

# **New Developments in Hydrocarbon Exploration Opportunities in Ghanaian Offshore Environment\***

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## **Abstract**

The new development in hydrocarbon exploration opportunities in the Ghanaian offshore environment was studied. West Africa is becoming a hot zone for the global oil and gas industry. There are spectacular findings that have shown Ghanaian offshore to be a fresh petroleum province with a multi-billion hydrocarbon potential. Three major discoveries have been made in the Ghanaian offshore: Mahogany-1, Hyedua-1, and Odum-1 from the four major sedimentary basins (Voltaian, Keta, Tano, and Cape Three Point) in Ghana. Three blocks of hydrocarbon deposits have been discovered and named the Jubilee Field, and this field has harvested millions of barrels of crude oil. The sedimentary basins in Ghana offshore have opened up several opportunities in the offshore deep water, offshore shallow water, and onshore basins. These developments have led to a massive turn out of major new hydrocarbon exploration and development opportunities with likely huge reserves of hydrocarbon lying under the offshore.

## **Introduction**

The term Hydrocarbon exploration is defined as the outlook for hydrocarbon deposits beneath the earth surface. The hydrocarbon deposits include oil and natural gas. Hydrocarbon exploration depends on sophisticated technology to detect and determine the extent of these deposits. It is an expensive and high-risk operation because it involves the task of finding oil and gas in commercial quantities. Therefore, there is need for a proper risk assessment for successful exploration. This begins from the point of identifying a prospect (a potential trap for hydrocarbons) to the point of exploration and production, significant amount of various investigations are carried out before drilling commences.

Recently, there has been a global spot light on Ghana (a West African country) due to the spectacular findings of hydrocarbons in their offshore environment (Derrick Petroleum). According to Derrick Petroleum, as of July 2011, there are 76 opportunities available and recorded in the whole of Africa. Out of this, 22 opportunities are in West and South-West Africa ([Figure 1](#)) (Derrick Petroleum).

The objective of the present review is to examine the new developments in hydrocarbon exploration in the Ghanaian offshore environment with a view to providing information on present opportunities in hydrocarbon exploration in Ghana offshore.

### **Geology of Ghana**

Ghana borders with Cote d'Ivoire (Ivory Coast) to the west, Togo to the East, Burkina Faso to the north, and the Gulf of Guinea of the Atlantic Ocean washing Ghana's southern shore. Ghana has a total area of about 238.5 km<sup>2</sup> and a 540 km coastline. Ghana lies on the eastern margin of the Precambrian West African shield, which occupies roughly 90% of the country (IUREP, 1985). The shield is covered by mostly Paleozoic sediments of the Voltaian Basin. The Precambrian Panafrican Mobile belt occupies the southeastern part of the country which is outside the shield area. At the Atlantic coast small Devonian-Carboniferous sedimentary basins are present and most of the Cretaceous to Recent sediments are also found. The Ghanaian part of the West African shield consists of isoclinally folded and steeply dipping lower Proterozoic rocks of the Birimian system. This shielded area in turn is covered by upper and lower Proterozoic basinal sediments of the Voltaian system. It is also noted that the shielded area also includes the lower Devonian. The Panafrican Mobile belt is a mountain chain cutting across the eastern border of Ghana. The belt consists of the Dahomeyan system, the Voltaian system, the Togo series and the Buem Formation ([Figure 2](#)) (IUREP, 1985). The Buem Formation belongs to the upper Precambrian and it consists mainly of shale, sandstone, and lava. Dahomeyan system is of the lower Precambrian and is made up of acidic and basic gneiss, schist, and migmatites. The Togo series consist purely of quartzite, shale, and phyllite. The Voltaian system consists of shale, mudstone, conglomerate, limestone, and quartzite. This system belongs to the Paleozoic. The Devonian-Carboniferous Accra and Sekonadi series form the minor sedimentary basins close to the Atlantic coast and consist mainly of shales and sandstones. The Eocene and Cretaceous basins are primarily made up of marine series of shale, sandstone, and limestone. Generally, the Cretaceous to Recent basins contain about 3600 m of sedimentary deposits consisting of partly glauconitic fossiliferous shales, sands, fossiliferous limestones, grey shales, bituminous sandstones, and shales ([Figure 3](#)) (IUREP, 1985).

