

GEOLOGY AND PETROLEUM POTENTIALS OF NIGERIA SEDIMENTARY BASINS

Introduction

The Federal Republic of Nigeria has a teeming population of over 130 million people. The country has an approximate surface area of about 924,000 square kilometers comprising thirty six (36) provincial states with the Federal Capital Territorial (FCT) at Abuja. Nigeria is a democratic nation endowed with abundant human and natural resources. The main natural resources being Petroleum resources.

Before the advent of Petroleum in 1950s, Nigeria was an agrarian society with ground nuts, Cocoa, Rubber etc. as the main agricultural produces.

Nigeria is the most populous African nation, located in West Africa sub-region. In the South, the country is bounded by the Gulf of Guinea, North by Mali, Niger Republic and Chad in the East by Cameroun and West by Republic of Benin.

Petroleum exploration in Nigeria began as far back as 1908. In 1956 the first commercial oil discovery was made at Oloibiri in the onshore Niger Delta and production of the crude oil commenced in 1958. Since that time, petroleum has played a progressively prominent role in the social and economic development of the Nigeria.

Today, petroleum resources account for about 99% of the national economy. In the global scene, Nigeria is ranked 6th in OPEC and 14th in the World in terms of oil production.

LEASE ADMINISTRATION

It is pertinent to note that the deepwater blocks and inland basins in Nigeria are currently being operated by Production Sharing Contract (PSC) arrangement. The PSC trends in Nigeria since the first entrant in 1973 have been encouraging. The first PSC agreement in Nigeria Deepwater started, with the allocation of over 6,000km² acreage in 1991, since then the PSC areas have gradually grown to well over 50,000.00 square kilometers as at 2003. These Contract areas indeed hold the key to the realization of government's desire of increasing the nation's current oil reserves of 30 billion in 2003 and 40.0 billion barrels by the year 2010.

The allocation of the open blocks is usually through competitive bidding in a continuous exercise. The Production Sharing Contract (PSC) and other relevant laws of the land govern the operations of the Nigeria Deepwater blocks. The fiscal regime is robust and flexible for attractive investment.

Presently, in Nigeria deep-water environment, Government signed into Law, the Provisions of the 1993 PSC through the Deep Offshore and Inland Basins Production Sharing Contracts Act No 9 of 1999 and as amended to authenticate its legality and applicability to lease administration in Nigeria.

The Department of Petroleum Resources is vested with the authority to monitor and regulate the Nigerian oil and gas industry. The Department oversees all the activities of all the companies licensed to engage in any petroleum activity in the country to ensure compliance with the terms and regulations relating to the conditions of the license. Furthermore, it monitors the industry's operations to make sure that the national goals and aspirations are met, and ensure that oil companies carry out their operations according to industry's standard and practices. It keeps records and other data of the oil industry's operations and informs Government about all the activities and occurrences in the petroleum industry. The Department over the years has helped in creating conducive business environment for investors in this sector hence the tremendous continuous growth.

REGIONAL GEOLOGY

Many major depositional episodes can be distinguished in Nigeria; these are particularly not limited to the following:

- Early to Late Cretaceous Pre-Santonian Transgressive and Regressive Complexes when the rift -like Benue depression and Abakaliki trough was formed as a result of the separation of the South American and African Continents. There are igneous activity and mineralization accompanying this geological episode. The Bima complexes which developed at the end of the Benue depression in North eastern Nigeria gave rise to the Chad Basin.
- Late Cretaceous – Palaeocene Post Santonian Anambra Basin situated on the northwest flank of the Abakalilki fold belt which began to develop as a regressive offlap sequence during Campanian Times.
- Cenozoic Niger Delta complex which developed as a regressive offlap sequence.
- The Maastrichtian transgression when the sea moved northwards from the Gulf of Guinea through the Mid-Niger Basin and southwards from the Mediterranean through the Sahara etc.

