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Source rock evaluation by integration of palynology, palynofacies and petrophysical analysis of LEO-1 well of the Niger Delta Basin

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ABSTRACT- This study deals with the integration of palynological, palynofacies and petrophysical analysis of shale sediments of the Agbada Formation to evaluate for their source rock potential. Palynological and palynofacies analysis were carried out using non-oxidizing preparation method on ditch cuttings from LEO-1 well with the aim of determining their thermal maturity and Kerogen types respectively while their total organic carbon (TOC) was estimated using the well corresponding petrophysical parameters. The thermal maturity was assessed using thermal alteration index (TAI). The miospore colour observed from light transmitting microscope ranges from yellow orange to dark brown. The TAI value results ranges from 2+ to 4-, with TAI value 3 dominant, which indicates that the studied sections of *LEO-1* well is thermally matured to generate hydrocarbon. The level of organic maturity (LOM) of 10.3 generated via vitrinite reflectance from the palynological analysis was used to evaluate for TOC using Passey's resistivity/porosity log overlay method. TOC value ranges from 0.9wt% - 2.2wt% with an average value of 1.5wt % which indicates fair to good grade and therefore exhibit the potential to generate hydrocarbon. Palynofacies analyses revealed four palynofacies groups (1 – 4) based on the percentage abundances of the sedimentary organic matter. Abundant terrestrial phytoclast (brown and black woody debris) and moderately abundant palynomorphs (miospores) and lesser AOM characterized the studied well confirming a type-III kerogen as the principal organic matters and inferring a gas prone source rock.

Index Terms- Source rock, Palynofacies, Palynology, Petrophysical, Niger Delta Basin.

I. INTRODUCTION

Organic-rich rock that has generated or expelled hydrocarbon in sufficient quantity to form commercial accumulation given sufficient exposure to heat and pressure is known as source rock. They are commonly shale and limestone that contain organic matter. These organic matters may be derived from aquatic organisms and land plant (Lijmbach, 1975). Source rock analyses of the Niger Delta Basin have shown that shale from the lower coastal plain, the marine-deltaic areas (prodelta) and the fully marine areas can be enriched in both land plant material and structureless organic matter (Stacher, 1995).

In developing countries, geoscientists are facing problems due to lack of funding to study the geochemical parameters using Rock-Eval pyrolysis because it is very expensive. It has been a global challenge in trying to develop cheaper methods and techniques for evaluating hydrocarbons potentials.

Odedede (2015) carried out work in two offshore wells in the Niger Delta Basin to ascertain the local source rock using palynological anaysis. He determined the thermal maturity utilizing TAI. The sediments of the Agbada Formation are estimated to be thermally mature with TAI 2.7 estimated for depths: 1863 – 2556 m and TAI 3.0 estimated for depths 2583 – 3663 m in the ANL – 1 well while the E -12 well sediments are composed of TAI 2.8 at depth 1932 -2238 m and TAI 3.0 at depth 2410 – 2603 m of the lower Agbada formation and are thermally mature.

Kachikwulu K. O, et al (2018) work on Palynofacies of the sediment in the Niger Delta Basin inferring a Kerogen Type III (gas prone) linked with overwhelming abundant terrestrial phytoclasts, palynomorphs and amorphous organic matter (AOM) of terrestrial origin.

Kaka Abiodun et. al, (2018) worked on source rock analysis using well logs in western Niger Delta. They applied the Passey's method by overlaying the three porosity logs on resistivity log to determine for TOC. The TOC result obtained were slightly higher to geochemical analytical result carried out. The TOC value of 2.7wt% was calculated using Passey's method while 3.8wt% was obtained from geochemical analysis. In this study, the source rock was evaluated by determining the kerogen type using palynofacies analysis; the thermal maturity using thermal alteration index (TAI) and total organic carbon (TOC) using petrophysical parameters from the corresponding well log.

Geology of the study area

The study area lies between latitudes 5° and 7° N and longitudes 5° and 6° E in the south-south geo-political region of Nigeria and it is within the Greater Ughelli Depobelt of the Niger Delta Basin.

The evolution of the Niger delta is controlled by pre- and synsedimentary tectonics described by Evamy et. al, (1978), Ejedawe (1981), Knox and Omatsola (1989) and Stacher (1995). The Niger Delta stratigraphic sequence comprises an upward-coarsening regressive association of Tertiary clastics up to 12 km thick (Weber and Daukoru 1975). Stratigraphically divided into three units; The Benin Formation-continental shallow massive sand sequence; the Agbada Formation-coastal marine sequence of alternating sands and shales; and the Akata Formation-a basal marine shale unit (Stacher, 1995).

