

## STRATIGRAPHY AND TECTONIC EVOLUTION OF THE OIL PRODUCING HORIZONS OF MUGLAD BASIN, SUDAN

By

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### ABSTRACT

Muglad Basin is recognized to be a major part of Sudanese interior rift basins. It trends northwest-southeast covering an area of over 1200km long and in excess of 300km wide. The major segment of the faulted strata in this basin lies beneath the Late Tertiary sediments.

Rift tectonic phases have controlled the geological settings of the African rift basins and their associated sedimentary cycles. Fractures of South African plate in early Mesozoic era was led to creation of deep troughs, this, together with sediment accumulations and faulting across the successively deposited beds formed structural and sedimentary conditions ideal for trapping of oil. Muglad trough was filled with non-marine sediments of upper Jurassic<sup>[1]</sup> derived from North African plate.

A generalized stratigraphic column and a modified map of Muglad basins illustrate:

- (1) The principal lithologies, maximum formation thickness, and producing formation of selected horizons from the Precambrian through Tertiary.
- (2) The evolution history.

### الملخص:

يمثل حوض المجلد الجزء الرئيسي للأحواض الداخلية السودانية. الاتجاه الجغرافي له هو شمال غرب - جنوب شرق ويغطي مساحة قدرها 750km طولاً و150km عرضاً، الجزء الأكبر من الطبقة المتصدعة لهذا الحوض تقع تحت الطبقة التي تنتمي إلى أواخر العصر الثلاثي (Tertiary).

تحكم الصدع التكتوني في المظاهر الجيولوجية والعمليات الرسوبية المصاحبة وتصدع اللوح الجنوبي للقارة الأفريقية مبكراً في الدهر الوسيط (Mesozoic) أدى إلى تكوين حوض عميق ساعد على عملية تراكم الرسوبيات التي صدعت فيما بعد مما أدى إلى خلق بيئة مناسبة لاصطياد وحبس البترول في

هذا الحوض. يحتوى حوض المجلد على رسوبيات ذات مصدر غير بحري يرجع عمرها إلى نهاية العهد الجوراسي (Upper Jurassic) تم جلبها من اللوح الشمالي للقارة الإفريقية.

العمود الاستراتيجرافي والخريطة المستنتجة لهذا الحوض توضح الآتي:

1- التركيب الليثولوجي الرئيسي والحد الأعلى لسمك التكوينات، بالإضافة إلى الطبقة المنتجة للنفط من العصر ما قبل الكامبري (Precambrian) إلى الثلثي (Tertiary).

2- التطور التاريخي لهذا الحوض.

## INTRODUCTION

The present paper presents review of the stratigraphic and tectonic evolution of the Muglad basin, the primary emphasis on the tectonic evulsions and geology of the oil productive horizon. The basement, source, and reservoir rocks of this basin are not uniformly distributed, since this basin had periods of complex tectonic operation. This presentation hopefully will be a significant contribution to the industry knowledge of the subject and will further stimulate the research interest in this basin.

Prior to exploration data depicted by Chevron Overseas Petroleum Co, these areas were viewed as the site of shallow intracratonic sags in which a few thousand feet of Cretaceous, Tertiary, and Quaternary sedimentary rocks had accumulated. This concept was based on sparse water-well data and limited outcrop. These basins are now interpreted to contain over 13,000m of Mesozoic-Cenozoic sedimentary rocks and were recognized to be a major segment of the central African rift system, which extends from Nigeria to Sudan. This system began to develop in the early Cretaceous during the breakup of Gondwana and separation of South America from Africa. In the Sudan, rifting continued into the Tertiary before ceasing during the Middle Miocene.

### Regional Geology:

The Muglad Basin is part of a trend of Cretaceous sedimentary basins of apparent rift origin, which cut across north central Africa from the Benue Trough in Nigeria, through Chad and the Central African Republic, into Sudan. (Fig. 1) The evidence for extension further southeast of this trend has been destroyed by Tertiary uplift associated with recent rifts in Ethiopia and Kenya.

