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Research Article

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Optical Geochemistry of Source Rock Samples from the Niger Delta Basin

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Abstract Optical geochemistry studies were carried out on source rock samples from Greater Ughelli depobelt, Central Swamp and Coastal Swamp depobelt via transmitted microscopy and fluorescent light analysis. Samples showed decrease in occurrence of phytoclast materials from the Greater Ughelli depobelt to the Coastal Swamp depobelt which infers increasing occurrence of oil/gas prone organic matter from Greater Ughelli to Central Swamp depobelt.

Keywords optical geochemistry, phytoclast, cuticle, depobelt, Niger delta, Microscopy

1. Introduction

Optical geochemistry is the study of organic matter that had been embedded in the rock matrix via microscopy as transmitted or reflective microscopy (Tyson, 1995). Transmitted microscopy entails the extraction of matrix embedded ancient organic matter. Microscopy had at one time been preferred due to potential delineation of the organic precursors which entails their biological sources and the processes of formation. Their compositional distributions can be derived from their structure, structureless matter have different composition relative to structured organic matter. Their preservation state can be confirmed from exposure to fluorescence. The hydrocarbon generating potential can be deduced from their structure. Thermal alteration stage/level and depositional environment such as redox, palaeosaline, can be deduced from the optical properties such as spore colour

These inferences are made from observing the morphology and optical properties such as reflectance, fluorescence and translucency (Tyson, 1995).

2. Geology of Niger Delta Basin

The Niger Delta Basin has been proposed to have been deposited in Mega Sequences between 5 to 10 millions years apart. The mega sequences are known as the depobelts (Reijers, 2011). Each depobelt is assumed to have had peculiar terain that could have foster deposition of peculiar organic matter. Each of the mega sequences have a deposited shale maker during sea level high stand. The sedimentary mechanism of the Niger Delta is described by the Escalator regression Model (Knox & Omatsola, 1987), which is a function of rate of deposition and rate of subsidence resulting in the progradation of Delta seaward (Evamy et al., 1978). Generally, the Niger Delta varies from Marine, into Paralic and into Continental Northwards (Oboh,1992a). However, the depobelt varies with the eustatic sea levels changes of varied duration

The Northern depobelt was deposited by sediments from he Abakalike high and South of the Anambra Basin in the Middle –Late Eocene, characterized by falling sea level. Sediments of the Late Eocene to Middle Oligocene formed the Greater Ughelli depobelt during the rising sea level. In the Middle–Late Miocene the high hinterland was the source of sediment that accumulated into the Central Swamp and the Northern sector of the Coastal

Swamp during Low sea level. In the Late Miocene–Early Pliocene, the Coastal Swamp (partly low sea level) and Offshore were deposited during high sea level and eventual incession events caused the Agbada, Soku and Afam channels (Reijers, 2011)

3. Samples and Sample treatment

Twelve (12) core samples of eleven (11) wells, in the onshore Niger Delta basin, were obtained from the geological surveys of Nigeria, Kaduna (based on availability). The samples were subjected to treatment with 37%hydrochloric acid (HCl) and 70% hydrofluoric acid (HF) for the removal of carbonates and silicate minerals. Kerogen was isolated by washing and mounted on a glass slide for analysis under transmitted white and fluorescence light for spore coloration index and kerogen type description, to estimate the relative abundances of vitrinites, inertinites, Amorphous Organic Matter (AOM), and maturity.

The analysis was carried out in the laboratory of PETROCI (Societe National d' Operation Petroliere de la Cote d'Ivoire), using a Transmitted Light and Fluorescent Light Microscope (Axioskop 40 FL).

