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إمكانية الاستفادة من الصخور المحلية من رواسب ANL-1 و E-12 في شواطىء دلتا النيجر، إستنادا إلى دراسات النضج العضوي لتوفير المواد الهيدروكربونية.

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الخلاصة

إمكانية الاستفادة من الصخور المحلية من الرواسب ANL-1 و E-12 في شواطئ دلتا النيجر تم تقييمها استنادا إلى دراسة مسألة النضج العضوي للتنقيب عن المواد الهيدروكربونية ، والدراسة تعرض الآبار palynoflora في مستويات طبقية مختلفة وتشير إلى أن طبقة palaeoecological ذات البيئة الترسيبية المتغيرة. الرواسب E-12 تتكون من انخفاض تشكيل Agbada وتكون ناضجة حراريا (TAI 2.8، 2238- 1932 م وTAI 3.0؛ 2410-2603 م)، وتبين أنها نافذة للنفط وتولد النفط والغاز السائل بكثافة في حين أن الجزء العلوي من (TAI 1.7، 1230-1770 م) المغطي بتشكيل من (TAI 1.5، 681-1176 م) و(TAI 1.3) الغير ناضجة حراريا ويتم تحديدها على عمق 216-1773 متر (تشكيل بنين) في الرواسب ANL -1 ، في حين يتم تحديد عمق-1863 2556 متر لتشكيل (TAI 2.7) الناضجة الحرارية وTAI 3.0 يتم تحديد في عمق 2583-3663 متر (تشكيل اجبدا). الصخر الزيتي يكون في الجزء السفلي والعلوي من تشكيل Agbada في الرواسب ANL - 1 وتشير الرواسب E-12 إلى مستوى النضج الأمثل لإمكانات الصخور كمصدر للمواد الهيدروكربونية.

Local source rock palynology of ANL -1 and E -12 wells sediments offshore Niger delta, Nigeria: Implication for hydrocarbon prospectivity.

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ABSTRACT

Local source rock potential of ANL-1 and E-12 well sediments in offshore, Niger Delta have been evaluated based on organic matter maturation studies to provide leads for hydrocarbon exploration. The studied wells display diverse palynoflora at different stratigraphic levels and indicate variable palaeoecological conditions of the depositional environment. E -12 well sediments are composed of the lower Agbada formation and are thermally mature (TAI 2.8; 1932 -2238 m and TAI 3.0; 2410 – 2603 m), showing top of oil window and intense generation of liquid hydrocarbon while the upper part (TAI 1.7; 1230 – 1770 m) and the overlying Benin formation (TAI 1.5; 681 – 1176 m) are thermally immature. Immature (TAI 1.3) thermal facies is determined for depths: 216 – 1773 m (Benin formation) in the ANL -1 well, while mature (TAI 2.7) thermal facies is determined for depths: 1863 – 2556 m and TAI 3.0 is determined for depths 2583 – 3663m (Agbada formation) in the ANL – 1 well. Shale of the lower and upper part of Agbada formation in the ANL – 1 and E – 12 indicates an optimum maturation level of a good hydrocarbon source rock potential.

Key words: Hydrocarbon; maturation; oil window; palynology; source rock

INTRODUCTION

Source rocks are generally organic rich fine grained sediments that are naturally capable of generating and releasing hydrocarbons in amounts to form commercial accumulations (Hunt, 1996). Major parameters controlling the generation of hydrocarbons are the type and amount of organic matter in the potential source rock and its organic maturation level. Colour variation of spores and pollen is considered as a function of sedimentary environment and thermal alteration. Pross *et al*., (2007) reported that temperature – dependent colour change of sporomorphs provides a promising alternative method for deciphering thermal alteration. The fact that the measurements are made on organic particles that are integral part of the hydrocarbon – sourcing kerogen rather than on potentially unrelated particles from bulk samples highlights the relevance of sporomorph colour analysis for hydrocarbon exploration

(Pross *et al* ., 2007). In addition, sporomorph colour variations are particularly sensitive in the lower range of thermal maturation where they can yield more precise information than vitrinite reflectance values (Pross *et al*., 2007). Techniques used to interpret past thermal history of particulate organic matter include: palynomorph colour, spore translucency, vitrinite reflectance, and fluorescence microscopy. However, most of these approaches require advanced equipments and relatively expensive analytical techniques. In the present study (Figure 1), less expensive, simple effective and globally accepted thermal alteration index (TAI) is applied using the changes in spore colour with depth. TAI (1 – 5 scale) values were determined by comparing the spore colour (Figures.2 – 3) with the spore colour chart of Staplin (1969), Staplin (1977) and Staplin (1982).

