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*

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Abstract

The Logone Birni Basin (LBB) situated in northern Cameroon and to the south of Lake Chad covers a total area of 27,000 km^2 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.

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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

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OUTLINE

- 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

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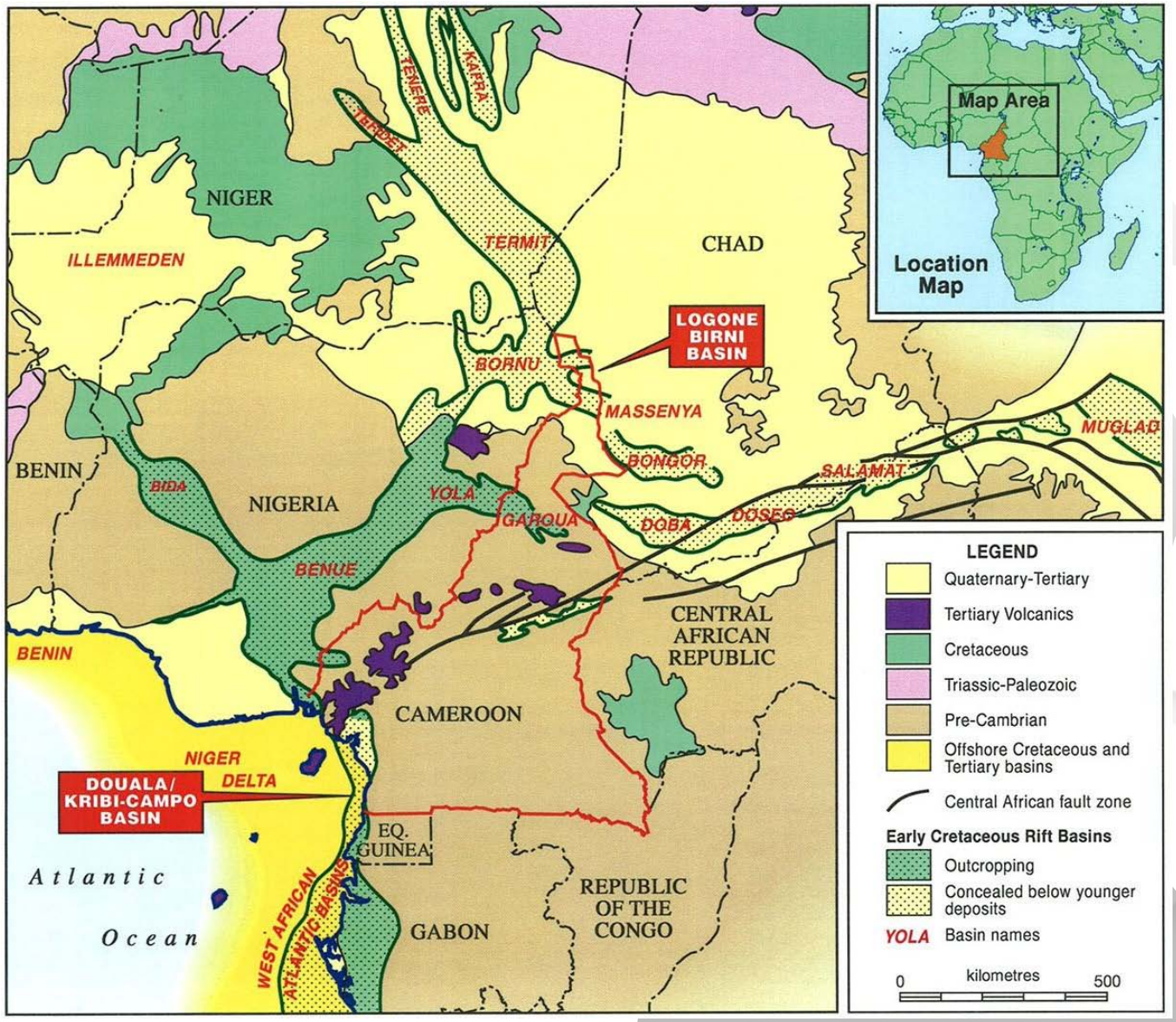
OBJECTIVES

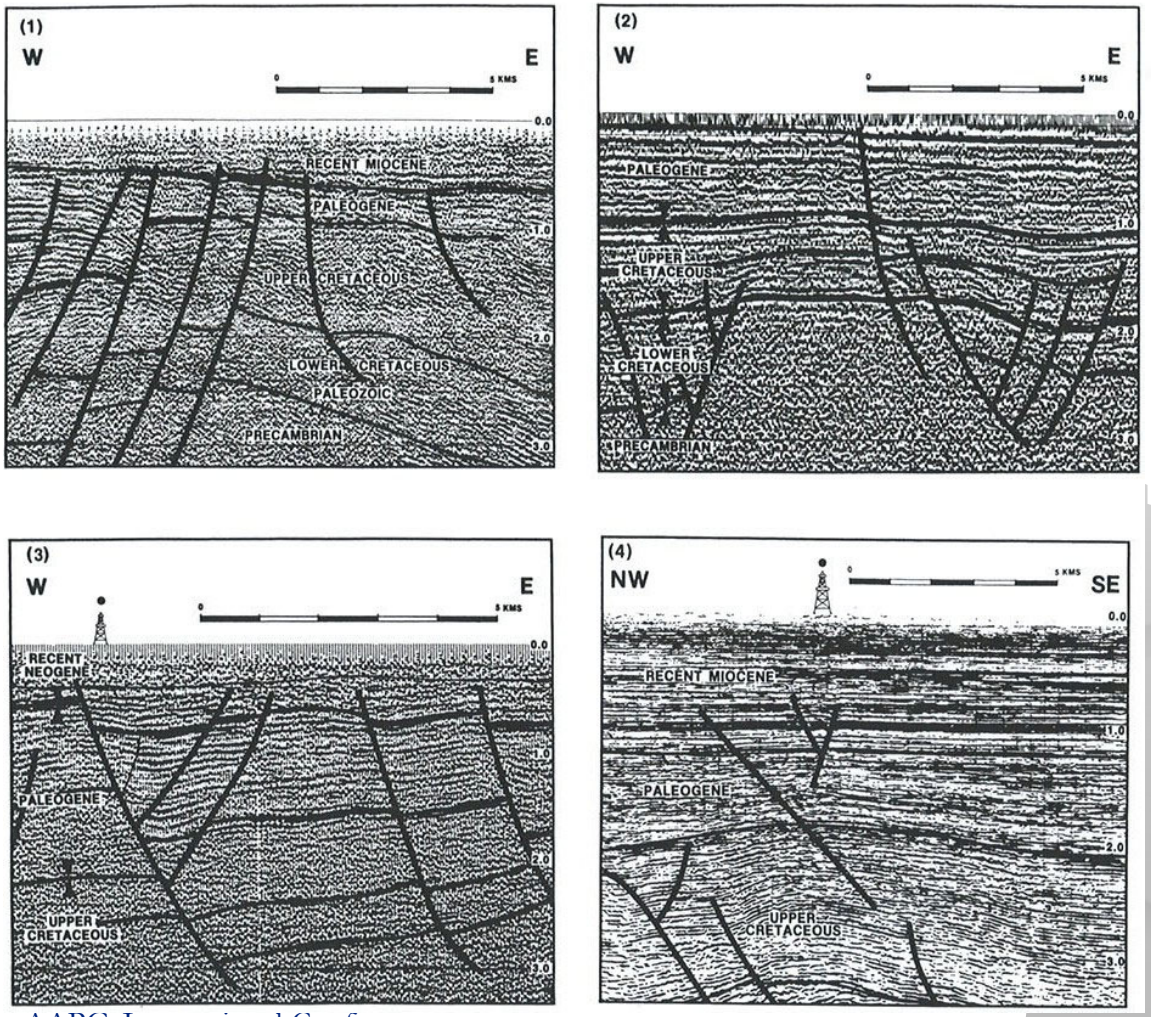
THE PRESENT STUDY AIMS AT:

- 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



REGIONAL TECTONIC AND ASSOCIATED STRUCTURAL STYLES



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)

