“New Insights into the Petroleum Potential of Sierra Leone”

24th Africa Oil Week (Africa Upstream)
23rd – 27th October, 2017
Cape Town International Convention Centre
Cape Town, South Africa

Presented by:
Director General Mr Raymond Kargbo

Sierra Leone- Background Information

- **LOCATION:** West Africa bordering the North Atlantic between Guinea and Liberia
- **CAPITAL:** Freetown
- **POPULATION:** 7.1 Million (2015 census)
- **LANGUAGES:** English (Official) – Spoken by 20% of population, Temne (North), Mende (South), Creole (English-based lingua franca spoken/understood by 95% of population)

Sierra Leone declared Ebola free on 17th March 2016 by WHO

Sierra Leone - Background Information

- AREA: 71,740 Sq. km.

- COASTLINE: 402 km.

- GOVERNMENT: Constitutional Democracy – President Elected for 5 – year terms (not more than 2 terms)

- Climate: Hot, Humid with 2 seasons
  - Rainy Season (May – Oct)
  - Dry Season (Nov – April)

- GDP: $4.4 billion (2017 est.)

- GDP PER CAPITAL: 1,737.9 (2017 est.)

- REAL GDP GROWTH RATE: 5% (2017 est.) – Dip in GR due to Ebola Outbreak with slowed down economic activity

- KEY NATURAL RESOURCES: Iron Ore, Diamonds, Titanium, Bauxite and Gold
Pursuant to executive powers conferred by H.E the President, Dr. Ernest Bai Koroma, the Director General of the Petroleum Directorate administers the Petroleum Exploration and Production Act (PEPA), 2011 and reports directly to the President.

The Petroleum Directorate under PEPA 2011 has a statutory responsibility for regulating the upstream oil and gas sector, and ensuring that all Operators conducting petroleum operations comply with the applicable Petroleum Legislation and any other regulation(s) or guideline(s) governing upstream oil and gas operations in Sierra Leone.
Our Mission is to:

“facilitate the optimal exploration and development of Sierra Leone’s Potential Petroleum Resources for the long term benefit of its people, through the development of regulatory guidelines and monitoring contract compliance, having due regard for the economy, the environment, safety, technology, as well as balancing the interests of the nation and investor”

The Petroleum Directorate’s Vision is:

“To become a functionally and fiscally independent high-reliability regulatory agency capable of delivering its mission in a sustained way”
Regulatory Framework

• All Petroleum Rights are vested in the State

• The Petroleum Directorate (PD) was created as successor to the PRU by Petroleum Exploration and Production Act (PEPA) – 2011

• The PD is mandated to:
  – Regulate and promote petroleum exploration, development and production
  – Administer the licensing round and facilitate the participation of commercial entities in the sector
  – Encourage, monitor and enforce the standards of operation and code of practice for petroleum operations
  – Ensure efficient and safe petroleum operations
Petroleum Legislation - Update

- Following last bid round in 2012, there has been considerable interest in onshore exploration.

- Hence, review of current Petroleum Legislation is at an advanced stage.

- Aim of the review is to establish the legal framework for onshore exploration and subsequently merge these provisions with the offshore legislation.

- New Law will provide for a detailed and competitive/progressive fiscal regime.

- New environmental provisions cover detailed standards and environmental principles of compliance and safety, and include issues of decommissioning of infrastructure, including wells and restoration of land.
Petroleum Legislation - Update

• The law provides for a new licensing regime and clear rules for acquisition of licences

• There are also detailed provisions relating to the conduct of well operations, steps for field development approval, assignment of petroleum interests, local content and the management of data.