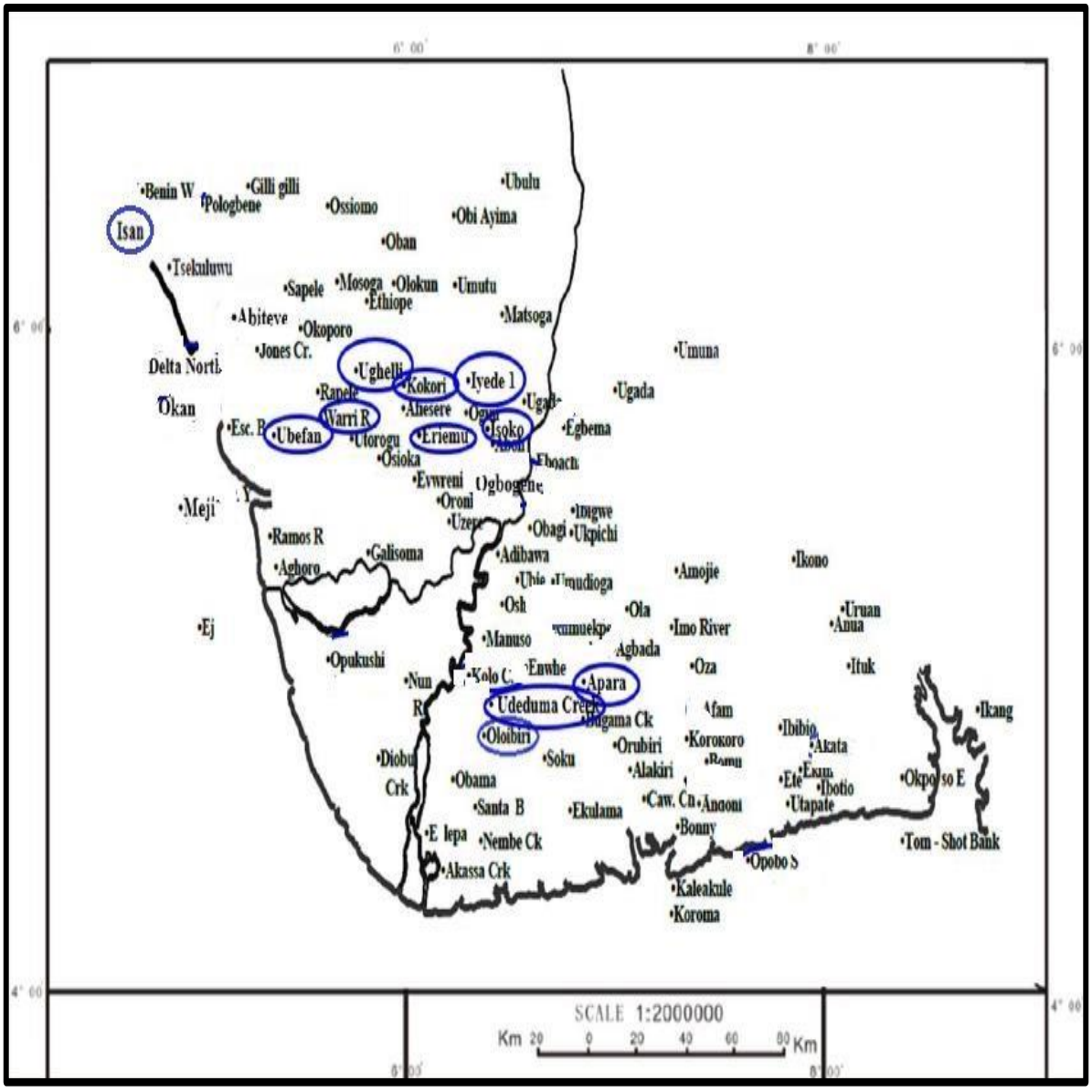

Figure 1: Samples Location Map. Blue circle indicates wells where samples were obtained.

4. Results

The results of transmitted and fluorescent microscopy and corresponding inferences are presented below.

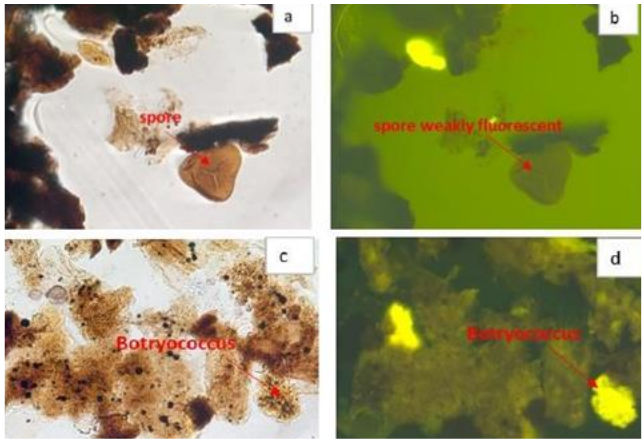

Figure 2: Kerogen particles from (upper) and 8087ft (Lower) Isan Well, 6760ft

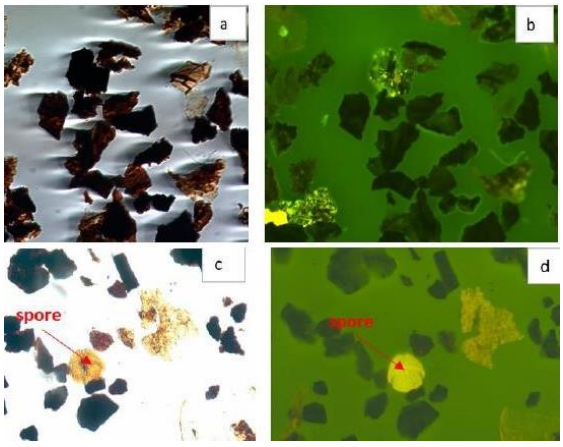

Figure 3: Kerogen particles from Iyede Well 9,555ft (Upper) and Ubefan Well 9,880ft lower

