

**A GEOLOGIC RECONNAISSANCE FIELDWORK  
REPORT FOR BITUMEN EXPLORATION IN  
OKITIPUPA AND ENVIRONS, ONDO STATE,  
SOUTHWESTERN NIGERIA.**

**By**

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# **CHAPTER ONE**

## **INTRODUCTION**

### **1.1 GENERAL STATEMENT**

Reconnaissance fieldwork is an integral part of geological investigation and is carried out at the preliminary stage before other stages. Reconnaissance involves a field trip to the site where further investigation is to be carried out to locate areas where the deposition of a particular resources can be found. This report presents the results of a 6-day geologic reconnaissance mapping carried out in Okitipupa and its environs: Araromi Ayeka, Ayeka, Okunmo, Ayika, Agric Alonge ode Aye, Egunre Jomo, Ibisi Oloto, Irele, Igbobeni (Fig. 1) in order to discover the bitumen potential of these areas.

The heavy (API gravity  $<21^\circ$ ) oil in tar sand is commonly called bitumen. In its raw state it is a sticky, viscous, black substance and easily soluble in organic solvents. Tar sand is formed by the up-dip migration of crude oil into porous sands near the surface of the earth where it is altered (biodegraded and water washed). Tar sand is composed of sand, heavy oil and clay that are rich in minerals and water. Bitumen is the viscous mixture of hydrocarbons that may occur as natural deposits or as a residue from petroleum distillation. It was discovered first in Nigeria around the 1900s, with its exploration beginning particularly in 1905.

In Nigeria, bitumen occurs naturally at few locations, and the deposits are found typically on the surface and sub-surface. This implies that they occur on the uppermost layer of the earth, as well as in the strata below the earth's surface. Bitumen is found in massive quantities mainly in the southwestern part of Nigeria, specifically in tar sand of Ilubirin, Loda, and Agbabu in Ondo. Other places are Lagos, Ogun, and the central-southern region, Edo state (Fig. 2). Nigeria has bitumen deposits extending around 120km approximately, thus ranking the second largest in the world's bitumen deposits. In Ondo state, the estimate of the amount of bitumen available for extraction (the probable reserve) is 16 billion barrels.

Bitumen deposits which are found naturally in Ondo State have two basic concentrated forms, which are: seepages and outcrops of bitumen - tar sands that yield bitumen and require further extraction processes.

Then the second form is the lower viscous bitumen; these are the seepages mainly gotten from wells without obvious connection with sand.

Generally, the total estimated reserve of bitumen in Nigeria is about 42.74 billion metric tonnes, which majorly remains to be exploited for years.

The aim of this study is to carry out a reconnaissance survey on the bitumen locations in Ondo State (Okitipupa local government and its environs) with a view to examine bitumen potential of the area and to give recommendation for further studies which will be helpful for exploitation in the area (Fig. 3).

