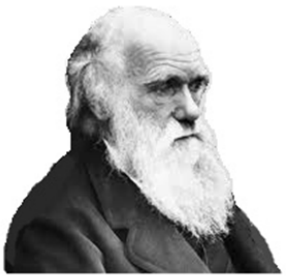
Available online at www.worldnewsnaturalsciences.com



World News of Natural Sciences

An International Scientific Journal

WNOFNS 19 (2018) 142-154 EISSN 2543-5426

Visual Kerogen Study of the Campano-Maastrichtian Nkporo Group of Anambra Basin, Southeastern Nigeria

K. C. Chiadikobi* and **O. I. Chiaghanam**

Department of Geology, Chukwuemeka Odumegwu Ojukwu University, Uli, Anambra State, Nigeria

*E-mail addres: kinsomino@yahoo.com

ABSTRACT

In this work, phytoclasts, opaques, Amorphous Organic Matter (AOM) and palynomorphs of the Nkporo group underwent Visual Kerogen analysis. Herein, the average percent counts of phytoclasts are about 42.08%, opaques are about 34.54%, Amorphous Organic Matter (AOM) is about 16.34% and Palynomorphs are about 7.08%. The highest number of percent counts produced is found in the phytoclasts (the value of 42.08% indicating Type III kerogen and Gas Prone) and Amorphous Organic Matter (AOM) (the value of which - 34.54% - indicates Oil/Gas Prone). Thus, from the results of the visual kerogen, in the Nkporo Group, the source rock is of Type III kerogen, which is gas prone, and also Type II/III, which is Oil/Gas prone.

***Keywords*:** Kerogen, Nkporo Formation, Phytoclasts, Palynmorphs, Amorphous Organic Matter

1. INTRODUCTION

The stratigraphic history of Anambra basin shows that the Nkporo Group comprises of the Campanian to Maastrichtian Enugu/Nkporo/Owelli Formations (Fig. 1). This is succeded by the Maastrichtian Mamu and Ajali Formations. The sequence is capped by the tertiary Nsukka Formation and Imo Shale (Fig. 2). The petroleum geology, biostratigraphy and peleoenvironmental description of Anambra basin have been carried out by many authors (Agagu et al. 1985; Ojo et al. 2009; Petters, 1978; Reijers, 1996; Chiaghanam, et al. 2013a; Chiaghanam, et al. 2013b).

(Received 07 July 2018; Accepted 19 July 2018; Date of Publication 20 July 2018)