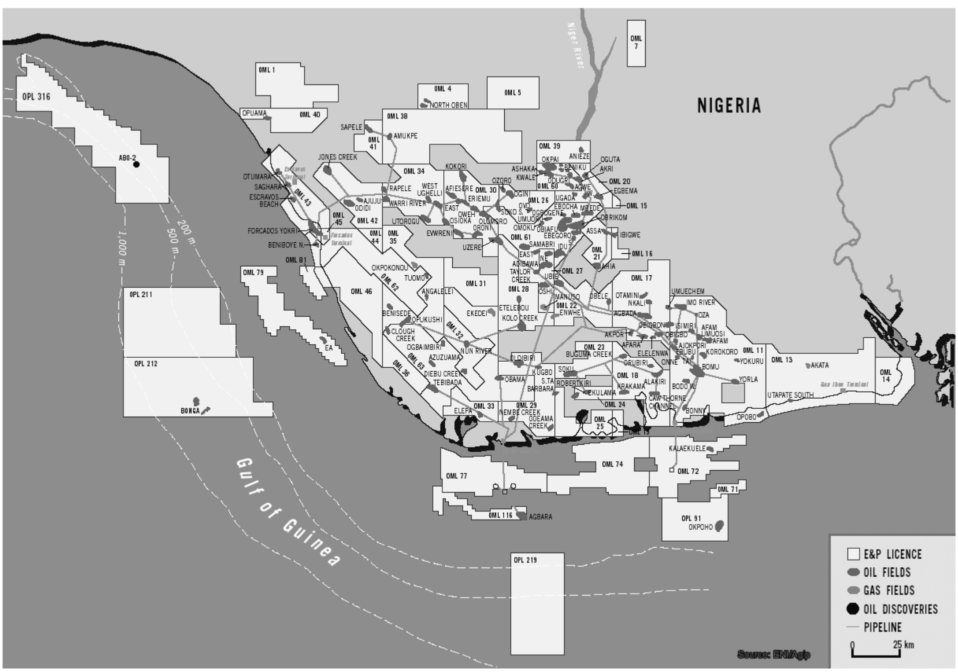


Fig. 1: Map of Niger delta showing the location of the studied wells.

GEOLOGICAL SETTING

Basin formation began in the early Cretaceous with the formation of the Benue Abakaliki Trough as a failed arm of a rift triple junction associated with the separation of the Africa and South America continents and subsequent opening of the South Atlantic. The three arms of the systems opened up at different times and different rates. In the South Atlantic, the opening started in the mid-Aptian by crustal stretching and down warping. (Evamy *et al*., 1978).The Benue Abakaliki trough filled with sediments later underwent folding, faulting and uplift with subsidence of the adjacent

Anambra platform to the west and Afikpo syncline to the east during the Santonian. The Basin flank basement adjorning the Anambra basin was then invaded by the sea floor for the first time (Whiteman, 1982).Uplift of the Benin and Calabar flanks in the Eocene initiated the growth of the present Delta. This led to the merging of the Niger, Benue and Cross river delta system in mid Miocene and a progressive out building of the Delta along a single wide front (Murat, 1972). Stratigraphically, it is made of three stratigraphic units; Akata, Agbada and Benin formations. Akata formation is of marine origin and it is composed of thick shale sequences (potential source rock). Weber & Daukoru (1975) reported that the Akata formation was formed during lowstands when terrestrial organic matter and clays were transported to deep water areas characterized by low energy conditions and oxygen deficiency. Overlying Agbada formation consist of turbidite sand (potential reservoirs in deep water) and minor amounts of clay and silt. It is the major petroleum bearing unit. The Agbada formation is overlain by the Benin formation, a continental latest Eocene to recent deposit of alluvial and upper coastal plain sands that are up to 2000 meters thick (Weber & Daukoru, 1975).