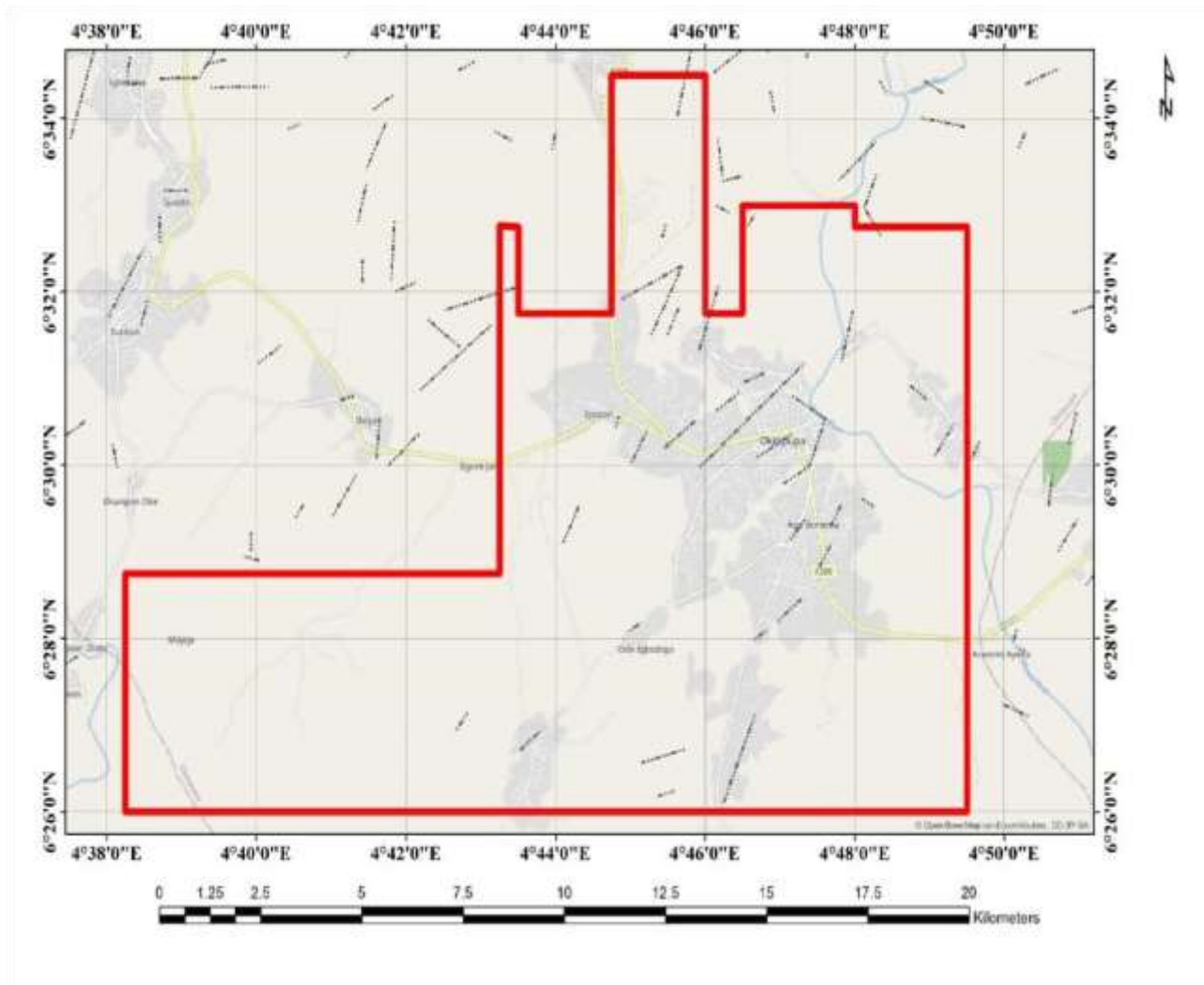


Fig 1: Map of the study area showing Okitipupa and its environs

## Bitumen Deposits In Nigeria

- No Concentrations
- Low Concentrations
- High Concentrations

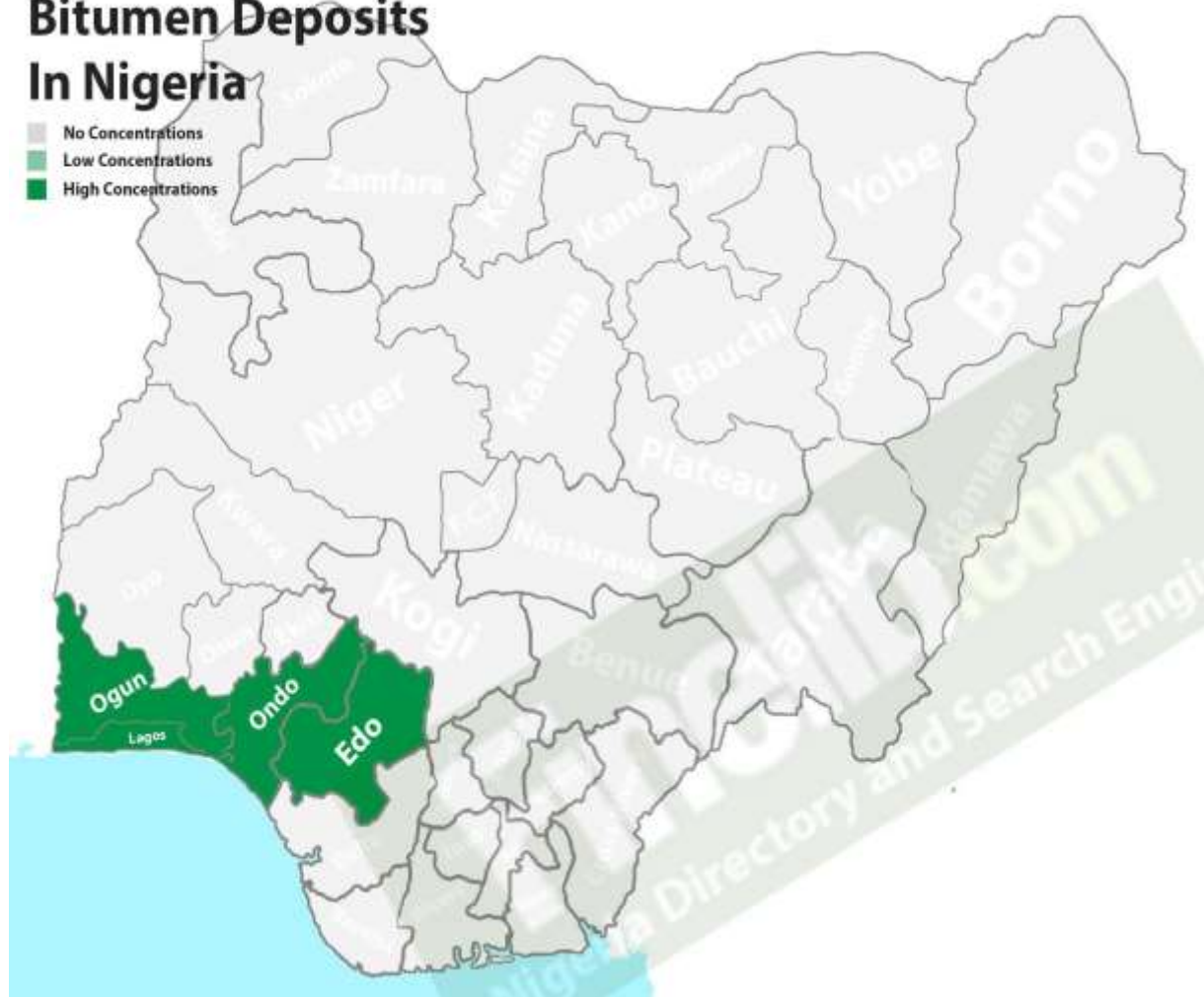


Fig 2: Map of Nigeria showing deposition of bitumen concentrations of different states