A culmination of these depositional events resulted in the formation of about seven sedimentary basins in Nigeria where active petroleum exploration activities can be carried out (figure 1). These basins include the following:

- Anambra Basin
- Benue Trough
- Benin Basin
- Bida basin

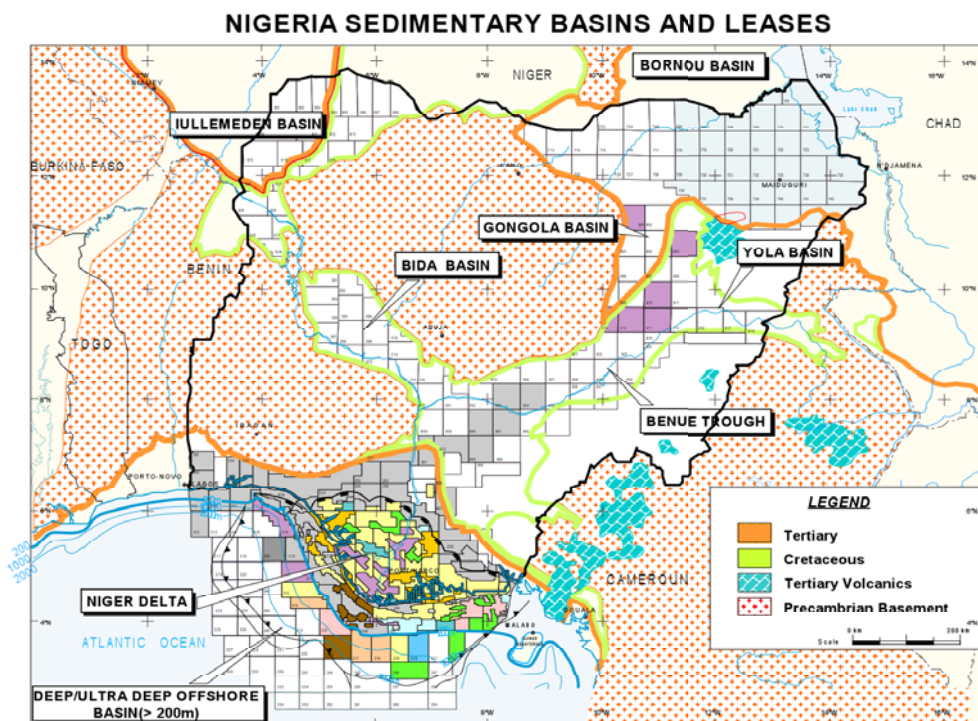
- Bornu Basin
- Niger Delta basin and
- Sokoto Basin.

ANAMBRA BASIN

The Anambra Delta complex may be thought of as a late Cretaceous – Palaeocene Proto Niger – Benue Delta Complex which was developed wholly upon the Continental Crust.

In terms of trapping mechanisms, this is somewhat smaller than the Niger Delta and does not seem to have developed large growth faults and shale diapirs as much as the Cenozoic Delta.

Figure 1:



The regressive offlap sequence began to develop in the Campanian times and prograded into the Maestrichtian and the delta development ended in the Palaeocene when the Imo shale Palaeocene transgression phase occurred. This is a pointer to the fact that the main source, reservoir and cap rocks which are related to the petroleum potentials of the basin are diagnostic in these sequences particularly in the Coal Measure facies, the Awgbi Shales and Agbani Sandstones.

Initial exploration activities conducted by Elf petroleum Nigeria Limited in this basin found oil in Anambra River – 1 well and mainly gas in subsequent wells. The company however relinquished the concessions and the exploration activities terminated. It should be noted that over years investors’ quest for exploration activities in this basins is on the increase based upon the petroleum geological attributes associated with the Anambra Basin.

In readiness for the Year 2005 licensing round, sixty one (61) open concessions are earmarked and available for the open competitive bidding by interested investors. These blocks are located as follows and as shown in Table 1.