### **Hydrocarbon Exploration in Ghanaian Offshore**

Before now there was absolutely nothing to write or talk about concerning hydrocarbon exploration in Ghana. As the years rolled by things changed. In June 2007, Ghana emerged from a decade of unsuccessful hydrocarbon exploration to a global exploration giant. A billion barrel Jubilee oil field was discovered by Kosmos Energy following the drilling of the Mahogany-1 well in Ghana offshore deep waters. According to Derrick Petroleum, this was the largest oil find in a decade in West Africa. This discovery was extremely

important as it was from a stratigraphic trap which is not like the easy identifiable structural traps. Locating and mapping these stratigraphic traps has the potential of hydrocarbon discoveries, just as the Jubilee discovery has shown. These recent exploratory successes bring focal attention to this region which is likely to have large reserves of hydrocarbon deposits beneath the offshore. Three major discoveries are discussed below:

### **Mahogany-1 Discovery**

This discovery was made on the 7th of June 2007. The Mahogany-1 is located about 63 km from Assini, the nearest coastal town, and 132 km southwest of the port city of Takoradi. The Mahogany-1 well was drilled to a total depth of 3826 m, in water depths of about 1322 m, penetrating gross reservoir sands of about 271 m and a net hydrocarbon pay of 6 m.

### **Hyedua-1 Discovery**

The Hyedua-1 discovery was made on August 7, 2007 and is located about 5.3 km to the south west of Mahogany-1 well in the Tullow Tano deep water block. The Hyedua-1 well was drilled to a total depth of about 4002 m and encountered a gross reservoir sand interval of 202 m and a net hydrocarbon bearing pay of 41 m.

### **Odum-1 Discovery**

Odum-1 discovery is the latest of Ghana discoveries. The well was discovered in February 2008 on the West Cape Three Points Block. The Odum-1 well is located 13 km east of the Jubilee Field. The well is 15 km from the coastline and 117 km southwest of the port city of Takoradi. This discovery is a Campanian fan that leads to the Ghana Tano sedimentary basin. The well, drilled to a total depth of 3386 m, encountered a gross oil reservoir of 60 m, and a net oil bearing pay of 22 m.

[Figure 4](#) and [Figure 5](#) (Kosmos Energy) are maps showing these discoveries.

### **Ghana Sedimentary Basins**

There are presently 4 major sedimentary basins that have been identified in Ghana. These basins include:

1. The Inland Voltaian Basin
2. Offshore Accra-keta Basin with an onshore extension
3. Offshore Tano Basin with an onshore extension

#### 4. Offshore Cape Three Points (Often considered as part of the Tano Basin).

The Cape Three Points (also called the Saltpond Basin) and the Voltaian basins are Paleozoic basins while the Tano and Keta basins are Cretaceous sedimentary basins. These basins have been explored to date. [Table 1](#) (Sutherland, 2008) gives an outlook of the various sedimentary basins and the number of wells drilled to date.

The Saltpond Basin also known as the Cape Three Points sedimentary basin comprises the Cape Three Points Deep Water Block, West Cape Three Points Block, Offshore Cape Three Points, and Offshore Cape Three Points South. Notable is the Offshore Cape Three Point Block (where the world class Jubilee Field was discovered in the adjacent license block ([Figure 6](#)) (Kosmos Energy in 2007) and the Offshore Cape Three Points South Block which has so far been awarded in June 2008.

The Tano Basin represents the eastern extension of the deep Ivorian Basin which resulted from rock deformation caused by tectonic activities in the Albian age. This deformation was associated with the opening of the Atlantic Ocean. The basin is a depositional environment that was created by a thick upper Cretaceous deep water turbidite sequence which in combination with a moderate Tertiary section provided sufficient thickness to mature an early to mid-Cretaceous source rock in the central part of Tano Basin (Kosmos Energy). These basins consist of the deep water Tano Cape Three Points block and the deep water Tano license ([Figure 6](#)) (Kosmos Energy).