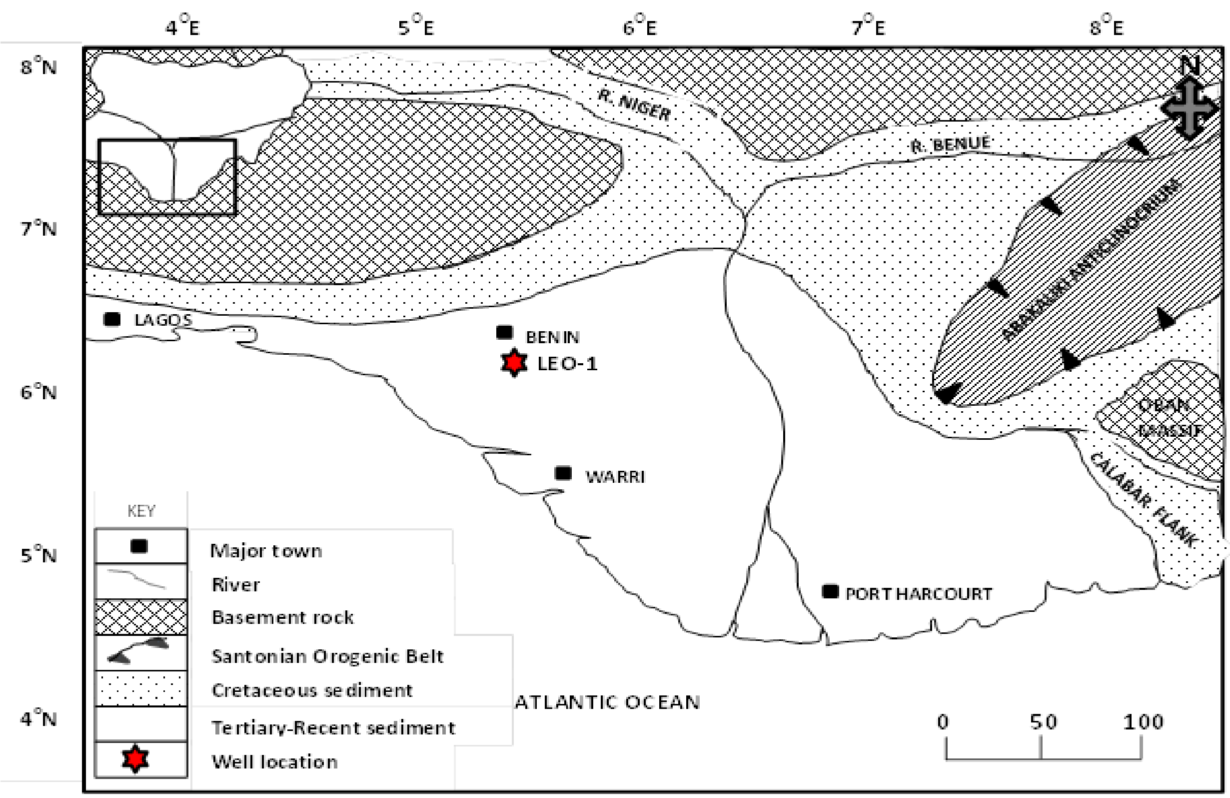


Figure 1: Map of the study area (modified after Aturamu *et. al*, 2015)

II. MATERIALS AND METHODS

The following materials were used for this research work:

- Palynological/Palynofacies materials

Ditch cutting samples, Fume Cupboard, Brason Sonifier 250, Plastic Cups, Hot Plate, Beakers, Test Tubes, Distilled Water, Glass Slides/ Cover Slips, Pipette and Norland mounting medium. Light transmitted microscope, MU500 AmScope digital camera and spore colour index chart.

- Well log materials

Well (Gamma ray, deep resistivity log, neutron porosity and density log) las file.

Softwares: Techlog, Microsoft office.

Palynological preparation

A total of Twenty five (25) ditch cuttings from LEO-1 well were subjected to standard non-oxidizing palynological slide preparation at Mosumolu laboratory. 20grams of each samples selected at 15 feet interval are ditched equally into well labeled cups and arranged in a fume cupboard to extract the released fume to the atmosphere.

Step 1: Removal of Carbonates: The samples are poured gently into the well labeled beakers with 10% hydrochloric acid (HCl) about 30ml applied on each samples. The beakers containing the samples are arranged on hot plate and heated for about 25 to 30 minutes. The samples are decanted at interval of 1 hour each 3 times.

Step 2: Removal of Silicates: 40% Hydrofluoric acid (HF) about 25ml are gently applied into each sample, properly stirred for digestion and left for about 24 hours. The next day samples were filled with distilled H_20 for an hour and decanted three times.

Step 3: Sieving and Separation: An ultrasonic device, Brason Sonifiers was used to filter away the remaining inorganic matter through a 5 micron sieve to retain only the organic matter residues.

Step 4: Preparation of Slide: The recovered organic matters are uniformly spotted with a pipette on arranged cover slips of 22/32mm, allowed to dry and mounted on glass slides using Norland adhesive mounting medium. The slides are then dried for 5-10 minutes after which they are ready for microscopic examination. The slides were examined with an Olympus light transmitted microscope with MU500 AmScope digital camera attached to it.

Palynofacies preparation

Palynofacies slides were prepared for twenty five ditch cuttings according to standard palynofacies procedures through the isolation of non-oxidative organic matter proposed by Tyson (1995). The prepared slides were subjected to a qualitative and quantitative analysis of structured and structureless organic matter.

Palynological analysis

Plants microfossils (specifically pollen and spores) recovered from samples which are subjected to non-oxidized acid digestion are utilized in this work to determine the thermal maturity of the source rock from TAI. The TAI is calibrated with vitrinite reflectance in a maturity chart of Staplin, (1969) modified by Pearson, (1984) where Vitrinite reflectance values were estimated. Level of organic maturity (LOM) were estimated either by cross plot of LOM and Ro (see fig 2) or by emphirical formula (see equation 1) proposed by Hood et al., (1975). The LOM is subsequently integrated into Passey's *et. al*, (1990) formulae to calculate for TOC. (See equation 5)

$LOM = 1.182\ (\%Ro^3) - 6.1109(\%Ro\ ^2) + 13.21\ (\%Ro) + 2.2919$.....(1)

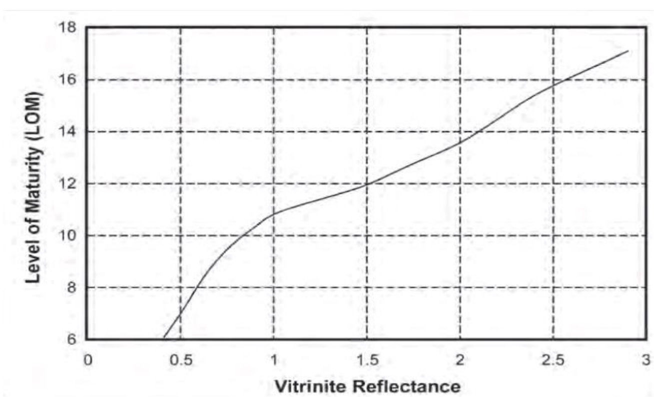


Figure 2: LOM and Vitrinite reflectance cross plot

Thermal Maturity

The colour change of miospores (spore and pollen) is utilized in assessing the thermal maturity of the sedimentary rock containing the organic matter. This colour change in miospores exines (wall) can be observed by viewing in well-adjusted light transmitting microscope. Recent deposits of miospore are pale yellowish to nearly colourless (immature). When subjected to heat by progressive deep burial the exine colour alters from yellow to orange to brown (mature), then dark brown and finally black (overmature). This colour change of miospore is tabulated into a thermal alteration indices partition into grades, Staplin (1969), Pearson (1984).