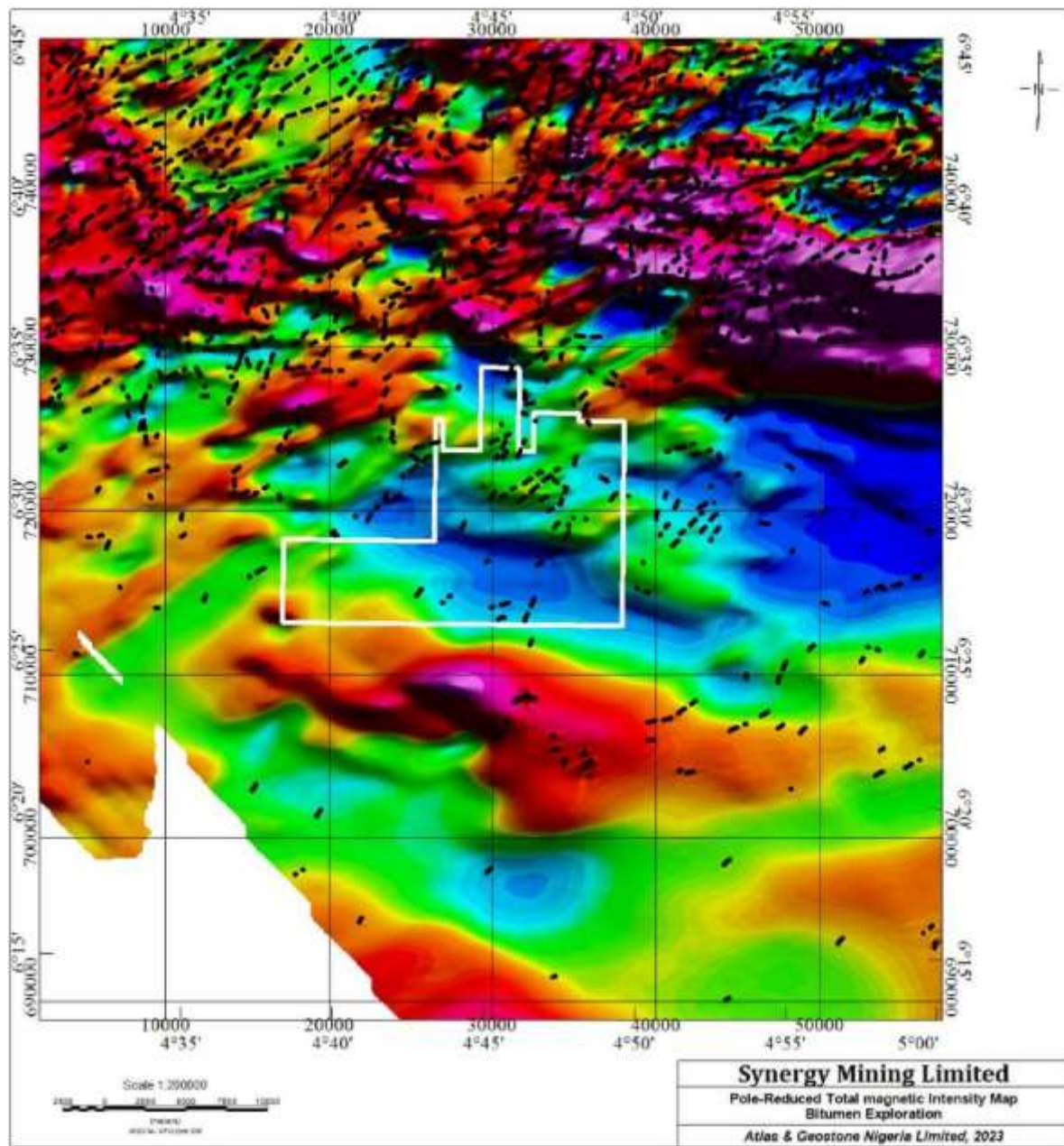


Fig 3: Magnetic map of the study area



## **CHAPTER TWO**

### **LITERATURE REVIEW**

#### **2.1 REGIONAL GEOLOGY OF THE DAHOMEY BASIN**

The Dahomey Basin is an extensive sedimentary basin on the continental margin of the Gulf of Guinea which extends from the Volta Delta in Ghana in the west to the Okitipupa Ridge in Nigeria in the east (Whiteman, 1982) (Fig. 4). The distance from the Volta delta to the axis of the Okitipupa Ridge or Ilesha spur is about 440km and the width of the basin measured from the northern onshore margin in Benin (Dahomey) to the 3,000m bathymetric contour is about 224km (Whiteman, 1982). The area of the onshore part of the Dahomey Basin in all four countries involved (Ghana, Togo, Benin and Nigeria) up to the shelf break, probably does not exceed 30,400sq.km (Whiteman, 1982). The basin contains extensive wedge of Cretaceous to Recent sediments up to 3000m, which thickens from the onshore margin (where the predominantly clastic Cretaceous sediments rest on the Basement complex) into the offshore (Fig. 5). Within the offshore area, thick fine grained Cenozoic sediments obscure the basin (Whiteman, 1982). The axis of the basin and the thickest sediments occur slightly west of the border between Nigeria and the Republic of Benin (Slanky, 1962; Billman, 1992).

Various aspects of the geology of the eastern Dahomey basin have also been discussed, viz: stratigraphy (Fayose, 1970; Ogbe, 1972; Omatsola and Adegoke, 1981); sedimentology (Elueze and Nton, 2004; Nton and Elueze, 2005) and hydrocarbon source potential (Nwachukwu and Adedayo, 1987; Ekweozor and Nwachukwu, 1989; Ekweozor, 1990; Elueze and Nton, 2004; Nton et al., 2009) among others. Nton et al. (2009), also conducted some Rock-eval studies of Maastrichtian-Paleocene shales and limestones within the offshore Dahomey Basin and reported that the organic matter is low- adequate arising from the total organic matter (TOC) values and that the sediments are terrestrial organic matter, immature to slightly mature, with prospect to generate gas rather than oil at appropriate maturity. The eastern Dahomey Basin (Nigeria sector) has attracted a lot of interests, especially in recent years in view of the availability of new boreholes and recent road cut exposures which have improved the knowledge of its geology and hydrocarbon potential assessment. This basin has proved to be of great geological interest, particularly because of extensive occurrences of limestone, glass sand and bitumen. Exploration activity commenced in

this sector of the basin in 1908, near Okitipupa, east of Lagos, where bituminous sands outcrop. Such investigations were later abandoned, and the wells termed “dry.” With the discovery of oil in the Niger Delta in 1956, focus shifted from the eastern Dahomey basin to the Niger Delta.

## **2.2 REGIONAL STRATIGRAPHY OF DAHOMEY BASIN**

The tar sand belt falls within the Nigerian sector of the eastern Dahomey basin.

The stratigraphy of the eastern Dahomey basin as proposed by Omatsola and Adegoke (1981) from oldest to youngest (Fig. 6) are as follows: i) the Abeokuta Group: Late Cretaceous – Tertiary ii) Ewekoro Formation: Paleocene iii) Akinbo Formation: Late Paleocene - Early

Eocene iv) Oshosun Formation: Eocene v) Ilaro Formation: Eocene vi) Coastal plain Sands (Benin FM): Oligocene to Recent. The Abeokuta Group is the oldest sedimentary unit resting unconformably on the basement complex (Fig. 7). The Abeokuta Group is divided into three formations. The Ise formation, the Afowo Formation and the Araromi Formation. The Ise Formation is made up of grits and conglomerate at the base overlain by coarse-grained loose sands with intermediate kaolinite. Both the cross-bedding azimuth of the sandstone and the pebble alignments point to a NE palaeo-current system (Nton, 2001). According to Omatsola and Adegoke, (1981) sporomorphs recovered by the Shell – BP palynologists include *Cicatricosisporites* sp. cf. *C. mohrioides*, *Pilosporites trichopapillosus*, *Klukisporites pseudoreliculatus*, *Aequitriradites* aff. *Verucosus* and *Stapilinisporites caminus*. These indicate a Neocomian (probably Valanginian – Barremian) age for the formation. Overlying the Ise formation is the Afowo formation which is composed mainly of coarse to medium-grained sandstone, with variable, thick interbedded shales, siltstones and clays; with the shale component increasing towards the top. The lower part consists of an alternation of brackish to marginal marine strata, with well-sorted, subrounded, clean, loose, fluviatile sands. Its maximum known thickness is 2,300m. The Afowo formation is overlaid by the Araromi Formation which is composed at the base fine to medium – grained sands which are overlain by shale and siltstone with thin interbedded limestones and marls. This formation is the youngest of the Cretaceous sequence in the eastern Dahomey basin (Omatsola and Adegoke, 1981). Occurrences of thin lignitic bands are also