The Keta Basin is a Cretaceous sedimentary basin located offshore eastern Ghana, positioned at the heart of the Voltaian River Basin. This basin covers an area of 5500 km<sup>2</sup> and water depth ranging from 1000 m to 2800 m ([Figure 6](#)) (Derrick Petroleum).

### **Developments in Hydrocarbon Exploration in Ghanaian Offshore**

Hydrocarbon has been explored in Ghana in a relatively small way since the nineteenth century but the discovery of a commercial level in 2007 has brought Ghana into the realms of major producing nation. The three blocks of hydrocarbon deposits uncovered 65 km off the coast of Ghana have been grouped together and named Jubilee Field. This field has already harvested millions of barrels of oil to date. Exploration plans for the year 2011 and 2012 in Ghana offshore environment have already been made. Since the above discovery of hydrocarbon in commercial quantities, there has also been an upsurge in hydrocarbon exploration activities, from the west to east of Ghana's coast ([Figure 4](#)) ([Table 2](#)) (African Energy, 2009). Derrick Petroleum planned exploration wells database shows a clear plan ([Table 3](#)) (Derrick Petroleum). The Ghana National Petroleum Corporation (GNPC) has attracted several companies to conduct hydrocarbon exploration activities in the offshore basin of the country. Their activities have resulted in the accumulation of a large volume of valuable data that will become useful for future operations in the search for oil (GNPC, 2008).

Sequel to this, the Ghanaian National Petroleum Corporation has signed the following agreements:

1. Kosmos Energy Ghana HC (Kosmos), over the Deep Water West Cape Three Points Block.
2. Tullow Ghana Limited (Tullow), over the shallow water Tano Fields including the discovered North and South Tano Fields; and the West Tano heavy oil discovery.
3. Tullow Ghana Limited, over the deep water Tano Basin.
4. Vitol Upstream Ghana Limited (Vitol – formerly Heliconia Energy Ghana Limited), over the offshore Cape Three Points area, east of the Kosmos acreage.
5. Vitol Upstream Ghana Limited, over South Cape Three Points acreage
6. Hess Ghana Limited (Hess) – (formerly Amerada Hess Ghana Limited).
7. Vanco Ghana Ltd. (Vanco), over the Cape Three Points Deepwater Block.
8. Aker ASA over South Deep water Tano contract area. This is the western part of the area given away by Vanco.
9. Gasop Oil (Ghana) Limited, over deep water Saltpond Basin.
10. Saltpond Offshore Producing Company Limited, over the existing Saltpond Field.
11. Oranto Petroleum International Limited, over the Saltpond area.
12. Afren Energy Ghana Ltd., over the deep water Keta Basin (Afren took over the Devon block).

According to the UK Trade and Investment Briefings in 2010, the recent discoveries in Ghana have opened the way for many companies to apply for exploration blocks in the coastal basins in Ghana (Ghana currently has about 23, 000 km<sup>2</sup> of open acreage offshore which is available for licensing. Opportunities for exploration are in the following sedimentary basins: Offshore Deep water and Offshore Shallow water. The offshore explorations have big players like: Kosmos Energy, Tullow Oil Plc, Ghana National Petroleum Corporation (GNPC), Anadarko Petroleum Corporation, Sabre Oil and Gas, and E.O. Group. These companies formed the consortium that made the Jubilee Field discovery in 2007. Currently, the Jubilee Field hold recoverable reserves of about 800 million barrels of light crude oil, with an upside potential of about 3 million barrels. According to GNPC, the Jubilee Field straddle two deep water blocks, i.e. the Tano Deep Water Basin, and the West Cape Three Points Deep – water basin, offshore the Western Region of Ghana.