In addition, Vitrinite reflectance is also a valuable tool for measuring the maturation stage of organic matter, especially of Type III kerogen. Other marine or lacustrine kerogens (Type I and Type II) may also contain particles resembling vitrinite, although their optical properties may be different, Tissot and Welte (1978).

Thermal maturity		Pearson's (1984) colour chart	Thermal Alteration Index (TAI)	Vitrinite Reflectance (Ro) %	Miospore colour
Immature			1		Pale yellow
			1+	0.2	Yellow
			2-	0.3	Lemon yellow
			2	0.5	Golden yellow
Mature	Oil		2+		Yellow orange
			3-		Orange
	Wet gas		3	1.0	Orange brown
			3+	1.3	Brown
	Dry		4-	2.0	Dark brown
Overmature			4		Black

Figure 3: Thermal alteration index chart (Pearson, 1984)

Palynofacies analysis

For palynofacies analysis, the relative proportions of the different material were determined by visual estimations, which is a standard method for palynofacies. Point-counting technique (Tyson, 1984) was used to quantitatively estimate the organic matter types which were grouped into three (3) classes: Amorphous organic matter (AOM), Phytoclast and Palynomorph, corresponding to Alginite, Vitrinite and Exinite kerogen / maceral types.

Passey's method for TOC determination

This technique employs the overlaying of a properly scaled porosity log (Sonic, Density or Neutron) on a resistivity curve (preferably deep resistivity). Passey proposed that when these curves are overlay together, the degree of separation between them could be an indication of TOC and the more these two curves separates, the larger the TOC value. This technique has been successfully applied to many wells worldwide. It is found to work adequately in both carbonate and clastic source rocks, and can be accurate in predicting TOC over a wide range of maturities.

Passey *et. al*, (1990) log overlay technique to estimate TOC in wt% requires level of organic maturity (LOM) which can be determined from vitrinite reflectance. The overlay relations between formation resistivity log and porosity log (sonic, density, neutron) is used to calculate the algebraic expression ΔlogR which is derived as:

$$\Delta LogR = \frac{\Delta logR\rho + \Delta logR\phi}{2} \dots\dots (2)$$

The Resistivity/density overlay is:

$$\Delta logR_{\square} = log_{10}\left(\frac{RES}{RES_{baseline}}\right) - 2.0 * (\square - \square_{baseline}) \dots . (3)$$

Where $\Delta logR_{\square}$ is the separation value of resistivity/density crossover, RES is the true resistivity log reading, ρ is the density log reading, $RES_{baseline}$ and $\square_{baseline}$ are the base-lined resistivity and density readings in front of non-source shale.

The Resistivity/neutron porosity overlay is:

$$\Delta logR_{\phi} = log_{10}\left(\frac{RES}{RES_{baseline}}\right) + 4.0 * (\phi - \phi_{baseline}) \quad (4)$$

Where $\Delta logR_{\phi}$ is the separation value of resistivity /neutron porosity crossover, R is the true resistivity log reading, ϕ is the porosity log reading, $R_{baseline}$ and $\phi_{baseline}$ are the base-lined resistivity and porosity readings in front of non-source shale. Passey method to determining TOC is thus calculated with the formula below:

$$TOC\ (wt\%) = \Delta logR * 10^{2.297-0.1688*LOM} * Scale\ factor \ldots (5)$$

III. RESULTS AND INTERPRETATIONS

Lithostratigraphy

The depth at which the samples were taken range from 8005 – 9120ft. The gamma log and samples collected was used to create the stratigraphic column. The strata comprises of shale, sandy shale and sandstone intervals.