common. The shales grade from light grey to black, and are mostly marine with a high organic content (Nton, 2001; Elueze and Nton, 2004). Overlying the Araromi Formation is Ewekoro Formation which is predominately limestone, the top is highly scoured and consists of red, dense, glauconitic, phosphatic and fossiliferous limestone. It also contains abundant foraminifera, ostracods and algae. It is Palaeocene in age and associated with shallow marine environment due to abundance of coralline algae, gastropods, pelecypods, echinoid fragment and other skeletal debris (Nton, 2001).

The Ewekoro Formation (where encountered) is overlain by predominantly shaley formation, which Ogbe, (1972) named the Akinbo Formation. According to Ogbe (1972), the base of the formation is defined by the presence of a glauconitic band. The Akinbo Formation consists of dark micro micaceous, fine-textured shale that is locally silty with glauconitic marl and conglomerate at the base (Dessauvage, 1975). It consists of laminated and glauconitic shale and clay sequence intercalation the clays are kaolinitic and concretionary (Nton and Elueze, 2005). In the field the shale are grey, fissile, clayey and concretionary and dip gently (<5°SW) (Nton, 2001). The Oshosun Formation overlies the Akinbo Formation and consist of greenish- grey or beige clay and shale with interbeds of sandstone. The shale is thickly laminated and glauconitic. This formation is phosphate-bearing and is compositionally phosphorite (Nton, 2001). The Ilaro Formation overlies the Oshosun Formation in the eastern Dahomey basin, and consist of massive, yellow, poorly consolidated, cross bedded sandstone (Nton, 2001). The Benin Formation, commonly referred to as the Coastal Plain Sands (Jones and Hockey, 1964), is the youngest sedimentary unit in the eastern Dahomey basin. It consist of a series of poorly sorted sands with lenses of clays and are in parts cross bedded (Agagu, 1985).

## **2.3 LOCAL GEOLOGY/ STRATIGRAPHY**

The sedimentary basin of Ondo State is bounded by Latitudes 5° 52' and 7° 00' N and Longitudes 4° 23' and 5° 54' E (Fig. 8). The terrain is flat with gently undulating topography. The sedimentary terrain of Ondo State falls within the eastern portion of the Dahomey Basin where the

geologic sequence is composed of the Nkporo Shale, Upper Coal Measures, Imo Shale Group, Coastal Plain Sands (Benin Formation) and Quarternary Coastal Alluvium (Fig. 9).

The Nkporo Shale is made up of shale, sandy clay and lenses of sand. The Upper Coal Measures consists of clay/sandy clay, sand, limestone and shale. The Imo Shale Group is composed of shale while the Coastal Plain Sands has alternations of clay/sandy clay and clayey sand/sand. The Quarternary Coastal Alluvium is composed of an alternating sequence of sand and silt/clay (Jones and Hockey, 1964 and Etu-Efeotor and Akpokodje, 1990).

