



EG Ronda 2019
Oil & Gas
Licensing Round in Equatorial Guinea



Historical Perspectives and New Insights on Oil and Gas Exploration in Equatorial Guinea

A Non-Exclusive Report prepared by

Perceptum Limited



in association with



May 2019

Perceptum Limited
450 Brook Drive, Green Park, Reading
RG2 6UU, UK
www.perceptumlimited.com

Historical Perspectives and New Insights on Oil and Gas Exploration in Equatorial Guinea

A Non-Exclusive Report

May 2019

DISCLAIMER

The opinions and interpretations presented in this report represent our best technical interpretation of the data made available to us. However, due to the uncertainty inherent in the estimation of all sub-surface parameters, we cannot and do not guarantee the accuracy or correctness of any interpretation and we shall not, except in the case of gross or wilful negligence on our part, be liable or responsible for any loss, cost damages or expenses incurred or sustained by anyone resulting from any interpretation made by any of our officers, agents or employees.

Perceptum Limited has undertaken this Non-Exclusive report under an agreement with the Ministry of Mines and Hydrocarbons. This report is available to license under standard terms and conditions from Perceptum Limited.

COPYRIGHT

© Perceptum Limited

The material presented in this report is confidential. This report has been prepared by Perceptum Limited and shall not be distributed or made available to any other company or person without the knowledge and written consent of Perceptum Limited, subject to the terms of the licensing agreement.

Historical Perspectives and New Insights on Oil and Gas Exploration in Equatorial Guinea

Contents

1	Introduction.....	9
2	Database.....	12
3	GIS Project Outline	20
4	Review of Exploration History, Discoveries and Fields.....	21
4.1	Exploration and Licensing Activity.....	21
4.1.1	1960-1990	21
4.1.2	1990-2000	21
4.1.3	2001-2010	22
4.1.4	2010-2013	24
4.1.5	2014 Licensing Round.....	24
4.1.6	2016 Licensing round.....	25
4.2	Hydrocarbon Fields and Discoveries of Equatorial Guinea.....	25
4.2.1	Alba Field.....	26
4.2.2	The Zafiro Field	27
4.2.3	The Ceiba Field	29
4.2.4	The Okume Complex-Rio Muni Basin	30
4.2.5	The Aseng Production Area - Douala Basin	31
4.2.6	The Alen Production Area - Douala Basin.....	32
4.2.7	The Fortuna Complex- Outer Niger delta	34
4.2.8	The Venus field and production and development area (“PDA”)	35
5	Regional and Petroleum Geological Review	56
5.1	Regional Geology	56
5.1.1	Tectonic Provinces	56
5.1.2	Crustal Types	56

5.1.3	Tectono-Stratigraphy.....	57
5.1.4	The Cameroon Volcanic Line.....	58
5.2	Biostratigraphic Review.....	58
5.3	Reservoir Presence and Quality	59
5.3.1	Early Cretaceous.....	60
5.3.2	Late Cretaceous.....	61
5.3.3	Paleogene.....	61
5.3.4	Neogene	62
5.4	Trapping Styles.....	63
5.4.1	Rio Muni Margin Basin.....	63
5.4.2	Douala Basin.....	64
5.4.3	Niger Delta.....	64
6	Source Rocks-Quality, Maturation and Charge - Evolving Understanding of Petroleum Systems (1999 to 2012)	74
6.1	Introduction and summary of previous work	74
6.2	Source Rocks identified	75
6.3	Oil and Seep Analysis	77
6.4	Thermal History Reconstruction.....	79
6.5	Basin Modelling.....	80
6.5.1	1D Basin Modelling	80
6.5.2	2D Basin Modelling.....	82
6.5.3	BasinView Modelling.....	82
6.6	Petroleum Systems Analysis (the understanding in 2012).....	87
7	Review of Regional Thermal History and Implications	102
7.1	Introduction	102
7.2	Background to Thermal History Reconstruction (THR)	102
7.3	Rio Muni Basin THR data	104
7.4	Vitrinite reflectance data in other wells	108
8	Evolving Understanding of Petroleum Systems and Play	114
8.1	Plays Recognised (2005)	114
8.1.1	Base Drift to Santonian Unconformity	114
8.1.2	Santonian Unconformity to Base Cenozoic	114
8.1.3	Base Cenozoic to Late Eocene.....	115
8.1.4	Late Eocene to Mid Miocene	116

8.1.5	Mid Miocene to Present day	116
8.2	Established Distal Niger Delta Plays.....	117
8.3	Established Douala Basin Plays.....	117
8.4	Rio Muni Shelf Plays.....	118
8.5	Deepwater Rio Muni / Douala Margin Plays	119
9	New Concepts for Petroleum Systems and Plays in Deep-water	138
9.1	Crustal Architecture, Crustal Fabric and Continental Break-up.....	138
9.2	Post-Break-up Tectonic History.....	140
9.3	Petroleum Geology.....	140
10	References.....	153
	Appendices	156
	Appendix 1 Report on GIS Project Structure	156

Figures (follow end of each section)