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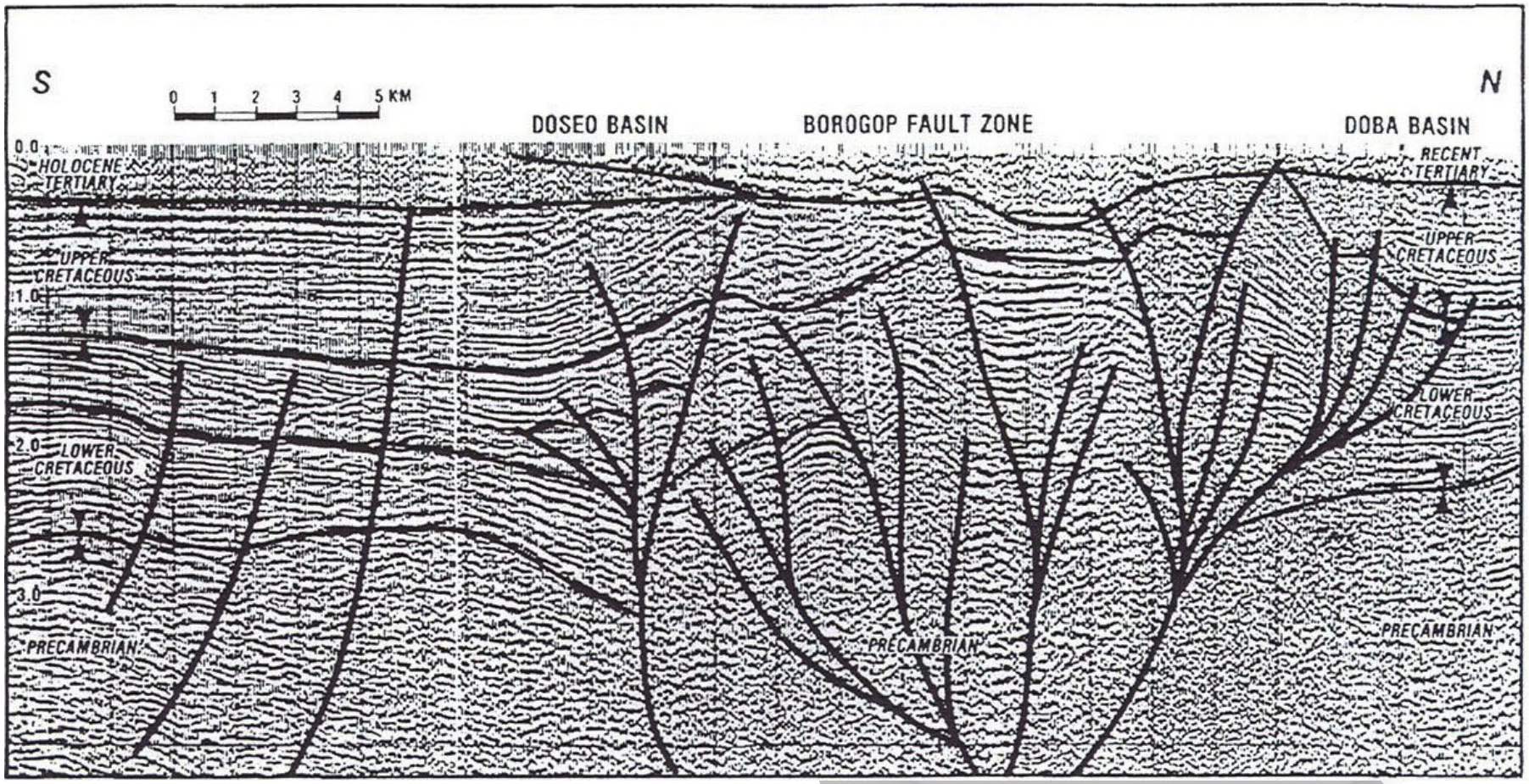
REGIONAL TECTONIC AND ASSOCIATED STRUCTURAL STYLES

(Cont' d1)



Composite Seismic Section Across Doseo and Doba Basins (CAS)

Transpressed basement blocks and

associated Positive Flower Structures **(Genik, 1993)**

REGIONAL TECTONIC AND ASSOCIATED STRUCTURAL STYLES

(Cont' d2)

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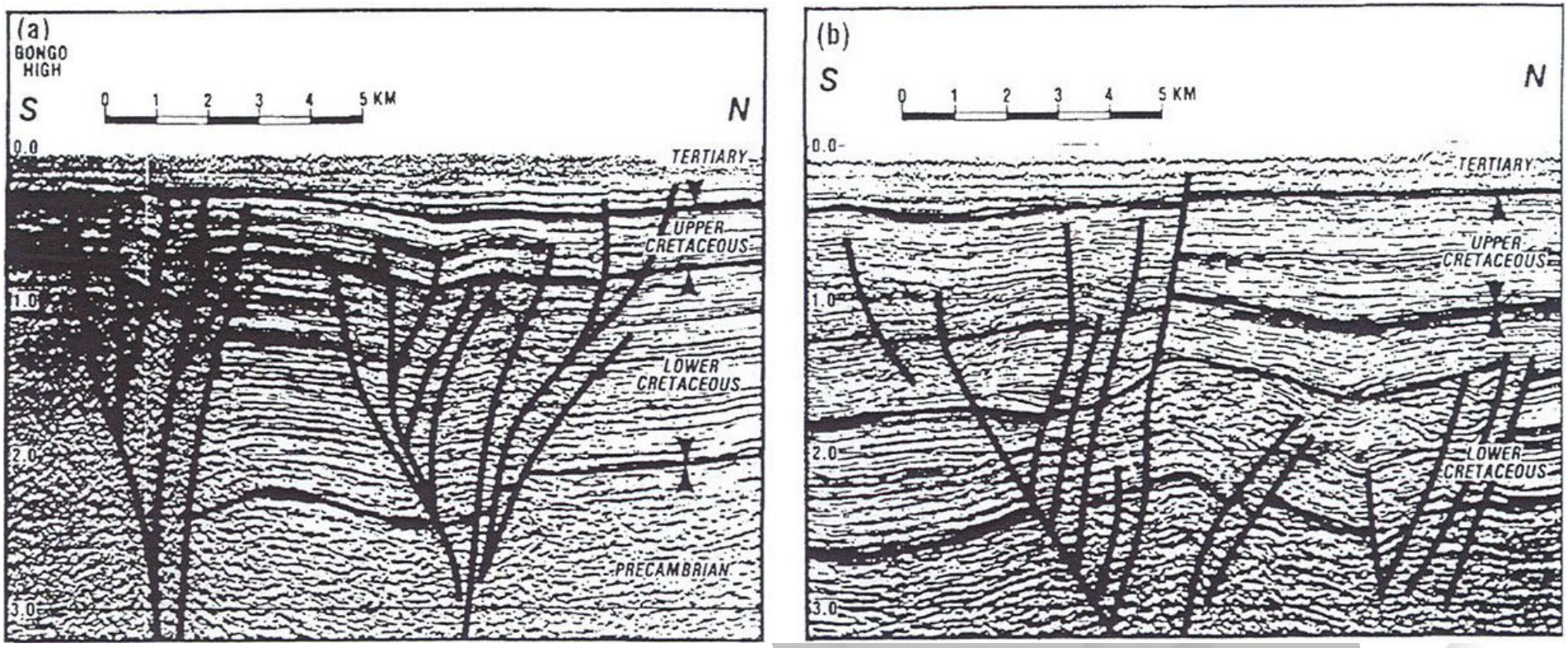


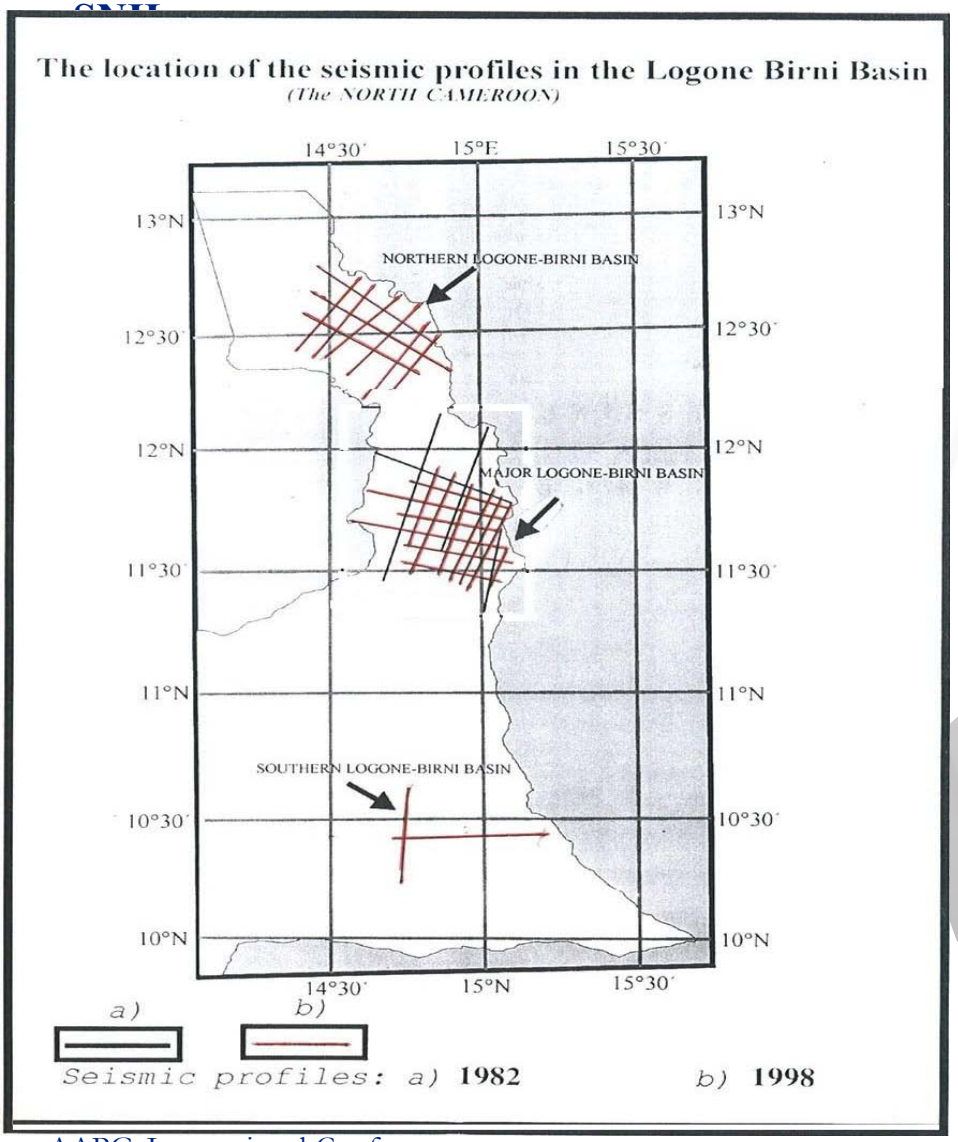
Doseo Basin (CAS)