Media reports have indicated that Kosmos Energy initiated moves to sell its equity in the Jubilee Field before oil starts to flow. There has been interest from Natural Gas Corporation of India, Royal Dutch Shell, Exxon Mobil, Chevron Corporation, ENI of Italy, and the China National Offshore Oil Company (IC Securities, 2009). Similarly, Kosmos has secured a USD 750 million loan to finance the phase one of the Jubilee Project. Exploration and production activities have picked up substantially in less than a year after discovery, 4, 411 km<sup>2</sup> of 3D seismic data has been acquired (IC Securities, 2009).

Another new development is the reconnaissance study which would be followed by 2D seismic acquisition over the Voltaian Basin is currently under way with a view to opening it up for exploration. There are other oil field blocks currently developed by other oil firms in Ghana apart from the Jubilee Field.

Below is a summary of other new developments in hydrocarbon exploration in Ghanaian offshore environment: (Derrick Petroleum)

1. A second exploration well apart from the Dzata-1 well in the Cape Three Points Deep Water Block has been planned to be drilled in 2011.
2. Afren Energy Plc is currently studying the results from the Cuda-1x exploration well and is planning to drill another exploration well in 2011.
3. Anadarko Petroleum, after encountering approximately 90 net feet of high quality oil, condensate, and natural gas pay in stacked Campanian – and Turonian-age reservoirs at the Teak-1 at West Cape Three Points Block has identified three (3) more prospects: Banda Deep/Cenomanian, south central channel, and Dahoma updip on the block and are planned to be drilled in 2011.
4. In 2010, an 860 km<sup>2</sup> 3D seismic survey was acquired in Offshore Cape Three Points Block and an exploration well will be drilled in 2011 in the eastern area of the block.
5. At the Offshore Cape Three Points South Block, more than 600 km<sup>2</sup> of extra 3D seismic survey has been carried out on the block. An exploration well was drilled in 2010 and the evaluation of the results is continuing in 2011.
6. Two or more prospects have been identified (Owo and Onyinwa) on the deep water Tano License which lies 16 miles west of the Jubilee Field on the adjacent West Cape Three Points Block. Owo prospect was drilled in early June 2010 and the second prospect Onyinwa is still being yet to be drilled in 2011.
7. Further exploration has been green-lighted and has been taken up in earnest by oil companies both international and domestic. The Ghana National Petroleum, has already drilled 79 separate wells and has secured some £550 million pounds of foreign investment to date, and is continuing the major exploration and production operations in four of the major sedimentary basins, Cote d' Ivories' – Tano Basin, Central Basin, the Accra/Keta Basin, and the Inland Voltaian Basin.

## **Conclusion**

Ghana has huge potential for growth in her hydrocarbon exploration offshore environment. With some 1.5 billion barrels of oil in the Jubilee Field alone, and many more fields expected to be discovered in the future, there are countless opportunities and the impact of Ghana's new oil and gas industry are already being felt across the nation. Consequently, a series of new discoveries has opened the floodgates for major new hydrocarbon exploration and development opportunities. Some 23,000 km<sup>2</sup> of untapped coastal basins rich with oil are awaiting companies ready to seize the opportunities.

