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PETROLEUM OCCURRENCE IN DAHOMEY(BENIN) BASIN

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Purpose: This research work reviews the occurrence of petroleum in the Benin basin. It examines the origin of petroleum in the basin, source rock and organic matter type, reservoir rocks, cap rocks/seals and potential hydrocarbon plays. Dahomey basin connects the Okitipupa structure which is surrounded by mountainous environment.

Methods: Base on an in-depth analytical review of research findings, using various scientific methodologies, the potential source rocks were identified, basing its analysis on the petrographic studies of shale samples from the Okitipupa structure.

Results: Kerogen extracts show mixture of sporonites, resinites and vitrinites. Gas chromatograms of saturate runs from shale extracts, giving indication of Marine influence. Sandy facies exist in the basin, acting as good reservoir rocks for oil and gas.

Conclusion: The Nigerian bituminous oil deposits which connect with the Dahomey basin is economically significant if commercially harnessed with the right technology, considering its huge reserve.

Key words: Bitumen, petroleum occurrence, source rock, organic matter, cap rock, hydrocarbon.

1. Introduction: The occurrence of the extensive oil seeps and sediments of cretaceous and younger age impregnated with tarry oil in the Okitipupa structure of the basin resulted in several attempts by various interest groups to explore, exploit and eventually study this deposit. Significance to this field guide is the contribution of the geological consultancy unit of the University of Ife (now Obafemi Awolowo University, OAU). They conducted the most comprehensive field investigation to date on the bituminous sands. Between 1974 and 1980, OAU in collaboration with TESCO of Hungary drilled and cored close to 50 holes, providing in addition to rekindling government's interest in the deposits, extensive sample material for the graduate students and staff of universities to conduct various level of research on the bituminous sands and the extracted bitumen [17–20].

The collective efforts of all of these are the indication of a huge resource lying within the sandstones, limestone, siltstones and shale. Estimates (Adegoke et al., 1980) have put the resource at 1.6 billion metric tones of oil sands and 1 billion barrels of bitumen. There are however, varying estimates of the quantities of bituminous sands that are recoverable by open mining and in-situ techniques [17] [20].

Conventional oil has been found in the basin, notably in some fields (offshore Republic of Benin) in the Western side of the basin. More recently, an indigenous oil exploration company discovered oil in Aje – 1 (offshore of Lagos area). Thus establishing the fact that the basin is a potential petroleum province. While indicating the presence of hydrocarbon, most of the findings are considered economic. Some are highly viscous and within very shallow reservoirs, thus can only be recovered by surface mining techniques or where they are of deep occurrence require secondary or tertiary enhanced recovery techniques (EOR) [1–4].

2. Origin of hydrocarbon: Coker and Ejedawe (1987) based on average geothermal gradient and burial history data, constructed oil genesis nomographs using TT1 model. They defined the present top of the oil generative window (OGW) for the basin at between 1350–2200 m, corresponding to temperatures of 80–132 °C respectively. These conditions, depending on organic matter type, would favour a wide range of hydrocarbon type grading from heavy to medium liquid hydrocarbon (80–105 °C) to light and gas condensate at temperatures as high as 132 °C. Their work also demonstrated two (2) main phases of hydrocarbon generation [6]:

An early phase, originating from cretaceous source rocks in graben settings at low generating temperatures (82–88 °C) and relatively shallower depths (1375–1762 m) would correspond to heavy thermally immature crude oils.

A later phase, generating light oil to gas condensate at much greater depth intervals (1936–2259 m) and much higher temperatures (118–132 °C).

These later phase hydrocarbons are restricted to the sag stage of basin evolution in Paleocene and younger sediments in the offshore of the basin. The initial oil generated from the graben sequence of the rift phase, migrated up dip and were reservoired in Maastrichtian and Paleocene sediments prior to the Oligocene when deposition was slow with little or no basin subsidence. This situation would account for the subsequent low thermal alteration process that characterize these near surface emplaced hydrocarbons [5, 7–8].

3. Source rock and organic type: Potential source rocks are:

a) The characteristic swamp and lake deposits of the graben phase, preserved under near anoxic conditions;

b) The associated shales and carbonates of the mid – cretaceous transitional phase and the transgressive shales and platform carbonates of the upper cretaceous and neogene sag phase. Petrographic studies

of shale samples from the Okitipupa structure (depth of 130m) and kerogen extracts show mixture of sporonites, resinites and vitrinites. Gas chromatograms of saturate runs from shale extracts, give indication of marine influence [5–6].

Total organic carbon determination both from direct measurements (Coker, 1982) and from theoretical calculation 9Emengo, 1986) making use of the Ibach et al., (1982) scheme that correlates sedimentation rate and total organic content and the sonic – transit time/ resistivity and density/resistivity cross – plots of Meyer and Nederloff (1984), gave values in the range of 0,7–19,4 % TOC. These values show that most of the shales and carbonates within the basin have good source rock potentiall [6–8, 9–12].