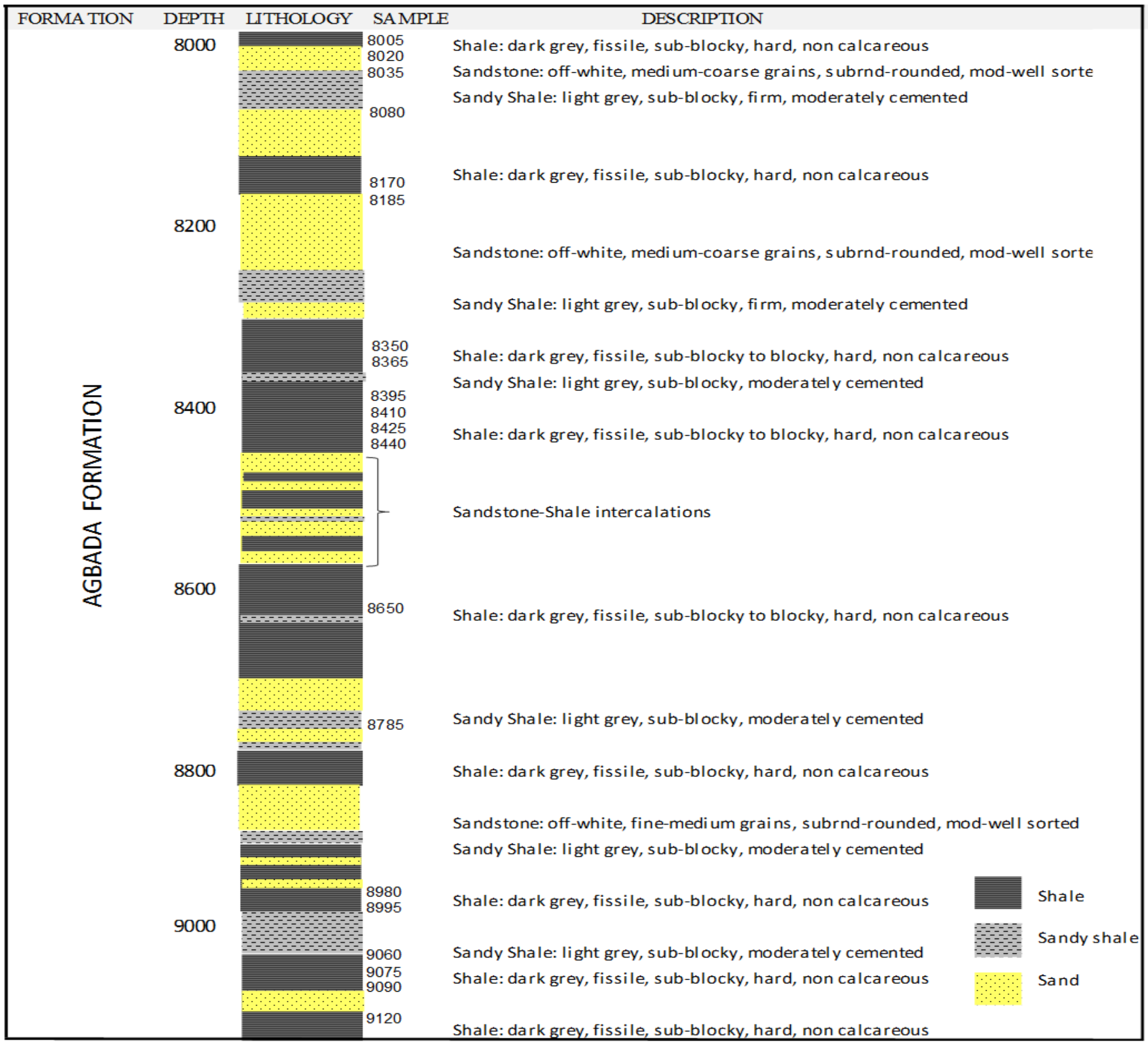


Figure 4: Lithostratigraphy of LEO-1 well studied section.

Thermal maturity result

The micro-optical analysis for thermal maturation indices using miospore colour from the studied section of well LEO-1 is presented in table 5 after careful matching of the miospore with the colour chart developed by Staplin 1969, Pearson (1984) as shown in figure 3. The photomicrography of the miospore used for this analysis is well presented in plate 1. The LEO-1 well which penetrated from 8005ft to 9120ft of the studied section is characterized with yellow orange, orange, orange brown, brown, and dark brown miospores with the orange brown to brown dominating the section having TAI value ranging from 2+ to 4- with TAI value 3 dominant in the studied section. This gives a clear indication that the organic matters in the studied stratigraphic interval are thermally matured and may have the potential to generate predominately wet gas and possibly some oil.

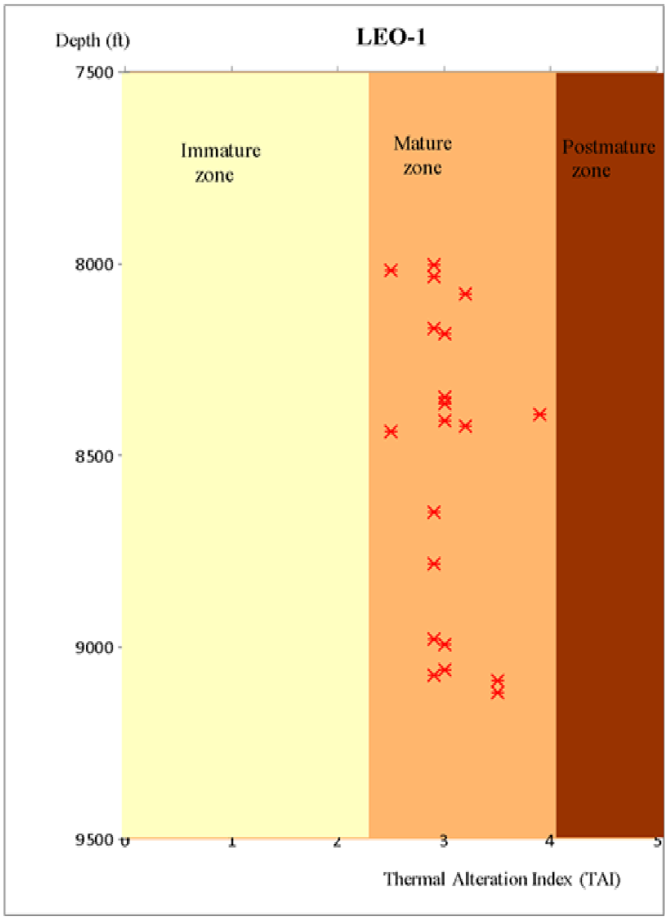
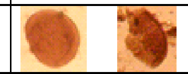
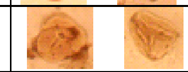
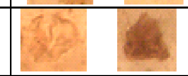
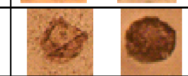
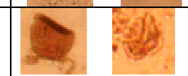
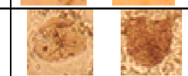
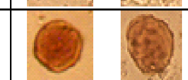
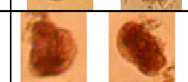
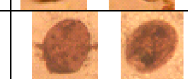
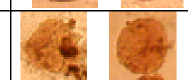
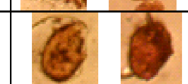
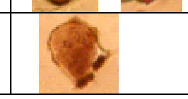
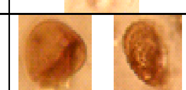
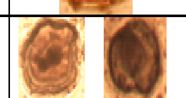
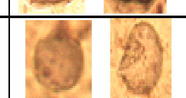
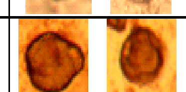
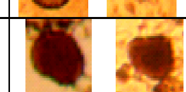
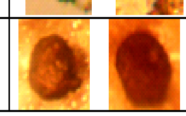


Figure 5: Depth and Thermal alteration index plot

Table 1: Thermal maturity result from miospores

SAMPLE DEPTH (FT)	MIOSPORES	MIOSPORE COLOUR	THERMAL ALTERATION INDEX (TAI)	THERMAL MATURITY
8005		Orange – orange brown	3- to 3	Matured
8020		Yellow orange	2+	Matured
8035		Yellow orange – orange brown	2+ to 3	Matured
8080		Orange brown – brown	3 to 3+	Matured
8170		Orange – orange brown	3- to 3	Matured
8185		Orange brown	3	Matured
8350		Orange brown	3	Matured
8365		Orange brown	3	Matured
8395		Dark brown	4-	Matured
8410		Orange brown	3	Matured
8425		Orange brown – brown	3 to 3+	Matured
8440		Yellow orange	2+	Matured
8650		Orange	3-	Matured
8785		Orange	3-	Matured
8980		Orange	3-	Matured
8995		Orange brown	3	Matured
9060		Orange brown	3	Matured
9075		Orange	3-	Matured
9090		Brown	3+	Matured
9120		Brown	3+	Matured

Vitinite reflectance (%Ro)

The vitrinite reflectance values obtain in the studied stratigraphic intervals ranges from 0.61-1.71 (see table 2). This indicates that the sedimentary organic matter in the studied intervals falls within the matured zone.

