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Research paper

Geochemistry and charge history of oils from the Yuqi area of Tarim Basin, NW China

Daofu Song [a, *], T.-G. Wang [a], Meijun Li [a], Jianfeng Zhang [a], Guangxi Ou [b], Zhiyong Ni [a], Fulin Yang [a], Chengyu Yang [a]

[a] State Key Laboratory of Petroleum Resources and Prospecting, China University of Petroleum, Beijing 10083, China
[b] Beijing Research Institute of Uranium Geology, Beijing 100029, China

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ABSTRACT

The geochemistry, origin and charge history of oils from the Yuqi area of Tarim Basin have been investigated, through GC, GC-MS and fluid inclusion microthermometry analysis. The Yuqi oils accumulated mainly in three intervals: (1) in the Lower-Middle Ordovician Yingshan Formation ($O_{1\text{-}2}y$) carbonate reservoirs; (2) in the overlying Upper Triassic Halahatang Formation (T_3h); and (3) in the Lower Cretaceous Yageliemu Formation (K_1y) sandstones. Oils from different reservoirs have distinct physical properties, varying from extra-heavy ($O_{1\text{-}2}y$), heavy (T_3h), to light oils (T_3h and K_1y). However, their geochemical compositions show a high degree of similarity, which indicates that they derive from the same source rock. Abundant tricyclic terpanes, gammacerane, dibenzothiophene and C_{21}–C_{22}steranes, together with a low level of diasteranes, indicate an anoxic marine source rock for oils in the Yuqi area. Oil-oil correlation shows that Yuqi oils derive from the same source bed as Tahe oils. The co-occurrence of intact *n*-alkanes and 25-norhopanes in all the samples supports the proposition that there is a mixture of an early filled severely biodegraded oil and a late filled fresh oil.

In this study, charge history is examined on the basis of integration of fluid inclusion homogenization temperature data with 1D burial-thermal history models. Two episodes of oil charging are identified in the $O_{1\text{-}2}y$ reservoir (well YQX1-1) at around 436-420 Ma (Middle-Late Silurian) and 10-3 Ma (Miocene to Pliocene), respectively. For the samples from the T_3h and K_1y intervals, only one episode of oil charge is indicated by the homogenization temperatures of coexisting aqueous inclusions with an inferred timing around 10-3 Ma. The T_3h heavy oil reservoir is assumed to be a secondary hydrocarbon pool, which accumulated by re-migration and re-distribution of hydrocarbons from $O_{1\text{-}2}y$ hydrocarbon pools. The few early biodegraded oils in the K_1y light oils were probably picked up along the migration pathway during the late fresh oil charging.

1. Introduction

The Lunnan low-uplift, located in the middle part of the Tabei uplift belt in the northern Tarim Basin, is one of the most petroliferous belts in the Tarim Basin. The southern part of the uplift is the Tahe Oilfield, which has been extensively explored and where 11 oil and gas fields/reservoirs have been discovered, with a total reserve of 7.68×10^8 t (Yan and Zhang, 2004). The northern part of the uplift is the Yuqi area, where is relatively unexplored (Kuang et al., 2010). However, there was a considerable breakthrough in the Yuqi area in 2004. Commercial levels of oil and gas flow (daily oil production; 83 m^3: daily gas production; 33 943 m^3) have been obtained from well YQ4 in the Upper Triassic Halahatang Formation (T_3h), which indicates a good prospect for oil and gas exploration (Kuang et al., 2010). In the following years, several additional wells were drilled in the area and significant amounts of petroleum were found (Huang and Cheng, 2012). The produced oils ranges from light oils, through normal black oils to heavy oils, and they accumulated mainly in three intervals: (1) in the Lower-Middle Ordovician Yingshan Formation ($O_{1\text{-}2}y$)carbonate reservoirs; (2)in the overlying Upper Triassic Halahatang Formation (T_3h); and (3) in the Lower Cretaceous Yageliemu Formation (K_1y) sandstones.

The geochemical characteristics of oils are commonly affected by secondary processes, such as biodegradation, in-reservoir

* Corresponding author.
E-mail address: songdaofu2008@163.com (D. Song).

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mixing, thermal cracking, water washing, evaporative fractionation and thermochemical sulfate reduction (Voge and Good, 1949; Orr, 1977; Seifert and Moldowan, 1979; Connan, 1984; Tissot and Welte, 1984; Lafargue and Barker, 1988; Behar et al., 1992; Palmer, 1993; Peters and Moldowan, 1993; Peters et al., 1996; Manzano et al., 1997; Masterson et al., 2001; Zhang et al., 2014). Due to multiple uplift and subsidence episodes, input of later stage light petroleum into previously biodegraded heavy oils is a widespread phenomenon in the Tabei Uplift (Zhang et al., 2000a; He et al., 2002a; Zhang and Huang, 2005). Biodegradation and mixing of severely biodegraded crude oil with fresh oil has been shown to affect oil quality, producibility and API gravity. Various physical properties of Yuqi oils suggest considerable secondary alterations of this kind. Thus, study of the geochemistry and charging history of oils in the Yuqi area is essential to a better understanding of hydrocarbon accumulation in the area.

However, up to now, the geochemical characteristics of Yuqi oils have not been fully investigated, and questions about the origin and charge history of these oils remain unanswered. The objective of this work is to characterize the geochemical compositions of oils from Yuqi area and to investigate their charge history. The geochemical signatures so obtained are then compared with those of neighboring Tahe oils. Following oil-oil correlation, data for discussion on their origin and source are provided.