(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

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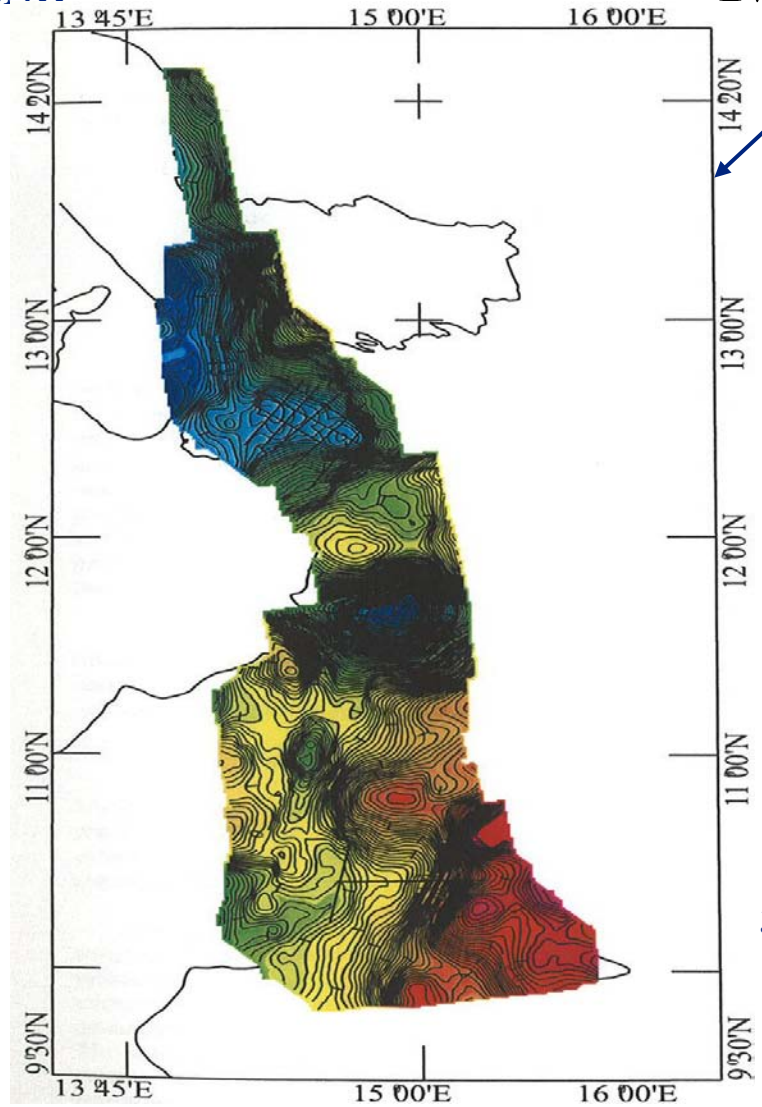
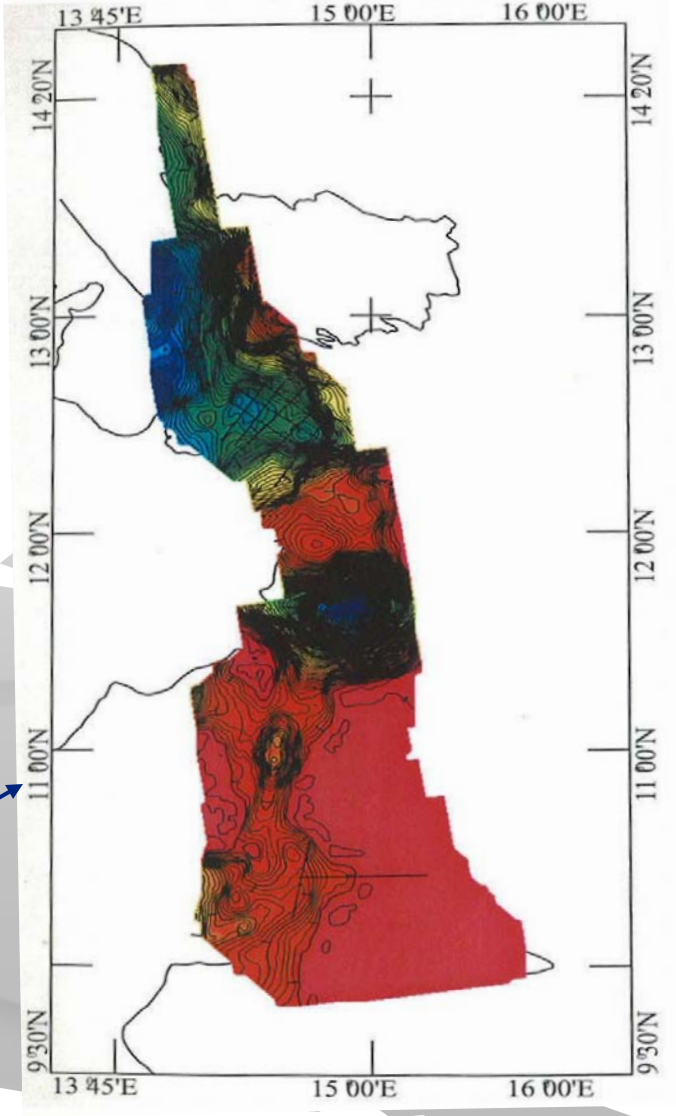


Constrained residual Bouguer



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

BASEMENT ARCHITECTURE – Interpretation

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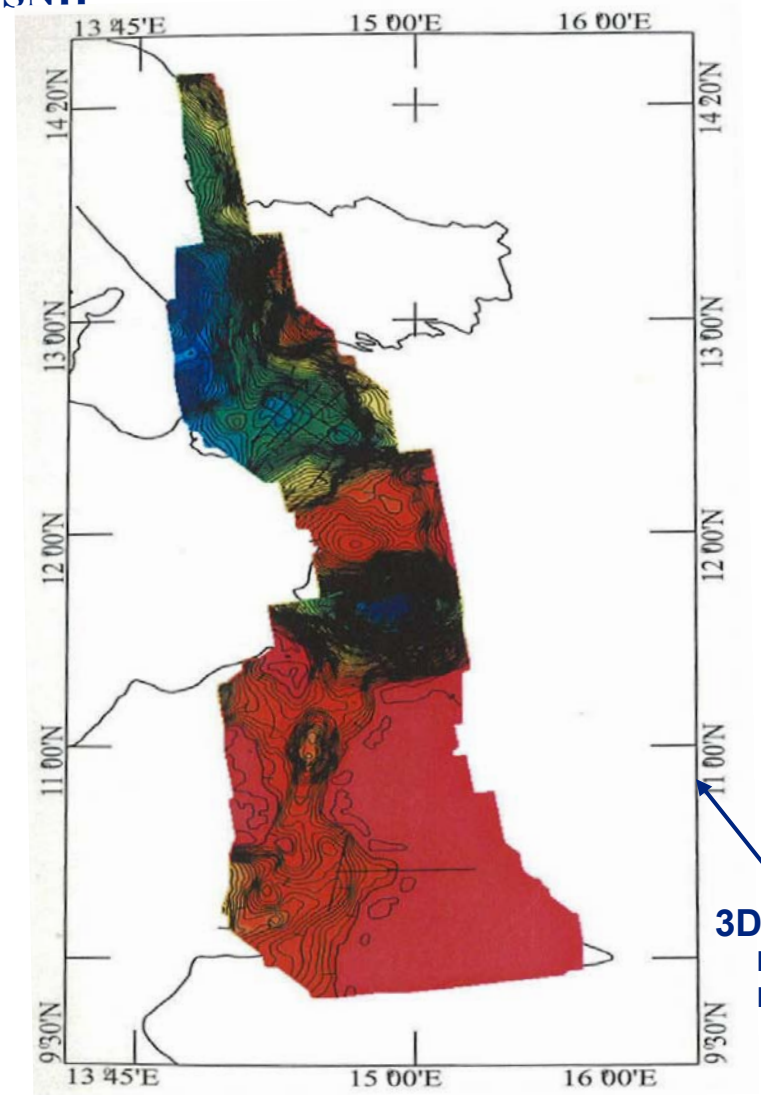
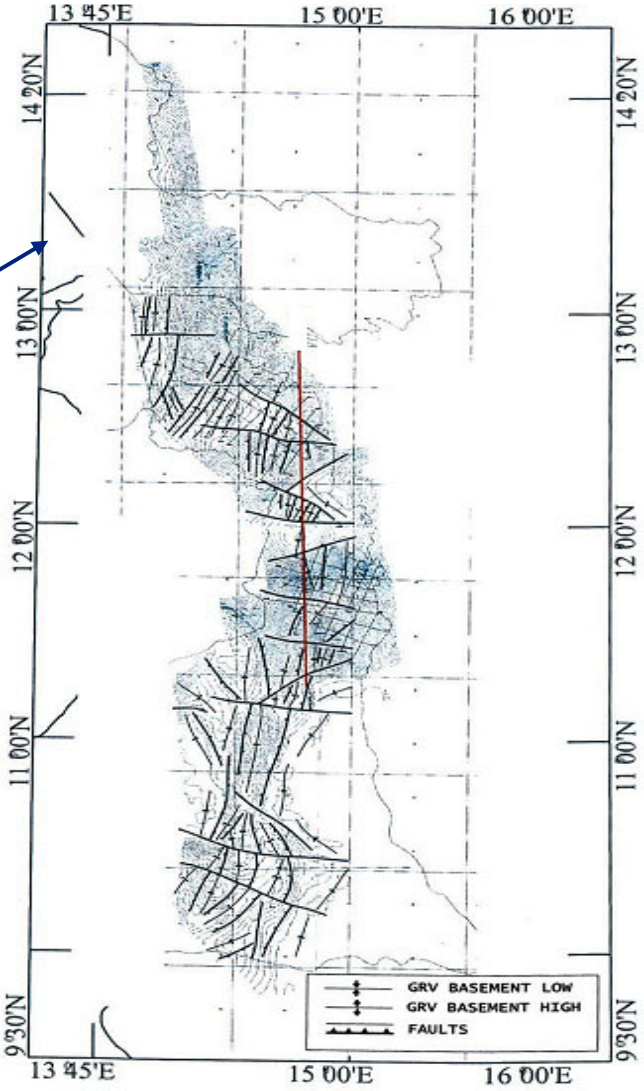