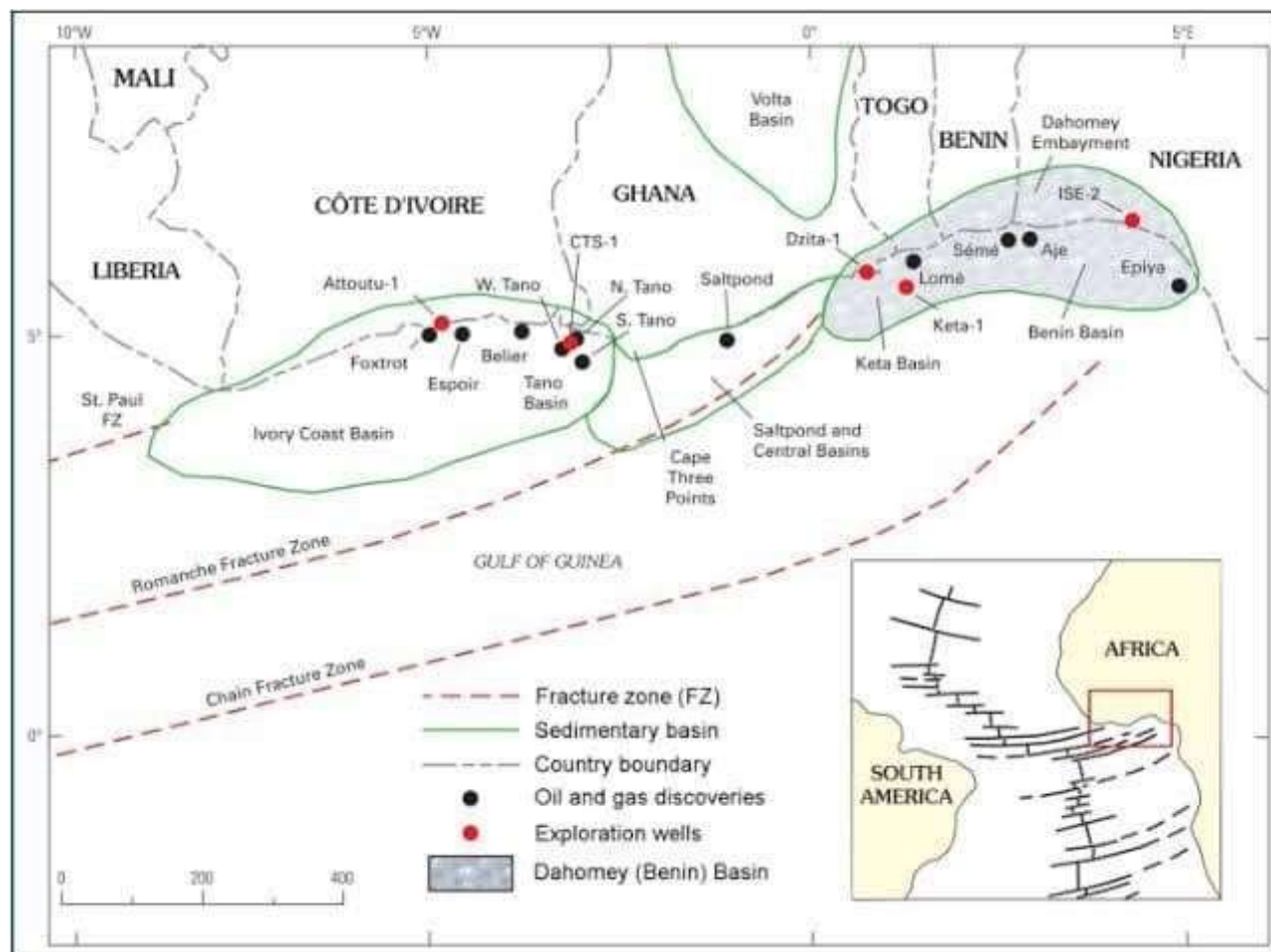


Fig 4: Geological map of Dahomey Basin showing major fault structures

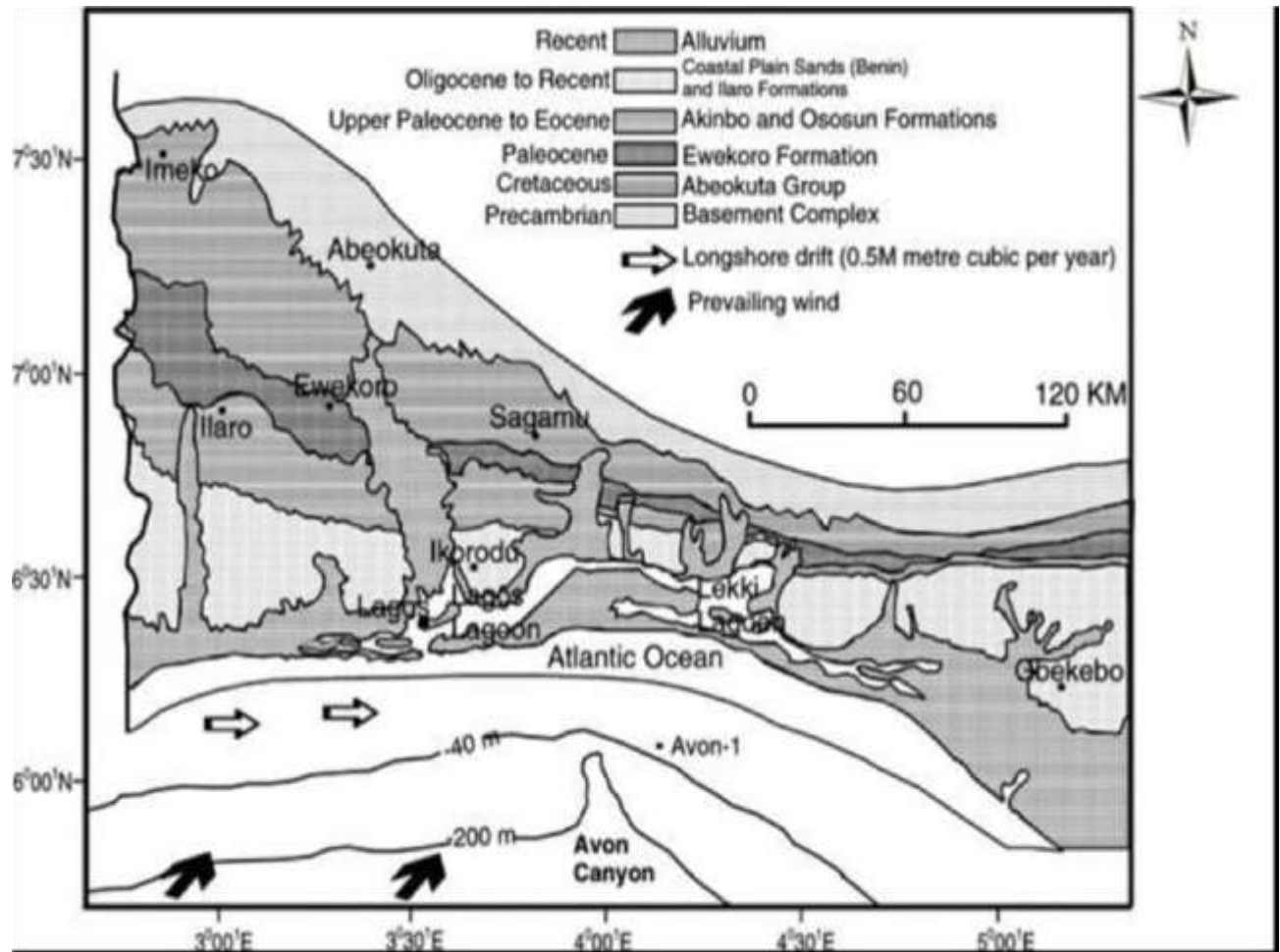


Fig 5: Outline of the geological Map of Dahomey Basin (West of Niger Delta). Map modified after Adekeye et al. (2006)