METHOD OF STUDY

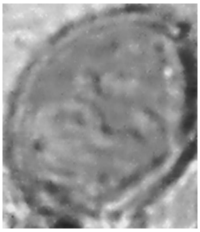
A total of 45 ditch cuttings samples (shales and sandstones) collected from stratigraphic intervals of ANL-1 and E-12 well were processed as adopted in previous works of Odedede (2013). The slides were examined using a light microscope equipped with a digital camera to photograph important palynomorph. Palynomorphs taxonomy was in accordance with Evamy *et al.,* (1978) and Jandu Chene *et al.,* (1978). Photographs of selected palynomorphs were taken with a digital camera (Fig.2 -3). Thermal alteration index (TAI) was determined for the studied area using the changes in spore colour with depth and TAI values were determined by comparing the spore colour with the spore colour chart of Staplin (1969), Staplin (1977) and Staplin (1982). Results of microscopic analysis for thermal alteration indices, using spore colouration, from the studied section are presented in Table 1 - 2.

Table 1. Assessment of thermal alteration index based on colour of spores/pollen and thermal maturation level in the E - 12 well

Formation	Depth	Spore colour	TAI	Thermal Maturation
Benin Formation	681	Pale Yellow	1.5	Immature
	924			
	942			
	1104			
	1176			
Agbada Formation	1230	Amber yellow	1.7	
	1266			
	1338			
	1482			
	1590			
	1608			
	1698			
	1752			
	1770			
	1932	Yellowish brown	2.8	Mature
	2022			
	2094			
	2130			
	2148			
	2238			
	2410	Orange – Deep brown	3.0	
	2490			
	2580			
	2603			

Table 2. Assessment of thermal alteration based on colour of spores /pollen and thermal maturation in the ANL - I