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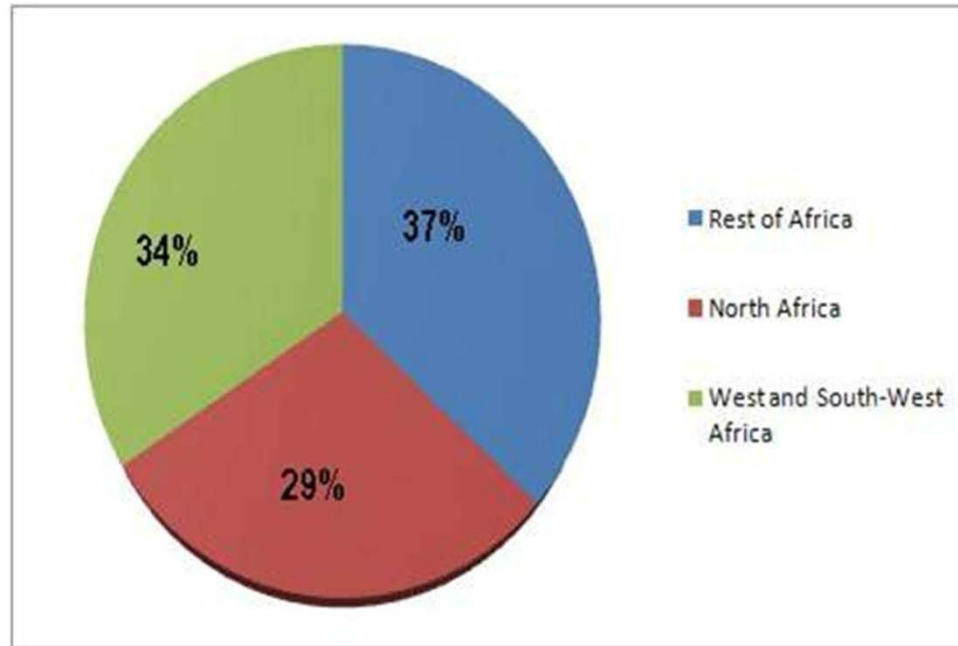


Figure 1. Breakdown of Hydrocarbon Exploration Opportunities in Africa. Source: Derrick Petroleum Database.

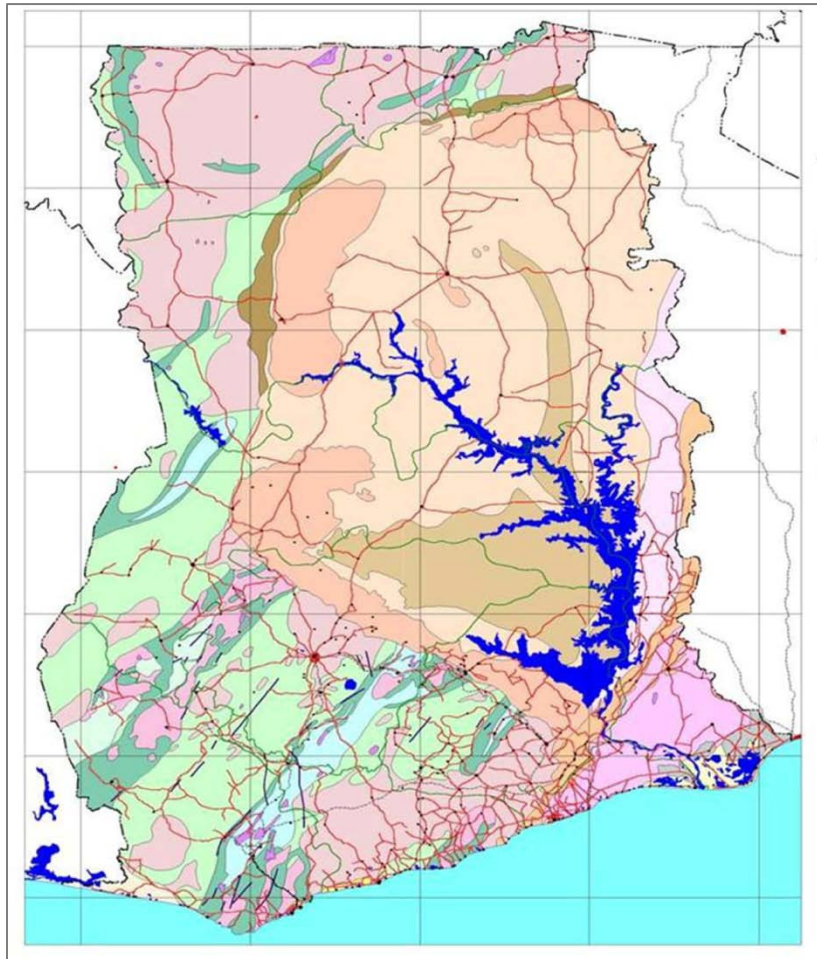


Figure 2. Map of Ghana showing the Geology of Ghana.