• There are also available in the new law, a range of ancillary licences, permits and authorities. These cover reconnaissance, scientific investigations, access, infrastructure, drilling operations and pipelines.
Sierra Leone Overview

• Located between the NW African Central Atlantic margin and Gulf of Guinea
• The Basin has a NW-SE orientation
• The WNW-ESE oriented Sierra Leone Transform projects through into the central part of the basin (shelf margin changes strike from NW-SE to WNW-ESE)
• This change also causes the basin configuration to change
• To the NW is a broad shelf area characterised by a stepped basement topography
• To the SE the shelf is narrow with the ocean-continent transition relatively close to the shelf edge
• The SE shelf area shows features typical of a rifted margin

(from Bennett & Rusk 2002)
Stratigraphy

<table>
<thead>
<tr>
<th>AGE (Ma)</th>
<th>EPOCH</th>
<th>STAGE</th>
<th>BASIN</th>
<th>STRATIGRAPHY</th>
<th>SHELF</th>
<th>HORIZON</th>
<th>GEOLOGICAL EVENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>0-10</td>
<td>Quaternary</td>
<td>Pleistocene</td>
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<tr>
<td>10-30</td>
<td>Neogene</td>
<td>Miocene</td>
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<td></td>
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<td>Gravitational Faulting/Sliding</td>
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<td>30-50</td>
<td>Oligocene</td>
<td>Oligocene</td>
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<td></td>
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<td>Passive Margin</td>
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<td>50-60</td>
<td>Eocene</td>
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<td></td>
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<td>On Set Spreading</td>
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<tr>
<td>60-120</td>
<td>Paleogene</td>
<td>Paleogene</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Uplift &amp; Erosion</td>
</tr>
<tr>
<td>120-160</td>
<td>Cretaceous</td>
<td>Late Cretaceous</td>
<td>Maastrichtian</td>
<td>Campanian</td>
<td>Santonian</td>
<td>Coniancia</td>
<td>Turonian</td>
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<tr>
<td>160-190</td>
<td>Late Cretaceous</td>
<td>Early</td>
<td>Albian</td>
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<tr>
<td>190+</td>
<td>Late Cretaceous</td>
<td>Late</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

- Pre-rift Jurassic/Triassic sediments
- Early cretaceous rifting (Aptian-Albian)
- Late Cretaceous to recent drift sequence of clastic deep water turbidites

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Petroleum System

SOURCE ROCK

- Aptian to early Cenomanian shales (HI\text{795-482} & TOC of 20-4\%). Geochemical analysis has confirmed the good quality and high potential of this source zone.

- Late Cretaceous, Cenomanian-Turonian shales (HI approx. 560 & TOC approx. 5\%)

- Both source rocks have reached the oil/gas window (0.8 to 1.2)

RESERVOIR

- Potential reservoir sequences include the Aptian, Albian, Cenomanian, Maastrichtian and Paleocene to Eocene.
Petroleum System

TRAP
- Stratigraphic, structural or a combination exists in Cretaceous to recent strata

SEAL
- The seal can be lateral, transformational shales or regional hemipelagic shales.
Exploration History

- Exploration began in the early eighties
- Initial work focused on shallow waters with 2D seismic & gravimetric surveys offshore
- Subsequent drilling of 2 offshore wells encountered hydrocarbon shows.
- A-1 in 1982 (Mobil) and A1-2 in 1985 (Amoco) were drilled in the country’s inner shelf, in water depths of <100m
- The wells penetrated significant thickness of reservoir quality Sandstone – Early to Late Cretaceous.
- Wells provided evidence of enough sedimentary cover and source rock types to spur on further exploration
- More exploration work followed with the acquisition of speculative 2D data (5,800 Sq. km.) by TGS-NOPEC between 2000 – 2001, which sparked the current cycle of exploration
- Sierra Leone’s offshore coast was divided into 7 exploration blocks following acquisition of this data.
Exploration History Continued

• 2001: PEPA 2001 passed by Parliament to govern petroleum operations. Established the Petroleum Resources Unit (PRU) to regulate and monitor petroleum operations

• 2003: First Bid Round held. 4 offshore exploration blocks were offered and awarded to bidding Companies

• 2004: Second Bid Round held. 1 exploration block was awarded. Repsol Exploration acquired 3-D Seismic data (2003 – 2004)

• 2006: 1 exploration block awarded through Direct Negotiation

• 2012: Third licensing round- 8 Blocks Awarded

• A total of 8 wells have been drilled, (6 wells between 2009 to 2013 with 4 discoveries).
Sierra Leone - Current Activity

Sierra Leone Licensed Blocks 2017

Legend
- Licensed Concession Areas 2017
- Open Concession Areas 2017
PDSL Technical Database

