The Logone Birni Basin (LLB) in Northern Cameroon: Transition Between the West African Rift Sub-System (WAS) and the Central African Rift Sub-System (CAS); Tectonic and Geophysical Models*

Jean-Pierre Loule¹ and Pospisil Lumbomil²

Search and Discovery Article #50171 (2009)
Posted April 21, 2009

*Adapted from oral presentation at AAPG International Conference and Exhibition, Cape Town, South Africa, October 26-29, 2008.

¹SNH, Yaounde, Cameroon (mailto:jploule@yahoo.com)
²Brno University of Technology, Brno, Czech Republic

Abstract

The Logone Birni Basin (LBB) situated in northern Cameroon and to the south of Lake Chad covers a total area of 27,000 km² and geographically belongs to the West and Central African Rift System (WCAS). The WCAS is divided into two coeval Cretaceous genetically related but physically separated rift sub-systems (Fairhead, 1986), namely the West African Rift sub-System (WAS) and the Central African Rift sub-System (CAS). Genik (1992) indicated that these two rift sub-systems, although genetically related, decipher some structural differences.

To unravel the tectonic and geophysical models of the inter-locked LBB, geophysical analyses and interpretation have been realized as an accompanying program of the 2D non-exclusive seismic survey carried out jointly by Geofyzika, a.s. and SNH. The seismic reflection data coupled with Grav/Mag and Remote Sensing data were used to model basement architecture, structural conditions of basin filling and distribution of buried volcanic bodies. The results arrived at confirm former basic knowledge on the tectonic and geophysical models of the WCAS, but also offer new insights on the peculiar tectonic conditions in the LBB.

The structural styles observed in the LBB include NE-SW mainly pre-Tertiary extensional faults, normal synthetic tilted fault blocks, NNE-SSW antithetic normal faults associated with sinistral wrenching, WNW-ESE normal faults, ENE-WSW fault blocks associated with dextral transtensional movement of Borogop fault zone to the south, transpressional draped anticlines, transpressed basement blocks, transpressed basement blocks with associated transtensional negative flower structures, and positive flower structures.

This blending of structural styles is attributed to the importance of strike-slip deformation within the LBB, compared to the adjacent CAS and WAS basins.
THE LOGONE BIRNI BASIN (LBB) IN NORTHERN CAMEROON:
TRANSITION BETWEEN THE WEST AFRICAN RIFT SUB-SYSTEM (WAS) AND THE CENTRAL AFRICAN RIFT SUB-SYSTEM (CAS);
TECTONIC AND GEOPHYSICAL MODELS

BY:

1/ Jean-Pierre LOULE
Director: Petroleum Information Centre
National Hydrocarbons Corporation (SNH)
Republic of Cameroon

2/ Pospisil LUMBOMIL
Lecturer
University of BRNO
Czech Republic
ACKNOWLEDGEMENTS

WE WOULD LIKE TO THANK

MINISTER Adolphe MOUDIKI,
EXECUTIVE GENERAL MANAGER OF SNH,

FOR GIVING HIS AUTHORIZATION FOR THIS PRESENTATION AND FOR HIS CONTINUED ASSISTANCE AND SUPPORT WITHOUT WHICH THE DATA TO BE PRESENTED WOULDN’T HAVE BEEN ACQUIRED.
OBJECTIVES

LOCATION OF THE LBB

REGIONAL TECTONIC AND ASSOCIATED STRUCTURAL STYLES

DATABASE FOR THE STUDY

BASEMENT ARCHITECTURE IN THE LBB

STRUCTURAL STYLES IN THE LBB

TECTONIC EVOLUTION OF THE LBB

CONCLUSIONS/ COMPARISON BETWEEN THE WAS, CAS AND THE LBB
OBJECTIVES

THE PRESENT STUDY AIMS AT:

- UNRAVELING THE TECTONIC AND GEOPHYSICAL MODELS OF THE LOGONE BIRNI BASIN USING GRAVITY, MAGNETIC AND 2D SEISMIC DATA ACQUIRED IN THIS BASIN IN THE LATE NINETIES, AND

- COMPARING THIS BASIN TO NEIGHBOURING RIFT BASINS
LOCATION OF THE LBB
Seismic Sections Across the Termit Basin (WAS)

- Normal synthetic tilted fault block
- Basement horst and KU draped anticline
- Antithetic, tilted fault block
- Transpressional anticline

(Genik, 1993)
Composite Seismic Section Across Doseo and Doba Basins (CAS)

Transpressed basement blocks and associated Positive Flower Structures

(Cont’d1)

(Genik, 1993)
REGIONAL TECTONIC AND ASSOCIATED STRUCTURAL STYLES
(Cont’ d2)

Doseo Basin (CAS)
(a): Wrench basement high block with transtensional Negative Flower Structures
(b): Positive Flower Structures

(Genik, 1993)
THE LOGONE BIRNI BASIN - DATABASE FOR THE STUDY

- AEROMAGNETIC DATA: 9,608 Km (Carson Services, 1989)
- AEROGRAVITY DATA: 8,166 Km (Carson Services, 1999)
- 2D SEISMIC DATA: 200 Km (ELF SEREPCA, 1982)
- 2D SEISMIC DATA: 1,000 Km (Geofyzika, 1998)
BASEMENT ARCHITECTURE – Methodology

3D Gravity inversion (depth map) of the constrained residuals

Constrained residual Bouguer
BASEMENT ARCHITECTURE – Interpretation

3D Gravity inversion (depth map) of the constrained residuals

Basement Architecture in the LBB
APPLICATION OF CONSTRAINED REGIONAL-RESIDUAL SEPARATION CANCELS THE EFFECT OF THE HIGH-DENSITY CRYSTALLINE PRECAMBRIAN BASEMENT.