• ANAMBRA BASIN-ONSHORE	9
• BENUE BASIN- ONSHORE	16
• BORNO BASIN- ONSHORE	12
• BENIN BASIN	
– DEEPWATER/ULTRA DEEPWATER	8
• NIGER DELTA BASIN	
– ONSHORE	6
– CONTINENTAL SHELF	6
– DEEPWATER/ULTRA DEEPWATER	4

TABLE 1A: APPROVED ONSHORE BLOCKS FOR YEAR 2005 LICENSING ROUND

BASIN/TERRAIN (Onshore Terrains)	BLOCK OPL	AREA (KM ²)	AVAILABLE DATA	DATA LOCATION		
ANAMBRA ONSHORE (9 Blocks)	901	2392.49				
	902	2589.58				
	903	2552.7				
	904	2506.47				
	905	2599.81				
	906	2550				
	907	2394.62				
	914	1674.75			2-D seismic and well data	Elf and DPR
	917	1310.57			based on Elf's previous activities	
BENUE ONSHORE (16 Blocks)	802	2583.7	2-D seismic and well data based on ELF, SNEPCO and CNL'S previous activities	Shell, Elf		
	803	2583.18				
	804	2586.23				
	806	2585.722				
	807	2588.77		Chevron and DPR		
	808	2583.18				
	809	2580.64				
	810	2583.68				
	811	2578.1				
	813	2575.55				
	814	2578.59				
	815	2573.02				
	816	2578.09				
	819	1634.2				
	823	2583.18				
	841	2535.6				

BASIN/TERRAIN (Onshore Terrains)	BLOCK OPL	AREA (KM²)	AVAILABLE DATA	DATA LOCATION
CHAD ONSHORE (12 Blocks)	704	2539.4	2-D seismic and well dat based on NNPC/FES previous activities	NNPC/FES
	706	2558.9		
	708	2539.4		
	709	2526.5		
	710	2533.8		
	711	2545.4		
	721	2564.9		
	722	2558.4		
	723	2571		
	733	2611.42		
	734	2610.48		
	735	2130.84		
	NIGER DELTA ONSHORE (6 Blocks)	135		
228		1584.73		
231		236.83		
234		1214.21		
235		1480		
236		1651.98		

TABLE 1 B: APPROVED OFFSHORE BLOCKS FOR YEAR 2005 LICENSING ROUND

BASIN/ TERRAIN	BLOCK	OPL	AREA Km²	AVAILABLE DATA	DATA LOCATION	WATER DEPTH
NIGER DELTA		241	1,257.44	2-D seismic and		0-100m
CON. SHELF		454	2,521.14	well data based on	Shell and DPR	0-100m
(6 Blocks)		233	125.74	Shell, CNL and		0-100m
		471	1,369.97	TGS/NOPEC's	TGS/NOPEC	0-100m
		239	64.67	previous activities	Chevron and	0-100m
		240	47.65		DPR	0-100m
DEEP OFFSHORE		257	425.70	3-D seismic	PGS	1000-2000m
(12 Blocks)		258	233.74	2-D Seismic	Mabon	1000-2000m
	Former 313	319	1,112.97	2-D Seismic		2000-3000m
	Former 314	314	1,112.97	3-D Seismic	PGS	1000-2000m
		321	1,112.97	2-D Seismic	PGS	1000-2000m
	Former 315	323	1,033.49			1000-2000m
		315	1,033.49	3-D seismic	PGS	1000-2000m
	Former 317	325	1,265.00			3000-4000m
		327	1,265.00	2-D/3-D seismic	Veritas	3000-4000m
	Former 319	328	894.72			3000-4000m
	Former 251	251	939.69	2-D Seismic/	Mabon/	2000-3000m
		252	939.69	3-D Seismic	Veritas	2000-3000m

TOTAL = 61 Blocks**NB: The former deepwater blocks have been divided into two OPLs as directed.**