Regional data are limited, but the aeromagnetic and gravity surveys indicate as much as 5kilometers of sediments<sup>[5]</sup>. Tectonics in the basin is highly complicated by faulting. Seismic data suggest large numbers of tensional faults have affected the overall basin and have defined several sub-basins. Structures within these sub-basins show significant variations in age of formation, complexity and size.

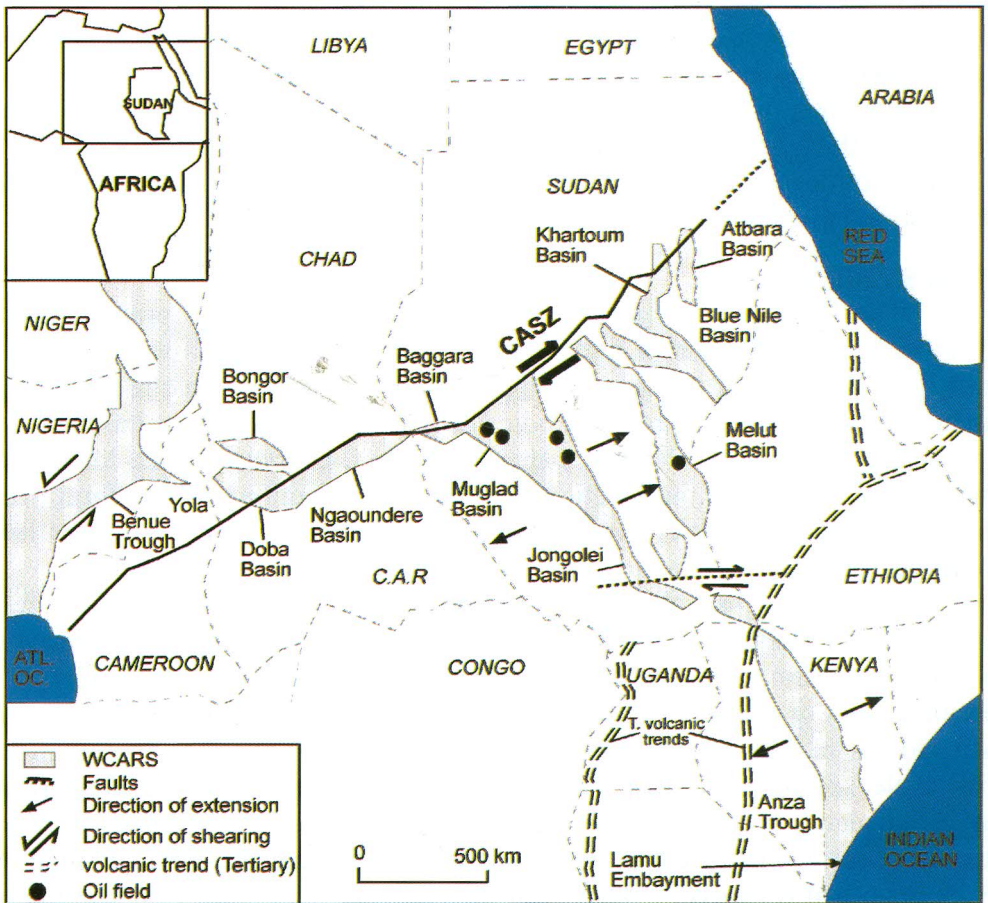


Fig. (1): Tectonic model of the West and Central African Rift System from Fairhead (1988)

Regional stratigraphy indicates that a major East African rift basin had formed in the early Jurassic whose structural axis paralleled the Rudolf Trough in Kenya<sup>[1]</sup>. The early rift sediments are probably dominated by coarse continental clastics, but some lacustrine or fluvial sediments may also have been deposited.

In the late Jurassic the rift basin continued to widen. Lacustrine sediments, with interbeds of coarser rift clastics derived from surrounding basement blocks, may have been the dominant types deposited. To this time, no Jurassic sediments have been penetrated in the area, due to the possibility that the Sudan Interior Basins may have begun forming at this time.

Previous wells and seismic data from the Sudan Interior Basins confirmed thick continental facies of Cretaceous and younger age. Control on geometry of deposition is poor, but numerous areas of low-lying basement hills probably supplied the sediments.