Sierra Leone Seismic Data 2017

3D Seismic & Wells

Legend:
- Oil Discovery
- Oil Show
- Dry Well
- SL-3D-2D - TGS 2013
- SL-04-05-3D - TGS 2014
- SL-04-05-3D (LAIK)
- SL-04-05-3D (KALAO)
- SL-04-05-3D (NOLU)
- SL-04-05-3D (NLU)
- SL-04-05-3D (NOLU)

Well Name  | Year  | Operator  | Well Status
---        |------|-----------|-------------
A-1        | 1982 | Mobil     | Oil shows
A-1-2      | 1985 | Amoco     | Oil shows
Venus B-1   | 2009 | Anadarko  | Discovery
Mercury-1   | 2010 | Anadarko  | Discovery
Mercury-2   | 2012 | Anadarko  | Appraisal
Jupiter-1   | 2012 | Anadarko  | Discovery
Djembe-1    | 2012 | Talisman  | Water wet
Savannah-1X | 2013 | Lukoil    | Discovery

Advances during 2017

- Drilling campaigns of 2009-2013 proved Sierra Leone basin as a petroleum basin, with abundant prospectivity

- Petroleum Directorate takes ownership of its Data

- ERCL (Getech Group Company) became new technical partner

- Opening of Freetown data room in March 2017

- Creation of an ArcGIS Online Data Portal

- Long Offset 2D Expression of Interest announced at PESGB Africa

- Collaborative projects between PDSL and ERCL Ltd (Getech Group) ongoing
  - Digital Atlas
  - Petroleum Geology Report
The Petroleum Directorate is pleased to announce that, following a successful collaboration with TGS Nopec, ownership of a series of 3D seismic surveys acquired by TGS under a multi-client agreement has now reverted to the Petroleum Directorate. The surveys include the Blocks 4 & 5 survey (2008), the Blocks 3, 4A, 4B / 4A Extension (2011 / 14) and the merged Fusion 3D dataset. The location of these 3D volumes is illustrated below.

These surveys are now available to view at the Data Room in PDSL offices in Freetown, and are available to license by companies wishing to evaluate the exploration prospectivity of Sierra Leone.

The Petroleum Directorate wishes to thank TGS Nopec for its work in helping to promote E&P opportunities in Sierra Leone to the oil industry, and notes that TGS retains rights to promote regional 3D seismic datasets.
ERCL (Getech Group Company) became new technical partner

- ERCL (A Getech Group Company) are now the technical partners of the PDSL.

- They provide training in seismic interpretation and prospect evaluation using the Kingdom suite software together with other G&G software.
Freetown Data Room is Open

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Arc GIS Portal

www.pd-sl.com/data-portal

2D Long Offset Seismic

- Call for Expressions of Interest announced at PESGB Africa 2017 conference

- Tender release during November 2017

The Petroleum Directorate is pleased to invite expressions of interest for long offset 2D multi-client seismic acquisition offshore Sierra Leone.

Please express interest to Director General Mr Raymond Kargbo via email by 30th September at:

raymond.kargbo@pd.gov.sl

The Sierra Leone Digital Atlas (SLE-DA) is a joint project between the Petroleum Directorate and ERCL to create the first digital petroleum atlas, both onshore and offshore of Sierra Leone.

The atlas is based on material from the PDSL archives including released data, and released reports supplemented by ERCL-Getech’s regional knowledge.

The first release will be available during Q4 2017 and can be licensed through ERCL (Getech Group Company).
Introduction to Sierra Leone Petroleum Geology & Prospectivity Report

• The ‘Introduction to Sierra Leone Petroleum Geology & Prospectivity Report’ is a joint project between the Petroleum Directorate and ERCL to create an introductory report into the petroleum geology and prospectivity of Sierra Leone for licensing by potential investors.

• The introductory report will encompass previous studies and work completed during the last 12 months by the PDSL.

