

**REGIONAL SEISMIC INTERPRETATION AND MAPPING
AND
INTEGRATED GEOLOGICAL STUDIES
OFFSHORE EQUATORIAL GUINEA**

PHASE II

June 2005

Exploration Consultants Limited
309 Reading Road,
Henley-on-Thames,
Oxon, RG9 1EL,
England

Tel: +44 (0)1491 415400
Fax: +44 (0)1491 415415

Email: office@ecqc.com
Website: www.ecqc.com

GG0634

LIST OF CONTENTS

Page No.

EXECUTIVE SUMMARY	i
1. INTRODUCTION	1
1.1 Study Background, Scope and Objectives	1
1.2 Report Structure	2
1.3 Recent Exploration History and Philosophy	4
2. DATABASE	6
2.1 Introduction and GIS Database	6
2.2 Geophysical Data	7
2.2.1 Seismic	7
2.2.2 Potential Field Data	8
2.3 Geological Data	10
2.3.1 Well Data and Well-Tie Synthesis	10
2.3.2 Published Material	10
3. REGIONAL GEOLOGY	12
3.1 Background and Methodology	12
3.2 Regional Geotectonic Elements	16
3.2.1 Introduction	16
3.2.2 North Gabon Rifted Terrane	16
3.2.3 Rio Muni Margin	16
3.2.4 Calabar Flank/Douala Margin	18
3.2.5 Benue Trough/Abakaliki Foldbelt	18
3.2.6 Niger Delta	18
3.2.7 Cameroon Volcanic Line (CVL)	19
3.2.8 Oceanic Domain/Fracture Zones	20
3.3 Geodynamic Evolution	22
3.3.1 South Atlantic Reconstruction	22
3.3.2 Rift-to-Drift 'Break-up' Model	22
3.3.3 Regional Events During Drift Phase	28

LIST OF CONTENTS Continued

	Page No.
4. STRATIGRAPHIC INTERPRETATION	32
4.1 Background.....	32
4.2 Tectonostratigraphy	33
4.3 Seismic and Sequence Stratigraphy.....	35
4.3.1 Methodology.....	35
4.3.2 Stratigraphic Analysis.....	36
5. STRUCTURAL OVERVIEW	44
5.1 Structural Styles/Geometries and Tectonic History.....	44
5.1.1 Rio Muni Margin Basin.....	44
5.1.2 Northern Gabon.....	46
5.1.3 Douala Basin.....	47
5.1.4 Niger Delta.....	47
5.2 2D Structural Modelling.....	48
6. SOURCE ROCKS	50
6.1 Regional Source Rock Development	50
6.2 Recognition of Source Rocks in the Study Area	55
6.2.1 Geochemical Database.....	55
6.2.2 Organic Content	55
6.2.3 Kerogen Typing.....	58
6.2.4 Generative Potential of Source Rocks.....	60
6.3 Source Rock Summary.....	62
7. BASIN MODELLING AND SOURCE ROCK MATURITY HISTORY	63
7.1 Introduction and Methodology.....	63
7.2 Thermal History Reconstruction.....	64
7.3 1D Basin Modelling.....	67
7.4 Maturation History.....	74

LIST OF CONTENTS Continued

	Page No.
8. PETROLEUM SYSTEMS ANALYSIS	77
8.1 Introduction	77
8.2 2D Fluid Flow Modelling	79
8.2.1 Methodology	79
8.2.2 Profile 4	80
8.2.3 Profile 7	84
8.2.4 Profile 10	87
8.2.5 Modelling Overview	90
8.3 Petroleum System Maps	92
8.3.1 Introduction	92
8.3.2 Apto-Albian	92
8.3.3 Albo-Turonian	94
8.3.4 Paleocene-Eocene	95
8.3.5 Oligo-Miocene	96
9. RESERVOIRS	98
9.1 Regional Reservoir Development	98
9.2 Reservoir Fairway Mapping	102
9.2.1 Introduction	102
9.2.2 Reservoir Fairway Maps	103
9.2.3 Present Day Bathymetry and Onshore Drainage Systems	107
10. PLAY ANALYSIS	109
10.1 Introduction	109
10.2 Play Fairway Mapping	110
10.2.1 Play Fairway Interval 1	110
10.2.2 Play Fairway Interval 2	111
10.2.3 Play Fairway Interval 3	113
10.2.4 Play Fairway Interval 4	115
10.2.5 Play Fairway Interval 5	116

LIST OF FIGURES

After Page No.