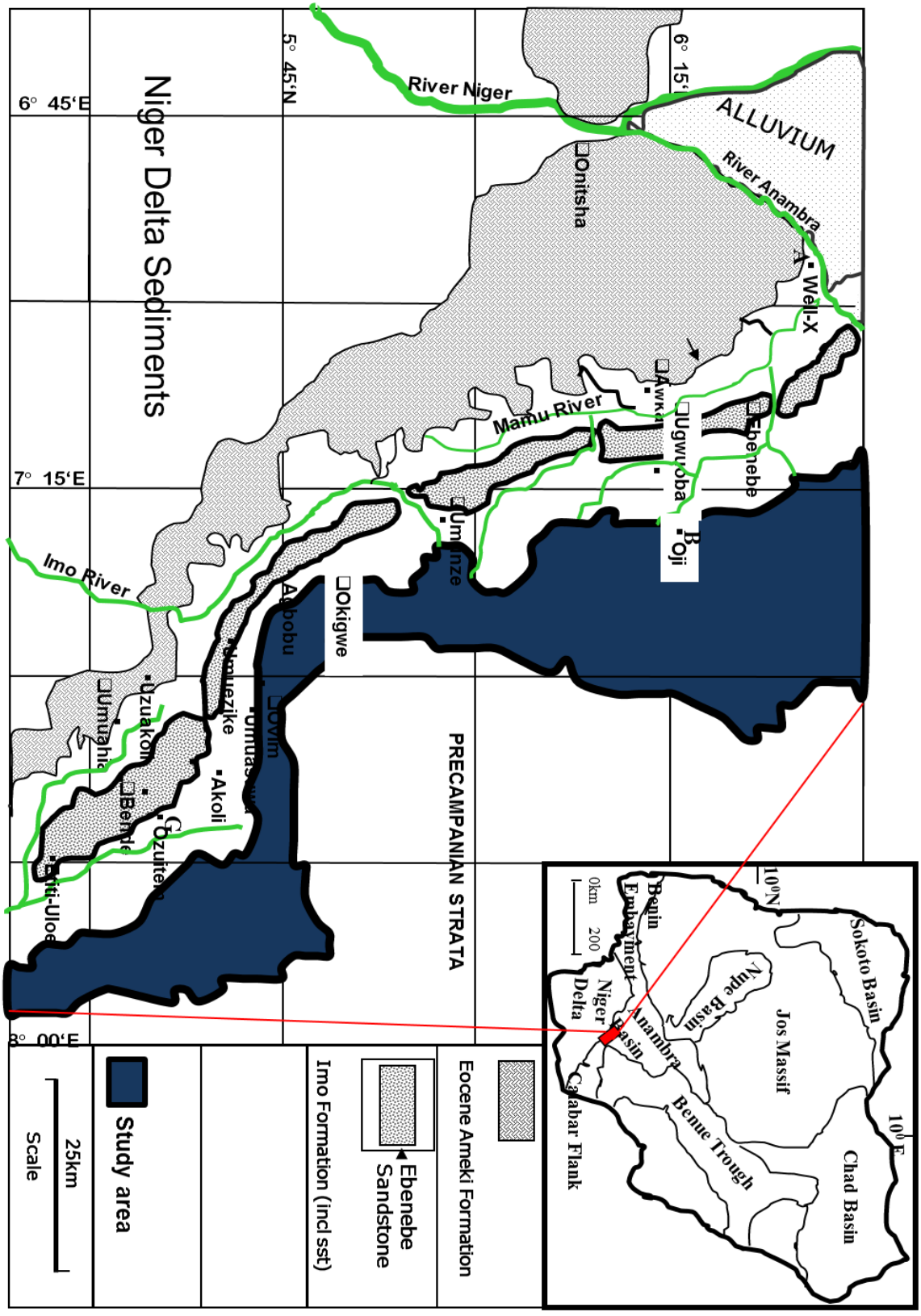


Fig. 1. Geologic Map showing the Study Area

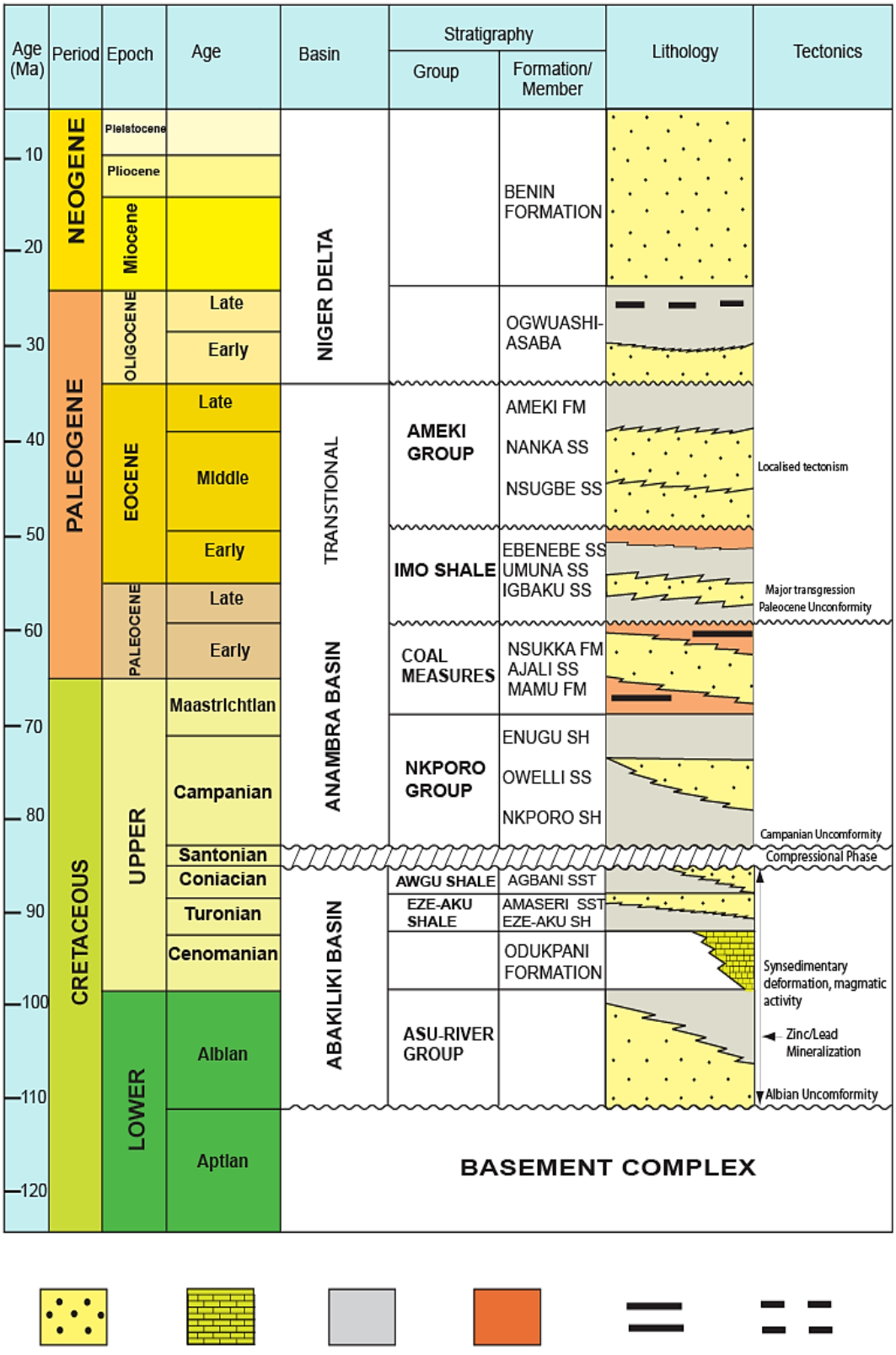


Fig. 2. Stratigraphic Succession of the Southeastern Nigeria showing the Study Area (Ekwenye and Nichols, 2016)

Agagu and Ekweozor, 1982 shows that the Awgu and Nkporo Formations constitute the main source and seal rocks in the Anambra Basin. Ekweozor and Gormy, 1983 described the Nkporo Formation as an example of a marine source rock composed of type II/III kerogens with low but consistent contribution from marine organic matter. Unomah and Ekweozor, 1993 reported that the organic facies of the Nkporo Formation are provincial with the Calabar Flank having the highest oil potential while those in the Anambra Basin and Afikpo Syncline are gas prone.

