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Research paper

Inversion tectonics in Central Africa Rift System: Evidence from the Heglig Field

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ABSTRACT

The Mesozoic-Cenozoic tectonic history of the Muglad Basin, is dominated by extension and inversion tectonics, but evidence of the inversion tectonics has not been well documented yet. In some other rift basins of CARS and WARS the phase of the inversion tectonics is well documented by several authors.

This paper presents a structural study of the Heglig field area located on the eastern flank of the Muglad Basin. Detailed 3D seismic interpretation allows a better understanding of the structural style of the Heglig field. The new structural analysis has shown that the Heglig field has a complex structural framework reflected in the presence of a combination of two structural styles. The extensional structure is influenced by inversion tectonics during the Santonian time that creates four-way dip anticline structure, overprinted by the subsequent extensional movement that creates tilted fault block. The presence of inversion tectonics has supported by different means including seismic reflection, velocity, and source rock maturity data. The authors attributed the trapping of oil in the Lower Bentiu reservoir, that requires a horizontal seal, to the presence of the four-way dip anticline structure created by the inversion tectonics.

The current interpretation of the Heglig field 3D seismic data sheds new light on the development and evolution of a key structure in the Muglad Basin. The results help to resolve long-standing discussion concerning hydrocarbon accumulation of the lower part of Bentiu Formation that lacks horizontal sealing.

1. Introduction

The intracratonic rift system of West and Central Africa (Fig. 1) provides a good chance to investigate relationships between initial extension and short compressional inversion over an extensive and genetically linked system, made up of multiple basins with variable orientation and basin fill histories. Examples from several basins highlight the degree of compression inversion as a function in part of the direction of the compression stress on original rift structures (Cooper and Warren, 2010). Sudanese rift basins are part of the West and Central Africa Rift System (WCARS) that proved to be rich in hydrocarbon resources. The hydrocarbon discoveries within the WCARS attracted the attention of geoscientists. The exploration and drilling activities provided tremendous amount data that assisted in understanding the tectonic regime within the region. Inversion tectonics of the WCARS has been widely recognized in some basins not far from the Muglad Basin.

The Muglad Basin (Fig. 1), which is an intracontinental basin that extends in both Sudan and South Sudan, remains an active exploration and development focus. In the basin, tilted fault blocks, horst blocks, anticlinal drapes, and hanging-wall rollovers along normal faults had been proven as hydrocarbon traps. Chevron Overseas Petroleum Inc. discovered the oil in the basin during the 1970s. The Muglad Basin contains some hydrocarbon accumulations of various sizes, the largest of which are the Heglig and Unity fields in Sudan and South Sudan, respectively. The basin accounts for the majority of Sudan's known oil reserves. Although the systematic hydrocarbon exploration in the interior basins of Sudan was started by Chevron Overseas Petroleum, Inc. in 1975 and significant hydrocarbon discoveries were encountered, Chevron terminated its contract in the 1990s.

The Heglig field (the study area) is located on an NW-SE oriented structural high in the SE part of the Muglad Basin. As the majority of the discovered area in the Muglad Basin, the Heglig field

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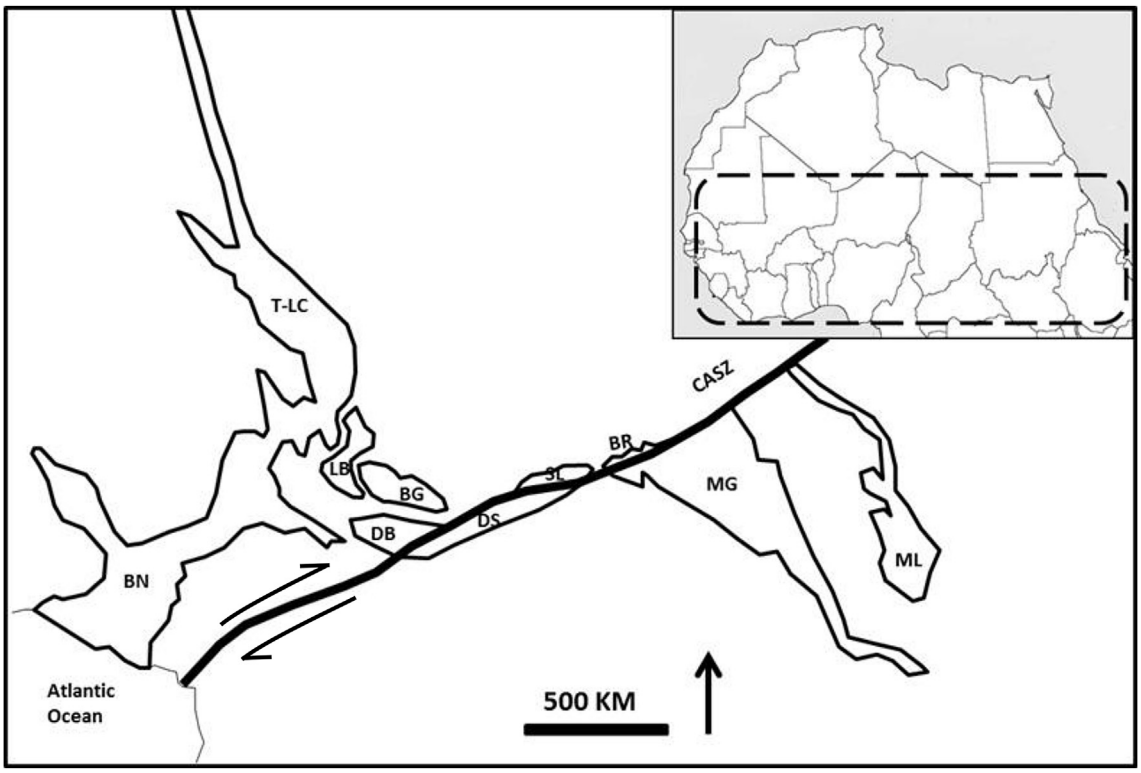