1.	Study Area Location Map	1
2.	GIS Structure	6
3.	Database Map	6
4.	Equatorial Atlantic Free Air Gravity	12
5.	Equatorial Atlantic Free Air Gravity and Interpretation	12
6.	Eastern Gulf of Guinea Free Air Gravity	12
7.	Eastern Gulf of Guinea Free Air Gravity and Interpretation	12
8.	Regional Structural Framework	16
9.	Probe Line 5 Across Rio Muni Margin and CVL	17
10.	Probe Line 5 – Gravity Modelling	17
11.	Probe Line 16 Across Rio Muni Margin and CVL	17
12.	Probe Line 16 – Gravity Modelling	17
13.	Syn-Kinematic Package – Seismic Example	17
14.	Syn-Kinematic Package – Seismic Example	17
15.	Marginal Ridge – Seismic Example	17
16.	South Atlantic Reconstruction	22
17.	NE Brazil / West Africa Reconstruction	22
18.	Satellite Gravity Reconstruction	22
19.	Red Sea / Gulf of Aqaba Analogue	23
20.	Pull-Apart Margin Development - Break-up Model	24
21.	Iberian Margin Example	28
22.	Crustal Types	28
23.	Regional Tectonostratigraphy	33
24.	Stratigraphic Relationships across Rio Muni	33
25.	Well Chronostratigraphic Chart	35
26.	Well Unconformity Chart (Gapogram)	35
27.	Stratigraphic Summary/Seismic Markers	36
28.	Geoseismic Stratigraphic Profile 1	36
29.	Geoseismic Stratigraphic Profile 2	36
30.	Geoseismic Stratigraphic Profile 3	36

LIST OF FIGURES Continued

	After Page No.
31. Geoseismic Stratigraphic and Wheeler Diagram Profile 4	36
32. Geoseismic Stratigraphic Profile 5	36
33. Geoseismic Stratigraphic Profile 6	36
34. Geoseismic Stratigraphic and Wheeler Diagram Profile 7	36
35. Geoseismic Stratigraphic Profile 8	36
36. Geoseismic Stratigraphic Profile 9	36
37. Geoseismic Stratigraphic and Wheeler Diagram Profile 10	36
38. Structural Styles of the Rio Muni Basin	45
39. Structural Model for Santonian Deformation Along the Rio Muni Margin	46
40. Structural Styles of Northern Gabon/Southern Rio Muni	47
41. Structural Styles of the Niger Delta Frontal Zone	47
42. TOC Histogram Showing Whole Dataset, Coloured by Lithostratigraphy	55
43. TOC Histogram Highlighting the Organically Rich Samples, Coloured by Lithostratigraphy	55
44. TOC Histogram Showing Whole Dataset, Coloured by Well	58
45. Pseudo Van Krevelen Plot, Coloured by Lithostratigraphy and Sized by TOC	58
46. Pseudo Van Krevelen Plot, Coloured by Well and Sized by TOC	59
47. T-Max vs. Hydrogen Index, Coloured by Lithostratigraphy	59
48. S2 vs. TOC, Coloured by Lithostratigraphy	60
49. S2 vs TOC for S2 Values 0-10, Coloured by Lithostratigraphy	60
50. Source Rocks Summary	62
51. Heat-Flow in Relation to Oceanic Lithosphere of Varying Ages	64
52. VR vs Depth	64
53. Present Day Heat-Flow Map	65
54. Burial History and Maturity Calibration Plots for Benito-1	68
55. Burial History and Maturity Calibration Plots for Eviondo-1	68
56. Burial History and Maturity Calibration Plots for Matondo-1	69
57. Burial History and Maturity Calibration Plots for Rio Muni-1	69
58. Burial History and Maturity Calibration Plots for Rio Muni-A1	70

LIST OF FIGURES Continued

After Page No.