Basement Architecture in the LBB

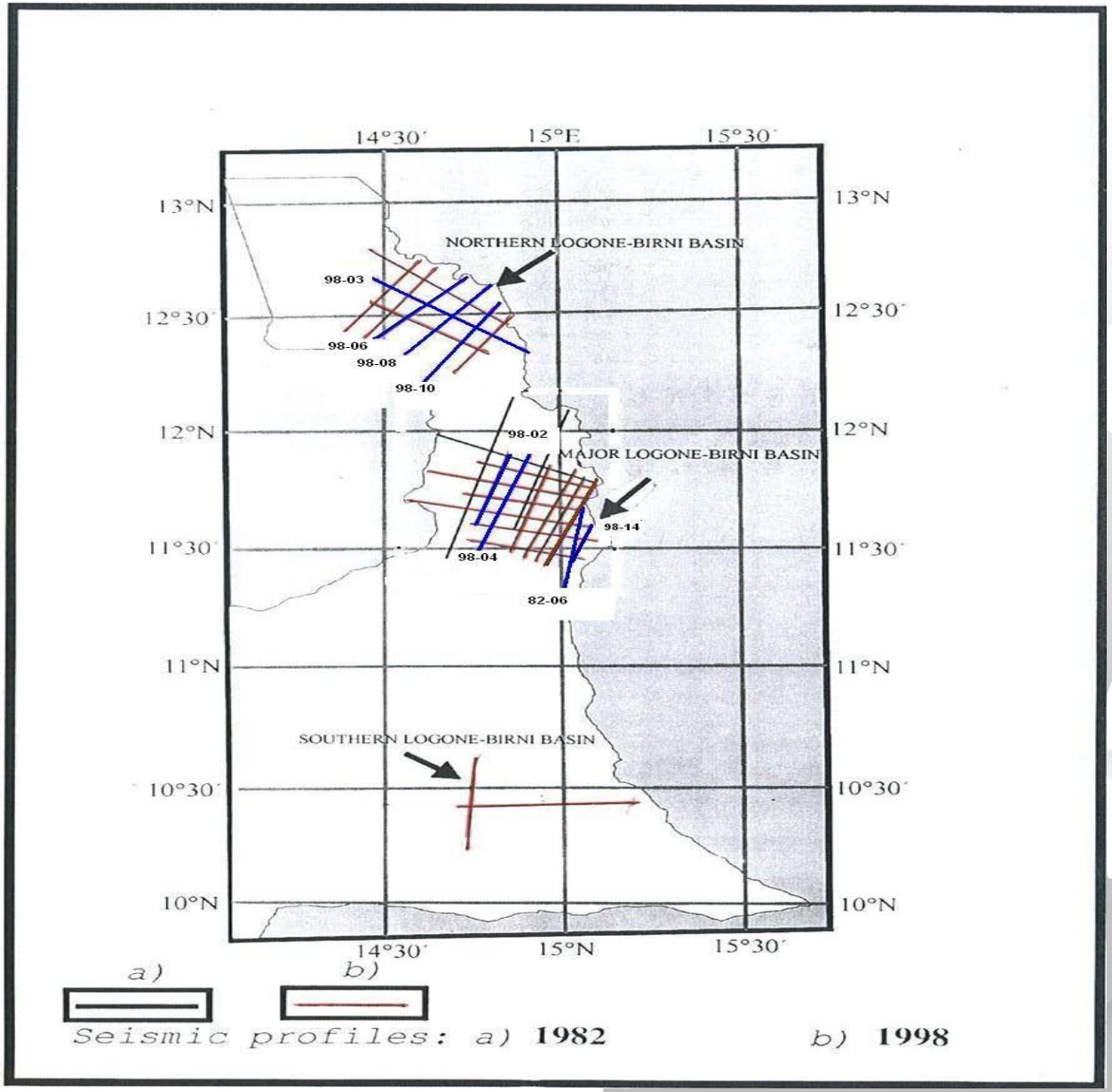
3D Gravity inversion (depth map) of the constrained residuals



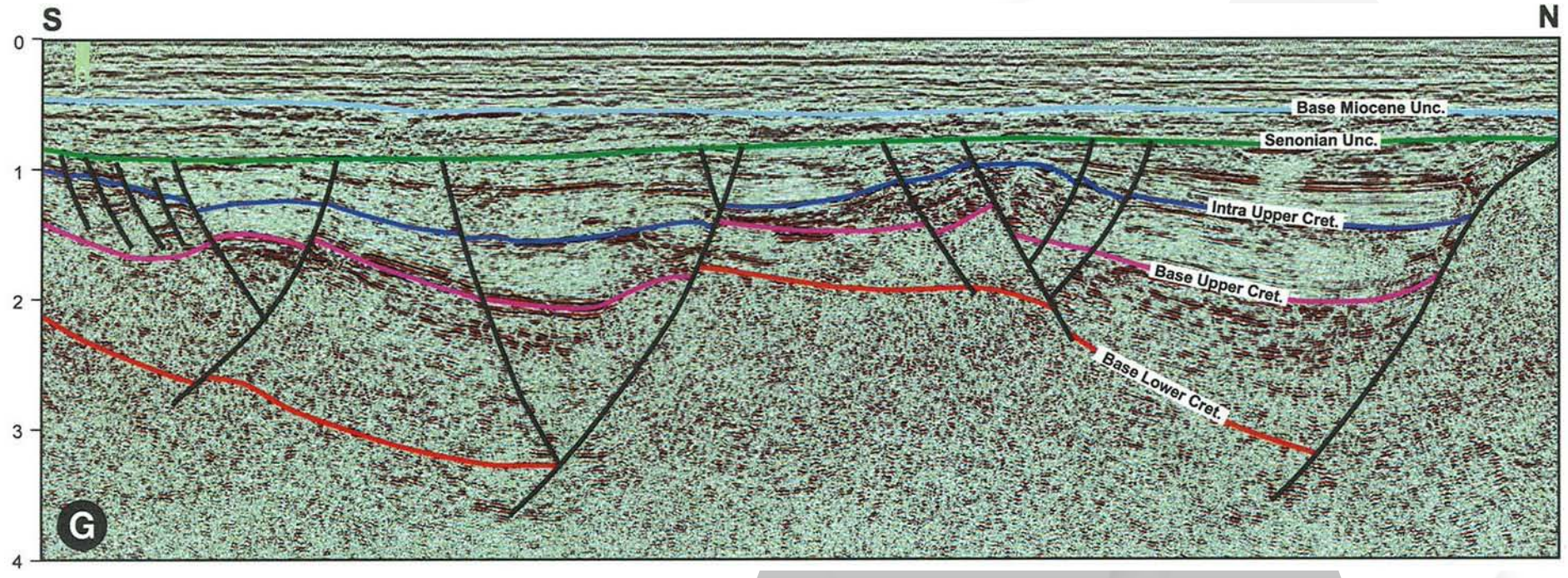
BASEMENT ARCHITECTURE CONCLUSIONS

- 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 STRUTURES"**
  - **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



STRUCTURAL STYLES IN THE LBB



Transpressed basement with associated tilted and rotated fault block inversion anticline and poorly developed Positive Flower Structures

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STRUCTURAL STYLES IN THE LBB (Cont' d1)