Table 2: Vitrinite reflectance estimated from TAI standard chart of D. L. Pearson, (1990)

Sample depth (ft)	Thermal alteration index (TAI)	Vitrinite reflectance (%Ro)
8005	3- to 3	0.88
8020	2+	0.61
8035	2+ to 3	0.85
8080	3 to 3+	1.10
8170	3- to 3	0.88
8185	3	0.98
8350	3	0.98
8365	3	0.98
8395	4-	1.71
8410	3	0.98
8425	3 to 3+	1.10
8440	2+	0.61
8650	3-	0.78
8785	3-	0.78
8980	3-	0.78
8995	3	0.98
9060	3	0.98
9075	3-	0.78
9090	3+	1.20
9120	3+	1.20

Level of organic maturity (LOM)

The LOM values obtained from LEO-1 wells ranges from 8.4 – 13 (see table 3). LOM value from 8 and above is the value in which significant hydrocarbon generation begins (Hood *et. al*, 1975). Therefore the LOM value obtained in these studies indicates that all analyzed samples have reached significant hydrocarbon generation stage.

The results of LOM were acquired using the two methods discussed above, which are the empirical formula of Hood *et. al*, (1975) (see equation 1) using vitrinite reflectance value obtained from TAI or the cross plot diagram of LOM versus vitrinite reflectance (figure 2).

The average LOM for LEO-1 well is 10.3. This is the LOM values that will be used in the Passey *et. al,* (1990) method to determine for TOC.

Table 3: LOM values for LEO-1 well

LEO-1 WELL		
Sample depth (ft)	Vitrinite reflectance (%Ro)	Level of Maturity (LOM)
8005	0.88	10
8020	0.61	8.4
8035	0.85	9.9
8080	1.1	11.1
8170	0.88	10
8185	0.98	10.5
8350	0.98	10.5
8365	0.98	10.5
8395	1.71	13
8410	0.98	10.5
8425	1.1	11.1
8440	0.61	8.4
8650	0.78	9.5
8785	0.78	9.5
8980	0.78	9.5
8995	0.98	10.5
9060	0.98	10.5
9075	0.78	9.5
9090	1.2	11.4
9120	1.2	11.4

Total organic carbon (TOC) results

For the LEO-1 well, the non-source rock baseline of resistivity (RES_b), density ($RHOB_b$) and neutron porosity ($NPHI_b$) were established at depth 8285ft indicated with green arrows as shown in figure 6. The RES_b value is 33.98, $RHOB_b$ value is 2.2037 and the $NPHI_b$ is 25.3785. These values were used to calculate for the densty/resistivity curve separation and the neutron porosity/resistivity curve separation known as $\Delta logR_{\square}$ (see equation 3) and $\Delta logR_{\phi}$ (see equation 4) respectively. The average of $\Delta logR_{\square}$ and $\Delta logR_{\phi}$ was calculated resulting to the $\Delta logR$ parameter, which was subsequently used with the LOM value of 10.3 obtain from palynological analysis. This integration leads to the determination of TOC values of the studied sections from Passey et al (1990) formula (see equation 5). The calculated TOC values ranges from 0.9wt% to 2.2wt% at depth 8350ft and 9120ft respectively as shown in

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Table 4. The average TOC value is 1.5wt%. They fall within fair to good TOC grade and they have the potential to generate hydrocarbon.