### **Basin Stratigraphy:**

The basement adjacent to the Muglad basin is predominantly Precambrian and Cambrian metamorphic rocks with limited occurrences of intrusive igneous rocks. The rock types are mainly metamorphic rocks, which include, granitic gneiss, and granodioritic gneiss. This gneissic basement is overlain by quartzite of Paleozoic age. From the Cambrian into the Mesozoic, the Muglad basin was the location of an extensive continental platform. The oldest sedimentary rocks are non-marine of lower Jurassic salt (halite), siltstones, and Permo-Triassic claystones of the Blue Nile basin.

The deepest part of the Muglad basin lies to the west of Unity field, it is estimated to contain over 4500m of Tertiary and 6000 to 9000m<sup>[5]</sup> of Cretaceous non-marine sediments derived from surrounding basement complex (Fig.1). The establishment of the stratigraphic column reflects three cycles of deposition in Muglad basin. The Sharef, Abu Gabra, and Bentiu Formations represent the first cycle, second cycle is the Cretaceous of Darfur Group and is characterized by a coarsening upward sequence, and the third one is Nayil formation<sup>[2]</sup>. The age of these cycles are (a) late Jurassic to Cenomanian, (b) Turonian to Paleocene, and (c) early Tertiary respectively. (Fig. 2.) General description of these formation are shown below (Table 1).

**Table (1): Stratigraphic units of the Muglad rift basin, their lithology and depositional environment (Modified after Schull 1988)**

FORMATION		LITHOLOGY AND ENVIRONMENTS	AGE		
K O R D O F A N	Zeraf Fm.	Predominantly iron-stained sands and silts with minor claystones interbeds.	Recent-middle Miocene	T E R T I A R Y	
	Adik Fm.	Braided streams/alluvial fans.			Oligocene-
	Tendi Fm.	Predominantly claystone/shale, interbedded with sandstones			Late Eocene
	Nayil Fm.	Fluvial/floodplain & lacustrine	Paleocene		
	Amal Fm.	Predominantly massive medium to coarse sandstones sequences. Braided streams/alluvial fans.			
D A R F O U R G R O U P	Baraka Fm.	Predominantly sandstones with minor shales and claystones interbeds.	Late Senonian Turonian	C R E T A C E O U S	
	Ghazal Fm.	Fluvial/alluvial fans.			
	Zarga Fm.	Predominantly sandstones shales with interbeds of siltstones and sandstones.			
	Aradeiba Fm.	Floodplain/lacustrine with fluvial/deltaic channel sands.			
Bentiu Fm.		Predominantly thick sandstones sequences. Braided/meandering streams.	Cenomanian Late Albian		
Abu Gabra Fm.		Predominantly claystones and shales with fine sandstones and siltstones. Lacustrine/deltaic.	Albian-Aptian		
Sharef Fm.		Claystones, shales with interbeds of fine sandstones and siltstones. Lacustrine/fluvial floodplain.	Barremian Neocomian		

 Source rocks       Reservoir rocks

**Basin Evolution:**

Muglad Basin in its present shape was formed as a result of rifting processes. Brittle fractures of upper crust were initiated north to the central African shear zone (Mid African plate) associated with a series of parallel depressions. These depressions were later filled with sediments of early Mesozoic and Tertiary age. (Fig. 3.)

Cambrian rocks that underlain the Darfour Group are marine in nature; and have been described as the “western Gondwanaland”<sup>[3]</sup>. These rocks are deposited as a result of sea level rising onto (Tethyan) geosynclines.