Chiaghanam et al. 2012; Chiaghanam et al. 2013a use the application of Sequence stratigraphy, palynological analysis and Lithofacies to describe the hydrocarbon potential of Campanian- Maastrichtian in the Anambra Basin. Odunze and Obi, 2013 also describe the hydrocarbon potential of the Nkporo Group (Campanian- Maastrichtian) in Anambra Basin. This paper attempts to determine the type of the organic matter and the thermal maturity of the source rocks in the Nkporo Group.

2. METHODOLOGY

25 kerogen slides were prepared, one for each sample, for their hydrocarbon source rock potential. Each slide was examined using the transmitted light microscopy at x10 , 40, and x60 magnifications in order to make a qualitative as well as a quantitative analysis of the particulate organic matter (POM), determination of the palynofacies and kerogen types, determination of spore /pollen colouration, and estimate the Thermal Alteration Index (TAI), Vitrinite Reflectance (Ro %) and organic thermal maturation (Fig. 3, Table 1).

Table 1. Batten's scale for palynomorph colours (Modified from Traverse, 1994)

Observed colour of palynomorph	Significance
1- Colourless, pale yellow, yellowish orange	Chemical change negligible; organic matter immature,
2- Yellow	Some chemical change, but organic matter still immature.
3- Light brownish yellow, yellowish orange	Some chemical change, marginally mature but not likely to have potential as a commercial source.
4- Light medium brown	Mature, active volatilization, oil generation.
5- Dark brown	Mature, production of wet gas and condensate, transition to dry gas phase.
6- Very dark brown-black	Overmature; source potential for dry gas.
7- Black (opaque)	Traces of dry gas only.

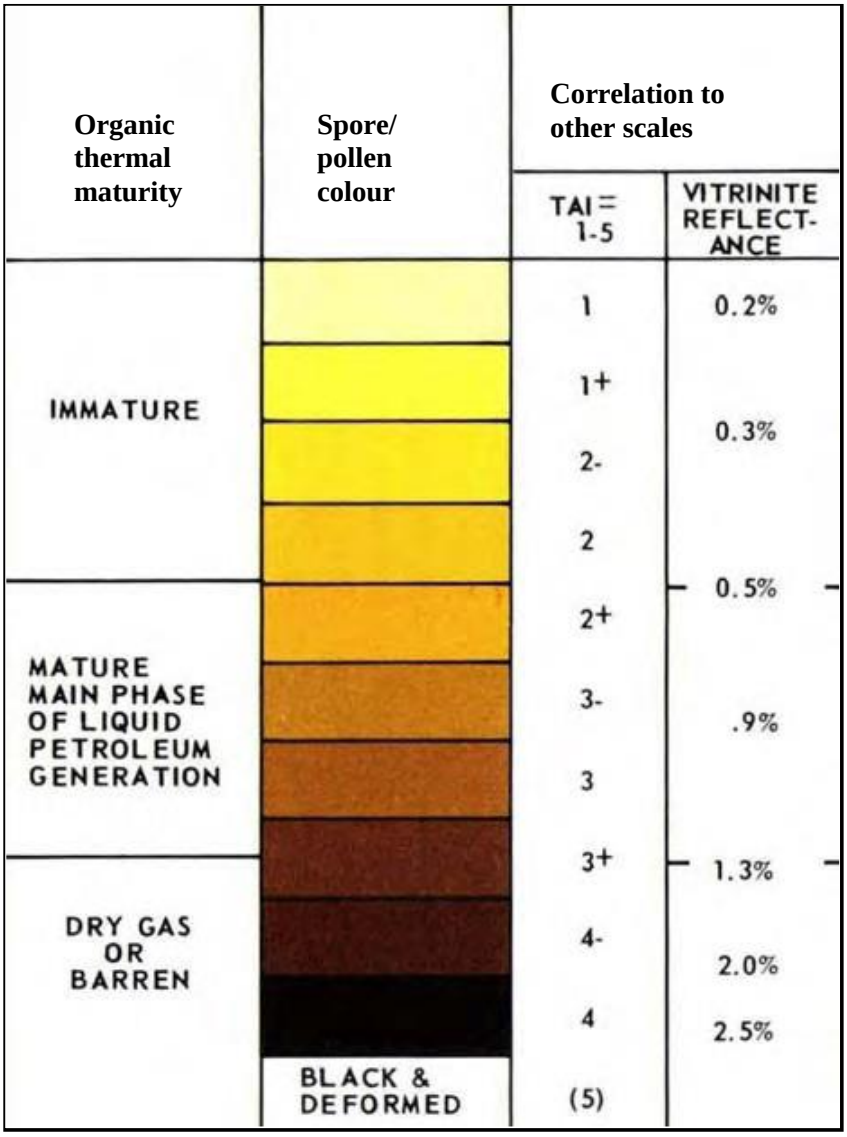


Fig. 3. Pearson's colour chart compared with organic thermal maturity, TAI and vitrinite reflectance (Modified from Traverse, 1994).