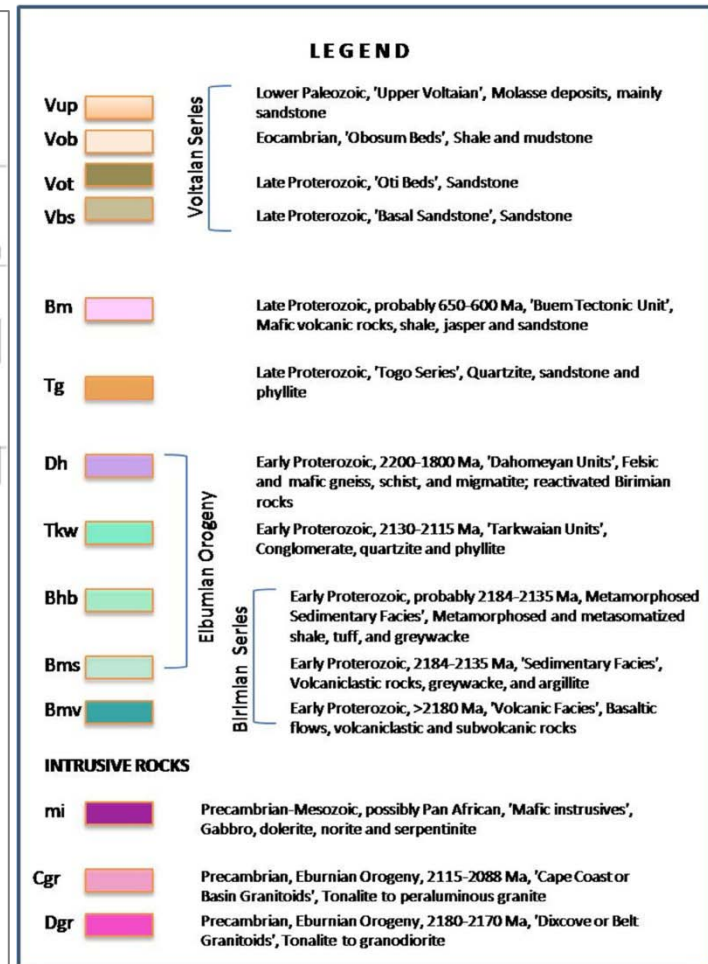


Figure 3. Legends to Figure 2.