59.	Burial History and Maturity Calibration Plots for Regional Well A	70
60.	Burial History and Maturity Calibration Plots for Dorado-1	71
61.	Burial History and Maturity Calibration Plots for Regional Well B	72
62.	Burial History and Maturity Calibration Plots for Regional Well E	73
63.	Maturity At Santonian Unconformity Time (85Ma) of the Base of Drift Level	76
64.	Maturity At Base Tertiary Time (66Ma) of the Base of Drift Level	76
65.	Maturity At Mid Miocene Time (16Ma) of the Base of Drift Level	76
66.	Maturity At Present Day of the Base of Drift Level	76
67.	Maturity At Base Tertiary Time (66Ma) of the Santonian Unconformity Level	76
68.	Maturity At Mid Miocene Time (16Ma) of the Santonian Unconformity Level	76
69.	Maturity At Present Day of the Santonian Unconformity Level	76
70.	Maturity At Mid Miocene Time (16Ma) of the Base Tertiary Level	76
71.	Maturity At Present Day of the Base Tertiary Level	76
72.	Maturity At Present Day of the Mid Miocene Level	76
73.	Profile 4 Oil Saturation – Present Day	82
74.	Profile 4 Gas Saturation – Present Day	82
75.	Profile 7 Oil Saturation – Present Day	86
76.	Profile 10 Oil Saturation – Present Day	89
77.	Profile 10 Gas Saturation – Present Day	89
78.	Petroleum Systems Summary	92
79.	Petroleum Systems Map-Apto-Albian SR Interval	92
80.	Petroleum Systems Map-Albo-Turonian SR Interval	94
81.	Petroleum Systems Map-Paleo-Eocene SR Interval	95
82.	Petroleum Systems Map-Oligo-Miocene SR Interval	96
83.	Reservoirs Summary	98
84.	Schematic Submarine Fan Model	102
85.	Reservoir Fairway Map Interval 1 (Base of Drift to Santonian Unconformity)	103
86.	Reservoir Fairway Map Interval 2 (Santonian Unconformity to Base Tertiary)	104
87.	Reservoir Fairway Map Interval 3 (Base Tertiary to Late Eocene Unconformity)	105
88.	Reservoir Fairway Map Interval 4 (Late Eocene Unconformity to Mid Miocene)	105

LIST OF FIGURES Continued

	After Page No.
89. Reservoir Fairway Map Interval 5 (Mid Miocene to Late Miocene)	106
90. Reservoir Fairway Map Interval 5 (Late Miocene to Base Pliocene)	106
91. Reservoir Fairway Map Interval 5 (Base Pliocene to Present Day)	106
92. Present Day Bathymetry and Onshore Drainage Systems	107
93. Play Fairway Map Interval 1 (Apto-Albian SR → Base of Drift to Santonian Unc.)	110
94. Play Fairway Map Interval 1 (Albo-Turonian SR → Base of Drift to Santonian Unc.)	110
95. Play Fairway Map Interval 2 (Apto-Albian SR → Santonian Unc. to Base Tertiary)	111
96. Play Fairway Map Interval 2 (Albo-Turonian SR → Santonian Unc. to Base Tertiary)	111
97. Play Fairway Map Intervals 3 to 5 (Apto-Albian SR → Tertiary Reservoirs)	113
98. Play Fairway Map Interval 3 (Albo-Turonian SR → Base Tertiary to Late Eocene Unc.)	113
99. Play Fairway Map Interval 3 (Paleo-Eocene SR → Base Tertiary to Late Eocene Unc.)	113
100. Play Fairway Map Interval 4 (Paleo-Eocene SR → Late Eocene Unc. to Mid Miocene)	115
101. Play Fairway Map Interval 4 (Oligo-Miocene SR → Late Eocene Unc. To Mid Miocene)	115
102. Play Fairway Map Interval 5 (Oligo Miocene SR → Mid Miocene to Present Day)	116

LIST OF TABLES

Page No. or After Page No.