2. Geological setting

The Tarim Basin is a typical superimposed petroliferous basin of China, with multiple source rock intervals, multiple charge phases and a variety of modification processes (Huang et al., 1999; Li et al., 2000; Xiao et al., 2000; Yang et al., 2003). It is a Paleozoic, cratonic basin developed on a basement of pre-Sinian continental crust, overlain in the south and north by Mesozoic–Cenozoic foreland depressions (i.e., Southwest and Kuqa Foreland Depression, Li et al., 1996). Fluctuating crustal activity has resulted in multiple unconformities (Jia and Wei, 2002; Zhang and Huang, 2005), causing the basin to form several tectono-stratigraphic entities. Detailed geological characteristics of the entire Tarim Basin are summarized in numerous publications (e.g. Li et al., 1996; Jia and Wei, 2002; Zhang and Huang, 2005).

The Tabei Uplift, located in the northern part of the Tarim Basin, consists of the Caohu sag in the east, the Lunnan low-uplift and Halahatang sag in middle, and the Nanke-Yingmaili anticline in the west (Fig. 1). The Yuqi block is located in the northern part of the Akekule uplift, with an area of 2350 km^2. It is bounded by the Halahatang sag to the west, the Caohu sag to the east, the Yakela faulted arch to the north, and the Tahe Oilfield to the south. The stratigraphy of the Tabei uplift comprises various sediments of Sinian to Ordovician marine, Silurian to Permian alternating marine-terrestrial rocks as well as Triassic to Quaternary terrestrial sediments (Cai and Kang, 2002; He et al., 2002b; Zhang, 2003, Fig. 2). The Tabei Uplift evolved through a number of stages, including the formation of (1) the Pre-Sinian basement and Sinian-Ordovician rift (during the Caledonian period), (2) the Silurian-Permian uplift and its evolution during the Hercynian orogeny (250–290 Ma, Permian), (3) the Triassic-Jurassic foreland basin

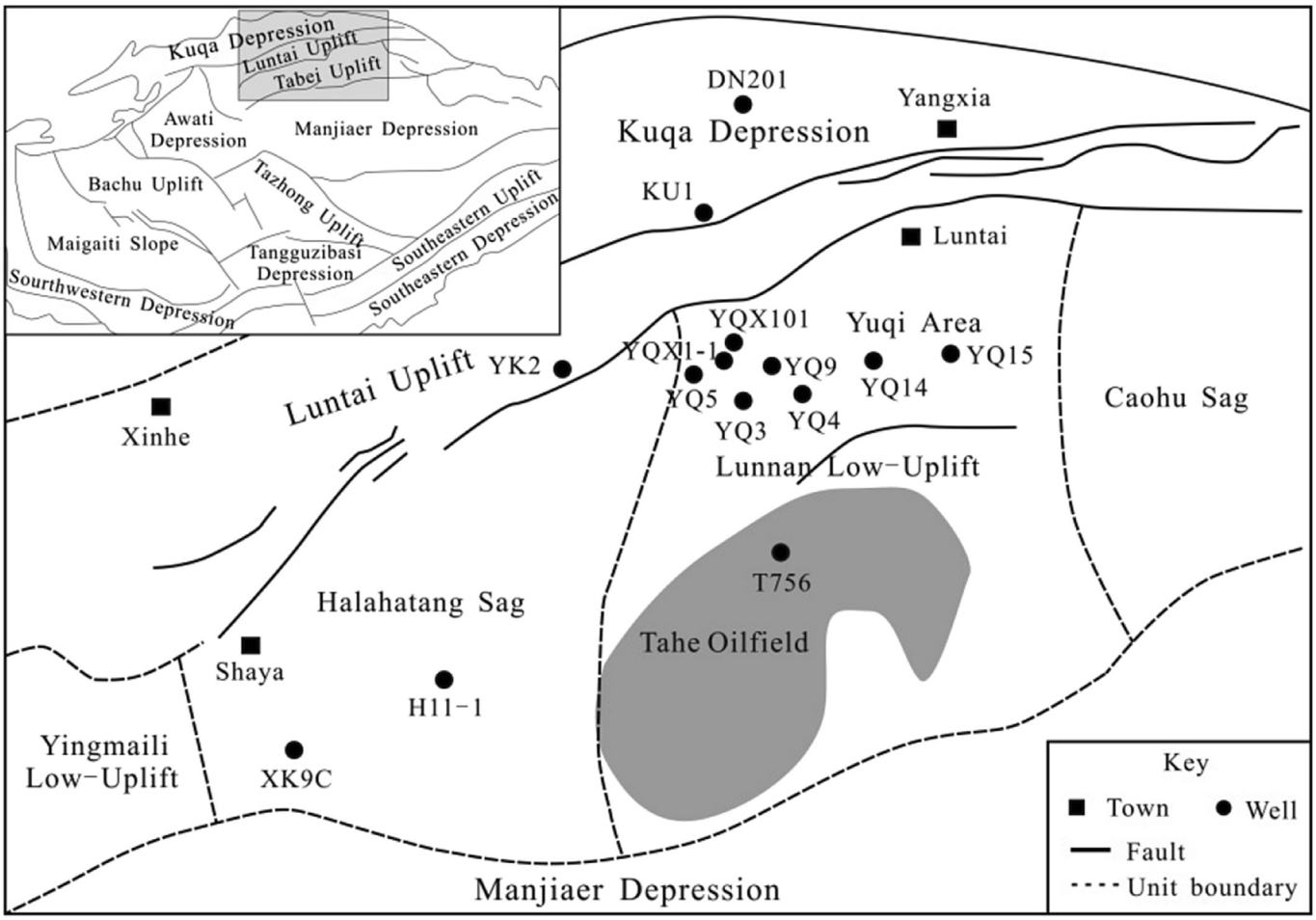

Fig. 1. Sample locations and structural unit division of Tabei Uplift.