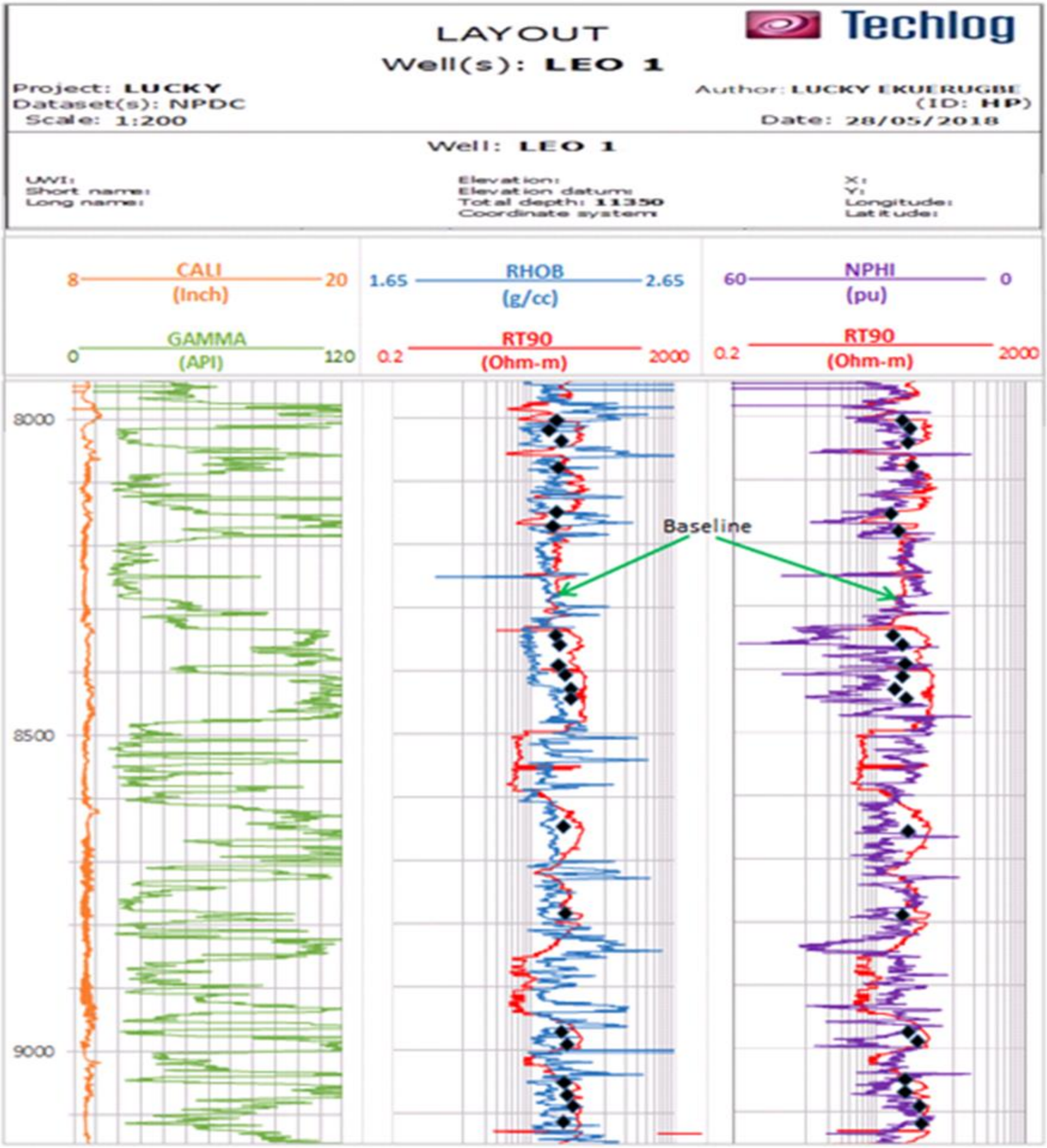


Figure 6: Density/resistivity and neutron porosity/resistivity overlay of LEO-1 well showing the baseline and the curve separation at the organic-rich interval.

Table 4: TOC results of LEO-1 well derived from petrophysical data and LOM.

LEO-1 WELL

DEPTH (ft)	RES (ohm-m)	RES_b (ohm-m)	RHOB (g/cm^3)	$RHOB_b$ (g/cm^3)	NPHI (p.u.)	$NPHI_b$ (p.u.)	$\Delta LogR_\rho$	$\Delta LogR_\phi$	ΔLogR	LOM	TOC (wt%)
8005	88.3877	33.98	2.3166	2.2037	28.3693	25.3785	0.133	0.535	0.334	10.3	1.1
8020	84.4911	33.98	2.3214	2.2037	27.8341	25.3785	0.101	0.494	0.298	10.3	1
8035	93.7056	33.98	2.166	2.2037	22.9127	25.3785	0.535	0.342	0.439	10.3	1.4
8080	62.3378	33.98	2.2114	2.2037	29.7134	25.3785	0.244	0.437	0.341	10.3	1.1
8170	67.0005	33.98	2.1792	2.2037	27.5511	25.3785	0.356	0.382	0.369	10.3	1.2
8185	73.3532	33.98	2.2228	2.2037	33.3508	25.3785	0.286	0.653	0.47	10.3	1.5
8350	92.3145	33.98	2.2231	2.2037	38.4662	25.3785	0.386	0.958	0.672	10.3	2.2
8365	87.5369	33.98	2.2287	2.2037	38.1318	25.3785	0.348	0.921	0.635	10.3	2.1
8395	88.2087	33.98	2.2635	2.2037	38.2306	25.3785	0.265	0.928	0.597	10.3	1.9
8410	111.1888	33.98	2.3489	2.2037	39.036	25.3785	0.152	1.061	0.607	10.3	2
8425	110.8477	33.98	2.3025	2.2037	38.1557	25.3785	0.267	1.025	0.646	10.3	2.1
8440	110.4091	33.98	2.3428	2.2037	33.4711	25.3785	0.164	0.835	0.5	10.3	1.6
8650	105.9587	33.98	2.3325	2.2037	35.8864	25.3785	0.172	0.914	0.543	10.3	1.8
8785	96.7477	33.98	2.2711	2.2037	28.4958	25.3785	0.286	0.579	0.433	10.3	1.4
8980	94.7644	33.98	2.2997	2.2037	28.6292	25.3785	0.205	0.575	0.39	10.3	1.3
8995	90.2891	33.98	2.3153	2.2037	28.1341	25.3785	0.145	0.535	0.34	10.3	1.1
9060	90.1931	33.98	2.3216	2.2037	28.2235	25.3785	0.129	0.538	0.334	10.3	1.1
9075	96.0059	33.98	2.3546	2.2037	28.3384	25.3785	0.074	0.569	0.322	10.3	1
9090	95.4457	33.98	2.3248	2.2037	28.7561	25.3785	0.146	0.584	0.365	10.3	1.2
9120	94.2097	33.98	2.3841	2.2037	28.4108	25.3785	-0.008	0.564	0.278	10.3	0.9

Palynofacies kerogen result

Four (4) palynofacies groups, viz: Palynofacies group 1, 2, 3 and 4 were recorded based on the palynofacies quantitative distribution (table 6).

Palynofacies group 1

This palynofacies group exists at the top and bottom section of LEO-1 at the following depth section (8005ft, 8080ft, 8410ft, 8425ft, 8980ft, 8650ft and 9120ft). It is defined by frequent AOM, frequent to abundant phytoclast and frequent to abundant palynomorphs. Black debris, brown debris, AOM and miospores are the most dominate organic components in this group and are common composition of a type II / III kerogen and suggestive of an oil/gas–prone facies.

Palynofacies group 2

This palynofacies group exists in the studied interval at the following depth section (8020ft, 8170ft, 8440ft, 8785ft and 9090ft). They are defined by common AOM, abundant phytoclast and frequent to abundant palynomorphs. Brown debris, black debris and miospores are the most dominate organic components in this group and are typical composition of a type III kerogen and suggestive of gas–prone facies.

Palynofacies group 3

This palynofacies group exists at depth (8035ft, 8350ft, 8365ft, 8185ft, 8995ft and 9060ft). It is defined by rare AOM, abundant phytoclast and common to frequent palynomorphs. The most dominant organic components in this group are the black debris, brown debris and miospores. These organic component are typical composition of a type III kerogen and suggestive of gas–prone facies.

Palynofacies group 4

This palynofacies group exists only at depth section 9075ft. It is defined by rare AOM, frequent phytoclast and abundant palynomorphs. Miospores and Brown debris are the most dominate organic components in this group and are common composition of a type III kerogen and suggestive of a gas–prone facies.