4. Reservoir rocks: Significant sandy facies exist in the basin to act as good reservoir rocks for oil and gas. In the lower – middle cretaceous, the sandy facies of the Ise and Union formation (Albian sands) and the interbedded sanstones of the Epiya formation should provide adequate reservoir rocks. In the tertiary interval, stratigraphic units with good reservoir potential include portions of the Ilaro and Afowo formations [6, 21].

5. Cap rocks/seals: The occurrence of seeps and oil sands on the north – eastern fringe of the basin clearly demonstrates the poor sealing conditions in the basin. The tectonic setting of the basin and the deposition of the sediments in the tertiary may give rise to re – juvenating fault system that may transcend the entire sequence, thus creating avenues for leaks. The southward structural plunge, monoclonal flexure of the basement floor may make up dip migration along basement wash very feasible and better explains the high incidence of seepage along the Okitipupa structure. This notwithstanding, there are other evidences such as thick shaly sequence and limestone beds basinward which should provide adequate sealing conditions for liquid and gaseous hydrocarbons [22].

6. Potential hydrocarbon plays: The type of hydrocarbon traps commonly found in petroliferous pull apart basin suggests that potential traps in the basin could be of four (4) main types [13–16]:

Structural horst and graben, combining with stratigraphic features, restricted largely to the cretaceous sequence;

Stratigraphic feature related to unconformities geometric sand bodies – burial channels, pinch out, lenses etc;

Growth fault and their associated roll over structure of varying combination limited to the tertiary strata;

Seals created by thick tar mats (heavy oil underlying thick columns of bituminous sands, basically Maastrichtian – Paleocene interval).

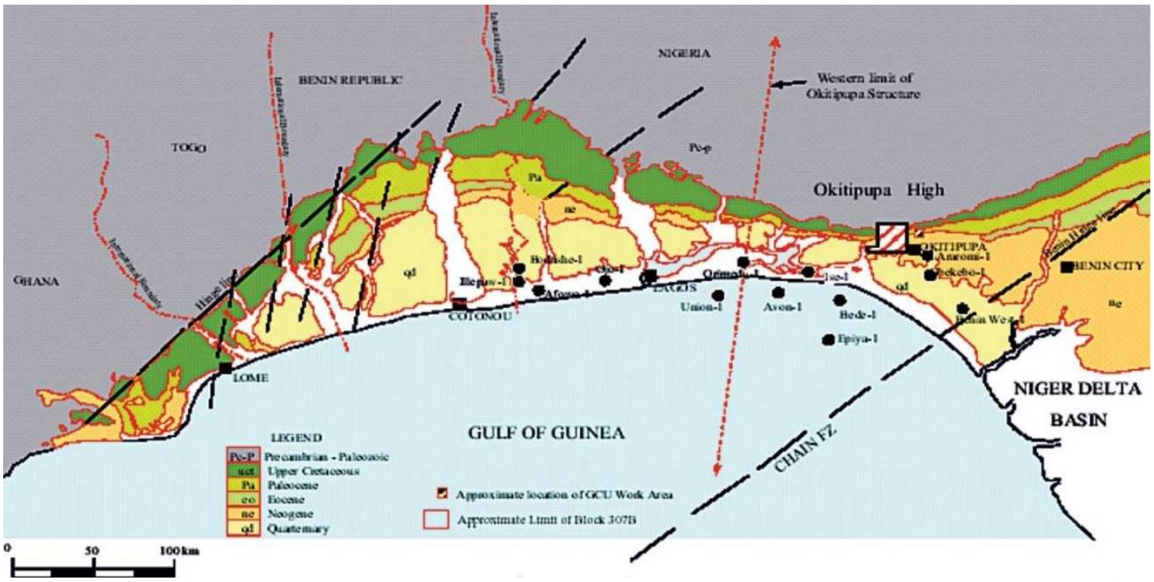

Figure 1 – Map of Dahomey basin, showing Okitipupa high [6]

A 1986 report by Geotrex Systems Limited on the hydrocarbon prospectivity of the Dahomey basin – Republic of Benin, indicates the following tested and potential hydrocarbon plays:

- Basement induced horst and graben related structures;
- Gravity fault related structures;
- Combined structural and stratigraphic plays;
- Stratigraphic hydrocarbon plays.

The relative timing of oil trap formation shows that oil was generated after the formation of most of the trap types in the basin. However, the numerous fault blocks would hinder lateral migration for the most times, in which case, strata in isolated fault bound basinal lows can charge individual structure. Fault planes, if not sealing, could however, serve as good conduits. Consequently, the cretaceous plays will be small in size.

In contrast, the upper cretaceous and lower tertiary trap development should should give rise to medium and large size oil fields, all other conditions being favourable, could provide target prospects [23–24].

Conclusion: The Nigerian bituminous oil deposits which connect with the Dahomey basin are economically significant if commercially harnessed with the right technology, considering its huge reserve.

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