Each slide was counted for its (POM) content, in which the first 200 particles were counted in terms of *abundant* (<35 %), *frequent* (16-35 %), *common* (5-15 %) and *rare* (>5 %) (Ibrahim *et al.*, 1997; Chiaghanam *et al.*, 2013b). In the present study, kerogen assemblages are categorized into four main groups similar to those identified by Ibrahim, *et al.* (1997).

These include:

- *Phytoclasts*, refer to all structured yellow to brown colour dispersed clay- to fine sand sized particles of plant derived kerogen other than palynomorphs.
- *Opaques*, refer to all structured brownish black to black colour oxidized or carbonized particles of plant derived kerogen.

- *Amorphous Organic Matter* (AOM) refers to all structureless dispersed clay- to fine sand sized particles of plant derived kerogen.
- *Palynomorphs*, refer to all structured HCl and HF resistant organic-walled microfossils.

3. RESULTS AND DISCUSSION

The classification of dispersed kerogen constituents is based primarily on their appearance, in an unoxidized state, using transmitted light with ancillary observation employing reflected fluorescent and ultraviolet methods. However, sample processing schemes are not standardized between studies. This makes comparison between studies difficult unless applied to strata of the same age from the same basin. Classification and processing procedures are under scrutiny for standardization, and quantitative measurements are being assessed using optical scanners.

Twenty-five (25) samples were analyzed from the Nkporo Group (Nkporo Formation and Enugu Shale) based on visual kerogen and the result are presented below (Table 2a and b). Visual Kerogen analysis was classified on the basis of *Phytoclasts*, *Opaques*, *Amorphous Organic Matter* (AOM) and *Palynomorphs.* The Nkporo Formtion samples has average percent counts of phytoclast of 45%, that of Opaques is about 33.11%, Amorphous Organic Matter (AOM) is about 14.08% and Palynomorphs is about 7.06% (Table 2a). This is confirmed by the histogram and area plots showing the abundance of various classes of visual kerogen of Nkporo Formation samples (Figs. 4a and 5a). The highest number of percent counts produced is the phytoclast having the value of 45% which indicates Type III kerogen (Gas Prone).

Table 2a. Results of Visual Kerogen Analysis showing the percent counts of Phytoclast, AOM, Opaques and Palynomorphs of Nkporo Formtion Samples

SAMPLE NO.	PHYTOCLAST (%)	AOM (%)	OPAQUES (%)	PALYNOMORPHS (%)
NKP/01/001	35	15	40	10
NKP/03/002	60	10	25	5
NKP/04/001	55	15	22.5	7.5
NKP/LST/05/002	28	22	45.5	4.5
NKP/06/001	62.5	7	20	10.5
NKP/07/002	57	12	22	9
NKP/08/001	65	10	20	5
NKP/09/002	60	5	20	15

NKP/10/001	40	5	50	5
NKP/12/001	45	30	20	5
NKP/13/001	40	30	25	5
NKP/14/002	50	10	35	5
NKP/15/001	40.5	8.5	45	6
NKP/16/002	25.5	25	45	4.5
NKP/16/004	35	20	40	5
NKP/16/008	40	15.5	35.5	9
NKP/17/001	35	8.5	50.5	6
NKP/17/003	30	5	55	10
Average	45	14.08	33.11	7.06

The Enugu Shale samples has average percent counts of phytoclast of 35.50%, that of Opaques is about 35.35%, Amorphous Organic Matter (AOM) is about 22.14% and Palynomorphs is about 7.14% (Table 3b). This is confirmed by the histogram and area plots showing the abundance of various classes of visual kerogen in Enugu Shale sample (Figs.4b and 5b). The percentage counts between the pyhtoclast and Amorphous Organic Matter (AOM) are the same which indicate Oil/Gas Prone. The results of the visual kerogen done for Nkporo Formaton and Enugu Shale show that the source rock is of Type III kerogen which is gas prone and also Type II/III which is Oil/Gas prone respectively (Table 3).

