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RESEARCH PAPER

Controlling factors of hydrocarbon accumulation in Termit rift superimposed basin, Niger

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Abstract: Based on the tectonic evolution and depositional characteristics of Central–West African Rift System and regional geologic background, the characteristics of oil and gas accumulation in the Termit rift superimposed basin were examined, and the factors controlling oil and gas accumulation there were discussed. The Termit basin is a rift superimposed basin formed by two stages of rifting in the early Cretaceous and Paleogene, where the Yogou Formation marine source rock is widespread. The two sets of reservoirs, the first member of the Paleogene Sokor Formation and the Cretaceous Yogou Formation, dominated by quartz sandstone, have relatively good porosity-permeability characteristics. They can form multiple sets of favorable caprock-reservoir assemblage below the regional caprock of the second member of Paleogene Sokor Formation. It is found that fault pattern and oil and gas migration pattern control the oil and gas accumulation patterns in the basin, including "Y-shaped" hydrocarbon migration and accumulation in the Araga graben, "multi-step" vertical hydrocarbon migration and accumulation in the Dinga faulted terrace, and the "composite" hydrocarbon migration and accumulation in the Fana transfer zone. Hydrocarbon enrichment in this basin was controlled by tectonic evolution of rift basins, that is, fault belts formed during the two stages of rifting controlled the horizontal distribution of oil and gas, while favorable reservoir-caprock assemblages in the sequences formed in the late rifting stage controlled the vertical hydrocarbon enrichment.

Key words: Niger; Termit basin; rift superimposed basin; hydrocarbon accumulation; controlling factor

Introduction

Statistically 31% of 877 large oil and gas fields with proved reserves of over 0.6×10^8 m^3 BOE around the world spread in continental rift basins[1–2], which may be classified into active rift basin and passive rift basin. The former is generated by lithosphere extension, thinning and rifting due to its bottom uplifting driven by thermal plumes. The latter is related to regional extension induced lithosphere thinning and rupture as well as subsequent thermal mantle uplifting and volcanic activities. In a rifting process, extensional rifting occurs first, followed by volcanic activities.

The Central-West Africa rift system is a Mesozoic-Cenozoic passive rift basin group formed in the process of Gondwana Land breakup and South Atlantic tensional fracturing in the Early Cretaceous Epoch[3]. By the end of 2016, economic oil and gas reservoirs had been discovered in the Termit Basin in Niger, Bogor Basin in Chad, and Muglad and Melut Basins in Sudan[4–5]. The Termit Basin in Niger is a superposed petroliferous basin composed of two-phase Mesozoic-Cenozoic rift basins in the West Africa rift system. Preceding research findings included basin structural evolution and forming mechanism as well as geologic and accumulation models of passive superposed rift basin; this led to the discoveries of some large oil fields, e.g. Dibeilla, Dinga, Fana and Koulele. In this study, hydrocarbon accumulation features and relevant control factors in this continental superposed rift basin are investigated, in the hope of providing reference for oil and gas exploration in this kind of basin.

1. Regional geologic setting

The West Africa Rift Basin is a rift basin in the African Plate seats on the Pre-Cambrian crystalline basement. Different from the Bongor and Bonue Basins, the Termit Basin there has not experienced large-scale tectonic reversal since the rifting process in the Early Cretaceous Epoch and hence been well preserved[6–10]. Trending NW-SE in wedge shape, it is 400 km long in the north-south direction and 60 km wide in the east-west direction at the narrowest north end and 140 km wide at the widest south end, and 3×10^4 km^2 in area. The basin is connected with the Lake Chad Basin on the south and

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Tenere and Tefidet Basins on the north. As per basal structure, residual formation thickness and regional fault distribution, the basin is divided into three tectonic units, i.e. Dinga Depression in the north, Moul Depression in the south, and Fana transfer zone in the middle. The Dinga Depression is subdivided into Dinga fault bench, Araga graben and Dinga sag; the Moul Depression is subdivided into Yogou slope, Trakes slope and Moul sag (Fig. 1). The tectonic activities in the basin are strong in the north and weak in the south, and the depressions and transfer zone extend obliquely in the basin, reflecting the impact of Central Africa shear zone strike-slipping on the basin forming.