1.	Significant Discoveries Offshore Equatorial Guinea	4
2.	The Study Seismic Database Used for Phases I and II	7
3.	Geochemical Data Available for this Study	57
4.	Transformation Ratio (%) and Expulsion Yields (kg hydrocarbon/tonne rock) for the Three Modelled Source Rock Intervals, Profile 4	82
5.	Transformation Ratio (%) and Expulsion Yields (kg hydrocarbon/tonne rock) for the Three Modelled Source Rock Intervals, Profile 7	86
6.	Transformation Ratio (%) and Expulsion Yields (kg hydrocarbon/tonne rock) for the Three Modelled Source Rock Intervals, Profile 10	89

LIST OF ENCLOSURES

1. Exploration and Licence Activity Map End 2004
2. Database Map 1:500,000
3. Regional Structural Framework 1:500,000-
4. Maturity At Santonian Unconformity Time (85 Ma) of the Base of Drift Level
5. Maturity At Base Tertiary Time (66 Ma) of the Base of Drift Level
6. Maturity At Mid Miocene Time (16 Ma) of the Base of Drift Level
7. Maturity At Present Day of the Base of Drift Level
8. Maturity At Base Tertiary Time (66 Ma) of the Santonian Unconformity Level
9. Maturity At Mid Miocene Time (16 Ma) of the Santonian Unconformity Level
10. Maturity At Present Day of the Santonian Unconformity Level
11. Maturity At Mid Miocene Time (16 Ma) of the Base Tertiary Level
12. Maturity At Present Day of the Base Tertiary Level
13. Maturity At Present Day of the Mid Miocene Level
14. 2D Basin Modelling Results of Profile 4
15. 2D Basin Modelling Results of Profile 7
16. 2D Basin Modelling Results of Profile 10
17. Petroleum Systems Map-Apto-Albian SR Interval
18. Petroleum Systems Map-Albo-Turonian SR Interval
19. Petroleum Systems Map-Paleo-Eocene SR Interval
20. Petroleum Systems Map-Oligo-Miocene SR Interval
21. Reservoir Fairway Map Interval 1 (Base of Drift to Santonian Unconformity)
22. Reservoir Fairway Map Interval 2 (Santonian Unconformity to Base Tertiary)
23. Reservoir Fairway Map Interval 3 (Base Tertiary to Late Eocene Unconformity)
24. Reservoir Fairway Map Interval 4 (Late Eocene Unconformity to Mid Miocene)
25. Reservoir Fairway Map Interval 5 (Mid Miocene to Late Miocene)
26. Reservoir Fairway Map Interval 5 (Late Miocene to Base Pliocene)
27. Reservoir Fairway Map Interval 5 (Base Pliocene to Present Day)
28. Present Day Bathymetry and Onshore Drainage Systems
29. Play Fairway Map Interval 1 (Apto-Albian SR → Base of Drift to Santonian Unc.)
30. Play Fairway Map Interval 1 (Albo-Turonian SR → Base of Drift to Santonian Unc.)
31. Play Fairway Map Interval 2 (Apto-Albian SR → Santonian Unc. to Base Tertiary)

LIST OF ENCLOSURES Continued

32. Play Fairway Map Interval 2 (Albo-Turonian SR → Santonian Unc. to Base Tertiary)
33. Play Fairway Map Intervals 3 to 5 (Apto-Albian SR → Tertiary Reservoirs)
34. Play Fairway Map Interval 3 (Albo-Turonian SR → Base Tertiary to Late Eocene Unc.)
35. Play Fairway Map Interval 3 (Paleo-Eocene SR → Base Tertiary to Late Eocene Unc.)
36. Play Fairway Map Interval 4 (Paleo-Eocene SR → Late Eocene Unc. to Mid Miocene)
37. Play Fairway Map Interval 4 (Oligo-Miocene SR → Late Eocene Unc. To Mid Miocene)
38. Play Fairway Map Interval 5 (Oligo Miocene SR → Mid Miocene to Present Day)