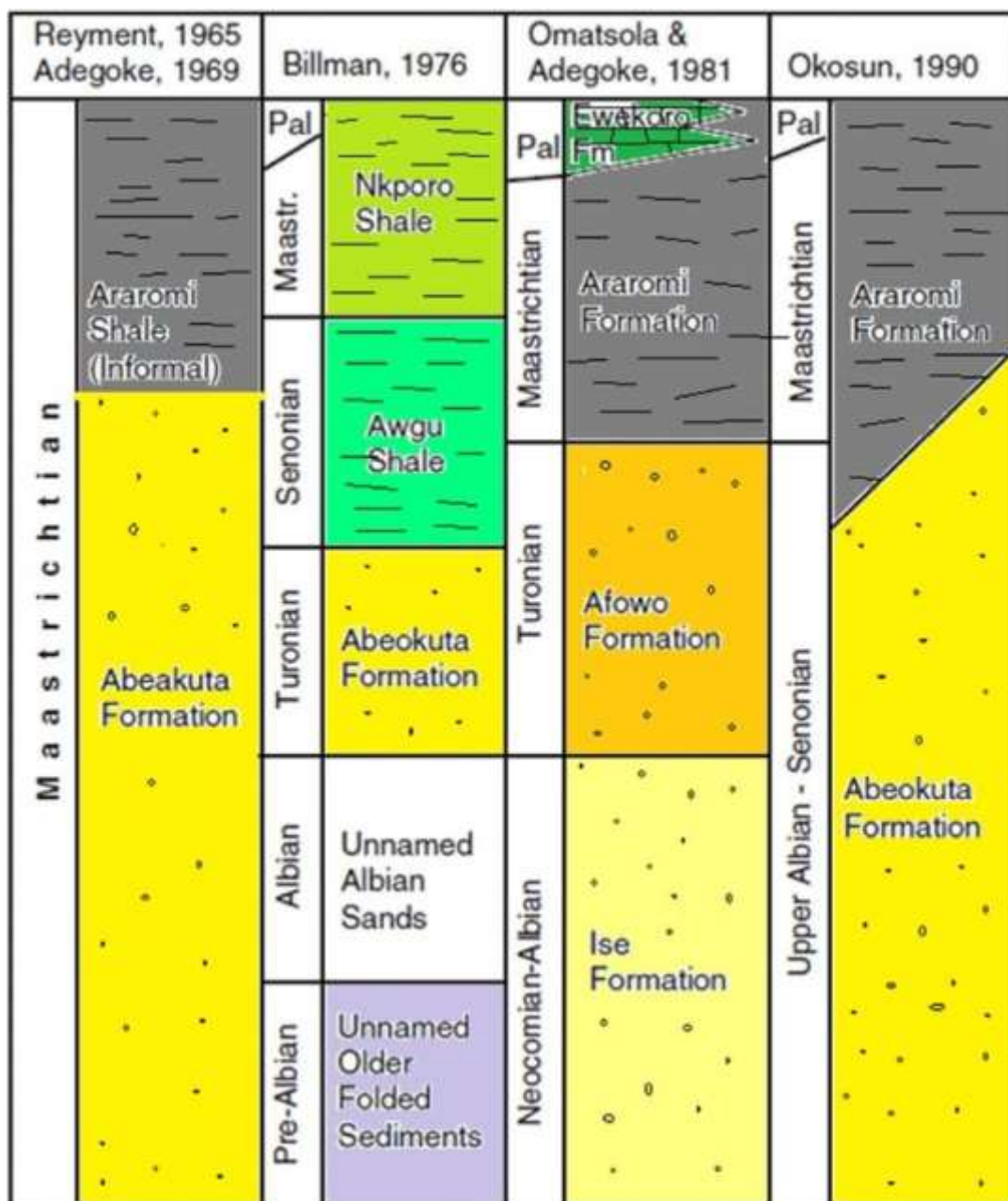


Fig 6: Stratigraphy of Dahomey Basin: After Omatsola and Adegoke






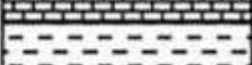


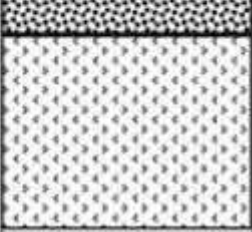
Age	Formation	Lithology
Pleistocene-Oligocene	Coastal Plain Sands	
Eocene	Ilaro	
	Oshosun	
Palaeocene	Akinbo	
	Ewekoro	
Maastrichtian-Neocomian	Araromi	
	Afowo	
	Ise	
Precambrian	Crystalline Basement	