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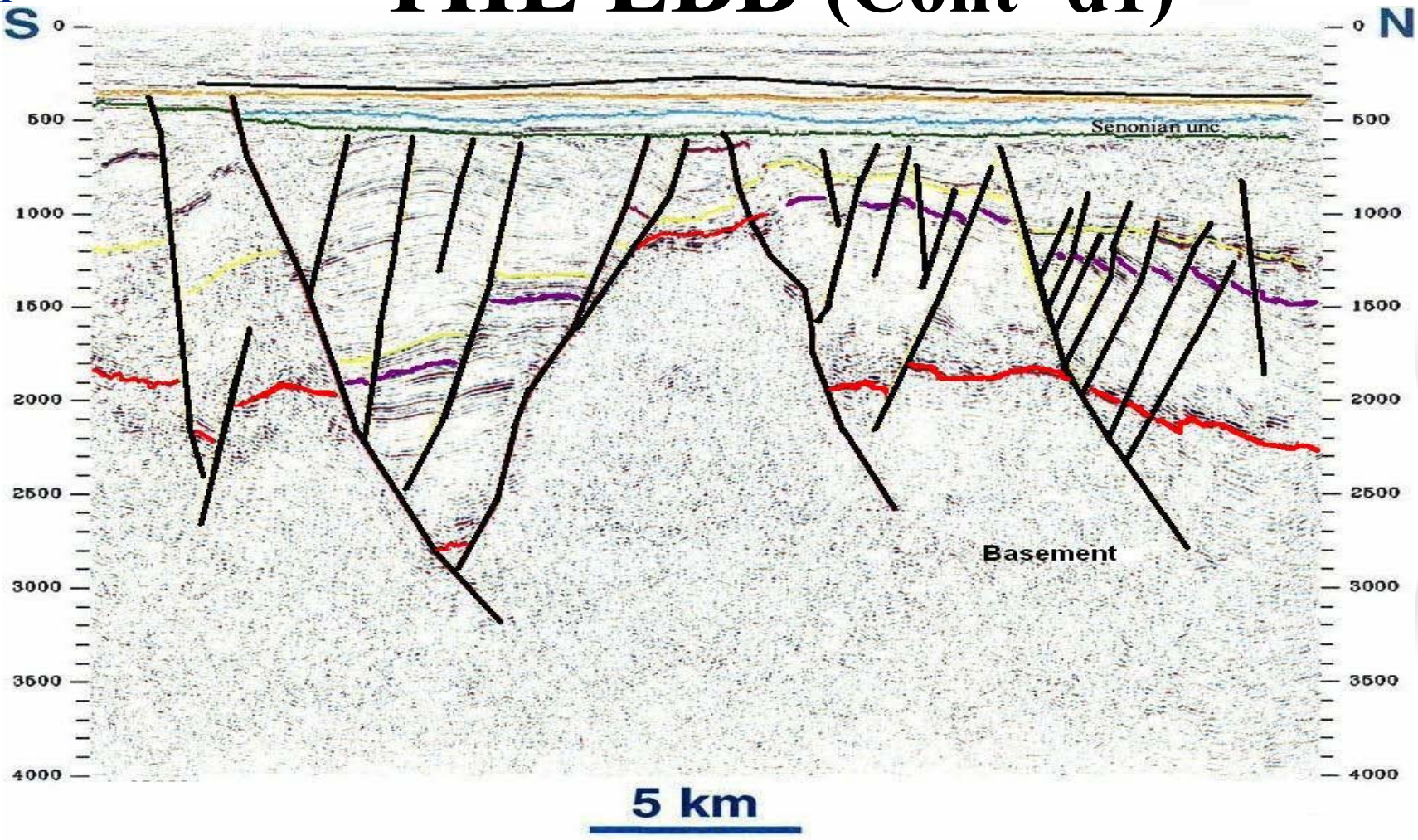
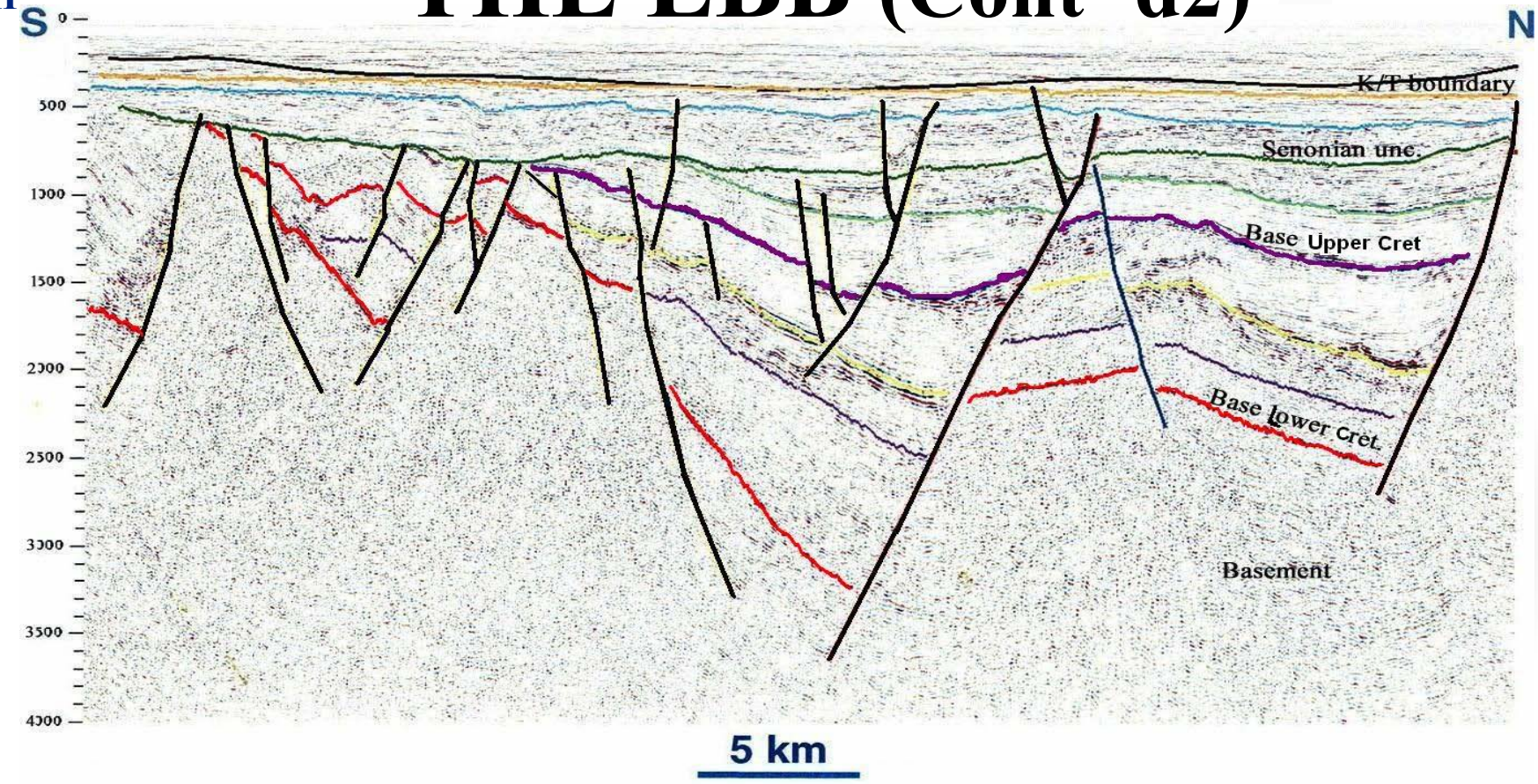