• The first release will be available during Q4 2017 and can be licensed through ERCL (Getech Group Company).
Prospectivity- Overview

• Undeveloped oil discoveries
  – Four Cretaceous Discoveries

• Onshore
  – Tilted fault blocks
  – Rumoured seeps on Sherbro Island

• Shallow water
  – Cretaceous tilted fault blocks
  – Two wells drilled in 1980’s by Amoco & Mobil (oil shows)

• Deep water
  – Structural plays associated with Sulima plateau
  – Cretaceous pinch out play
Undeveloped Discoveries

Water Depth: 1800m, TD: 5636m in Albian
Hydrocarbons: ~14m of pay in Cretaceous good reservoir quality sand (channel/fan), penetrated several source rock intervals, and several good reservoir quality intervals all the way down to TD.

**Mercury – 1 (2010, SL License Block SL-07)**
Water Depth: 1600m, TD: 4862m in Albian
Oil in two Cretaceous fan systems, 34.7m of 34° – 42° API oil in the primary objective and 6.4m of 24° API oil in a shallower secondary objective.

**Jupiter-1 (2012 License Block SL-07B-11)**
Water Depth: 2,199m, TD: 6465m
The well intersected 30m of hydrocarbon pay in the primary Upper Cretaceous objective and did not encounter a hydrocarbon water contact.

**Savannah-1X (2013, License Block SL05/11)**
Water Depth:2153, TD 4737m
The well intersected ~3m oil pay in the primary objective and encountered an OWC.
Onshore Prospectivity

- The present day shelfal area lies inboard of the Atlantic rift margin on a continental mobile belt.

- These shelfal areas contain Palaeozoic rift basins and sediments formed before rifting of the Atlantic.

- Palaeozoic petroleum systems produce oil onshore North West Africa suggesting the shelfal area of Sierra Leone is also likely to be prospective.
Shallow Water Prospectivity

- Rifted fault blocks present in proximal offshore of Sierra Leone
- Targets are up dip of deep water discoveries & provide significant prospectivity with reduced drilling costs

Newly digital Amoco 1980’s interpretation
Deep Water Prospectivity

- Proven hydrocarbons in deep water Cretaceous turbidite plays
- Structural and stratigraphic plays identified in deep water by PDSL
- Abundant remaining potential

Undrilled turbidite fan systems
Fourth Licensing Round Pre-Announcement

- The Petroleum Directorate of Sierra Leone is pleased to pre-announce the Fourth Licensing Round which will run from 15th January until May 31st 2018

- The round will focus on the offshore and will feature a new block system

- The fourth round will include the areas of undeveloped discoveries from the previous drilling campaigns, shallow water and deep-ultra deep water

- Newly released well and 3D PSDM seismic data are available to license from PD with technical studies available from our partners at ERCL (Getech Group)

- A state of the art data room is currently open in Freetown, with a UK data room to open at our partners ERCL’s office in January 2018

- We are currently formulating our plans and would welcome input from interested companies

- There has been very strong interest from seismic contractors for the long offset 2D seismic expression of interest

- A tender for the long offset will be issued during November with responses by end December 2017
Final Remarks

Sierra Leone offers good exploration opportunities:

– Good prospective acreage available (from onshore, shallow water to deep water)
– Favourable legal, regulatory and fiscal framework
– Political stability

Sierra Leone offers good investment opportunities:

– The socio-economic indicators are steadily growing after Ebola Outbreak
– GDP growth slowed down due to Ebola crisis, but is on the rise again
– The fiscal incentives for foreign investment are attractive
– The infrastructures such as roads, telecommunications and Electricity Supply have improved substantially
Thank you
Aeromagnetic Interpretation

- The 2013 Sierra Leone aeromagnetic survey is 24,000 km²
- The survey was shot partly over land and partly over the offshore.
- The offshore present day shelf has water depths of up to 150m.

Prolongations of the Sierra Leone FZs onto the shelf and onshore are clearly visible as ridges in the high pass filtered magnetic merge.

Example from the aeromagnetic survey showing the rift basin geometry.
Recent Infrastructure Advancements

- 24/7 power backup installation
- Server purchase and setup
- Security and Network upgrade
- Cloud hosted email rollout
- G & G workstation setup
- Kingdom License Server Installation
- NAS Storage-12tb for technical team
- 9 Arc GIS Licenses
National Data Archive

Collection and collation of all Petroleum data in Sierra Leone

GIS Capacity Building

- Installation of ESRI ArcGIS software and licenses
- Collation of all PDSL GIS data