Table 2b: Results of Visual Kerogen Analysis showing the percent counts of Phytoclast, AOM, Opaques and Palynomorphs of Enugu Shale Samples

SAMPLE NO.	PHYTOCLAST (%)	AOM (%)	OPAQUES (%)	PALYNOMORPHS (%)
ENU/20/001	**45**	**15**	**25**	**15**
ENU/21/003	**55**	**10**	**25.5**	**9.5**
ENU/22/001	**60**	**5**	**30**	**5**
ENU/23/001	**15**	**50**	**30**	**5**
ENU/24/001	**18.5**	**40**	**35**	**7.5**
ENU/25/001	**30**	**25**	**42**	**3**

ENU/27/001	25	10	60	5
Average	35.50	22.14	35.35	7.14

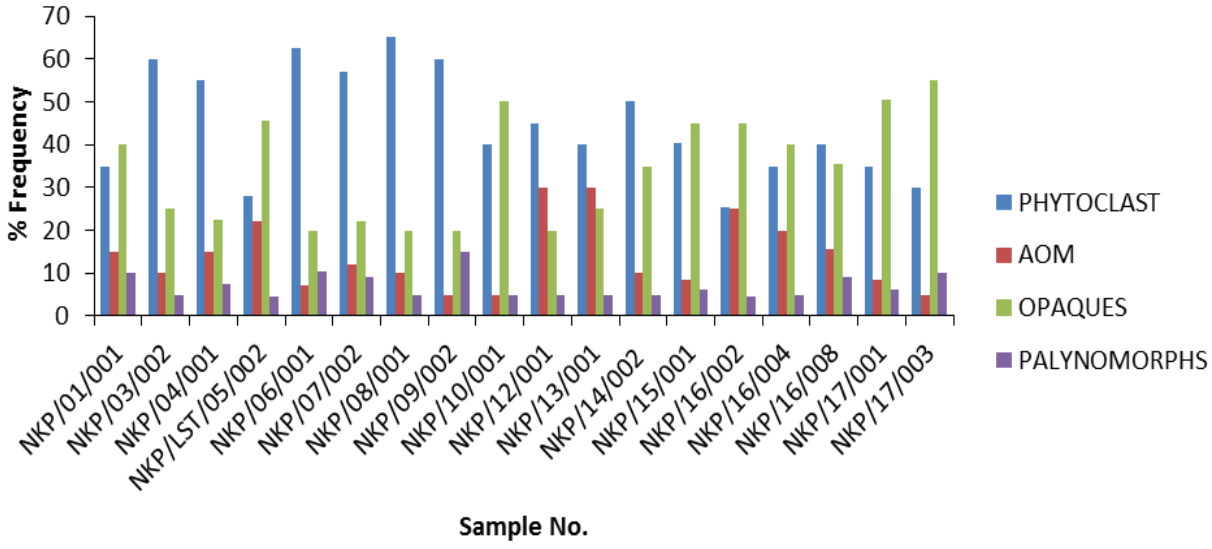


Fig. 4a. Histogram showing the comparism of source rock samples and their percent counts between the Phytoclast, AOM, Opaques and Palynomorphs of the Nkporo Formation samples

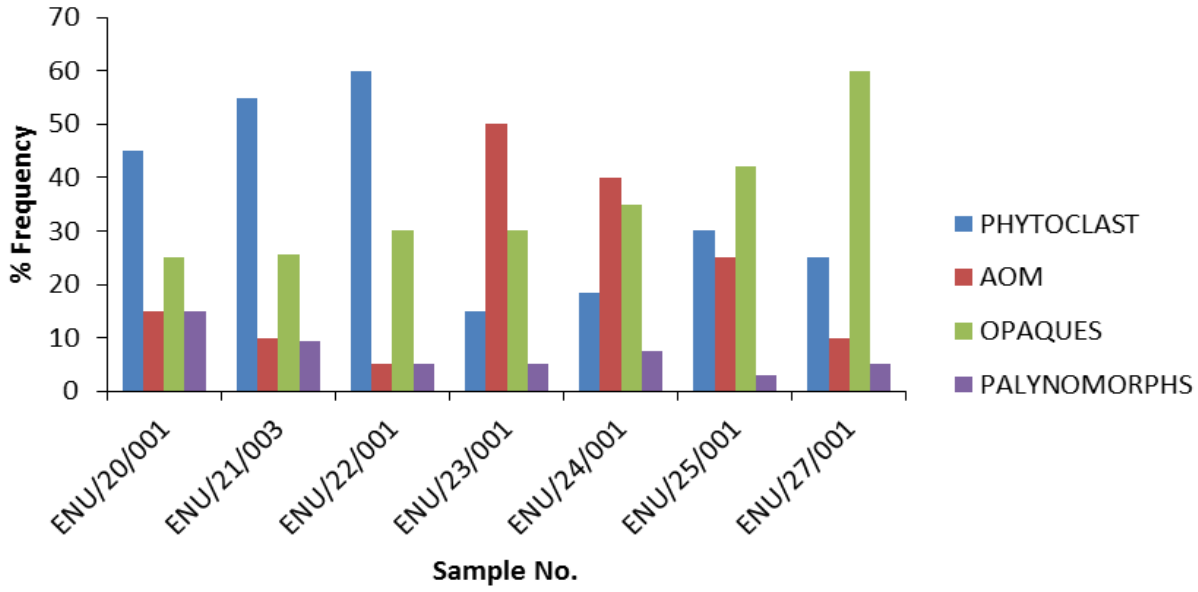


Fig. 4b. Histogram showing the comparism of source rock samples and their percent counts between the Phytoclast, AOM, Opaques and Palynomorphs of the Enugu Shale samples

