Palaeogeography, Palaeoclimatology, Palaeoecology xxx (xxxx) xxx–xxx

Contents lists available at ScienceDirect

Palaeogeography, Palaeoclimatology, Palaeoecology

journal homepage: www.elsevier.com/locate/palaeo

Organic geochemical characteristics and depositional models of Upper Cretaceous marine source rocks in the Termit Basin, Niger

Hongfei Lai[a], Meijun Li[a,b,*], Jiguo Liu[c], Fengjun Mao[c], Hong Xiao[a], Wenxiang He[b], Lu Yang[a]

[a] State Key Laboratory of Petroleum Resources and Prospecting, College of Geosciences, China University of Petroleum, Beijing 102249, China
[b] Key Laboratory of Exploration Technologies for Oil and Gas Resources, Ministry of Education, College of Resources and Environment, Yangtze University, Wuhan 430100, China
[c] Research Institute of Petroleum Exploration and Development, PetroChina, Beijing 100083, China

A R T I C L E I N F O

Keywords:
Sequence stratigraphy
Biomarker
Organic matter
Palaeoenvironment
Sea level

A B S T R A C T

Upper Cretaceous marine mudstones are widely known as the most important source rocks in the Western African rift basins. However, geochemical studies on their occurrence and formation mechanism are scarce. In this study, a detailed geochemical investigation within a sequence stratigraphic framework was carried out to reconstruct the palaeoenvironmental conditions and to establish models on the depositional history of Upper Cretaceous marine mudstones in the Termit Basin (Niger), western African. A total of six third-order sequences (DSQ1, DSQ2, YSQ1, YSQ2, YSQ3 and MSQ1, from bottom to top) were identified in the Upper Cretaceous. The distribution of biomarkers from 33 mudstone samples in different sequences indicate that mudstones from YSQ3 were mainly deposited in a suboxic to oxic environment, with significant contributions from mixed terrigenous higher plants and lower aquatic organisms in fresh-brackish water column. In contrast, the other sequences (YSQ2, YSQ1, DSQ2 and DSQ1) mainly represent a suboxic to anoxic marine environment with a stratified water column (0.59 < pristane/phytane < 1.71, 20.78% < gammacerane/C_{30} hopane < 52.23%), dominated by marine aquatic organisms such as algae and bacteria. Accumulation models of organic matter (OM) for different sequences were established to delineate the combined effects of a variety of geological and environmental controlling factors, such as global sea-level fluctuations, seawater circulation patterns, palaeoclimatic conditions, input of terrigenous OM and inherited rift palaeotopography. Most notably, the relative changes of global sea level and the patterns of seawater circulation were the critical factors controlling the sources, depositional conditions and preservation of organic matter in the Termit Basin. Organic matter rich marine mudstones in Termit Basin are closely related to high supply of terrigenous OM. This study not only provides practical depositional models for marine mudstones in the Termit Basin, but also improves the general understanding of marine organic matter accumulation in a relatively restricted inland rift environment.

1. Introduction

The Termit Basin, located in the southeast of Niger (Fig. 1), is one of the largest Cretaceous-Tertiary rift basins in the West and Central Africa Rift System (WCARS) (Fairhead, 1986; Genik, 1992, 1993; Guiraud et al., 2005). It has been proven to be a hydrocarbon-rich basin (Xue et al., 2014; Wan et al., 2014). The hydrocarbons discovered to date have mainly been sourced from Upper Cretaceous marine mudstones with thickness of ~500–2000 m (Genik, 1992, 1993; Harouna and Philp, 2012; Liu et al., 2015). However, controlling factors leading to the geochemical heterogeneity of potential source beds are yet poorly understood, and the large variety of sources, accumulation and preservation of organic matter has not yet been investigated in detail.

A series of accumulation models of organic matter have been established in published literature in order to demonstrate the factors controlling the occurrence and formation of marine source rocks in the continental marginal basins or bathyal to abyssal basins (Tissot, 1979; Peters et al., 2000; Fleck et al., 2002; Bertrand et al., 2003; Frimmel et al., 2004; Götz et al., 2005; Gambacorta et al., 2016; Knapp et al., 2017). However, the palaeotopography, hydrodynamic and palaeoenvironmental conditions of the Termit Basin during the Late Cretaceous are significantly different from those continental marginal basins or bathyal to abyssal basins (Genik, 1992, 1993; Guiraud et al., 2005). Relevant studies focusing on the geochemical characteristics and comprehensive accumulation models of marine OM in such a special marine-invaded depositional environment (inland rift basin) are scarce.