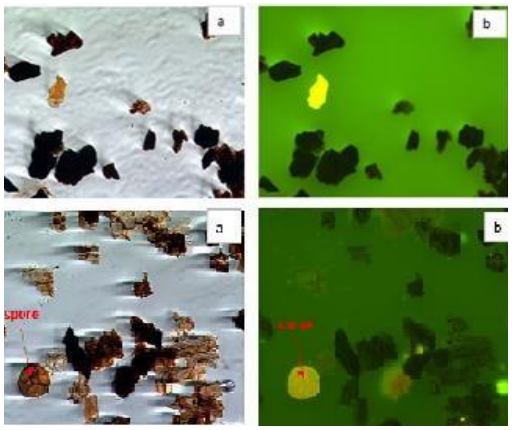

Figure 4: Kerogen particles from Ughelli Well 11,120ft

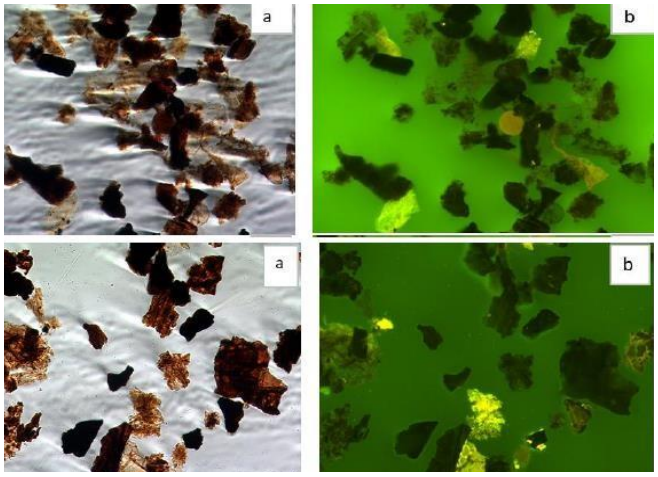

Figure 5. Kerogen particles from Kokori Well 12,140ft (Upper) Appara Well 11,800ft (lower) (Upper) Eriemu Well 11,120ft (lower)