1.1. Basin formation and evolution

Through analyzing basin structural evolution and sedimentation in the West Africa rift system, it is concluded the structural evolution of the Termit Basin can be divided into three stages and five sub-stages, i.e. (1) pre-rifting Cambrian-Jurassic stable craton, (2) syn-rifting Early Cretaceous fault subsidence, Late Cretaceous subsidence, and Paleogene fault subsidence, and (3) post-rifting Neogene-Quaternary subsidence[7]. In this process, the rift evolution from the Early Cretaceous Epoch to the Paleogene Period is of crucial significance to basin formation (Fig. 2).

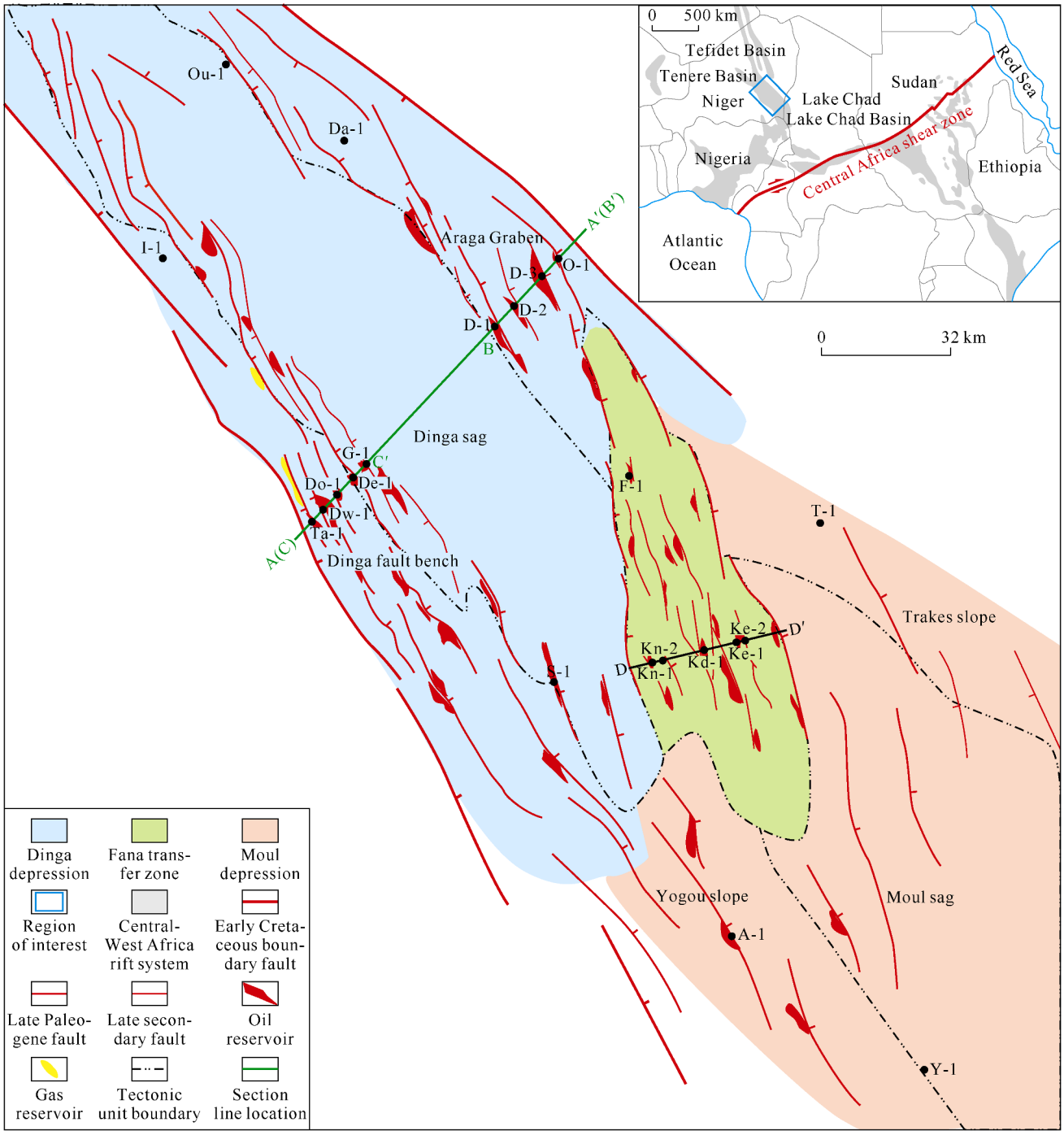

Fig. 1. Tectonic units in the Termit Basin.