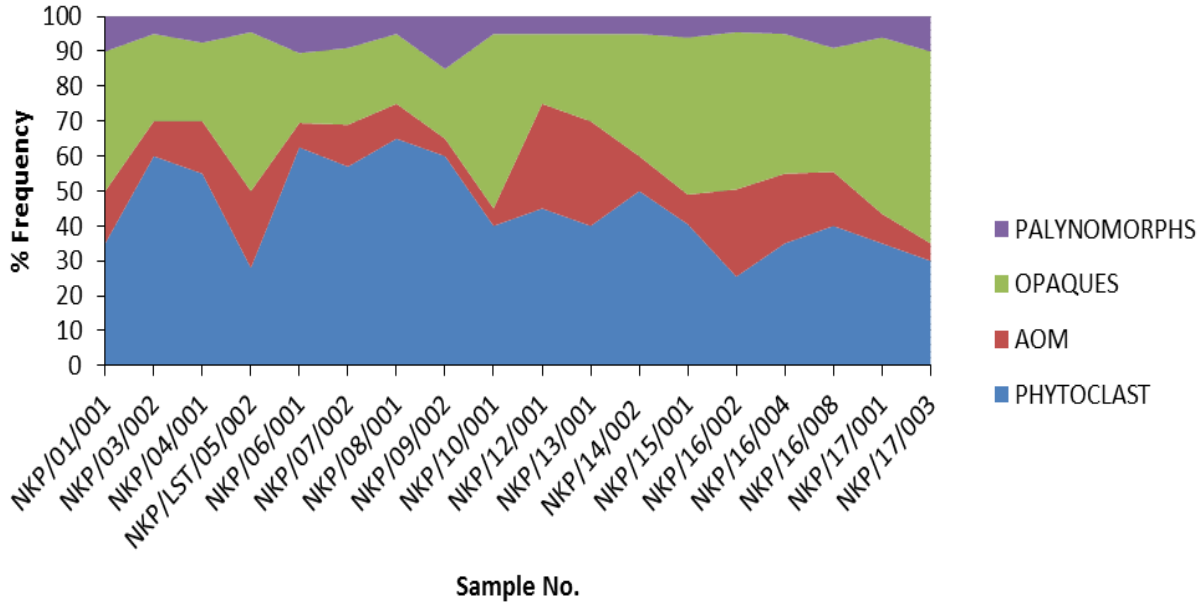


Fig. 5a. Area graph showing their percent counts between the Phytoclast, AOM, Opaques and Palynomorphs of the source rock samples of the Nkporo Formation samples

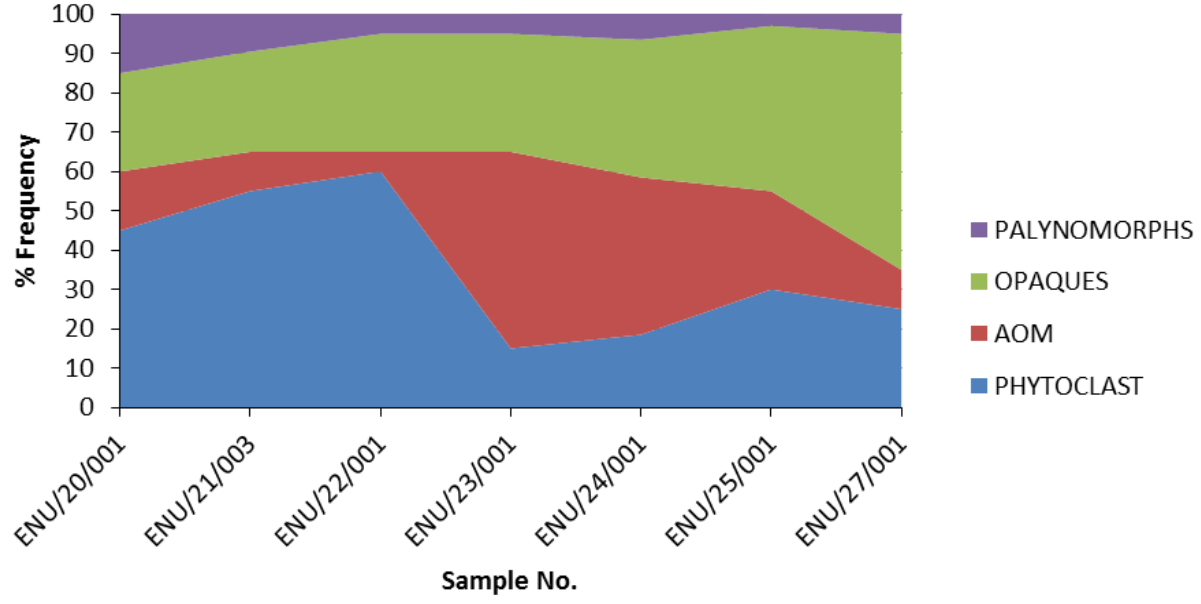


Fig. 5a. Area graph showing their percent counts between the Phytoclast, AOM, Opaques and Palynomorphs of the source rock samples of the Enugu Shale samples

Table 3. Summary of the Kerogen Optical Assessment and Interpretation of Nkporo Formation and Enugu Shale samples