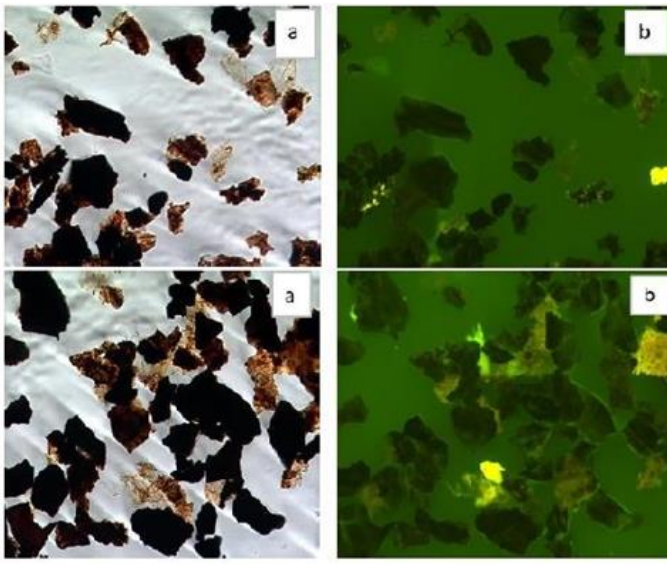

Figure 6: Kerogen particles from Warri River Well

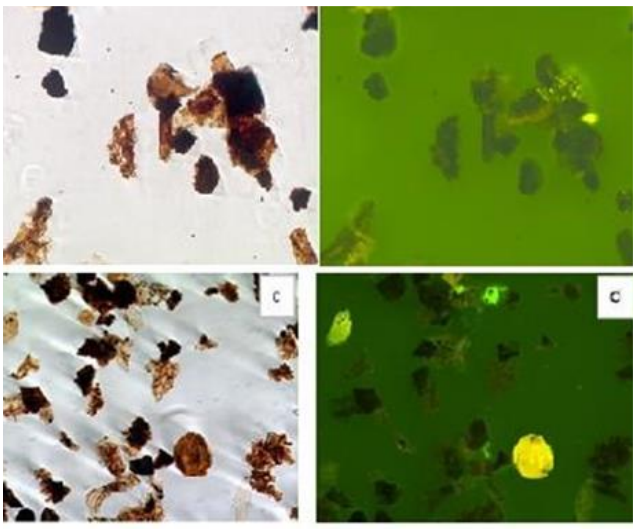

Figure 7: Kerogen particles from Oloibiri Well 7170ft 12,260ft (Upper) Isoko Well 13,400ft (lower) (Upper) Udeduma Well 12,340ft (lower)

Table 1: Data on Microscopy analysis of samples from different Wells

Wells	Depth(m)	AOM (%)	Vitrinite (%)	Inertinite (%)	SCI
Isan 9	6760	80	20	0	4
Benin West	7840	80	15	5	4
Isan 9	8680	80	15	5	7
Iyede 1	9555	0	70	30	5
Ubefan	9800	10	90	0	4
Ubefan	11120	20	80	0	5
Appara	11800	10	80	10	5
Kokori	12140	20	70	10	5
Erienm	12200	30	70	0	7
Warri River	12260	15	70	15	7
Udeduna Creek	12340	15	70	15	7
Isoko	13400	10	70	20	7-5

5. Discussions

The organic matter study is focused principally on that of transmitted white light microscopy and it entails aspects such as: Origin, Structure, Morphology (descriptive), Optical properties and chemical composition (Mendonça Filho, et al., 2012) (Batten, 1996) (Oboh, 1992b).

Figure 2 presents the organic matter for Isan Well. It has no shape, no define cell wall, it is structureless, matches an extra or intra cellular gelatinous material, this is an amorphous organic matter and has been identified as the lake algea, botryococcus. However, also there is a particle that is descret, individual non-colonial entity, it has an oval shape which is definite and corresponds to an organic walled microfossil which infers sporomorphs (either a spore or pollen). The spore is fluorescence in incident fluorescent light, this indicate good preservation. It is not translucent which indicates its maturity. There are also particles that are structured, fragmentry with broken outline, but do not have animalian feature hence phytoclasts. The phytoclast are opaque, non fluorescent some are equidemensional while few are rectangular, also spore coloration index (SCI) ranges from 4 to 7.

The above characteristics of organic matter in source rock from Isan Well indicates oil prone organic matter, which is preserved and mature and which were deposited between proximal and distal environment. The SCI indicates organic matter at the beginning of the oil window.

Figure 3 shows the result of organic matter from Iyede Well 9,555ft (Upper part) and Ubefan Well 9,880ft (lower part), both samples have particles that are structured in their outline which are fragmentry with no animalian feature, these are phytoclast. There are lots of particles with equidemension shape. There are also oval shapes descret individual entity with organic wall, these are spores. Some particles are coloured light yellow which fluorescence in incident fluorescent lights. The optical geochemical characteristics show that spore coloration index ranges 4 to 5 indicating moderately matured organic matter. Some of the organic matter are preserved and deposited in proximal environment i.e. nearshore or coastal environment and of good to fair oil potential.

Figure 4 is the result of Ughelli Well 11,120ft (Upper part) Appara Well 11,800ft (lower part), both results show presence of phytoclasts of equidemensional sizes which are equants, the Appara Well show the presence of light brown non fibrous, length parallel stripes or bands, these are tracheids. High tracheids are of Gymnosperm origin. The presence of spores are also observed which are mature and fluorescent. These characteristics are of source rock that is deposited in nearshore or coastal marine environment, whose organic precursors is mainly vascular plant materials which are of fair oil and gas potential.

Figure 5 presents the photomicrograph of Kokori Well 12,140ft (Upper) and Eriemu Well 11,120ft (lower), there is a high density of particles which varies from light brown to dark brown in colour and have define shape indicating structured matter, these are phytoclast with near equal distribution of equants and laths. There are also 2D fluoresecent sheets-clast materials with no animalian feature, infering phytoclast cuticle. The SCI ranges from 5 to 7. These characteristics implies source rock with vascular plant materials, deposited in nearshore or

coastal marine environment. The organic matter is moderately mature to mature and of oil and gas hydrocarbon potential.