Fig 7: Stratigraphy of Dahomey Basin showing the various lithologies



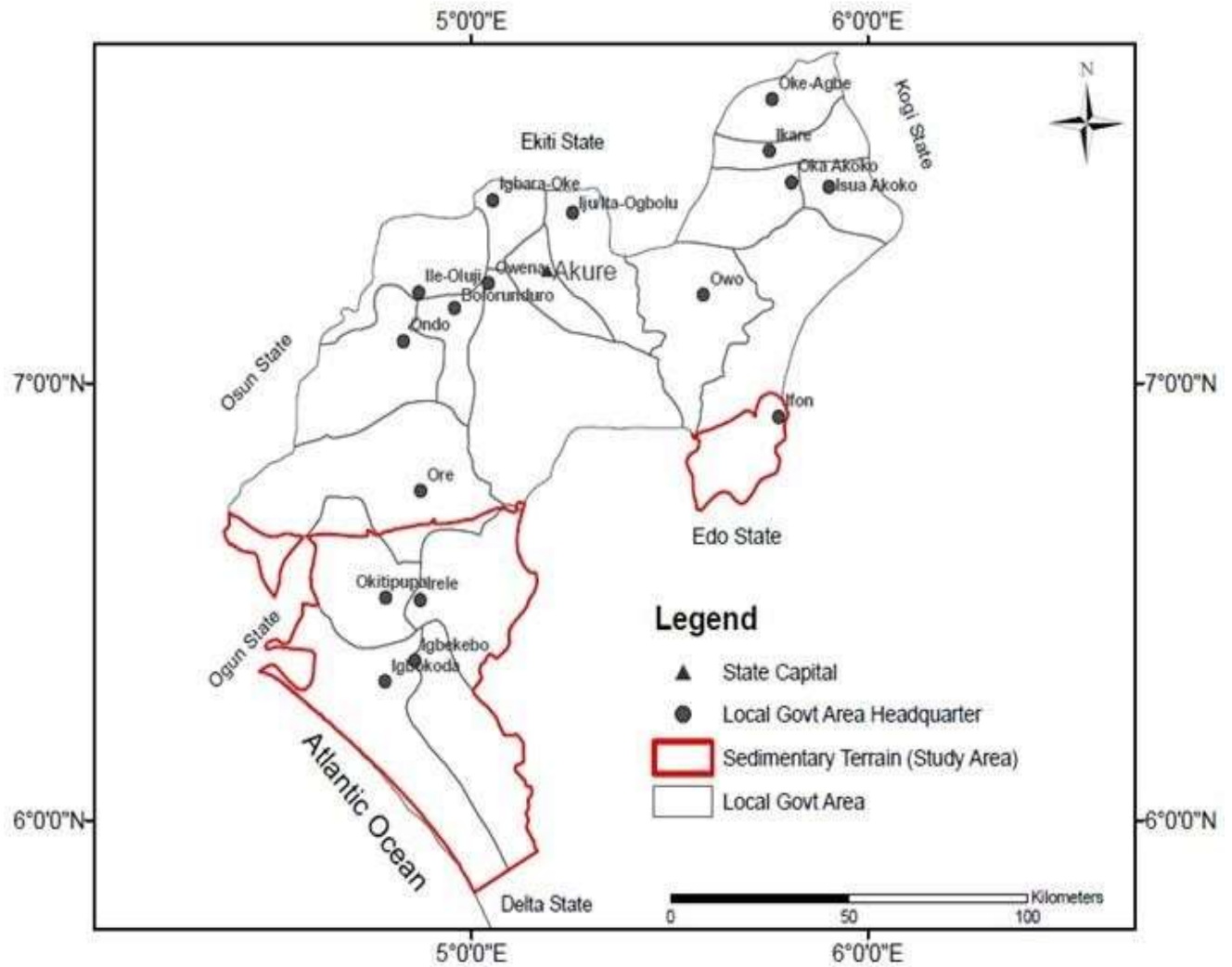


Fig 8: Administrative Map of Ondo State (Modified from Administrative Map of Ondo State published by the Office of the Surveyor General of Ondo State, 1998)

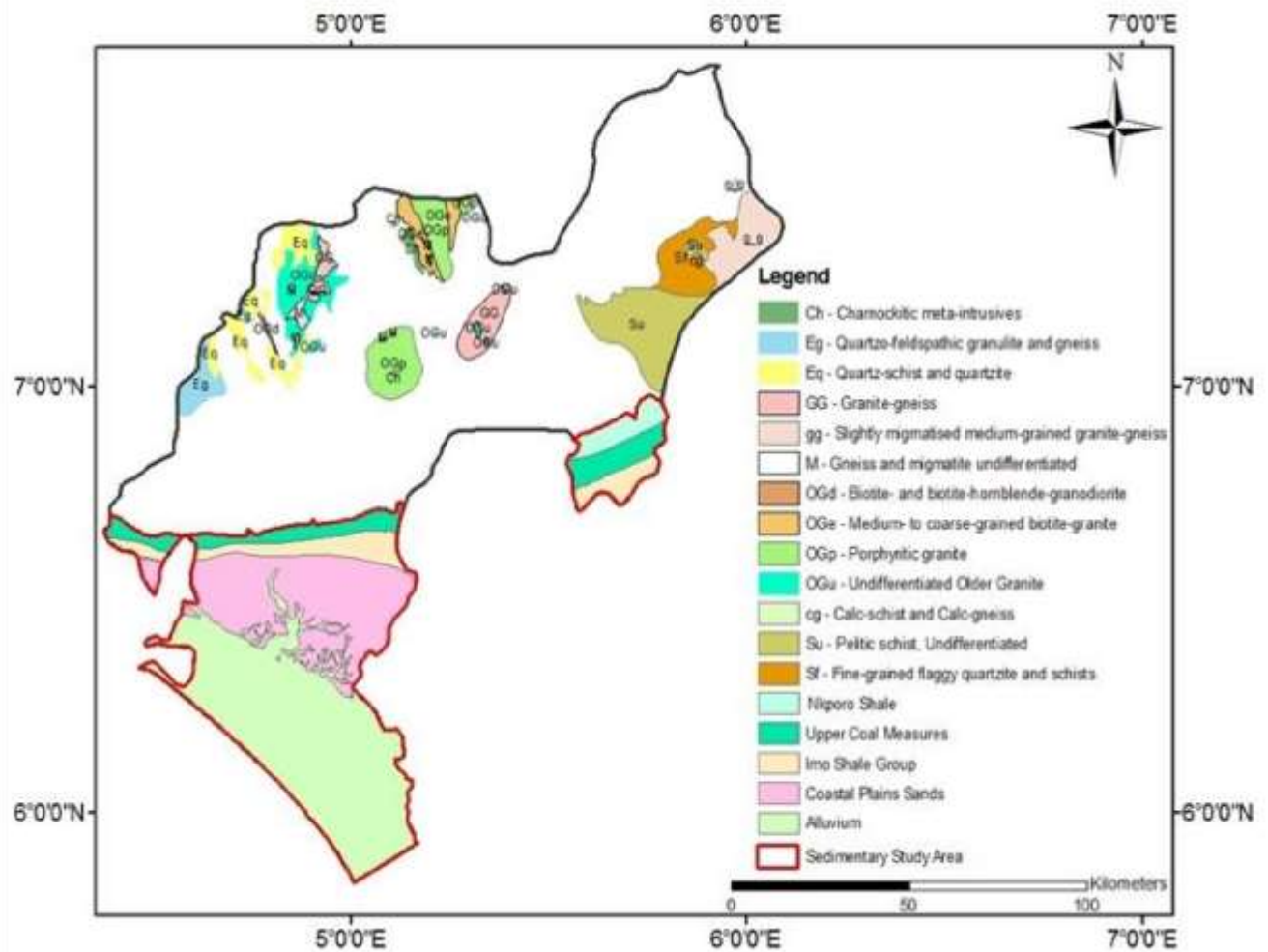


Fig 9: Generalized Geologic Map of Ondo State (Adapted from the Geological Survey of Nigeria (GSN, 1966))

## **CHAPTER THREE**

### **MATERIAL AND METHODOLOGY**

#### **3.1 List of Major Materials/Equipment and Their Uses**

- i. Global Positioning System (GPS): The GPS was used to get the actual Longitude, Latitude and elevation at each location the type used is Garmin,model GH7.
- ii. Base (Topographic) Map: The study area's topographic map provided a basic understanding of the area's physical features such as relief, potential outcrop area, and stream/river channels.
- iii. Camera: Used for taking photograph of structures, and other features on the outcrop.
- iv. Field note: use for taken note of important features on the field.

#### **3.2 Methodology**

The primary method was used in this study in which the coordinates of bitumen deposit, seepages, sealed well, open well and borehole was located, these positions in the study area were recorded using the Global Positioning System (GPS). A description of each location in the study area was noted and some bitumen samples were also collected at each location.

## CHAPTER FOUR

### RESULT AND DISCUSSION

Bitumen deposits which are found naturally in Ondo State have two basic concentrated forms, which are:

1. Seepages and outcrops of bitumen: These are tar sands that yield bitumen and require further extraction processes.
2. The lower viscous bitumen: These are the seepages mainly gotten from wells without obvious connection with sand.

These two categories of concentrates were observed during the reconnaissance fieldwork.