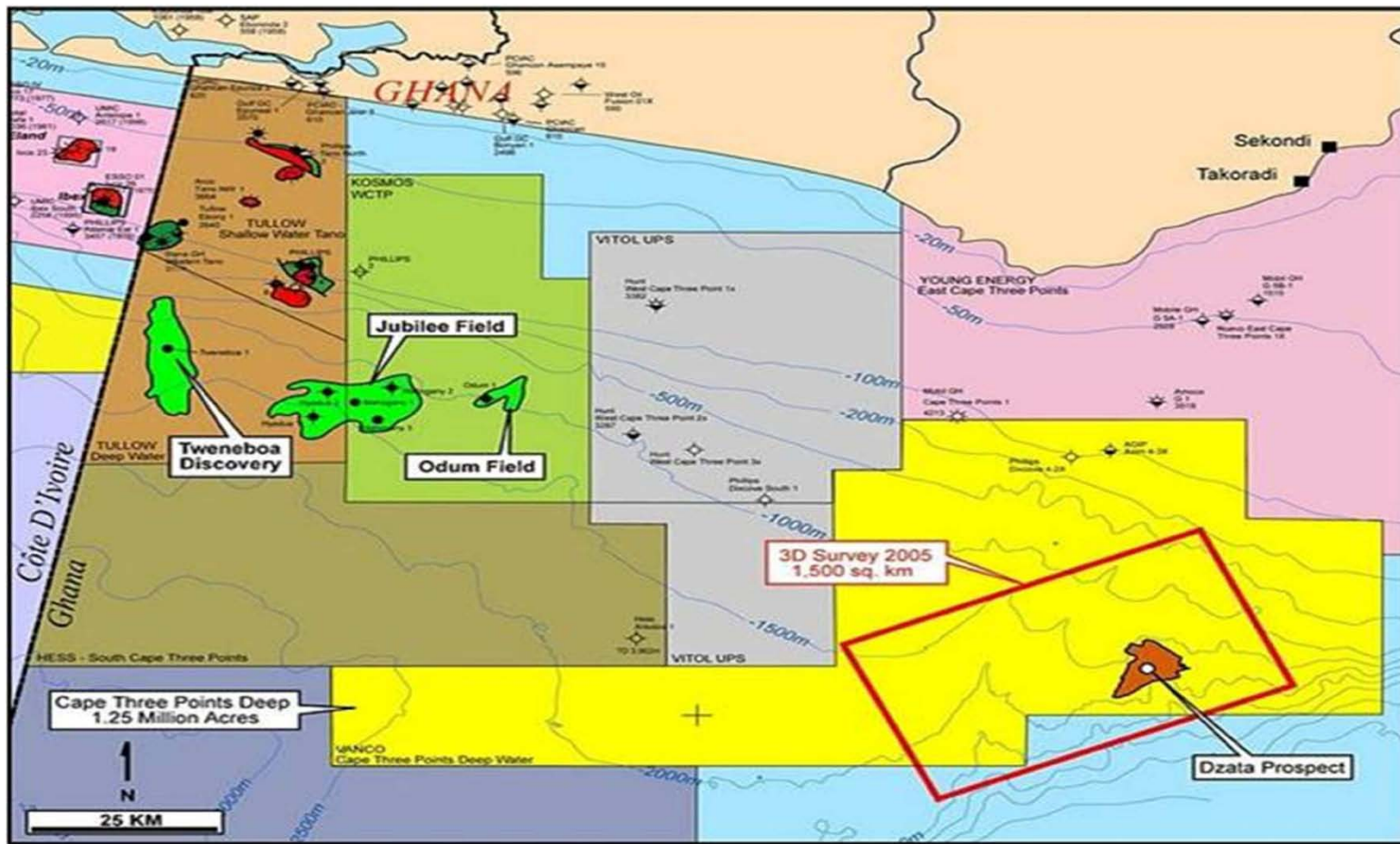


Figure 4. Map Showing Discoveries. Source: Kosmos Energy.



Figure 5. Map Showing Hydrocarbon Exploration in Ghana.