Figure 6 is showing a photomicrograph of organic matter in the Warri River Well 12,260ft (Upper) and Isoko Well 13,400ft (lower). The presence of fair to high density of particles is observed. The particles are phytoclast of light to dark brown colour. Phytoclast cuticle are present which also fluorescence in incident fluorescent light. The phytoclast are more of equants than laths. There are no spores, nor any clast with animalian feature. The SCI varies from 7 to 7.5. The optical characteristics represents source rock that consist of precursor organic matter from vascular plant materials, which were deposited in nearshore to coastal environment. The organic matter is matured and gas prone in terms of hydrocarbon potential.

Figure 7 is a transmitted white light photomicrograph of organic matter in the Oloibiri Well 7170ft (Upper) Udeduma Well 12,340ft (lower). The photomicrograph show a lower particle density with more phytoclast cuticle relative to phytoclast woody tissue. The morphology is that of structured phytoclast particles which indicates more of equants relative to laths. Also identified are some spores with good fluorescence in incident fluorescent light. There are no clast with animalian feature, tracheids are also not present. The characteristics observed entails that of organic matter embedded in the source rock samples are vascular plants that are mostly angiosperms landplants materials relative to gymnosperm woody tissues. The transluency indicates slightly mature organic matter while the fluorescence indicates oil prone organic matter. The depositional environment is inferred to be nearshore to coastal marine environment. The hydrocarbon potential is that of gas and oil potential.

The samples were sourced according to availability, and by the location of the Wells from which the sample were sourced as in figure 1, samples covered the Greater Ughelli, Central Swamp and Coastal Swamp. Sediments of the Greater Ughelli were deposited during rising sea level from Late Eocene to Middle Oligocene during which flow energy may be average corresponding to an influx of marine waters and lots of marine related organism may accompany the influx. Also there is a seaward mix of fluvial supply culminating into a mixture of both terrigenous and marine organic matter.

The source rock samples obtained from the greater Ughelli depobelt includes Ughelli, Iyede, Kokori and Isoko. The optical characteristics show high phytoclast relative to spores and amorphous organic matter with few fluorescent materials which is a reflection of oil and gas prone organic matter.

Sediments of the Central Swamp depobelt were deposited during low sea level corresponding to regression and low stand from the Middle to Late Miocene. During this period active sediment supply is fluvial. There may be two sub-depo points consisting of outer shelf point of marine organic matter and an inner shelf point of terrigenous organic matter. The samples from the Central Swamp depobelt are Eriemu, Warri R., Ubefana and Apara. The optical characteristics show smaller size phytoclasts that are equants which indicates proximal depositional environment and are of near equal numbers with cuticles and spores with more frequent fluorescent materials indicating more gas prone organic matters relative the oil prone.

The Coastal Swamp source rocks were obtained from Olobiri Well and Udeduma Creek Well, these sediments were deposited during rising sea level in the period from Late Miocene to Early Pliocene. Active sedimentation is by the influxing marine waters, carrying spores leaves and pollens. Also sub-active is the fluvial supply from the hinterland mostly terrigenous matter. Thus some cases of mixed of organic matter is observed. The optical characteristics show phytoclast of smaller sizes mostly equants and more of a mix of cuticles and spores that are fluorescent under incident florescent light.

The optical characteristics of the source rocks from the Greater Ughelli to the Central Swamp and Coastal Swamp depoblt shows a decrease in the density of phytoclast relative to cuticle and spores. The source rocks of the Coastal Swamp depobelt has more cuticles and spores relative to the phytoclast.

This infers the occurrence/presence of relatively more favorable conditions for the deposition of oil/gas prone organic matter during the geologic progression to more modern era.

The Isan Well source rock samples shows the presence of botryococcus algae which is a fluorescent algae that indicates lake environment. The botryococcus algae indicates oil prone source rock, the Isan Well seems to be part of an ancient lake system that might have been modified due to the changing nature of the infilling terrigenous sediments consisting spores and pollens and phytoclast materials.

7. Conclusion

Optical geochemistry consisting transmitted and reflected white light microscopy remains a valued technique for characterization and screening of source rocks. The key advantage is that it provides information on abundance, origin, preservation state, thermal alteration of organic matter and hydrocarbon potential via direct observation The study unvails that there is gradual decrease in phytoclast materials in the source rock samples from Greater Ughelli depobelt to the Coastal Swamp depobelt. This may infer increasing occurrence of more oil/gas prone organic matter in source rock samples from Greater Ughelli to the Coastal Swamp depobelt. it may be deduced that more hydrocarbon prone source rocks may be deposited in the coastal and offshore depobelts.

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