* Corresponding author at: College of Geosciences, China University of Petroleum, No.18 Fuxue Road, Changping District, Beijing 102249, China.
E-mail address: meijunli@cup.edu.cn (M. Li).

https://doi.org/10.1016/j.palaeo.2018.01.024
Received 3 October 2017; Received in revised form 5 January 2018; Accepted 17 January 2018
0031-0182/

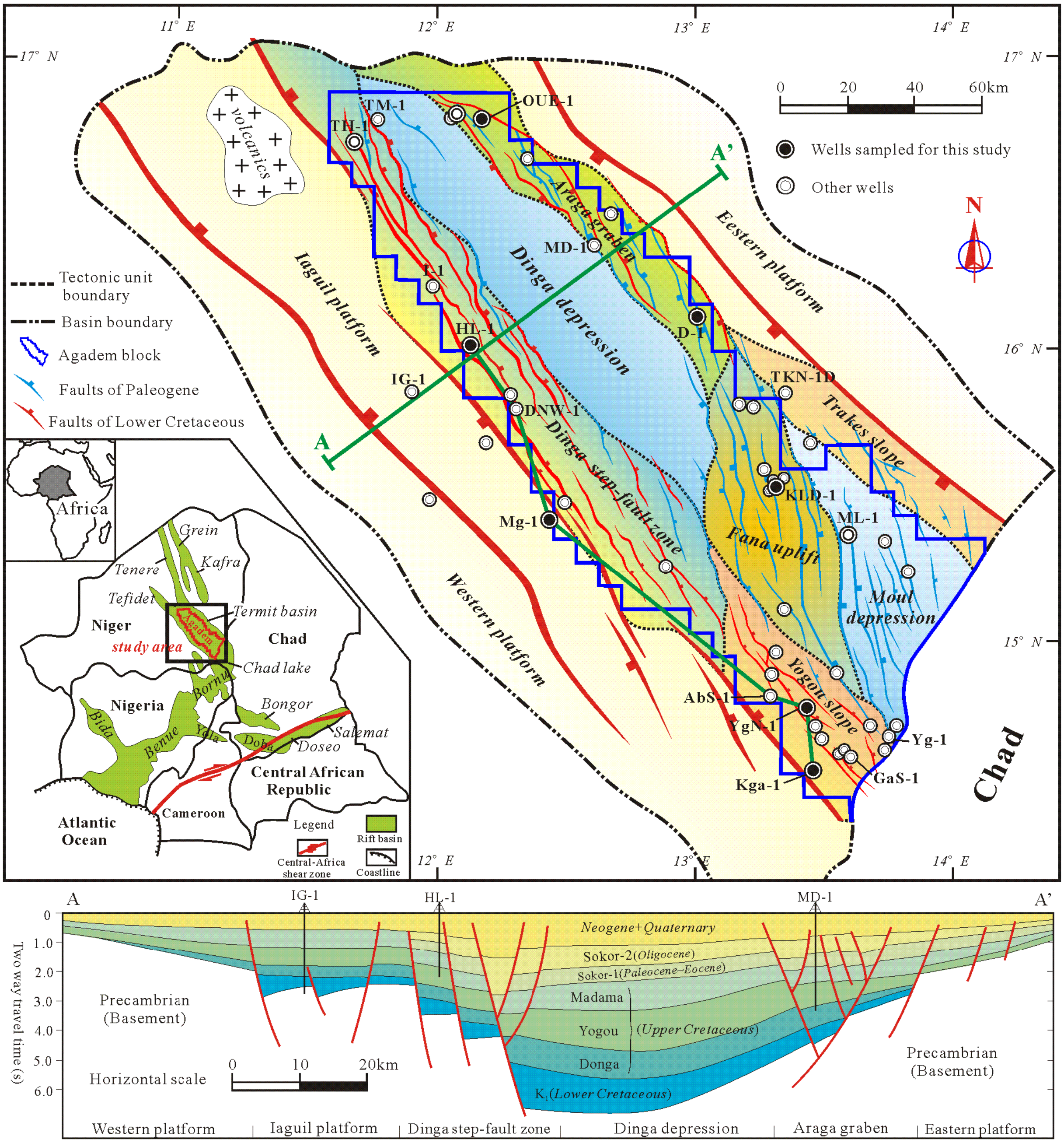

Fig. 1. Map of the geographic location and schematic structure of the Agadem block in the Termit Basin, Niger (modified after Genik, 1993) and a representative geological profile (section A-A') showing the stratum, faults and basement of the Termit Basin.

An integrated approach based on a combination of sequence stratigraphy and organic geochemistry, i.e. sequence stratigraphic geochemistry, has been adopted to reconstruct the depositional environment and biological sources of OM in various types of worldwide basins (Peters et al., 2000; Bohacs et al., 2000; Bombardiere and Gorin, 2000; Fleck et al., 2002; Li and Zhou, 2003, Li et al., 2005; Frimmel et al., 2004). This approach also helps to estimate the petroleum potential of source rocks and to quantify the amount and quality of the reservoir hydrocarbons within a sequence stratigraphic framework. The aim of this paper is to study the controlling factors leading to the deposition of Upper Cretaceous marine mudstones and their geochemical variations using sequence stratigraphic geochemistry. We present comprehensive depositional models of variations in organic matter sources and quality for the Upper Cretaceous in the Termit Basin, which provides a basis for robust estimates of source rock quality and hydrocarbon generation potential. Our data may, therefore, be highly significant for future hydrocarbon exploration and development in this region. Furthermore, these results expand the general understanding of marine organic matter deposition in relatively restricted inland rift basins with large scale marine transgression.

2. Geological setting

The Termit Basin is the second largest extensional asymmetric rift basin in the WCARS. The central part of the main depression (Agadem block, Fig. 1) has an area of approximately 27,000 km^2, with a length of nearly 300 km and a width of ~60–110 km (Liu et al., 2012a). The basin is divided into nine tectonic units: the Western platform, Iaguil platform, Dinga step-fault zone, Dinga depression, Yogou slope, Fana uplift, Moul depression, Araga graben and the Trakes slope (Fig. 1). The