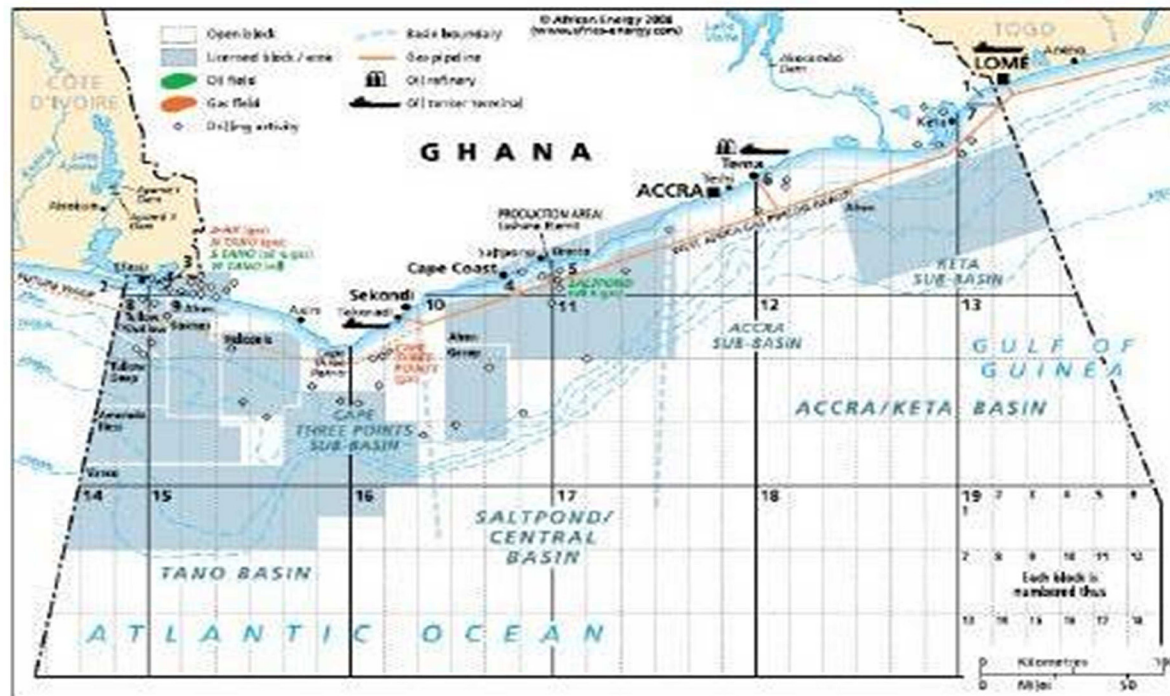


Figure 6. Map Showing Discoveries. Source: Tullow Ghana Limited.

<b>BASIN</b>	<b>AGE OF SEDIMENTS</b>	<b>WELLS DRILLED TO DATE</b>
TANO	Cretaceous	62 wells includes appraisal wells and shallow onshore boreholes
KETA	Cretaceous	10
SALTPOND (CAPE THREE POINTS)	Paleozoic	20 wells includes appraisal
VOLTAIAN	Paleozoic	1

Table 1. Showing the Various Sedimentary Basins Explored.

Discovery / Field	Year	Discoverer	Discovery Well	Onshore/ Offshore	Oil/ Gas
Saltpond	1970	Signal-Amoco Consortium	10-1	Offshore	oil
Tano South	1978	Phillips Petroleum		Offshore	oil & gas
Tano North	1980	Phillips Petroleum		Offshore	gas
South Tano 3AX Satellite	1980	Phillips Petroleum	South Tano-3AX	Offshore	oil&gas
Jubilee (Mahogany/Hyedua)	2007	Kosmos Energy	Mahogany-1 Hyedua-1	Offshore	oil
Odum	2008	Kosmos Energy	Odum-1	Offshore	oil
Ebony	2008	Tullow	Ebony-1	Offshore	oil&gas
Tweneboa	2009	Tullow Oil	Tweneboa-1	Offshore	oil&gas
Sankofa -1A	2009	Vitol	Sankofa - 1A	Offshore	gas&oil
Mahogany East (x-Jubilee SE)	2009	Kosmos Energy	Mahogany-3	Offshore	oil
Dzata	2009	Vanco Energy	Dzata-1	Offshore	oil&gas
Enyenra (x-Owo)	2010	Tullow Oil	Owo-1	Offshore	oil&gas
Teak	2010	Kosmos Energy	Teak-1	Offshore	oil

Table 2. List of Offshore Discoveries in Ghana up to 2011.

Block/ Prospect Name	Operator	Onshore/Offshore	Status	Wells planned in 2011	Wells planned in 2012+
Cape Three Points Deep Water	Vanco Energy Co	Deep Offshore	Ongoing	2	
Keta	Afren Plc	Deep Offshore	Ongoing	1	
West Cape Three Points Block	Kosmos Energy (Africa)	Deep Offshore	Ongoing	1	
Deepwater Tano Cape Three Points	Hess Corporation	Deep Offshore	Ongoing	1	
Offshore Cape Three Points	ENI	Deep Offshore	Ongoing	1	
Offshore Cape Three Points South	ENI	Deep Offshore	Ongoing		
Deepwater Tano Licence	Tullow Oil	Deep Offshore	Ongoing		
Offshore Accra Contract Area	Tap Oil Ltd	Shallow Offshore	Announced		1

Table 3. Hydrocarbon Exploration Plans in Ghanaian Offshore.