

Airborne gravity gradiometer surveying of petroleum systems under Lake Tanganyika, Tanzania

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# Outline

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- Geology
- Exploration History
- FALCON Airborne gravity gradiometry
  - survey acquisition, processing, and results
- Data interpretation
- Discussion
- Summary



# Introduction and Geology



- East African Rift is 3,500 km long; 50-120 km wide
- Follows reactivated
  Precambrian structures
- Eastern volcanic branch commenced in the Palaeogene
- Western branch commenced in the Neogene; less volcanics
- Elevated rift margins



# Introduction and Geology

- The Lake Tanganyika South block is within the western arm of the East African Rift System, formed during the Miocene to present-day rifting of central Africa.
- This rifting event created all the major lakes within eastern Africa.
- Lake Tanganyika is over 600 kilometers long and 40 to 80 kilometers wide.
- The Lake Tanganyika South block is approximately 7,200 km<sup>2</sup> and covers the southern portion of the Tanzanian side of Lake Tanganyika



# **Exploration History**

2D seismic data from 1980's shows

- sufficient sediment thickness for hydrocarbon generation
- inter-layered sequence of sands and shale, could provide source, reservoir and seal for oil and gas.

Natural oil seeps indicate a working petroleum system underneath the lake.

Prospectivity enhanced by large oil discoveries in the similar geological environment of Lake Albert in Uganda

No wells drilled on the lake to date

 Beach Energy was 100% Interest holder and operator of the block until July 2014 – 70% farmed out to Woodside – will remain Operator – new seismic is ongoing



# FALCON<sup>®</sup> Airborne Gravity Gradiometry

- FALCON AGG offers the highest resolution airborne gravity gradiometry data.
- The FALCON AGG system adapted US Navy technology specifically for use in a survey aircraft.
- CGG operate 5 systems globally.







# Survey acquisition, processing, and results

- In 2010 Beach Energy commissioned CGG to fly a FALCON AGG and a high-resolution airborne magnetic (HRAM) survey over the Lake Tanganyika South block in order to map the basin structural framework and the depth to magnetic basement.
  - Flight line spacing: 330m
  - Tie line spacing: 1500m
  - Total line km: 27,700 line km
  - Average flight height: Draped survey: 140m clearance
  - Flown in September and October 2010 in 42 sorties



## Survey acquisition, processing, and results Data Overview: Airborne Magnetic Data



# Survey acquisition, processing, and results Data Overview: Airborne Magnetic Data

#### East of Lake Tanganyika boundary:

 Short wavelength, moderate amplitude magnetic anomalies over outcropping or shallow basement

West of Lake Tanganyika boundary:

- Long wavelength, low amplitude magnetic anomalies over buried basement in the southwest
- Flat magnetic response over deep magnetic basement in the northwest



### Survey acquisition, processing, and results Data Overview: Airborne Magnetic Data



# Survey acquisition, processing, and results Data Overview: FALCON Gravity Data

Vertical Gravity (gD):

- Total variation of 180 mGals.
- Long wavelength anomalies predominate.
- Anomalous high response located east of the lake boundary.
- Two distinct lows formed west of lake boundary in the north and west central area.
- Steep gradient developed between the high (east) and lows (west).



### Survey acquisition, processing, and results Data Overview: FALCON Gravity Gradient Data



## Data Interpretation Data Overview

The interpretation incorporated relevant data supplied by Beach Energy as well as data obtained by CGG. The primary datasets used in the interpretation consisted of:

- Newly acquired airborne magnetic and FALCON<sup>™</sup> AGG data acquired by CGG
- Digital elevation model acquired by the FALCON<sup>™</sup> airborne LIDAR system and detailed bathymetry provided by Beach Energy
- Regional gravity and magnetic data provided by Beach Energy
- Four interpreted 2D seismic lines provided by Beach Energy
- Location of oil seeps, provided by Beach Energy
- Open file geology reports and publications
- Landsat data provided by Beach Energy



## Data Interpretation Data Overview: Digital Elevation and Bathymetry Data

SRTM, LIDAR and detailed bathymetry data were merged to produce the final DTM which was used for:

- Gravity terrain corrections during the processing phase
- Structural interpretation
- Depth to basement analysis to convert depths to elevations and to generate a sediment thickness map



# NPA-mapped Regional cover in East African Rift System



#### NPA East African Rift System Mapping

- Uses Landsat 15m resolution data as a mapping base, supplemented by 30m resolution Shuttle Radar Topography Mission (SRTM) DEM data for structural and tectonic mapping
- Uses a combination of more than 200 1:100,000 – 1:1million scale geological maps, used to redefine stratigraphic boundaries using a common stratigraphic template and chronostratigraphic table.
- By project completion, all map features will feature deep meta-data and full attribution to illustrate provenance, author and name of feature, if appropriate.



# SRTM DEM with some interpretation superimposed





## Data Interpretation Structure



## Data Interpretation - Magnetics Structure



# Data Interpretation – Gravity and Gravity Gradient Structure





## Data Interpretation Magnetic Depth Slices



## Data Interpretation Gravity Depth Slices



## Data Interpretation Gravity Gradient Depth Slices



## Data Interpretation Basement Elevation Model

- The basement elevation model was generated using 3D Euler deconvolution of the TMI grid data
- Results of the modelling has highlighted a number of apparent basement lows, predominantly located in the north and west central area.
- Basement outcrop was interpreted from the magnetic data and Landsat image. East of this line, the basement elevations equal the DTM.



# Data Interpretation Sediment Thickness Model

- The sediment thickness model is generated by subtracting basement elevations from the bathymetry.
- Good correlation with major features in the structural interpretation.
- Basement lows form NW-SE orientated troughs.



## Discussion



Lake Tanganyika South block potential play types from the 2012 2D marine seismic data, red = gas, green = oil



# Summary

- Lake Tanganyika rifts occur dominantly as half-grabens following reactivated Precambrian structures.
- Four major half grabens have been identified in the South Block area.
- Numerous oil seeps located at the flanks of the grabens and at the buried intra basinal highs indicate presence of an active petroleum system.
- The 3D Euler depth to basement analysis provides a broad overview of basement architecture and forms a good starting point for a more detailed investigation along profile data.
- Two major depocentres have been identified in the DTB map in the north and west central part of the survey area with sediment thicknesses in excess of 4km and 3km, respectively. Smaller, shallower depocentres (less than 3km of sediment) occur in the southern region.





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# **Questions?**



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