Fig. 1. Mesozoic-Tertiary rift systems of West and Central Africa Rift System. T-LC = Termit/Lake Chad; LB = Logone Birni; BN = Benue Trough; BG = Bongor; DB = Doba; DS = Doseo; SL = Salamat; MG = Muglad; ML = Melut; BR= Baggara; CASZ = Central African Shear Zone (modified after Genik, 1993; Manga et al., 2001; Cooper and Warren, 2010).

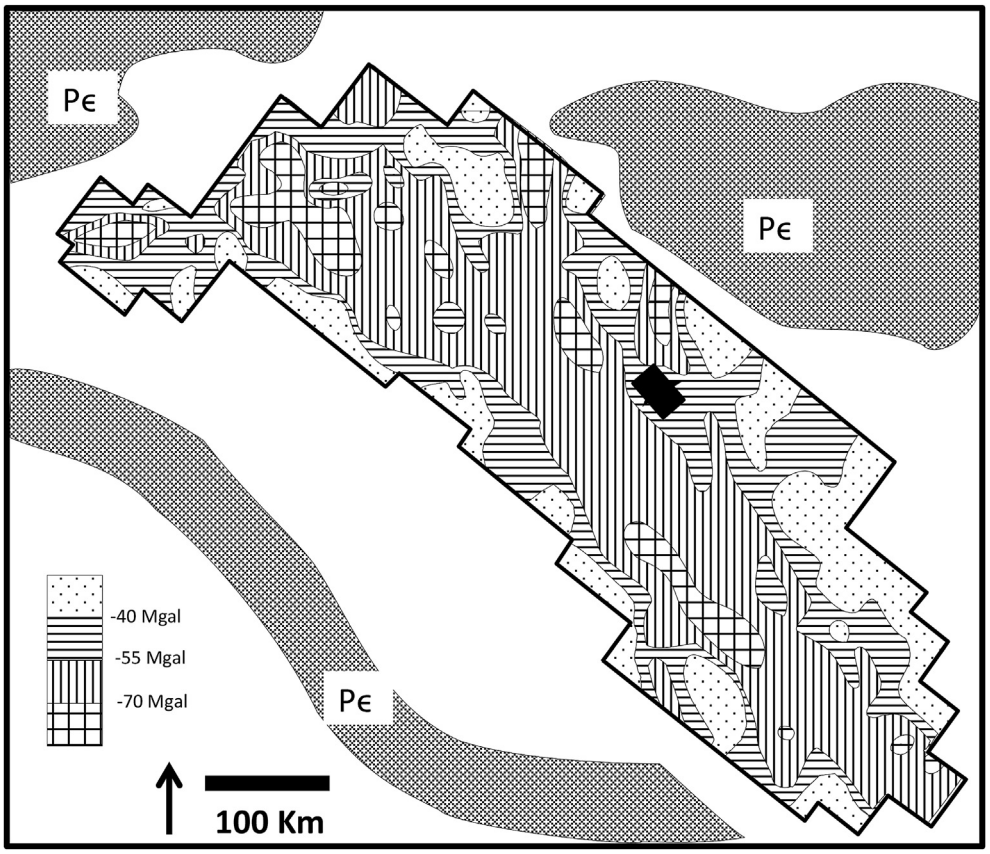

Fig. 2. Bouguer gravity map of the Muglad Basin (after Giedt, 1990) with location of the study area (black rectangular).