Formation	Depth (m)	Spore colour	TAI	Thermal Maturation
Benin Formation	216	Pale yellow	1.3	Immature
	324			
	720			
	900			
	1107			
	1557			
	1701			
	1773			
Agbada Formation	1863	Orange	2.7	Mature
	1881			
	1971			
	1989			
	2043			
	2079			
	2556			
	2583	Orange yellowish brown	3.0	
	2799			
	3177			
	3231			
	3645			
	3663			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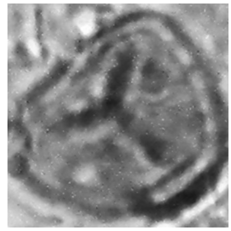
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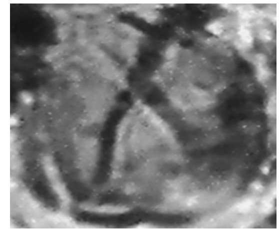
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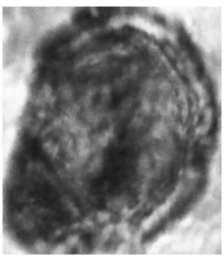
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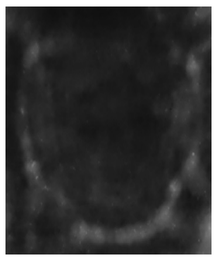
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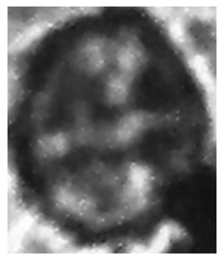