Table 5: Palynofacies quantitative count

DEPTH (ft)	Amorphous Organic Matters (AOM)	PHYTOCLASTS					PALYNOMORPHS	
		Brown debris	Black debris (Opaque)	Tubes, filament and hair	Cuticles	Total	Terrestrial (Miospores)	Marine
8005	17	10	41	5	4	60	24	0
8020	4	20	7	0	0	27	23	0
8035	1	5	18	0	0	23	8	0
8080	2	3	2	0	0	5	4	0
8170	4	15	15	1	0	31	9	0
8185	1	16	17	3	2	38	3	0
8350	7	32	78	5	1	116	23	0
8365	1	7	20	2	0	29	6	0
8395	1	7	12	12	0	31	13	0
8410	7	8	13	2	1	24	9	0
8425	4	2	8	1	1	12	5	0
8440	1	2	5	0	0	7	2	0
8650	4	2	2	0	0	4	6	0
8785	4	1	14	1	1	17	13	0
8980	4	7	6	1	1	15	5	0
8995	0	5	5	2	0	12	2	0
9060	0	3	2	2	0	7	1	0
9075	0	3	2	2	0	7	12	0
9090	3	3	11	2	0	16	10	0
9120	3	2	2	0	0	4	4	0

Table 6: Percentage distribution of palynofacies

LEO-1			
DEPTH (ft)	AOM %	PHYTOCLAST %	PALYNOMORPHS %
8005	17	59	24
8020	7	50	43
8035	3	72	25
8080	18	46	36
8170	9	70	21
8185	2	91	7
8350	5	79	16
8365	3	80	17
8395	2	69	29
8410	17	60	23
8425	19	57	24
8440	10	70	20
8650	29	29	42
8785	12	50	38
8980	17	62	21
8995	0	86	14
9060	0	87	13
9075	0	37	63
9090	10	55	35
9120	28	36	36

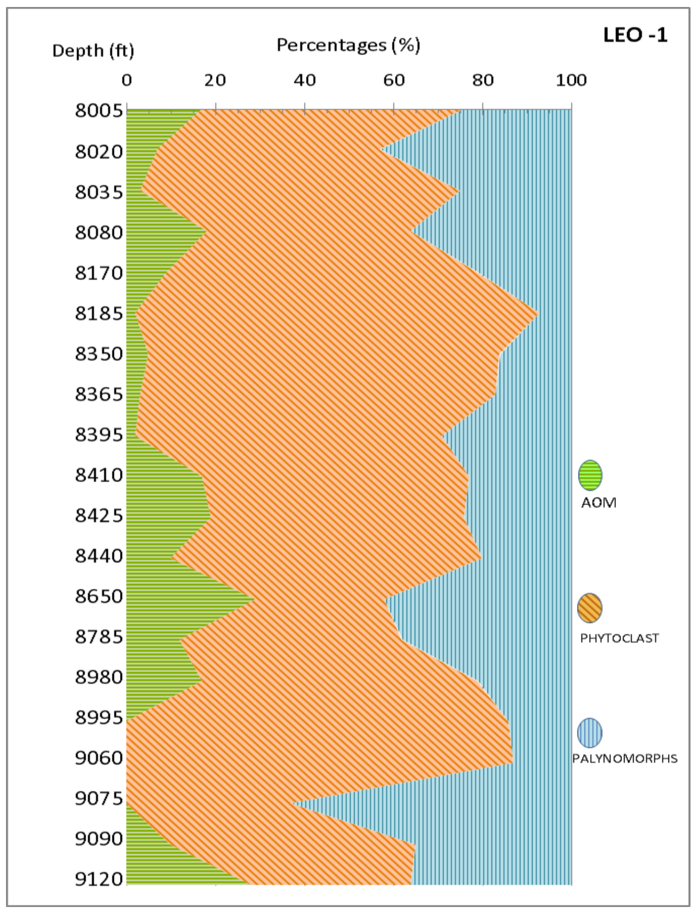
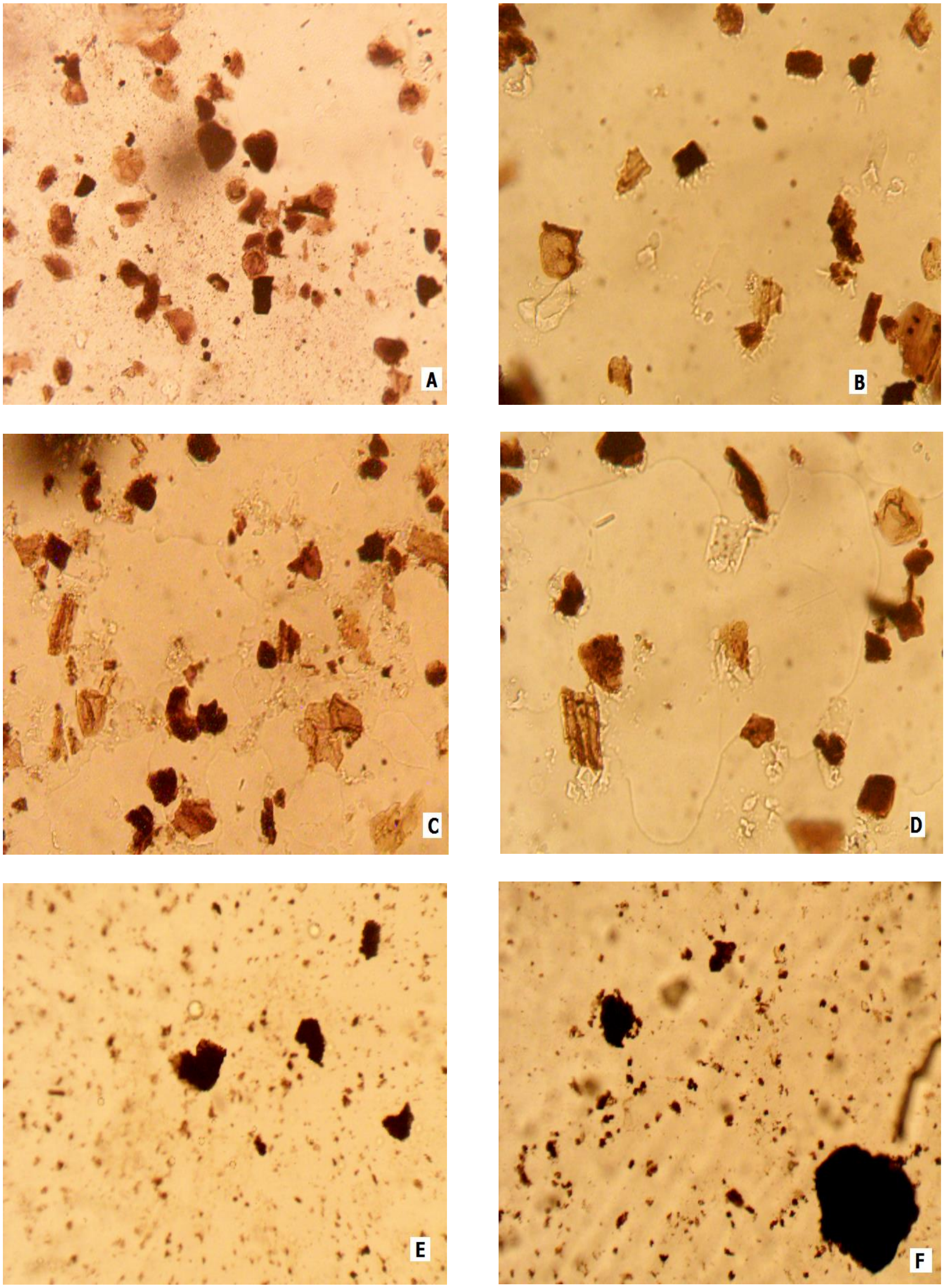


