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The Quality of Oil from Abeokuta's Tar Sands in South Western Nigeria's Dahomey Basin

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ABSTRACT

Studying the oils recovered from the Dahomey Basin's oils sand helped to determine their quantity and quality. The acquired results indicated that the oils under study are concentrated in the polar portion, which is in line with the characteristics of biodegraded oils. It is thought that these oils were initially produced as light oil, which then transformed into heavy oil. In order to reach the reservoir rocks, which are located at shallower levels, oil generation has to travel considerable distances along the planes of unconformity from deeper-buried source rocks. Degradation of the oil may have happened in the reservoir rocks or during migration. According to the trisnorhopane thermal maturity indicator, the investigated oils exhibit thermal maturity levels between 0.66 and 1.32% Ro, which is in line with the bitumen that has transitioned from early to late formation.

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INTRODUCTION

The term tar sand, also known as oil sand (in Canada), or (more correctly) Bituminous sands, commonly describes sandstones or friable sand (quartz) Impregnated with viscous bitumen (a hydro carbonaceous material soluble in carbon disulfide). Significant amounts of fine material, usually largely or completely clay, are also present. The degree of porosity varies from deposit to deposit and is an important characteristic in terms of recovery processes.

The bitumen makes up the desirable fraction of the tar sand from which liquid fuels can be derived (Speight, 2013d, 2014a). However, the bitumen is usually not recoverable by conventional petroleum production techniques. Furthermore, the properties and composition of the tar sands and the bitumen significantly influence the selection of recovery and treatment processes and vary among deposits. In the tar sands that are recognized as being water-wet (rather than bitumen-wet) in the Athabasca deposit, a layer of water surrounds the sand grain, and the bitumen partially fills the voids between the wet grains. On the other hand, the Utah tar sands lack the water layer and the bitumen is directly in contact with the sand grains without any intervening water.

The search for hydrocarbons in the Cretaceous source rocks in the Nigerian in land sedimentary basins has been a major task for many decades now. The efforts were to bust the oil and gas exploration and production activities and also adequately tap the natural resources in the country. Geoscience research in the aspects of hydrocarbon search in the Nigeria sector of the Dahomey basin has been so few for many years. In the last decade, there have been considerable interest and geosciences researches in the aspects of hydrocarbon search in the basin. Recent exploration and prospect re-evaluation efforts in the Nigeria segment of the basin have been encouraged following oil discovery and

production in the neighboring Benin republic sector west of the basin and the social unrest in the prolific Niger Delta, east of the basin. The Dahomey Basin is an extensive sedimentary basin, in the Gulf of Guinea which extends from southeastern Ghana through Togo and Benin Republic on the west side to the Okitipupa ridge/Benin Hinge line on the east side in the southern, part of Nigeria Brownfield and Charpentier (2006). The basin evolution involved basement fragmentation, block faulting and subsidence of the Jurassic basement complex couple with wrench movements of the basement blocks (Arthur et al. 2003). The basin consists of sedimentary formations (Cretaceous —Tertiary) that outcrop in an arcuate belt roughly parallel to the coastline (Omatsola and Adegoke, 1981). This basin has attracted a lot of geoscientific interest, especially in the recent years in view of the availability of the new boreholes and recent road cuts which have improved the knowledge of its geology and hydrocarbon potential assessment.

The Dahomey Basin forms one of a series of West African Atlantic Margin basins that were initiated during the period of rifting in the late Jurassic to early Cretaceous. (Omatsola and Adegoke, 1981). The basin stretches along the coast of Nigeria, Benin Republic, Togo and Ghana in the margin of the Gulf of Guinea (Fig. 1). It is separated from Niger Delta in the Eastern section by Benin Hinge Line and Okitipupa Ridge and marks the continental extension of the chain fracture zone (Coker and Ejedawe, 1987, Onuoha, 1999). It is bounded on the west by Ghana Ridge, and has been interpreted as the Romanche fracture zone (Burke, 2003). The basin fill covers a broad arc-shaped profile, attaining about 13 km maximum width in the onshore at the basin axis along Nigerian and Republic of Benin boundary. This narrows westwards and eastwards to about 5 km (Coker and Ejedawe, 1987).