1. **Outcrops of bitumen deposit:** These are large deposits of bitumen that require further extraction processes. Large outcrop of bitumen of about 5-10m in extent was encountered at Agric. along Ode Aye road in location 17 (Fig. 10 and table 1), this outcrop occurs along a stream channel. Sample was taken and photographs were also taken. The bitumen is dark, viscous and sticky.
2. **Seepage of bitumen and abandoned well due to bitumen seepage:** These are the seepages mainly gotten from wells without obvious connection with sand. In location 3, 4, 5, and 6 along Ayika road traces of bitumen seepages were observed in figures 11a and b, this is an indication that the bitumen was not carried far from the source areas or probably due to seepage of bitumen from the underground. This seepage was continuous across the track. At location 2 in Okumo Alonge, a stream channel the village claimed that bitumen seepage was also noticed and the sand samples in those areas show traces of bitumen, probably deposited not far from this area. Also, abandoned wells were seen in location 18, (fig. 12), the villagers claimed the wells were abandoned due to the seepage of bitumen from the well and samples of the bitumen collected from the well were shown to us. The borehole shown in figure 13 at Ilu Ago in Ese Odo local government was abandoned because the villagers

could not drink the water because of the taste and color of the water due to bitumen contaminant.

3. **Sealed well:** At locations 9, 10, 11 and 12 in Egunre Jomo, location 5 in Okumo, locations 19 and 20 in Ibi Oloto and location 1 in Araromi Ayika wells that have been formerly dug for bitumen extraction were seen. For example, in Egunre Jomo (fig. 14) three different sealed wells were observed not far from each other which indicates the likelihood of bitumen deposit in the formation below the surface. At Ibi Oloto the king claimed the well was dug probably around 1905 and since then, no further work has been done. The sealed wells in Okunmo and Araromi Ayika have the same inscription on it which is SPDC (Shell Petroleum Development Company).
4. **Destructions of palm oil plantation due to bitumen seepage:** Many palm oil plantations were noticed to have been affected by bitumen spills in Agric farm settlement, Egunre Jomo (fig 15), this has led to loss of farmland. There is high possibility of bitumen deposit below the earth surface in these areas. Samples of soils in those areas were taken.

Table 1a: Field description of the study area

S/N	LOCATION	GPS READING	OBSERVATION
1	Araromi Ayika	N 06° 26' 41.7" E 04° 45' 52.0"	Sealed well dug for bitumen exploration (SPDC)
2	Okunmo	N 06° 27' 59.8" E 04° 49' 58.5"	Traces of bitumen seepage
3	Along Araromi Ayika road	N 06° 26' 58.2" E 04° 49' 49.2"	Traces of bitumen seepage
4	Along Araromi Ayika road	N 06° 26' 58.2" E 04° 49' 49.2"	Traces of bitumen seepage
5	Along Araromi Ayika road	N 06° 26' 58.2" E 04° 49' 49.2"	Traces of bitumen seepage
6	Agric along Ode Aye road	N 06° 32' 47.3" E 04° 45' 09.3"	Traces of bitumen seepage
7	Agric along Ode Aye road	N 06° 32' 41.9" E 04° 44' 43.8"	Traces of bitumen seepage
8	Agric Farm Settlement along Ode Aye road	N 06° 32' 47.6" E 04° 46' 55.3"	Soil contamination with bitumen seepage leading to destruction of palm trees
9	Ejure Jomo	N 06° 28' 53.7" E 04° 43' 18.1"	Pole 1 showing direction
10	Ejure Jomo	N 06° 28' 48.9" E 04° 43' 18.4"	Pole 2: sealed well dug for bitumen exploration
11	Ejure Jomo	N 06° 28' 48.9" E 04° 43' 17.5"	Pole 3: sealed well dug for bitumen exploration

12	Ejure Jomo	N 06° 28' 49.7" E 04° 43' 18.3"	Pole 4: sealed well dug for bitumen exploration
13	Okunmo	N 06° 25' 40.9" E 04° 46' 59.7"	Sealed well
14	Ilu Ago	N 06° 31' 24.2" E 04° 51' 46.3"	Abandoned borehole due to oil seepage
15	Ilu Ago	N 06° 35' 48.2" E 04° 47' 59.2"	Post showing a formerly dug well
16	Agric farm settlement	N 06° 32' 42.6" E 04° 44' 39.1"	Traces of bitumen seepage
17	Agric farm settlement	N 06° 32' 41.8" E 04° 44' 38.2"	Major exposure of bitumen
18	Agric farm settlement	N 06° 33' 5.8" E 04° 45' 1.2"	Abandoned open well
19	Ibisi Oloto	N 06° 29' 24.9" E 04° 38' 17.7"	Post 5
20	Ibisi Oloto	N 06° 28' 10.5" E 04° 37' 47.5"	Post 6



Fig. 10a: Bitumen exposure, Location 17 at agric Alonge ode aye road (N 06° 32' 41.8", E 04° 44' 38.2")





Fig 10b: Bitumen exposure, Location 17 at agric Alonge ode aye road (N 06° 32' 41.8", E 04° 44' 38.2")



Fig 10c Hand sample of the bitumen exposure, Location 17 at agric Alonge ode aye road (N 06° 32' 41.8", E 04° 44' 38.2")



Fig 11: Seepage of bitumen Alonge Ayika road, Location 3





Fig 12: Abandoned well, Location 18 Agric. along Ode Aye (N 06° 33' 5.8", E 04° 45' 1.2")



Fig. 13: Abandoned borehole in Ilu Ago, Ese odo due to bitumen seepage





Figs 14a and b : Sealed wells at Egunre Jomo and Okunmo, location 9 (N 06° 28' 53.7", E 04° 43')

18.1") and 5



Fig 15: Showing Abandoned plantation due to bitumen contamination

## **CHAPTER FIVE**

### **CONCLUSION AND RECOMMENDATION**

#### **5.1 Conclusion**

The reconnaissance survey revealed bitumen deposits and seepages at several locations in the study area, indicating the presence of natural fractures and faults that provide pathways for the migration of bitumen from deeper sources. The study area also has high potential for oil exploration and exploitation

#### **5.2 Recommendation**

Further geophysical survey and detailed mapping should be carried out in the location indicated in this reconnaissance survey in order to ascertain the extent of bitumen deposit. This will help in the decision making concerning drilling and production



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