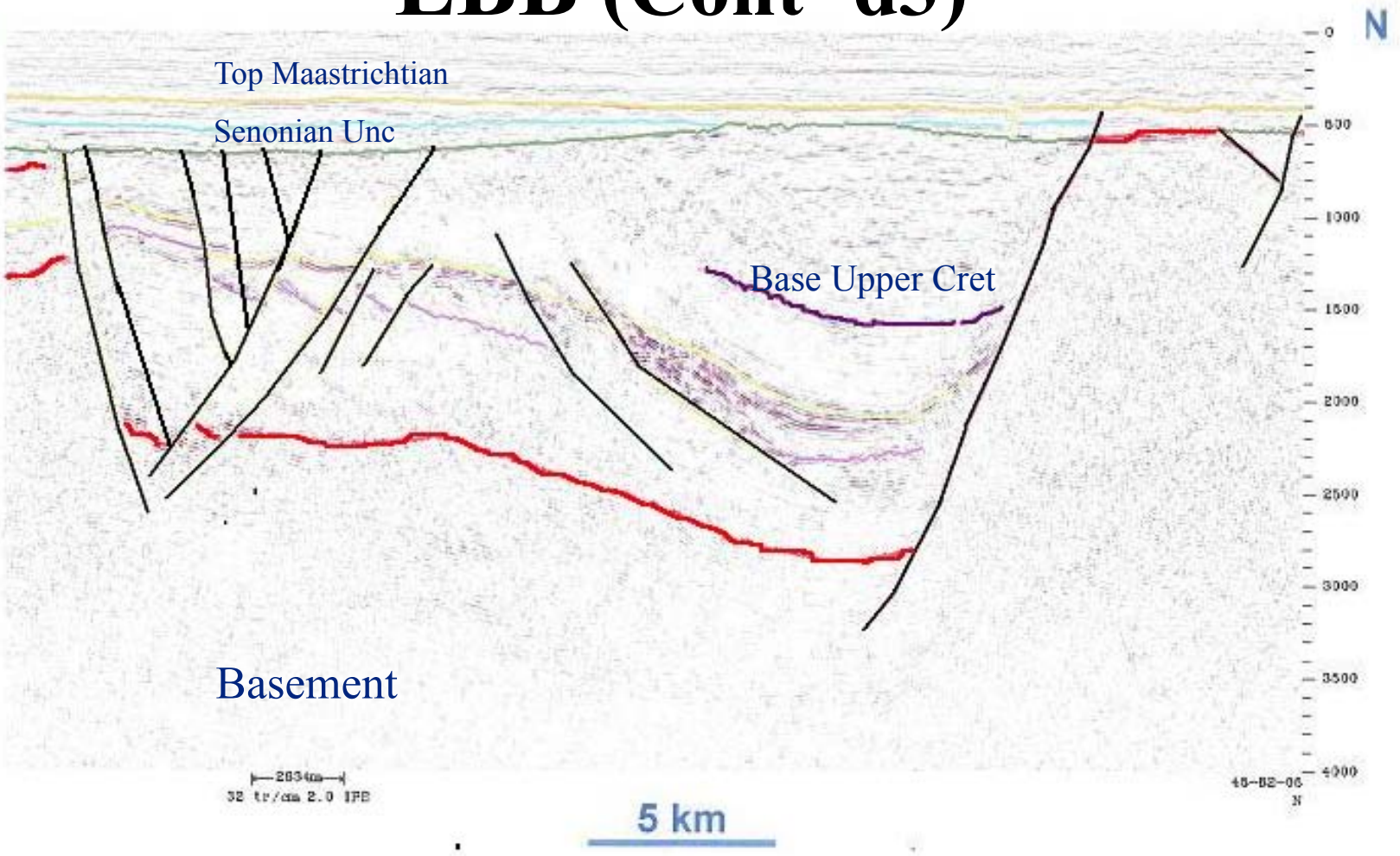
Positive flower Structures produced by Upper Cretaceous dextral wrenching

STRUCTURAL STYLES IN THE LBB (Cont' d2)



Transpressed basement block with associated normal faulting

STRUCTURAL STYLES IN THE LBB (Cont' d3)



Half Graben, Basement Horst, Negative Flower Structure to the South

STRUCTURAL STYLES IN THE LBB (Cont' d4)

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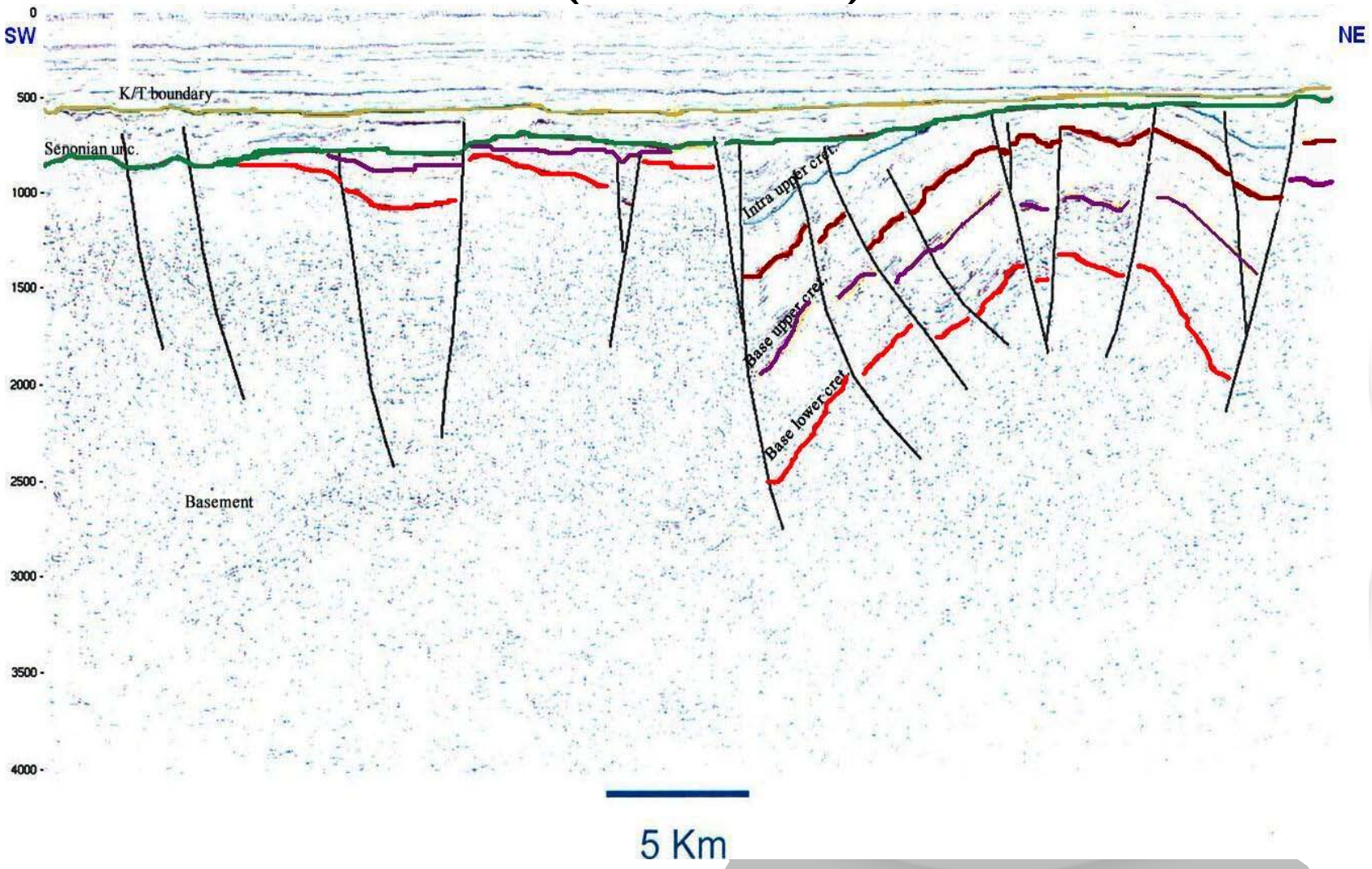
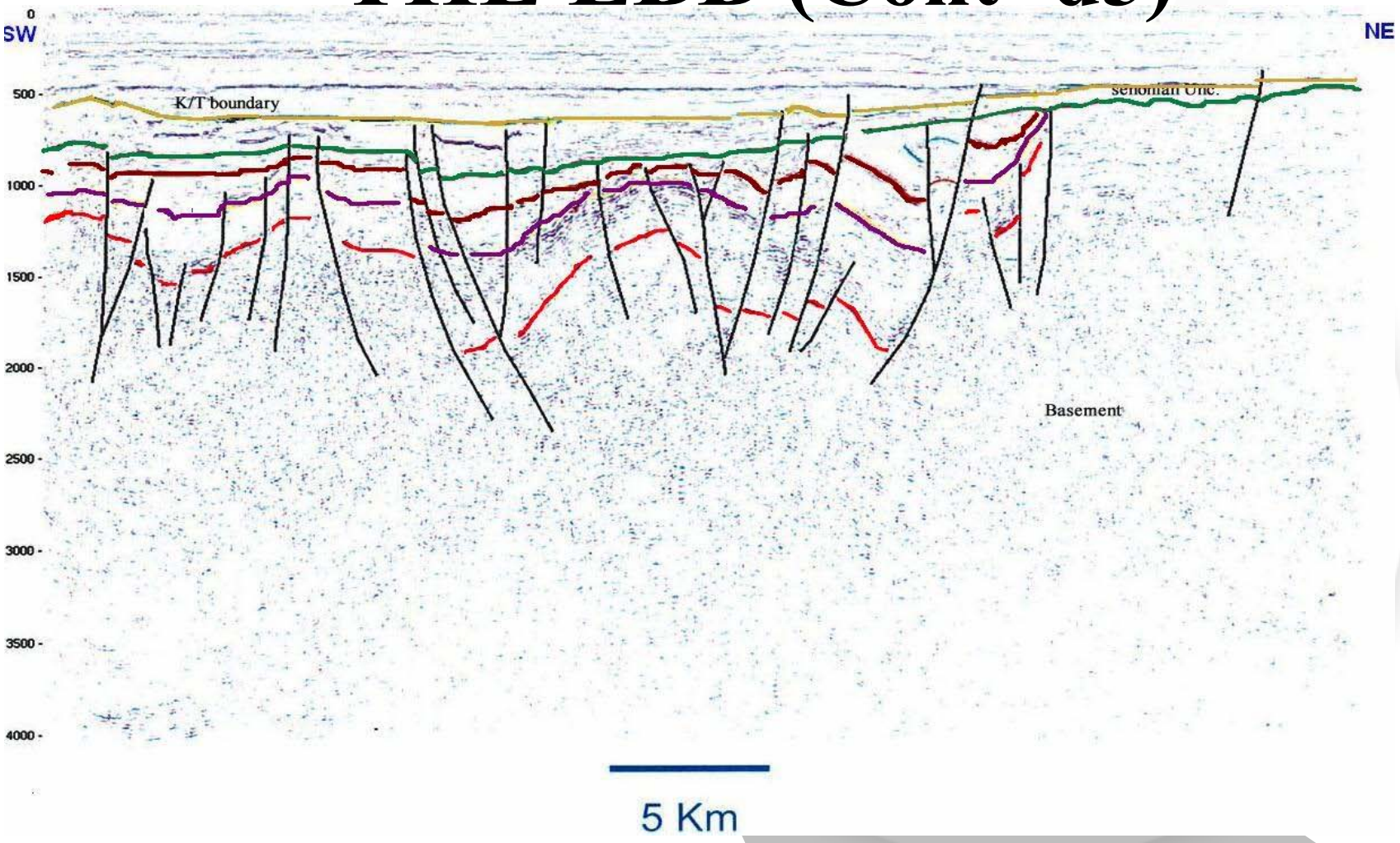