NIGER DELTA

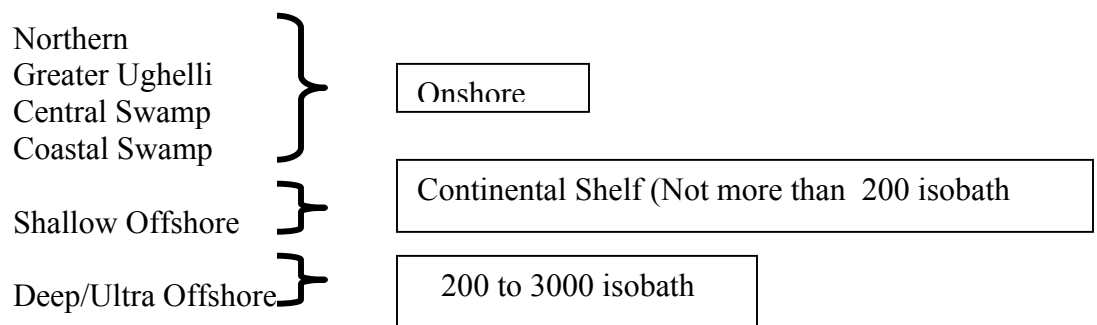
Cenozoic Niger Delta complex was developed as a regressive offlap sequences. The delta complex which has been described as an arcuate-lobate shape was built across the Anambra Basin and the Cross River margins and eventually extended onto the Late Cretaceous continental margin. Geologists believe that these sediments were part of the West African miogeocline derived from adjoining older rocks which were transported and deposited by the help of the Rivers Niger and Benue onto the cooling and subsiding oceanic crust which has been generated as the South American and African Continents spread apart.

The Geophysicists and Geologists have shown that the Niger Delta Basin has spectacularly maintained a thick sedimentary apron and salient Petroleum geological features favourable for Petroleum Generation, expulsion and trapping from the Onshore through the Continental Shelf and to the deepwater terrains.

In 1956, the first commercial onshore discovery was made in Oloibiri by Shell and about seven years after, Chevron discovered the Okan field, the first commercial offshore field in 1963. Thus, among the sedimentary basins in Nigeria, aggressive exploration has been concentrated in the Niger Delta Basin.

The Niger Delta Basin to date is the most prolific and economic sedimentary basin in Nigeria by the virtue of the impact size petroleum accumulations, discovered and produced as well as the spatial distribution of the petroleum resources to the Onshore, Continental Shelf through Deepwater terrains.

Classic integrated geological studies have shown that several different depobelts are abundant in the Niger delta basin (Figure 2). These depobelts are:



While three (3) categories of structural styles are common in the Niger Delta Onshore, Continental Shelf and Deepwater terrains:

- Extensional Zone – Growth faults
- Translational Zone – Diapirs
- Compressional Zone – Toe thrust

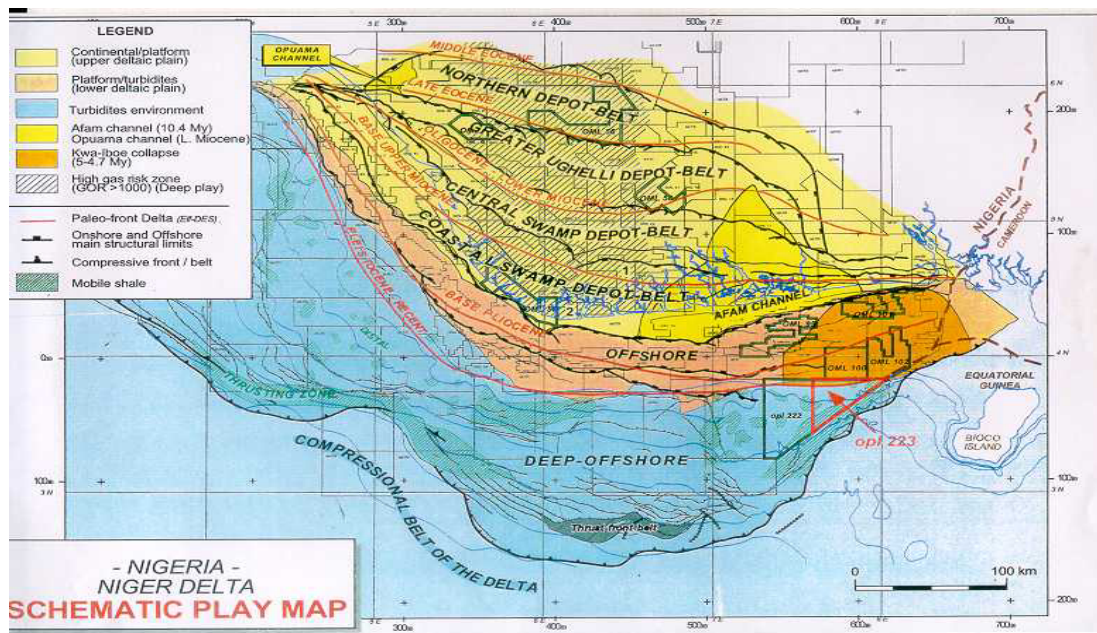
Onshore and Continental Shelf Niger Delta