Rifting processes as early as Permo-Triassic times could have formed the Blue Nile basin. Rifting of the central Sudanese Melut, and Muglad basins, however, appears to have been initiated during the Cretaceous, or possibly Jurassic.<sup>[4]</sup>

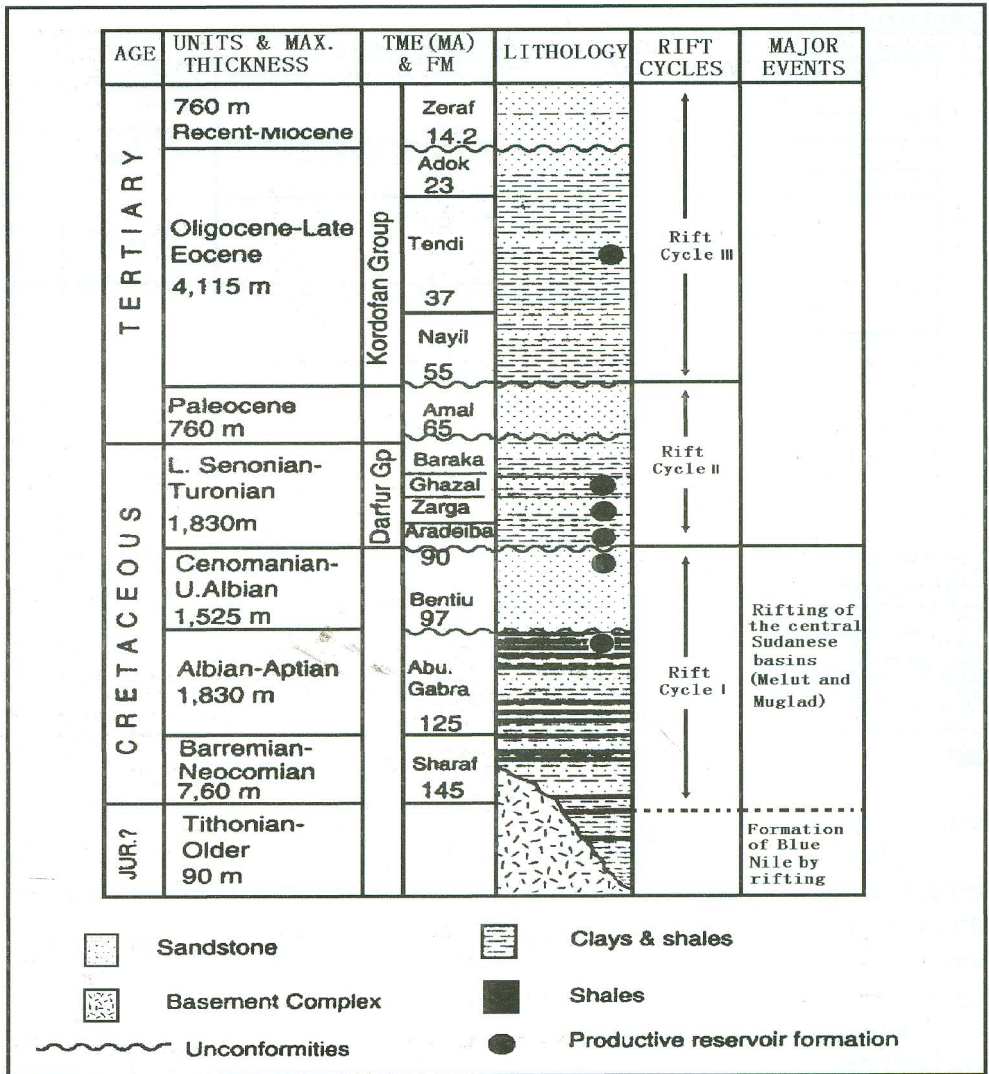


Fig. (2): Generalized stratigraphic column for the Muglad Basin showing principal lithologies, maximum formations thickness, producing horizons, and unconformities. Cycles rifting are also shown. (Modified from Schull, 1988; Giedt, 1990; Mohamed *et al.* A.Y, 2000).