AT LEAST TWO (02) MAJOR FAULT TRENDS ARE OBSERVED:

- NE - SW TO NNE – SSW PROBABLY “ESSENTIAL STRUCTURES”
- WNW – ESE TO NNW-SSE

CHANGES IN THE ORIENTATION OF THE ANOMALY AXES ARE INDICATIVE OF STRIKE-SLIP DEFORMATION
LOCATION OF SEISMIC SECTION IN LBB
Transpressed basement with associated tilted and rotated fault block inversion anticline and poorly developed Positive Flower Structures
Positive flower Structures produced by Upper Cretaceous dextral wrenching
STRUCTURAL STYLES IN THE LBB (Cont’ d2)

Transpressed basement block with associated normal faulting
Half Graben, Basement Horst, Negative Flower Structure to the South
Tilted and Rotated fault blocks with an inversion anticline
Faulted Symetric transpressional anticlines
STRUCTURAL STYLES IN THE LBB (Cont’ d6)

K/T boundary

Senonian Une.

Base Upper Cret.

Basement

5 Km
SE-NW Normal Synthetic Faulting Parallel to basin margin
STRUCTURAL STYLES IN THE LBB: TOP BASEMENT DEPTH STRUCTURE MAPS-FAULTS TRENDS

MAJOR LBB

-NE-SW
-NNW-SSE
-W-E to WNW-ESE

NORTHERN LBB
TECTONIC EVOLUTION OF THE LBB

( Modified after MANGA et al, 1999)
## CONCLUSIONS: COMPARAISON BETWEEN THE WAS, CAS AND LBB

<table>
<thead>
<tr>
<th>STRUCTURES/FEATURES</th>
<th>WAS</th>
<th>CAS</th>
<th>LBB</th>
</tr>
</thead>
<tbody>
<tr>
<td>Orientation of Pan African Crustal Discontinuities (Essential Structures)</td>
<td>NW - SE</td>
<td>ENE - WSW</td>
<td>NE-SW to NNE - SSW</td>
</tr>
<tr>
<td>Structural Styles</td>
<td>Extentional normal fault blocks</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Transtensional synthetic normal fault blocks</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Transtensional antithetic normal fault blocks</td>
<td>+</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>Transpresional anticlines</td>
<td>Transpresional anticlines</td>
<td>+</td>
</tr>
<tr>
<td></td>
<td>-</td>
<td>-</td>
<td>Inversion Structures</td>
</tr>
<tr>
<td>Volcanics</td>
<td>yes</td>
<td>yes</td>
<td>yes</td>
</tr>
<tr>
<td>Maximum Sedimentary Pile</td>
<td>&gt; 14,000 m</td>
<td>≈ 7,500 m</td>
<td>≈ 6,000 m</td>
</tr>
<tr>
<td>Type of Sediments / age</td>
<td>Continental to marine / Lower Cretaceous to Recent</td>
<td>Terrestrial / Lower Cretaceous</td>
<td>Continental to marine / Lower Cretaceous to Recent</td>
</tr>
<tr>
<td>Age of Source Rocks</td>
<td>Upper Cretaceous and Paleogene</td>
<td>Lower Cretaceous lacustine shales</td>
<td>Possibly Lower Cretaceous lacustine shales (TOC : 16-36%)</td>
</tr>
<tr>
<td>Age of Reservoirs</td>
<td>Upper Cretaceous and Paleogene</td>
<td>Lower and Upper Cretaceous</td>
<td>Lower and Upper Cretaceous</td>
</tr>
<tr>
<td>Age of Seal</td>
<td>Upper Cretaceous and Paleogene</td>
<td>Lower and Upper Cretaceous</td>
<td>Lower and Upper Cretaceous</td>
</tr>
</tbody>
</table>
INTEGRATION OF POTENTIAL METHODS, GEOLOGY AND SEISMIC INTERPRETATION SHOW THE LBB DECIPHERING STRUCTURES ENCOUNTERED BOTH IN WAS AND CAS.

THREE FAULT PATTERNS:
1-NE-SW DIRECTION FOR BORNU BASIN TO THE WEST
2-NNW-SSE DIRECTION FOR TERMIT-AGADEM BASINS TO THE NORTH
3-W-E to WNW-ESE FOR BONGOR, DOBA AND DOSEO BASINS TO THE SOUTHEAST

THE STRUCTURAL STYLES OF THE LBB COMBINED BOTH THOSE OF THE WAS AND CAS. NOTABLY EXTENSIONAL NORMAL FAULT BLOCKS AND TRANSTENSIONAL NORMAL FAULT BLOCKS.
CONCLUSIONS (Cont’2)

. STRUCTURES DUE TO STRIKE-SLIP (FLOWER STRUCTURES AND INVERSION FEATURES) ARE PRESENT IN THE SOUTHERN PART OF LBB AS IN CAS.

.MAXIMUM SEDIMENTARY PILE IS LESS THAN IN WAS AND CAS.

.THE CAMPANIAN MARINE FLOODING MOST LIKELY AFFECTED THE LBB AS THE WAS.

.THE LBB IS THEREFORE A DIVERGENT STRIKE-SLIP BASIN LAND-LOCKED BETWEEN THE WAS AND CAS.
Selected References

DOI: 10.1144/GSL.SP.1986.025.01.03