The Onshore and Continental Shelf Niger Delta are now matured terrains in terms of petroleum exploration and exploitation having been explored and produced for more than half a century now.

Three characteristic geological formations namely Akata formation, which is composed of marine shales formed the main source rocks for petroleum, the formation is overlain by the paralic Agbada formation which consists of the main reservoir units. The Agbada formation is made up of intercalations of Sand and shale sequences. The sands are mainly unconsolidated reservoir sands while the shales also function as source rocks and cap rocks

Most of the Oil and Gas so far discovered and produced to date in the Niger Delta basin have been reservoired in the Agbada formation. The Agbada formation is overlain by the continental Benin formation. This formation which is mainly composed of sand units has little petroleum bearing status.

Figure 2: Niger Delta Depobelts



The three lithostratigraphical units have been established in both the Onshore and Continental Shelf terrains as the main petroliferous units in Niger Delta of Nigeria.

Unlike the Onshore, Niger Delta Continental Shelf in places is characterized with shale diapirs and growth faults. The shale diapir has not been found in the Onshore Niger Delta to date. The presence of growth faults and associated rollover anticlines in nearly

all terrains of the Niger delta basin point to the fact that structural trapping mechanism for petroleum is common in the delta.

The geological age of the Niger Delta ranges from Paleocene to present. Oil and gas have been found in reservoir rocks ranging from Oligocene to Miocene.

To date, the Onshore and Continental shelf of Niger Delta account for the oil production which is put at about 2.2 MMbopd. Exploration activities continue in these terrains which commenced oil production in the Onshore in 1958 and Continental shelf in 1965 owing to huge petroleum potentials. Fourteen (14) onshore blocks, OPLs 135, 201-204, 207 and 208, 228, 231, 233 – 236 and 452 have been carved out and are available for competitive bidding by interested investors.

In the continental shelf, seven (7) OPLs such as OPL 227, 239, 240, 241, 454, 467 and 471 have been earmarked for competitive bidding by interested investors. Recently government through TGS-NOPEC and Mabon Limited had acquired 2-D/3-D speculative seismic data to boost the prospectivity of this terrain.

