lithozones 71, Lithozones 73, Lithozones 76, Lithozones 77, Lithozones 78, Lithozones 79, Lithozones 80, Lithozones 83, Lithozones 85, Lithozones 87, Lithozones 88. The mineralogical assemblages are basically mica and iron. One environments of deposition was penetrated which is the intercalation of sand and shale (parallic environment). Furthermore, lithostrtigrpahic and sedimentology has been demonstrated to be a hierarchical stratigraphic technique that has application in lithostrtigrpahic methodologies to independently characterize reservoir potentials and source rock potentials of the lithologies in the well.

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