SAMPLE NO.	PALYNOFACIES ASSOCIATION	S/P COLOUR	THERMAL ALTERATION INDEX (TAI)	VITRINTE REFLECTANCE (Ro %)	THERMAL MATURATION	KEROGEN TYPE	SOURCE ROCK POTENTIAL
NKP/03/002 NKP/04/001 NKP/06/001 NKP/07/001 NKP/08/001 NKP/09/001 NKP/14/001 ENU/20/001 ENU/21/003 ENU/22/001	Mostly phytoclast followed by opaque debris	Colourless to Pale yellow	1 to +1	0.2% to 0.3%	Immature	Type III	Gas Prone
NKP/01/001 NKP/LST/05/002 NKP/10/001 NKP/15/001 NKP/16/002 NKP/16/004 NKP/17/001 NKP/17/003 ENU/27/001	Mostly opaque followed by phytoclast debris						
NKP/12/001 NKP/13/001 NKP/16/008 ENU/23/001 ENU/24/001 ENU/25/001	Mostly AOM followed by opaque debris					Type II/ III	Oil - Gas Prone

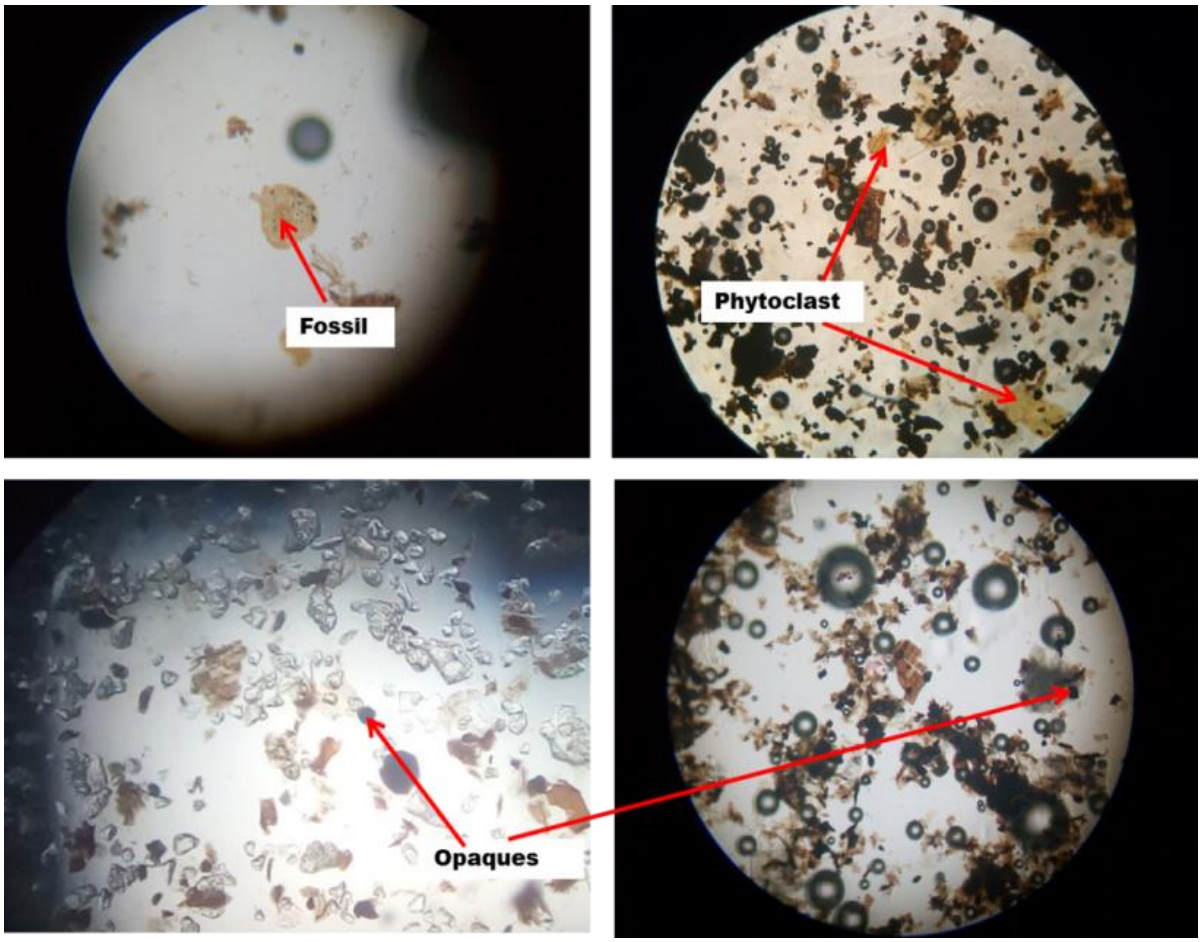


Fig. 6. Photomicrographs of the kerogen slides showing the various particulate organic matter (POM) of Nkporo Formation and Enugu Shale

4. CONCLUSIONS

Visual Kerogen analysis were classified on the basis of Phytoclasts, Opaques, Amorphous Organic Matter (AOM) and Palynomorphs.The average percent counts of phytoclast is about 42.08%, that of Opaques is about 34.54%, Amorphous Organic Matter (AOM) is about 16.34% and Palynomorphs is about 7.08%. The highest number of percent counts produced is the phytoclast having the value of 42.08% which indicates Type III kerogen (Gas Prone) and Amorphous Organic Matter (AOM) having the value of 34.54% which indicate Oil/Gas Prone; i.e the results of the visual kerogen, the Nkporo Formation shows that the source rock is of Type III kerogen which is gas prone while that of Enugu Shale is of Type II/III which is Oil/Gas prone.