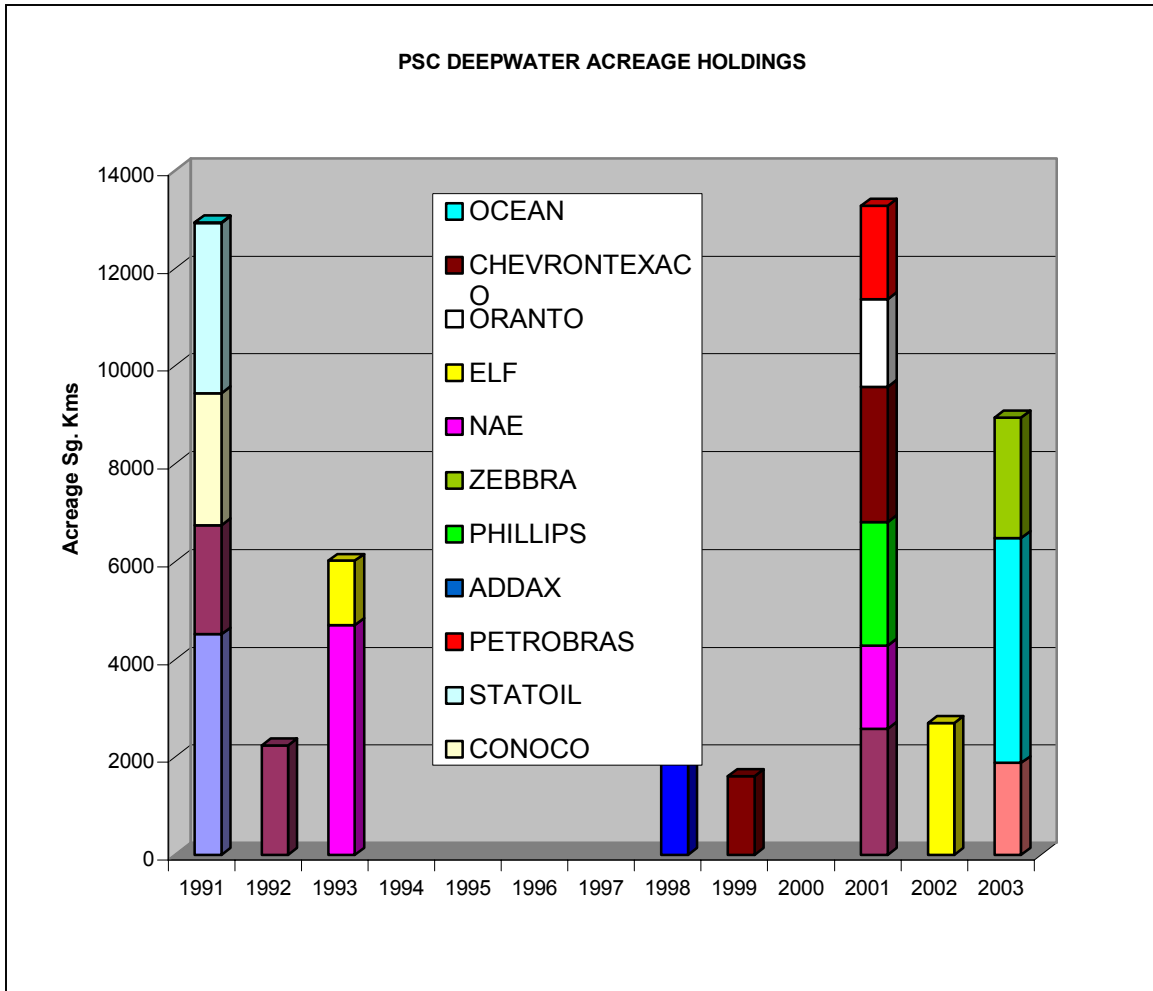
Deepwater Niger Delta

In a renewed drive to increase exploration activities and pursuant to Government's determination to increase the national reserves base to 30 Billion barrels by the year 2003 and 40 Billion barrels by 2010, TGS/MABON acquired Speculative 2-D seismic data in 1990 in the Deep Offshore for Government. Subsequent speculative 2-D and 3-D seismic data have been acquired by Veritas DGC and PGS/IDSL to unveil the petroleum potential of the Nigeria Deep Offshore.

The direct application of risk – reducing 3D –seismic data by Shell Nigeria Exploration and Production Company, Statoil, South Atlantic Petroleum, Esso Exploration and Production, Nigerian Agip Exploration, Allied Energy, Conoco and Chevron Texaco etc. have made impacts to the technical and commercial discoveries in Nigeria deepwater.

It is pertinent to reiterate that the deepwater blocks and inland basins in Nigeria are currently being operated by Production Sharing Contract (PSC) arrangement. The PSC trends in Nigeria since the first entrant in 1973 have been encouraging. The first PSC agreement in Nigeria Deepwater started, with the allocation of over 6,000km² acreage in 1991, since then the PSC areas have gradually grown to well over 50,000.00 square kilometers as at 2003 and the licence holders also increased (Figure 5). The contract areas indeed hold the key to the realization of government's desire of increasing the nation's current oil reserves of 30 billion in 2003 and 40.0 billion barrels by the year 2010

Figure 3:



In 1995, the world – class Bonga field, the first commercial oil discovery was made by Shell and encouraged by subsequent operator, the Nigeria Deepwater has become the main exploration focus for the realization of Government aspiration of its reserves base. Nigeria

The main structural styles are composed of a variety of extensional, translational and compressional zones. The main impact size exploration focus lies within the these zones where world-class standard fields have been found to date (Table 1).