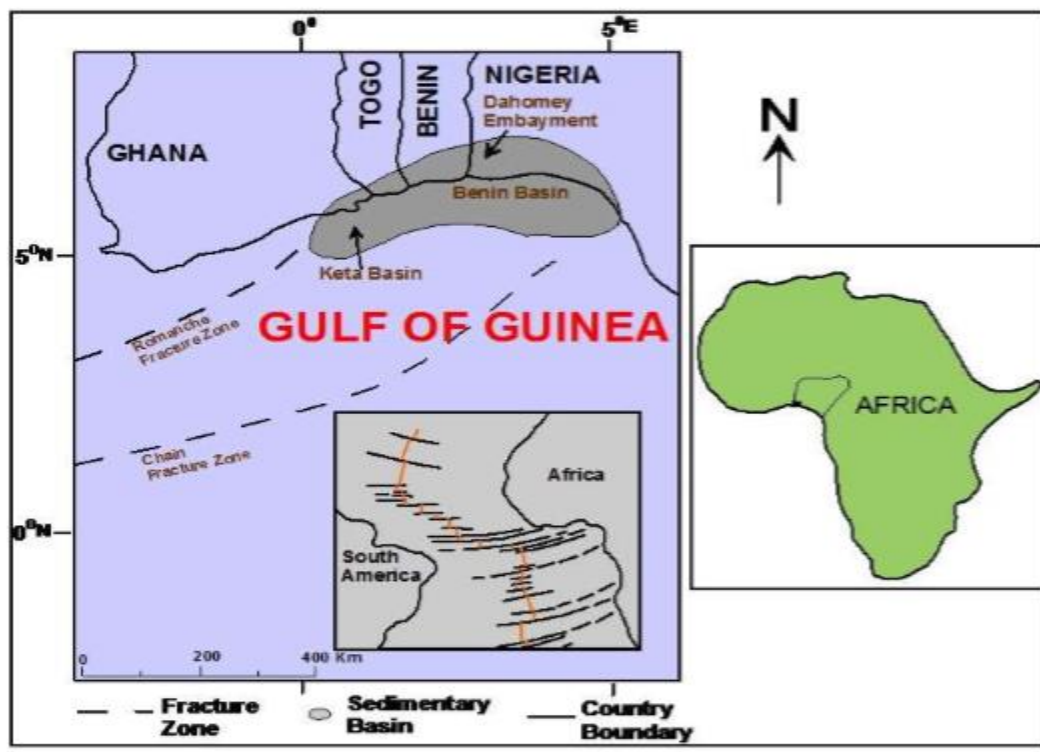


Figure:1 Regional map of four countries showing the location of the Benin (Dahomey) Basin in the Gulf of Guinea (modified from Brownfield and Chapentier, 2006).

MATERIALS AND METHODS

Geochemical Analysis

The ultimate aim of any geochemical analysis is to subject a sample (rock) to a series of fractionations and analytical techniques and arrive at a point where either the presence or absence of specific target compounds (biomarkers) can be established or fingerprints for specific classes of compounds can be obtained and used for correlation purposes (Philip, 2000). Regarding petroleum exploration, such fingerprints are used for oil-source-rock or oil-oil correlation studies.

Oil Extraction (Soxhlet extraction)

Rock samples preparations began by cutting the samples to appropriate sizes (100g each) and cleaning the weathered or contaminated outer

parts followed by rinsing in either distilled water or methanol/acetone. These were then left to dry before being crushed into fine powder in Tema mill. 50g of the crushed samples were raw weighed, put in a timble which was then plugged with cotton wool and placed in a soxhlet extractor where it was heated to reflux for forty-eight hours (48 hrs.) using 93:7 dichloromethane/methanol (DCM/MeOH) till the oil was extracted. A blank was extracted to check for contamination. After extraction, the solvent DCM/MeOH was evacuated entirely from the extracted bitumen by rotary evaporation and then stream nitrogen gas. The bitumen obtained was re-dissolved in DCM and then transferred into a 3.5 mL glass vial of known weight before evaporating the DCM solvent again under a stream of nitrogen gas.