Tilted and Rotated fault blocks with an inversion anticline

STRUCTURAL STYLES IN THE LBB (Cont' d5)

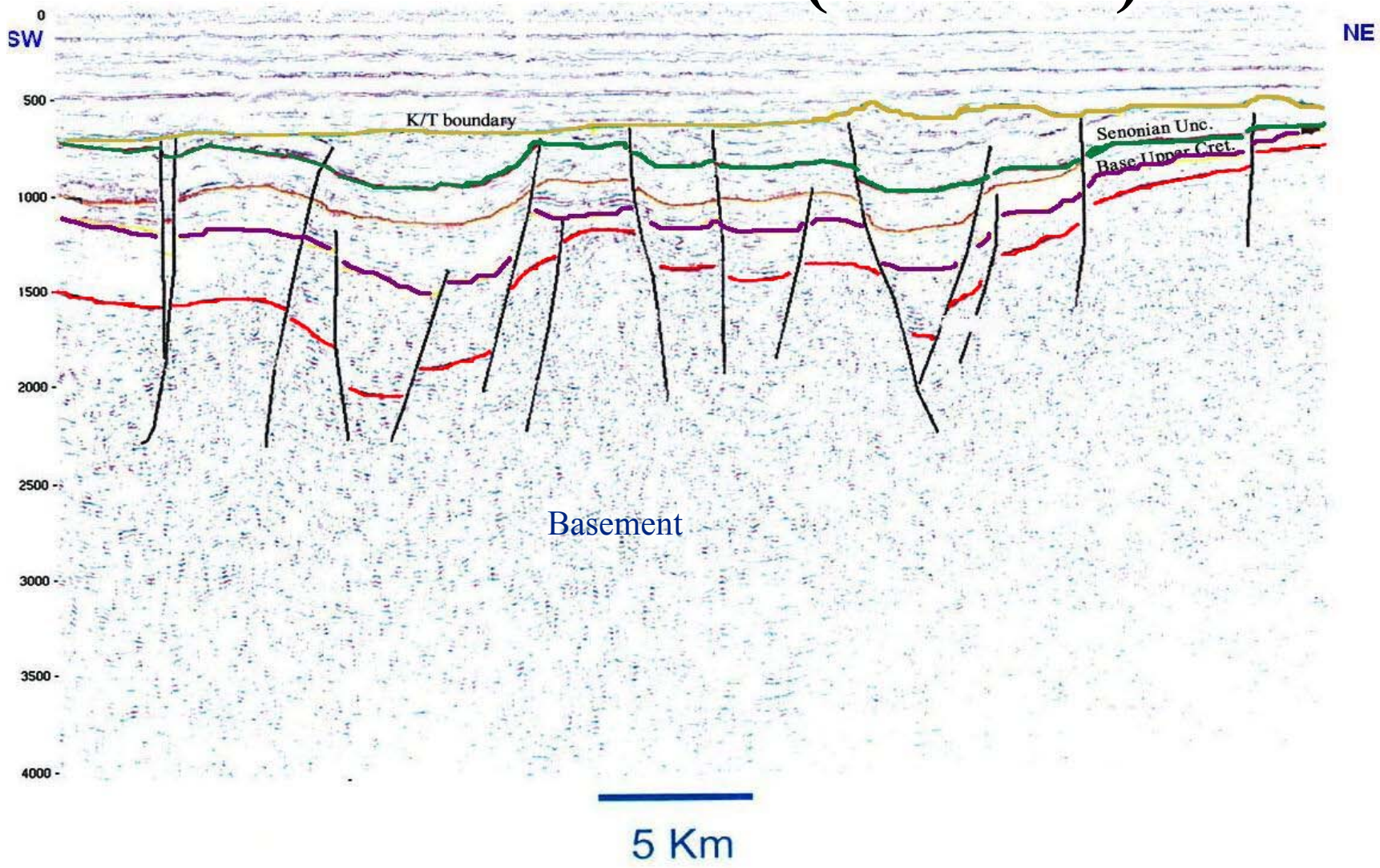
SNH



Faulted Symetric transpressional anticlines

STRUCTURAL STYLES IN THE LBB (Cont' d6)

SNH

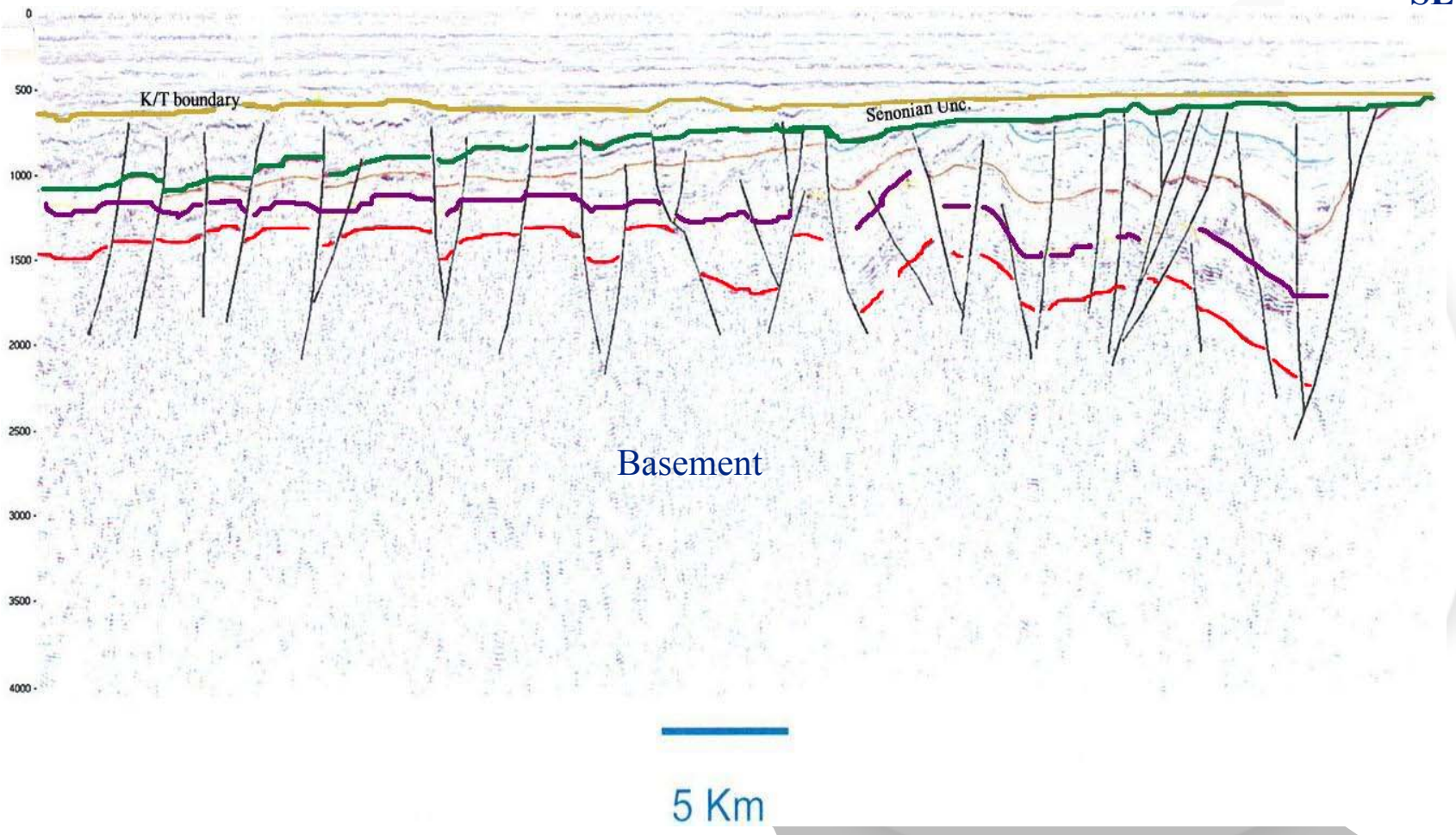


STRUCTURAL STYLES IN THE LBB (Cont' d7)