Table1: World Class Oil Discoveries resulting from previous licensing rounds

NIGERIAN DEEP OFFSHORE MAJOR DISCOVERIES CONT'D

FIELD	YR OF DISCOVERY	WATER DEPTH (M)
NNWA	1999	1200
AKPO	1999	1360
IKIJA	1999	1400
DORO	1999	1280
BONGA SW	2001	1245
BOLIA	2001	1100
USAN	2002	746
NSIKO	2003	1750

The Turbidite systems in terms of submarine fan models are the main exploration strategy. Nigeria deepwater turbidities include particularly the following:

1. Amalgamated Channels
2. Isolated Channel Complex
3. Sinuous Channels
4. Channel sand complexes and
5. Levee/overbank deposits etc.

Majority of the deepwater wells evaluated the turbidite reservoir sands of middle Miocene to Oligocene age in slope and basin fan settings.

By the discovery of the world-class standard fields in the region, Nigeria deepwater has been described as a petroleum province. Initially, operators of the deep offshore blocks had restricted drilling operations to water depth below 200m, but with the acquisition of high-resolution 3D seismic and well control, there has been better understanding of the geology, thus drilling further offshore and into the water depth between 500 – 1900 metres has tripled the discovery.

The Petroleum system and Basin modeling carried out by the ENI-AGIP group revealed that Turbidite associated shales from Mid-Miocene and late Oligocene age are Kerogen Type II and III, which are co-producers of Oil and Gas in addition to massive, mobile and overpressured underlying marine shales .

The Deepwater Petroleum Exploration in Nigeria has reached an advanced stage. The update of Oil and Gas discoveries has revealed impact size Exploration in the region and deep water oil production has been started by the ENI-AGIP group. The deepwater environment is a high cost environment with the risks and challenges ranging from logistics, water depths, funding, technology and geology etc (Figures 4 & 5).

Towards the realization of vision 2010, Government has placed emphasis that the activities of the licensed blocks are to find commercial hydrocarbon accumulations so as to establish an economic development. The most environmental consideration of the deepwater is the zero flaring policy from the first oil to the entire life cycle of the field.

Figure 4:

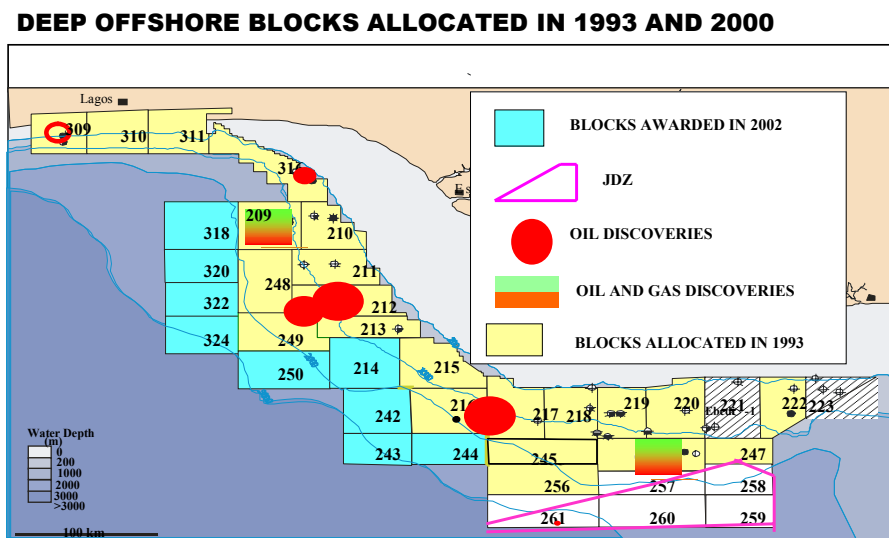


Figure 5: Acreage Allocation trends in Nigeria Deepwater

