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Characteristics of the Middle Jurassic marine source rocks and prediction of favorable source rock kitchens in the Qiangtang Basin of Tibet

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ABSTRACT

We have evaluated the hydrocarbon-bearing potential of Middle Jurassic marine source rocks in the Qiangtang Basin, Tibet, through a comprehensive study of samples from a large number of surface outcrops in different structural units, and from the Qiang-D2 Well in the southern Qiangtang Depression. Data that were acquired, including the depositional environment, thickness of sedimentary units, and organic geochemistry, are used to identify the principal controlling factors and predict the location of favorable hydrocarbon kitchens. The source rocks are mainly platform limestone of the Middle Jurassic Buqu Formation. This formation comprises a suite of intra-platform sag marls, micrites, and black shales that were deposited in a deep-water and restricted depositional environment. The marls form hydrocarbon-rich source rocks with organic matter that is mainly type II and in the mature to highly mature stage. In the Dongco–Hulu Lake and Tupoco–Baitan Lake deep sags, limestone also forms a medium-level source rock. In the Qiangtang Basin, limestone is the favorable source rock kitchen and is more significant in this regard than mudstone. The results provide important constraints on evaluating the hydrocarbon potential of Jurassic marine source rocks and for locating petroleum resources in the Qiangtang Basin.

1. Introduction

The Qiangtang Basin is located in the northern part of the Tibet Autonomous Region and in the southern part of Qinghai Province. This region covers the eastern section of the Tethys structural domain, which is known to be rich in oil and gas reserves. Tectonically, the Qiangtang Basin lies in the northern Tibetan Plateau, between the Kekexili–Jinsha River and Bangong Lake–Nujiang River suture zones, which cover an area of ca. 183,000 km^2. This large, onshore, petroleum-bearing basin has been the subject of little exploration or research. The tectonic framework of this region comprises an area of uplift between two depressions (Figs. 1a and b). Mesozoic marine sediments occur extensively throughout the basin, which preserves a complete sequence of Triassic and Jurassic rocks of the Tibetan Plateau. Triassic units are primarily clastic rocks intercalated with carbonate and some volcanic rocks. Jurassic units comprise very thick (>10,000 m), interbedded carbonate and clastic rocks (Fig. 2) (Wu et al., 2008).

Surface petroleum and bitumen shows are widespread throughout the basin. Regional field surveys for oil and gas, including the Qiang-D2 Well on the Tibetan Plateau, have revealed >200 oil and gas shows, five oil seepages, and a considerable volume of oil shale. Marine oil shales occur at Biloco, in the south Qiangtang Depression, and in the Shenglihe area of the north Qiangtang Depression. Approximately 90% of the shales are Triassic or Jurassic in age (Chen et al., 2008; Liu and Zeng, 2008). The reservoirs that have oil and gas shows are primarily limestones that are concentrated on or in slopes, fault zones, and areas of relatively high ground. Two important dolomite paleo-reservoirs have been found in the south Qiangtang Depression within the Middle Jurassic Buqu Formation (i.e., Longeni and Biloco–Angdaerco). Oil asphalts have also been discovered in Jurassic dolomites of the Qiang-2D Well and in conglomerate units (Fu et al., 2008; Nan et al., 2008; Wang et al., 2007, 2009; Wu et al., 2008).

Analyses have confirmed that the oil seepages are of light oil with marine crude characteristics. A comparison of oil sources indicates that the crude oil in the paleo-reservoir originates from Middle Jurassic shales or limestones. These discoveries of oil and gas shows, and paleo-reservoirs indicate that hydrocarbon generation, migration, and accumulation have taken place in the Qiangtang Basin. Consequently, buried Jurassic–Middle Jurassic strata in the basin represent good prospects for oil exploration in China (Qiu et al., 2007).