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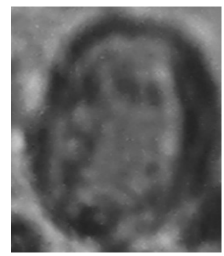
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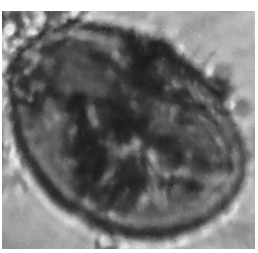
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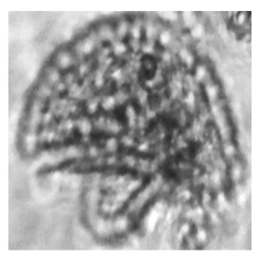
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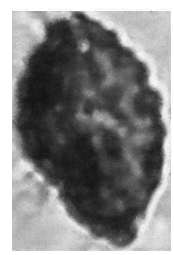
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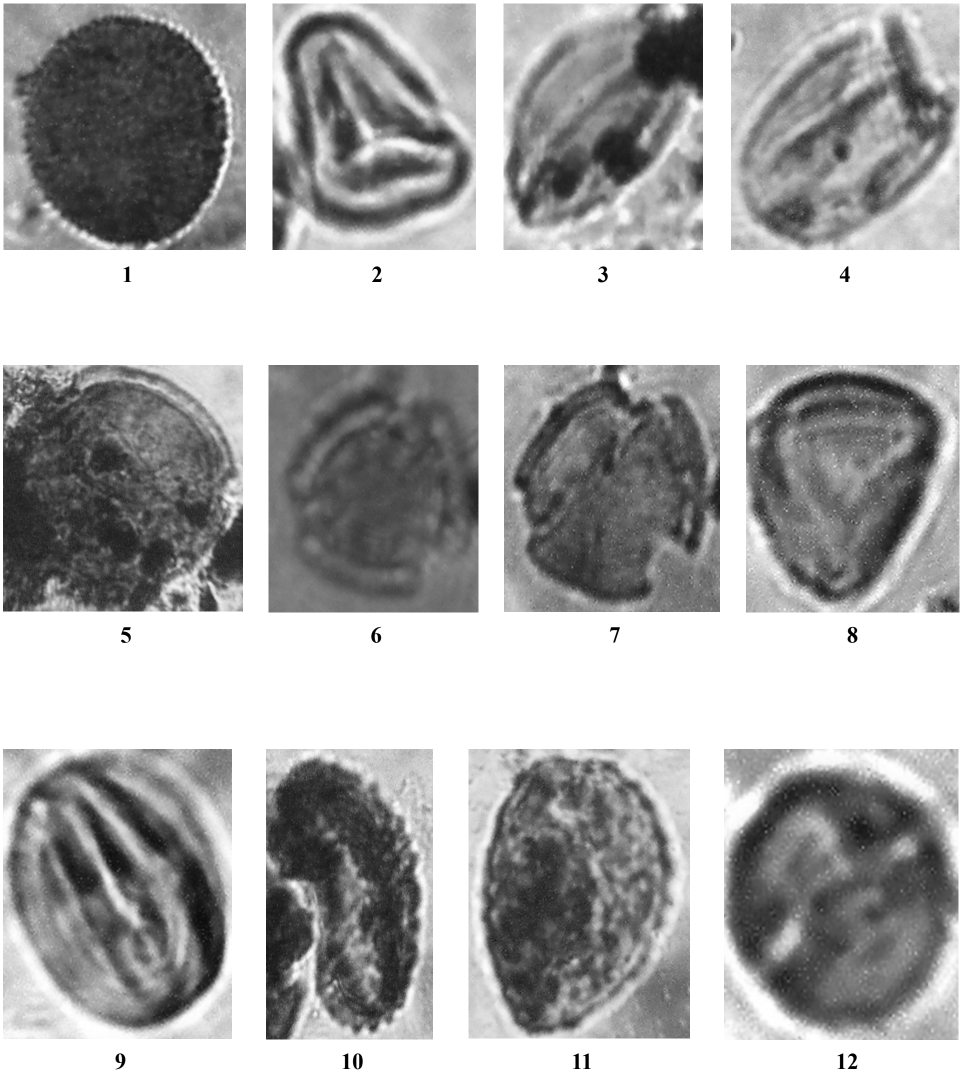
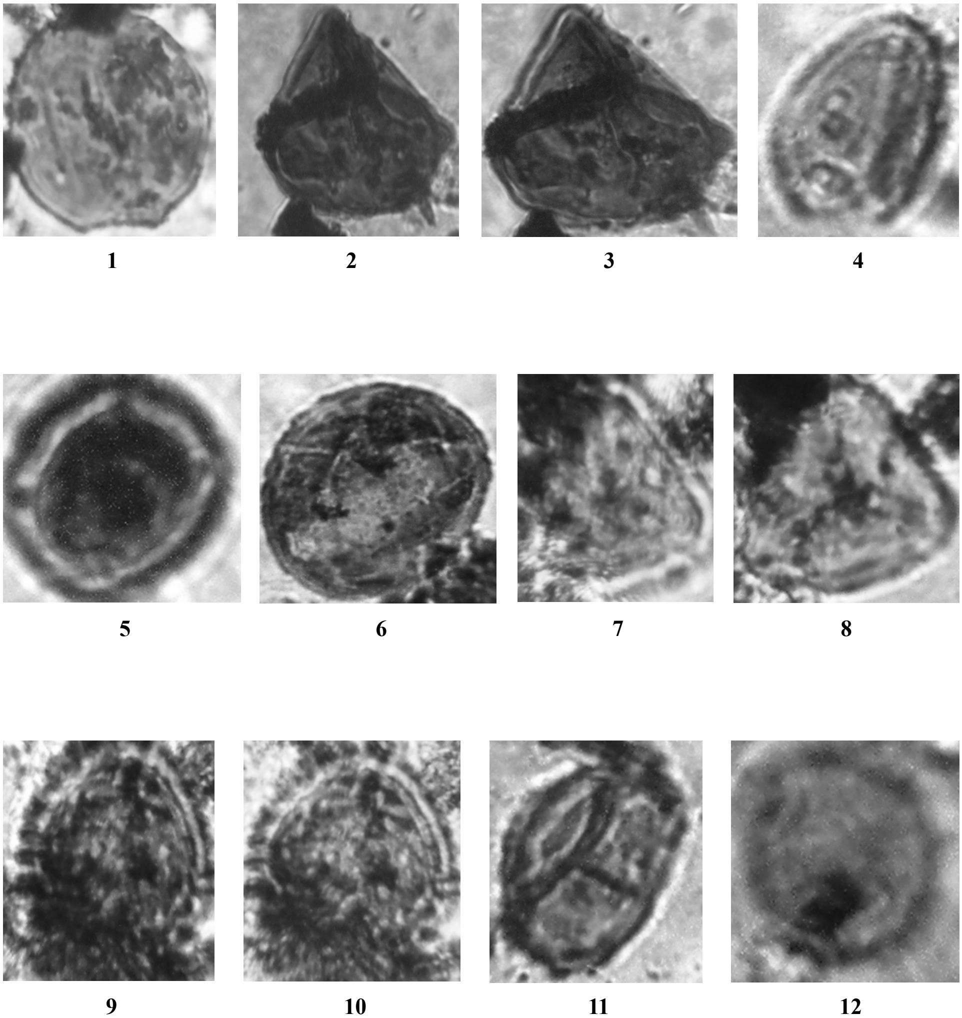
1. Laevigatosporites sp.
2. 3. Leiotriletes sp.
4. Monoporites annulatus
5. 6. Pachydermites diederixi
7. Poluspissusites digitatus
8. Psilatricolporites sp.
9. 10. Tricolpites sp.
11. Verritricolporites rotundiporus
12. Verrucatosporites usmensis