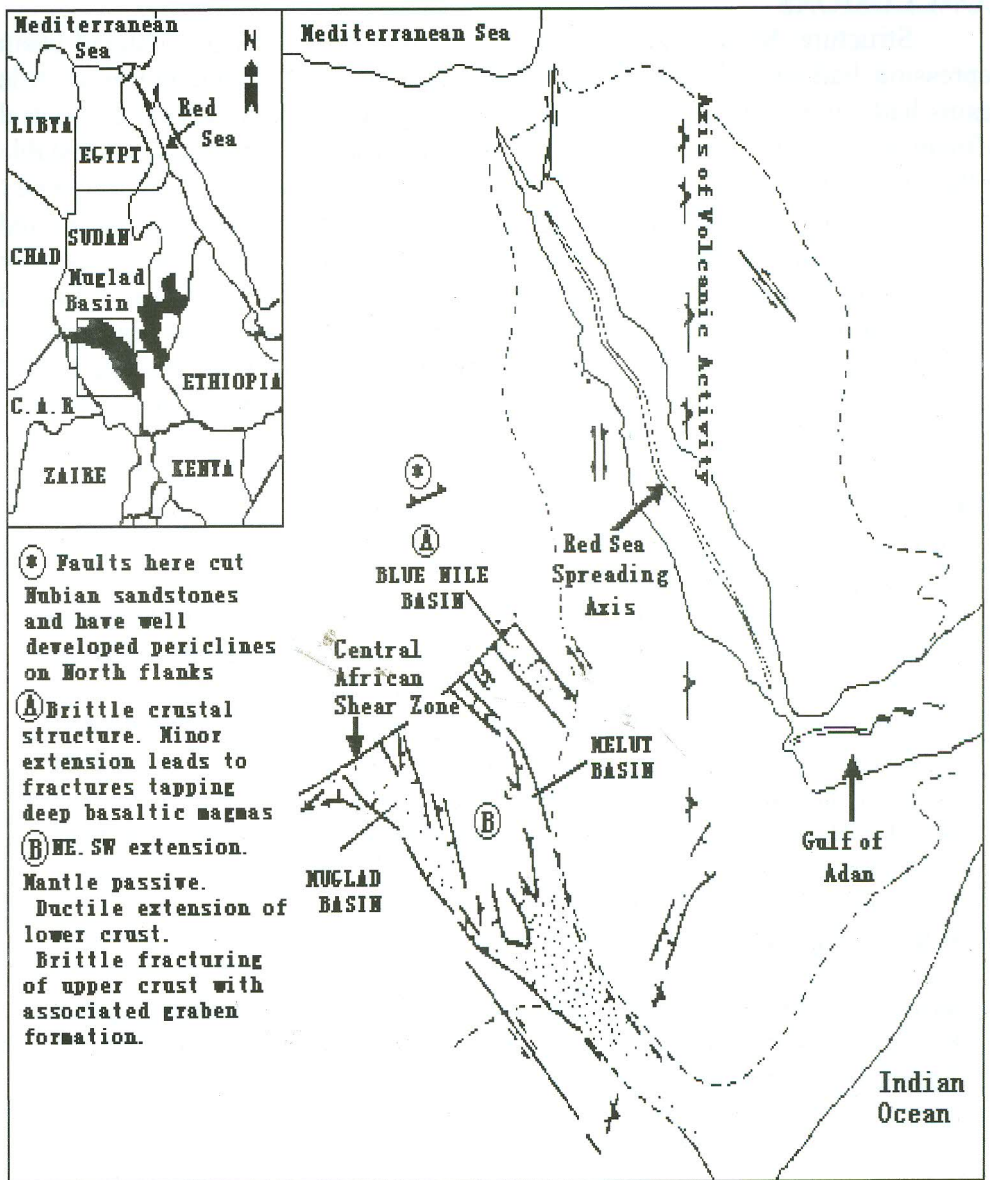


Fig. (3): Tectonic evolution of Muglad Basin (Modified from Almond, 1986; Schull, 1988)

## CONCLUSIONS

Structure, Stratigraphy, and sedimentation show that the Muglad basin depression had periods of growth, and extension. The Melut and Blue Nile basins had similar interruptions in their development. The area west to Central African Shear Zone (deep basaltic magmas) apparently, remained more stable at the time of rifting. Movement of such shear zone influenced the sedimentary processes; where subsidence of the basin permitted relatively uninterrupted deposition. Rising of the sea level onto Tethyan Geocyncline during Mesozoic era caused deposition of the lower Sharef and Abu Gabra Formation followed by deposition of other layers. Subsidence of this basin in late Mesozoic was led to creation of deepest trough, this, together with sediment accumulation, and faulting across the successively deposited beds formed structural and sedimentary conditions ideal for trapping of oil.

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