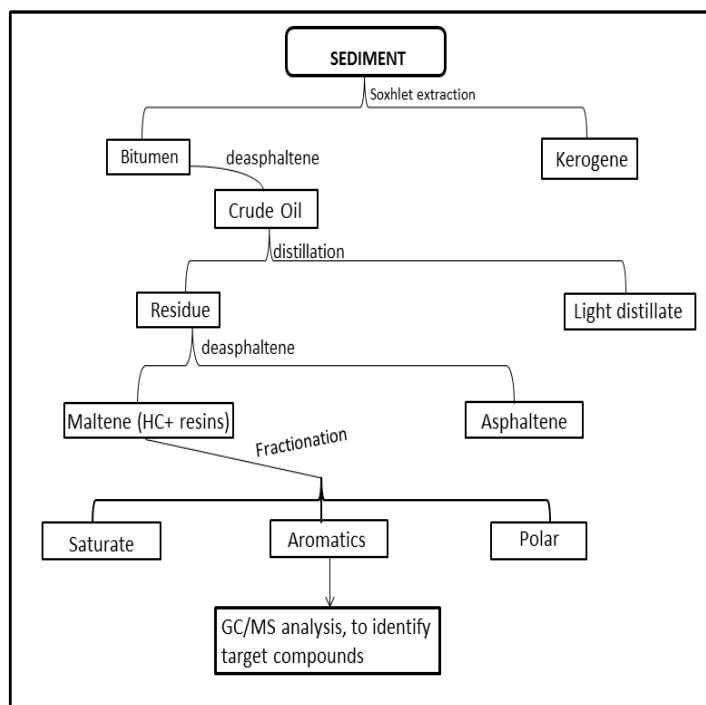


Figure 2. A Summarized Description of the Geochemical Analyses Procedures Conducted on the Afowo Formation samples' Oil Extracts (After Bata, 2016).



Figure: 3 Field Photograph of the studied Subara Locality

Oil Geochemistry

A ternary plot showing the bulk properties of oils extracted from the studied Dahomey Basin is presented. Also presented are the oil bulk

properties of typical Afowo oil (from Afowo Formation) for comparison purposes. Oils extracted from the studied Afowo Formation are enriched in the polar fraction, which is consistent with oils that have been biodegraded.

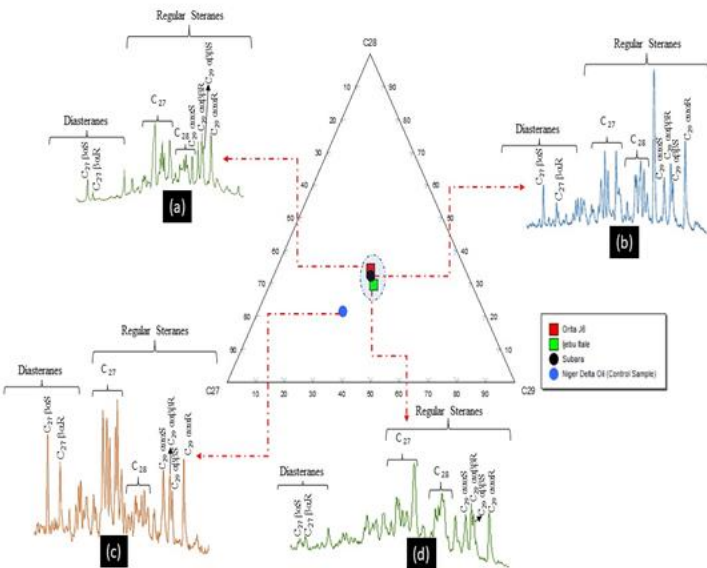


Figure 4: Ternary plot for oils from Dahomey Basin Oils showing the relative abundance of Saturate, Aromatic and Polar constituents; inset are their individual TIC finger-prints showing UCM (Unresolved Complex Mixture Humps (b and c) indicating biodegradation

1	Nigeria	Dahomey Basin	Afowo Formation (Aptian)	29.2	17.1	31	22.1
Ijebu Itale							
2	Nigeria	Dahomey Basin	Afowo Formation (Aptian)	22.7	14.9	28.6	33.8
Orita J6							
	Nigeria	Dahomey Basin	Afowo Formation (Aptian)	26.1	12.1	35.3	26.5
Subara							

The Ts (trisorneohopane) to Tm (trisorhopane) ratios, calculated as Ts/(Ts+Tm) or Ts/Tm, is a thermal maturity assessment parameter (Farrimond et al., 1996) and increases with organic matter maturity. But it may also be influenced by the source lithology (Seifert & Moldowan, 1978). The Ts/Tm ratios for all the oils (table 2) hover between 0.83 and 0.92 (less than unity); thus, indicating higher values of Tm over Ts and early oil window maturation (catagenesis) phase.

Conclusion

The bulk and molecular properties of both oils including biodegradation, Pristane/Phytane ratios, Isoprenoids/n-Alkane ratios, steranes parameters, homohopanes isomerization ratios, terpanes parameters, Gammacerane indices and trisorneohopane/ trisorhopane (Ts/ Tm) ratios among other properties show positive correlation between the oils. Both oils originated from mixed organic matter sourced from both marine and terrestrial sources and deposited in an aquatic environment under anoxic/ suboxic conditions. Diagenetic changes conspicuously increased the Limestone Member's porosity. Catagenesis and thermal maturity took place till the oils entered early oil window.

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