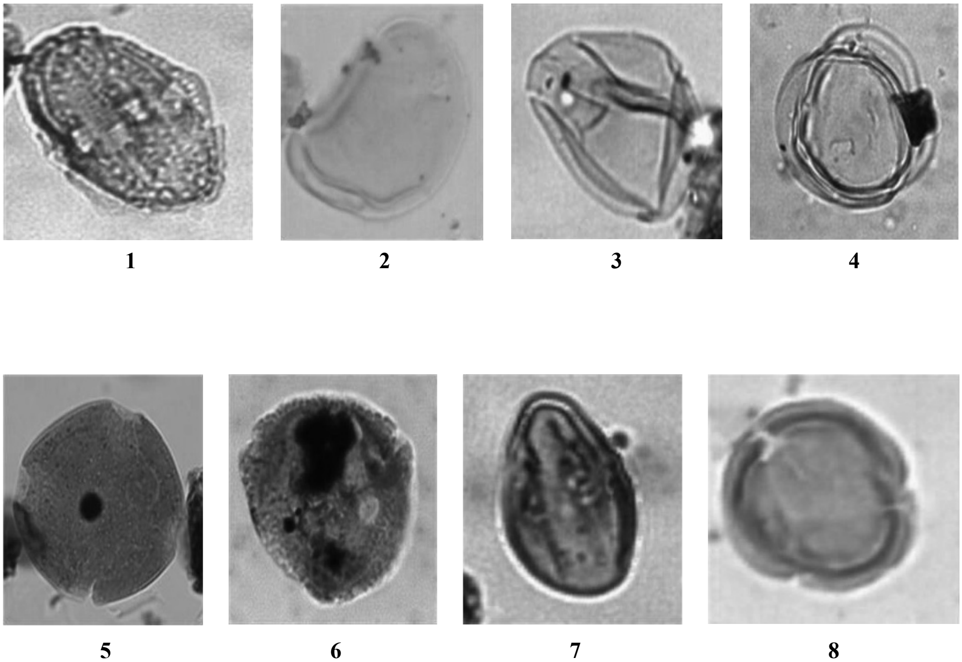


1. Croton type
2. Leiotriletes sp.
3. 4. Monoporites annulatus
5. Pachydermites diederixi
6. 7. Psilatricolpites sp.
8. Syncolporites sp.
9. Tricolporites sp.
10. Verrucatosporites usmensis
11. Verrutricolporites rotundiporus
12. Zonocostites ramonae



1. Ctenolophonidites sp.
2. 3. Crassoretitriletes vanraadshooveni
4. Monocolpites marginatus
5. Pachydermites diederixi
6. Psilatricolporites crassus
7. 8. Pteris sp.
9. 10. Retitricolporites sp.
11. Steriosporites sp.
12. Triporites sp.

Fig. 2. Photomicrographs of some characteristic palynomorphs associated with E – 12, Niger delta basin



1. Belskipollis elegans
2. Laevigatosporites sp.
3. Monoporites annulatus
4. Nymphaepollis clarus
5. Pachydermites diederixi
6. Retibrevitricolporites obodoensis
7. Sapotaceoidaepollenites sp.
8. Zonocostites ramonae

Fig. 3. Photomicrographs of some characteristic palynomorphs associated with ANL Well - 1, Niger delta

DISCUSSION

Results of palynological analysis for thermal alteration indices, using spore colouration, from the studied section are presented in Table 1 - 2. In the E -12 well, the lower Agbada formation is thermally mature (TAI 2.8; 1932 – 2238 m and TAI 3.0; 2410 -2603 m), showing top of oil window and intense generation of liquid hydrocarbon while the upper part (TAI 1.7; 1230 – 1770 m) and the overlying Benin Fm (TAI 1.5; 681 – 1176 m) are thermally immature. Immature (TAI 1.3) thermal facies is determined for depths: 216 – 1773 m (Benin formation) in the ANL -1 well, while, mature (TAI 2.7) thermal facies is determined for depths: 1863 – 2556 m and TAI 3.0 for depths 2583 - 3663 m) (Agbada formation) in the ANL – 1well. Shale of the lower part of Agbada formation in the ANL – 1 and E-12 indicates an optimum maturation level of a good hydrocarbon source rock potential. These interpretations are consistent with the work of Saxby (1982). Saxby (1982) suggested that yellow to orange spore colours represent the breakdown of carboxyl groups in acids and esters, brown corresponds to oil evolution and black occurs at the point where aliphatic and aromatic carbons break to form methane. The present study lends support to these interpretations.

CONCLUSIONS

- Effective source rocks with oil prone capabilities have been observed in E-12 well between 1932 – 2603 m and 1863 – 3663 m in the ANL -1 well.
- Thermally immature sediments occur between 1230 – 1770 m, 681 – 1176 m in the E -12 and 216 – 1773 m in ANL -1 wells respectively.
- Shale of the lower and upper part of Agbada formation in the ANL -1 and shale of the lower part of Agbada formation in the E -12 indicates an optimum maturation level of a good hydrocarbon source rock potential.
- Overall, source rock palynological study indicates that a significant amount of hydrocarbon may have been generated by the mature sections.

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