Biography

Chiadikobi, K.C. is currently pursuing doctoral degree in Petroleum Geology at Nnamdi Azikiwe University, Awka, Nigeria. He is a Lecturer in Chukwuemeka Odumegwu Ojukwu University, Uli, Anambra State, Nigeria.
Email: kinsomino@yahoo.com

Chiaghanam, O.I. is a Ph.D holder in Stratigraphy/Sedimentary Geology in Nnamdi Azikiwe University, Nigeria. He is a Professor of Geology in Chukwuemeka Odumegwu Ojukwu University, Uli, Anambra State, Nigeria.
Email: oichiaghanam@yahoo.com

References

[1] O.K. Agagu and C.M. Ekweozor, Source Rock characteristics of Senonian Shales in the Anambra Syncline, Southern Nigeria. *Journal of Mining and Geology* 19 (1982) 52-61

[2] O.K. Agagu, E.A. Fayose, and S.W. Petters, Stratigraphy and Sedimentation in the Senonian Anambra Basin of SE Nigeria. *Journal of Mining and Geology* 22 (1985) 25-35

[3] O.I. Chiaghanam, O.N. Ikegwuonu, K.C. Chiadikobi, K.K. Nwozor, A.E. Ofoma and A.O. Omoboriowo, Sequence Stratigraphy and Palynological Analysis of late Campanian to Maastrichtian Sediments in the Upper-Cretaceous, Anambra Basin. A Case Study of Okigwe and its Environs, South-Eastern, Nigeria. *Advances in Applied Science Research*, 3 (2012) 964

[4] O.I. Chiaghanam, K.K. Nwozor, K.C. Chiadikobi, A.O. Omoboriowo, C.G. Soronnadi-Ononiwu, L.N. Onuba, and A.E. Ofoma, Lithofacies, Palynology and Paleoenvironmental Study of Early Campanian to Mid-Maastrichtian deposits of Udi and Environs in the Anambra Basin, South Eastern, Nigeria. *International Jornal of Science and Technology*, 2 (2013a) 6, 453-470.

[5] O.I. Chiaghanam, K.C. Chiadikobi, O.N. Ikegwuonu,, A.O. Omoboriowo, O.C. Onyemesili and E.J. Acra, Palynofacies and Kerogen Analysis of Cretaceous (Early Campanian –Maastrichtian) Enugu Shale and Mamu Formations in Anambra Basin, Southeastern Nigeria. *International Journal of Scientific & Technology Research*, 2 (2013b) 8, 225-229.

[6] C.M. Ekweozor, and J.R. Gormy, Petroleum Geochemistry of the Early Tertiary Shales Penetrated by the Akwakwa -2 well in the Anambra Basin Southern Nigeria. *Journal of Petroleum Geology* 6 (1983) 207-216.

[7] M.I.A. Ibrahim, N.M. Abul Ela and S.E. Kholeif, Paleoecology, Palynofacies, thermal maturation and hydrocarbon source-rock potential of the Jurassic-Lower Cretaceous Sequence in the subsurface of the North Eastern Desert, Egypt. *Qatar University Science Journal*, 17 (1997) 1, 153-172.

[8] S.O. Odunze and G.C. Obi, Sedimentology and Sequence Stratigraphy of the Nkporo Group (Campanian to Maastrichtian) Anambra Basin, Nigeria. *Journal of Paleogeography*, Vol. 2 (2013) 192-208

[9] O.J. Ojo, O.A. Kolawole and S.O. Akande, Depositional Environments, organic pictures and petroleum generating potential of the Campanian to Maastrichtian Enugu Formation, Anambra Basin Nigeria. *The Pacific Journal of Science and Technology* 1 (2009) 614-628.

[10] D.L. Pearson, Pollen/Spore Color ―Standard, Version 2. Phillips Petroleum Company privately distributed (1984).

[11] S.W. Petters, Stratigraphic Evolution of the Benue Trough and its implications for the Upper Cretaceous Paleogeography of West Africa. *Journal of Geology* 86 (1978) 311-322.

[12] J.J.A. Reijers, Sedimentary geology and Sequence Stratigraphy in Nigeria and three case studies and a field guide: selected chapters In geology: Shell Petroleum Development of Nigeria corporate reprographics servile Warri 197 (1996).

[13] Traverse, Sedimentation of organic particles: Cambridge, Cambridge University Press, 547 (1994).

[14] G.I. Unomah, and C.M. Ekweozor, Petroleum Source Rock Assesment of the Campanian Nkporo Shale Lower Benue Trough Nigeria. *Nigeria Association of Petroleum Explorationists Bulletin*, 8 (1993) 172-186