- Figure 1.1 Summary of Previous Regional Studies
- Figure 2.1 Well Database
- Figure 2.2 2D Seismic Database
- Figure 2.3 3D Seismic Database
- Figure 2.4 Drilling Activity Pre-1980 to Present
- Figure 2.5 2D Seismic Activity (Pre-1980s to Present)
- Figure 2.6 3D Seismic Activity (Pre-1980s to Present)
- Figure 3.1 GIS Structure
- Figure 4.1 Concessions Map (EG Ronda 2019 round)
- Figure 4.2 Historical Oil & Gas Production and Hydrocarbon Mix
- Figure 4.3 Structure of the Alba Field in the frontal deformation zone
- Figure 4.4 Top Reservoir Structure Map, Alba Field
- Figure 4.5 Zafiro Field Qua Iboe Sandstone Slope Channel Reservoirs
- Figure 4.6 Structure of the Zafiro Field as observed on legacy 2D seismic
- Figure 4.7 Ceiba Field trap configuration
- Figure 4.8 Legacy 2D seismic section across the Ceiba Field
- Figure 4.9 Layout of the Ceiba and Okume Complex
- Figure 4.10 Upper slope channels of the Oveng Field observed on 2D seismic
- Figure 4.11 Well locations in the Ebano Field and air permeability vs. depth from core data of well F2ST
- Figure 4.12 Location of the Fields and discoveries in the Aseng-Alen Area
- Figure 4.13 Legacy seismic illustrating the amplitude anomalies which demarcate the Lower Miocene Aseng Field and Yolanda discovery
- Figure 4.14 Schematic to indicate the Block R traps
- Figure 4.15 Seismic section illustrating the Fortuna discovery
- Figure 4.16 Seismic section illustrating the Tonel-1 discovery
- Figure 4.17 Seismic and amplitude response of Block R reservoirs
- Figure 4.18 Location of the Block R discoveries and prospects
- Figure 4.19 Top Fortuna reservoir depth map
- Figure 4.20 Viscata top reservoir map
- Figure 4.21 Top reservoir depth map for the Tonel discovery
- Figure 4.22 Silenius hub amplitude map shown discoveries and prospects
- Figure 5.1 Regional Structure and Basins of Equatorial Guinea
- Figure 5.2 Schematic Cross Section of Douala-Rio Muni Basin and CVL
- Figure 5.3 Stratigraphic column for Douala - Rio Muni Basin System
- Figure 5.4 Campanian Sand Fairway
- Figure 5.5 Amplitude response of a distal Upper Cretaceous basin floor turbidite fan

- Figure 5.6 Upper Cretaceous Channels (in Block EG-18)
- Figure 5.7 Cretaceous Play Fairway
- Figure 5.8 Sandstone Depositional Fairways in the Niger Delta
- Figure 5.9 Amplitude response of an Aquitanian turbidite fan
- Figure 5.10 Lower Miocene Channels
- Figure 5.11 Seismic section of the Rio Muni Margin
- Figure 5.12 Seismic section across the outer Niger delta, Equatorial Guinea
- Figure 6.1 Source rocks identified in Equatorial Guinea
- Figure 6.2 Tectonic position of source rocks in Equatorial Guinea
- Figure 6.3 Location of Oil Samples for Geochemical Analysis
- Figure 6.4 Distribution of the 4 Oil Families identified in the Gulf of Guinea
- Figure 6.5 Basin Modelling - 1D points and 2D Profiles
- Figure 6.6 Present day Oil saturation and gas Saturation from 2D Rio Muni Profile 4
- Figure 6.7 Present day Oil saturation from 2D Douala Basin Profile-7
- Figure 6.8 Present day Oil saturation and gas Saturation from 2D Niger Delta profile-10
- Figure 6.9 The study area and extended pseudo well locations used as calibration for BasinView modelling
- Figure 6.10 Petroleum Systems Summary / Stratigraphy
- Figure 6.11 Petroleum Systems Summary Map (2012)
- Figure 7.1 Study wells and outcrop locations sampled for AFTA and Vitrinite Reflectance
- Figure 7.2 Rio Muni Basin - Overall style of thermal history
- Figure 7.3 Simplified paleo-temperature depth plots for 3 of the Rio Muni study wells
- Figure 7.4 Generalised stratigraphic column and thermal episodes recognised by the thermal history data
- Figure 7.5 Plot of Vitrinite Reflectance versus Depth, Equatorial Guinea wells
- Figure 8.1 Play Fairway Map Interval 1
- Figure 8.2 Play Fairway Map Interval 2
- Figure 8.3 Play Fairway Map Interval 3
- Figure 8.4 Play Fairway Map Interval 4
- Figure 8.5 Play Fairway Map Interval 5
- Figure 8.6 Play Cartoon for the Niger Delta
- Figure 8.7 Distal Niger Delta Play/Trap combinations
- Figure 8.8 Play Cartoon for the Douala Basin
- Figure 8.9 Play cartoon for the Outer Douala Basin, Cameroon
- Figure 8.10 Rio Muni Play / Trap Combinations
- Figure 8.11 Typical reservoirs and structures in the northern part of Block K
- Figure 8.12 Amplitude response of an Aquitanian Turbidite Fan
- Figure 8.13 Amplitude response of a distal Upper Cretaceous basin floor turbidite fan

- Figure 8.14 Structural Elements of Geoex 3D Seismic Data
- Figure 8.15 Full-Stack Sections from Geoex 3D Seismic Data
- Figure 8.16 Example of Type II and III AVO's (courtesy of Geoex)
- Figure 8.17 Example of AVO response in Structural Prospect (courtesy of Geoex)
- Figure 8.18 FARS and NEAR Angle Stack Displays for Structural Prospect (courtesy of Geoex)
- Figure 9.1. LO-7 showing crustal types
- Figure 9.2 Crustal Types of Eastern Gulf of Guinea
- Figure 9.3 Chronology of Rio Muni Break-up
- Figure 9.4 Probe Line 8 showing oceanic crust deformation
- Figure 9.5 Stratigraphy-Petroleum Geology of Rio Muni
- Figure 9.6 Petroleum Systems
- Figure 9.7 L-2 distal well with Paleogene sands
- Figure 9.8 Distal Plays Fairways
- Figure 9.9 Petroleum Systems & Plays associated with Fracture Zones