SNH

NW

SE



SE-NW Normal Synthetic Faulting Parallel to basin margin

STRUCTURAL STYLES IN THE LBB: TOP BASEMENT DEPTH STRUCTURE MAPS-FAULTS TRENDS

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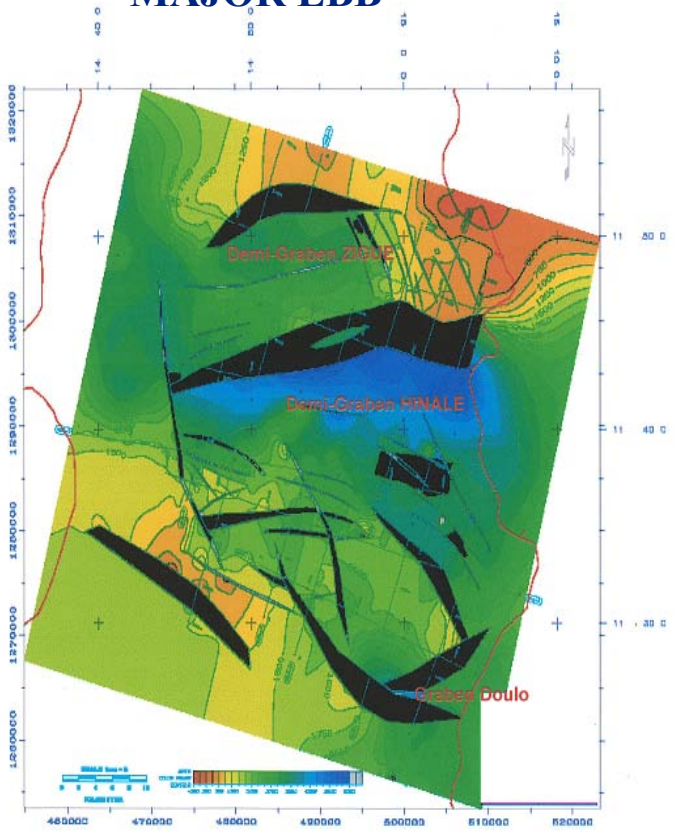
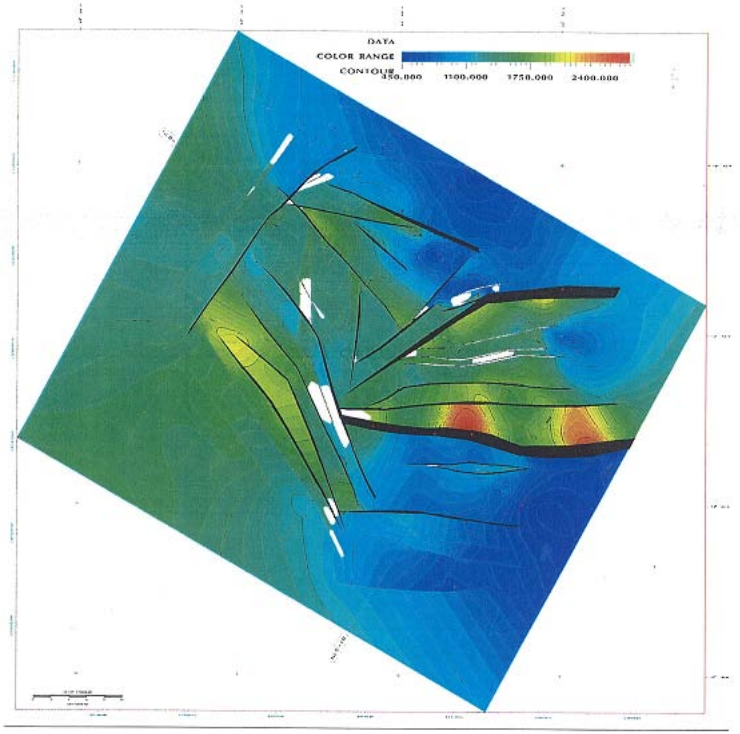
MAJOR LBB



NORTHERN LBB



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

TECTONIC EVOLUTION OF THE LBB

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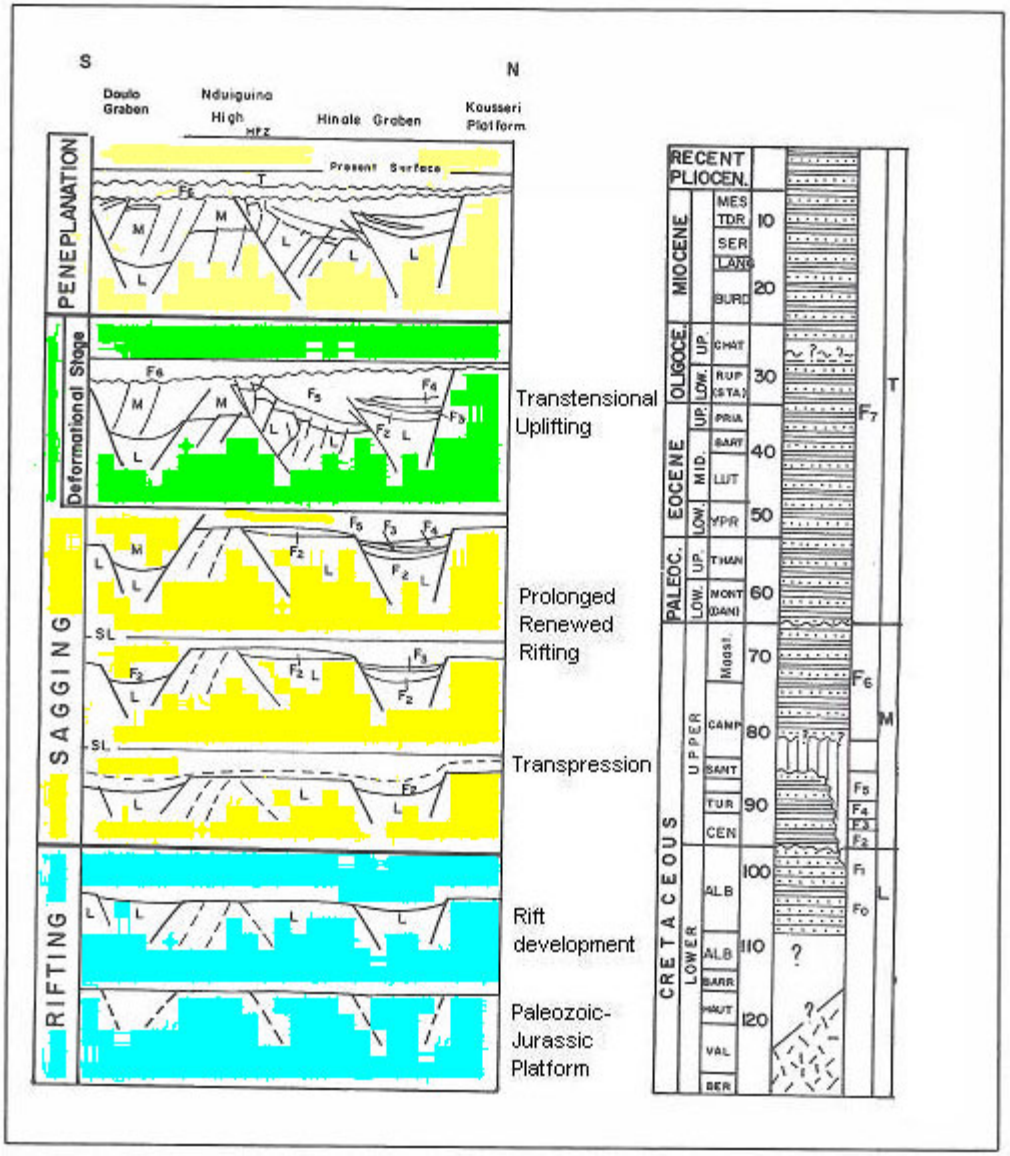

(Modified after MANGA et al, 1999)

CONCLUSIONS :COMPARAISON BETWEEN THE WAS, CAS AND LBB

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STRUCTURES/FEATURES	WAS	CAS	LBB
Orientation of Pan African Crustal Discontinuities (Essential Structures)	NW - SE	ENE - WSW	NE-SW to NNE - SSW
Structural Styles	Extensional normal fault blocks	+	+
	Transtensional synthetic normal fault blocks	+	+
	Transtensional antithetic normal fault blocks	+	+
	Transpressional anticlines	Transpressional anticlines	+
	-	Flower Structures, both Positive and Negative	+
	-	Inversion Structures	+
Volcanics	yes	yes	yes
Maximum Sedimentary Pile	> 14, 000 m	≈ 7, 500 m	≈ 6, 000 m
Type of Sediments / age	Continental to marine / Lower Cretaceous to Recent	Terrestrial / Lower Cretaceous	Continental to marine / Lower Cretaceous to Recent
Age of Source Rocks	Upper Cretaceous and Paleogene	Lower Cretaceous lacustine shales	Possibly Lower Cretaceous lacustine shales (TOC : 16-36%)
Age of Reservoirs	Upper Cretaceous and Paleogene	Lower and Upper Cretaceous	Lower and Upper Cretaceous
Age of Seal	Upper Cretaceous and Paleogene	Lower and Upper Cretaceous	Lower and Upper Cretaceous

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CONCLUSIONS (Cont'1)

.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.

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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

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DOI: 10.1144/GSL.SP.1986.025.01.03

Genik, G. J., 1992, Regional framework, structural and petroleum aspects of rift basins in Niger, Chad and the Central African Republic (C.A.R.) (*in* Geodynamics of rifting; v II, Case history studies on rifts; North and South America and Africa, Ziegler,): Tectonophysics, v. 213-1/2, p. 169-185.Fairhead, 1986