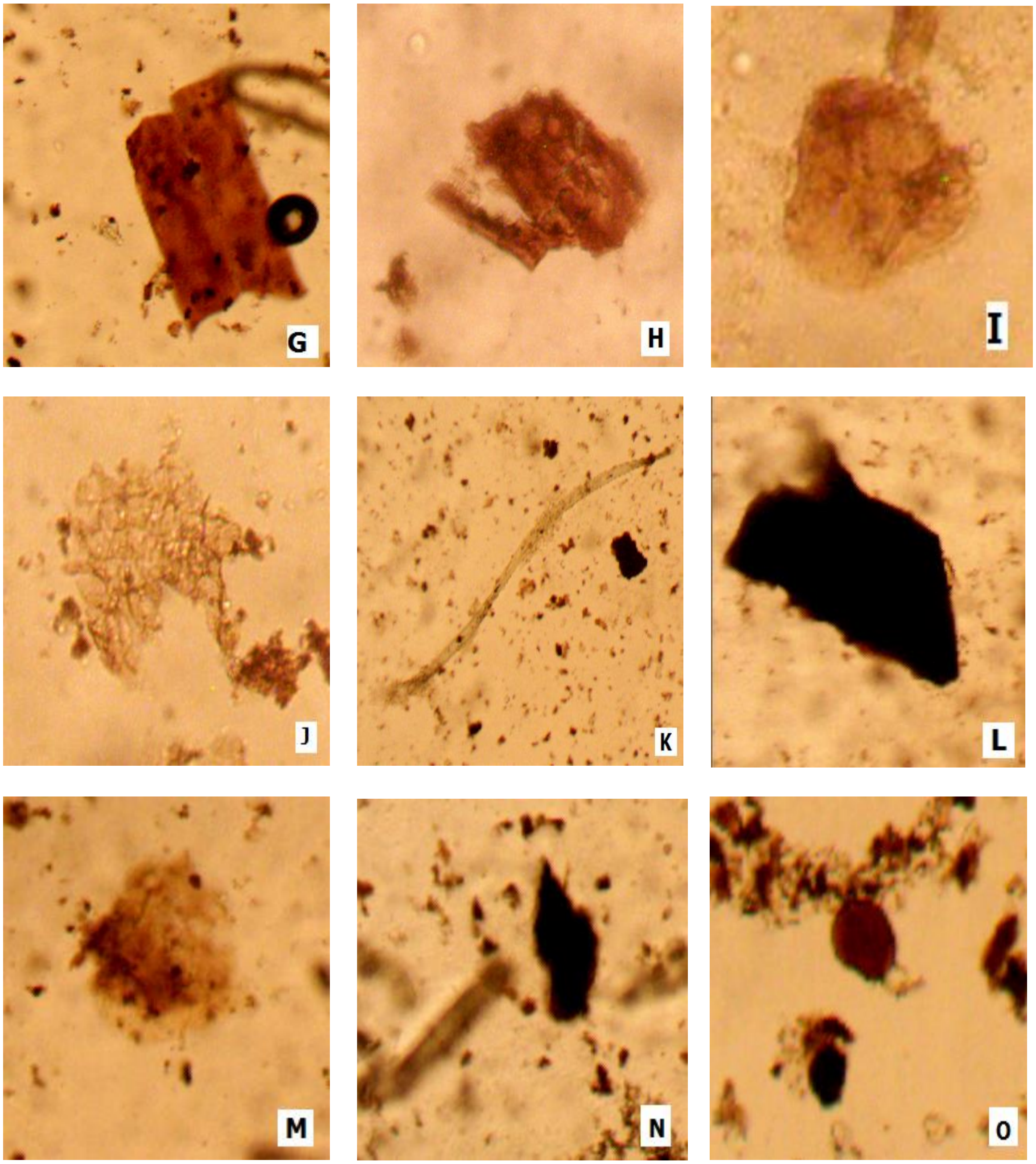
Figure 7: Percentage distribution chart

PLATE 1



All figures magnification = 20µm

PLATE II



(A) Palynofacies with well-preserved palynomorphs, brown and black debris. (B, D) Brown phytoclast dominant, miospore and opaque debris present. (C) Degrading phytoclast, amorphous organic matters, opaque debris and miospores. (E, F, L). Black debris. (G) Well-preserved phytoclast (H) Degrading phytoclast (I) Miospore (Cyathidites) (J) Cuticle (K) Plant filament. (M) Amorphous organic matter. (N) Opaque debris and filament. (O) Miospore and opaque debris.

All figures magnification = 200μm

IV. CONCLUSION

The integration of palynofacies, palynology and petrophysical analysis to evaluate for hydrocarbon source rock potential is not common in the Niger Delta Basin. This study was carried out for this purpose by integrating these aspects of geological science in order to evaluate for thermal maturity, total organic carbon and palynofacies kerogen. The studied well section is thermally matured, estimated total organic carbon is sufficient to generate hydrocarbon and palynofacies type III kerogen dominate the well sections thus indicates a gas-prone source rocks.

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