Previous studies have evaluated the distribution of source rocks in the basin based on organic geochemical analyses of outcrop samples and studies of sedimentary facies and organic petrology (Alsharhan and Abdel-Gawad, 2008; Dai et al., 2010, 2011; Henrik

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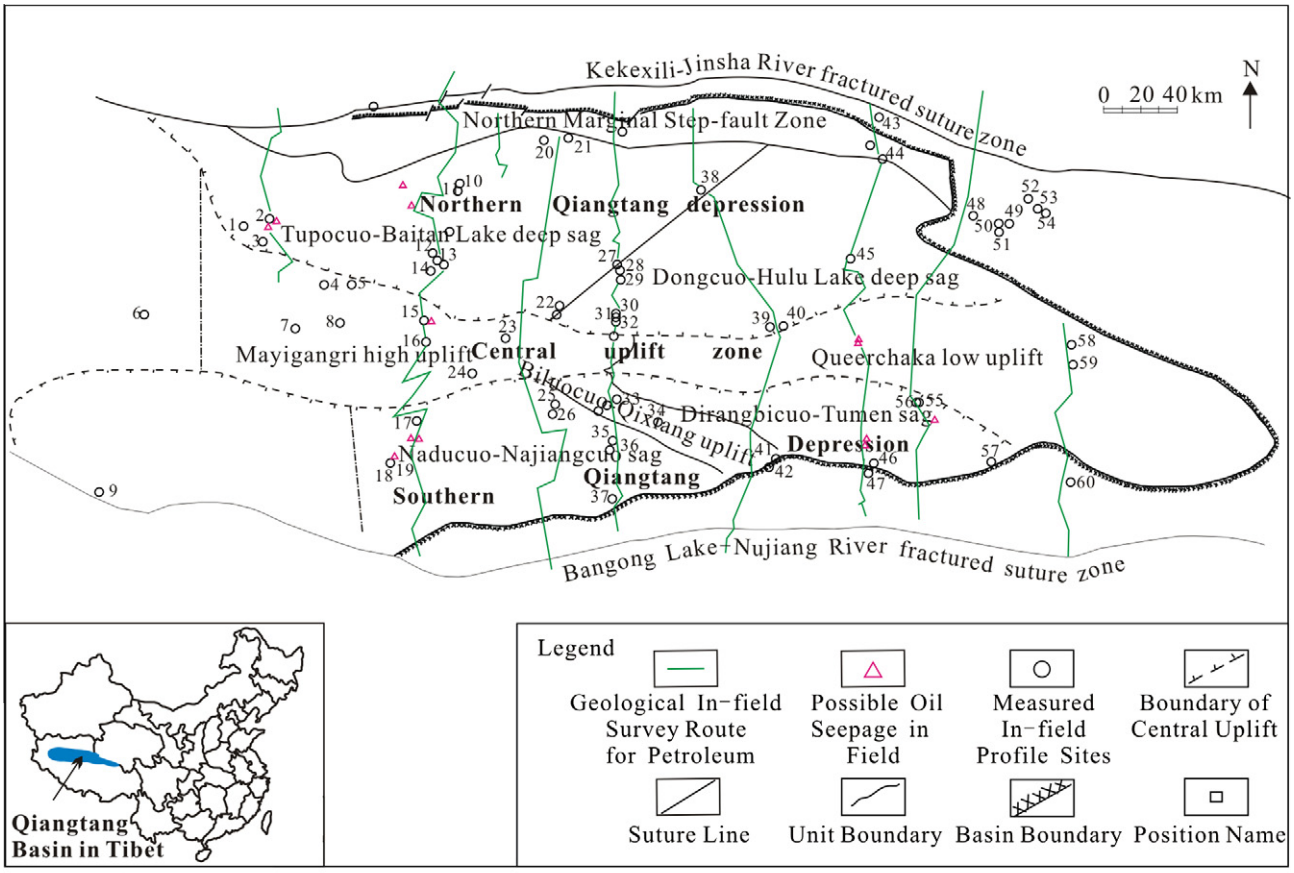

1 Laxiongcuo (LP0)
2 Duxui Mountain (DP05-TP02)
3 Zhaosha MountainZP06
4 North Gemucuo (CP15)
5 Juhua Mountain (JP03-04)
6 Nadigangri (P04)
7 Duxue Mountain (DP05-TP02)
8 Guoganjianiu Mountain (GP13)
9 Gaicui
10 South Bailongbing River (BP)
11 Tupocuo (TP09-10)
12 Yeniu Channel (YP)
13 Tianshuibing (TP)
14 Suona Lake (SP)
15 Rejuechaka (DPL-11)
16 Mayigangri (MP)
17 Hanbuchaka (YBP)
18 Xiaxiancuo (XXP)
19 Dongsangbei (DP)
20 P07
21 P08
22 Nadigangri (PM)
23 Hongshui Channel (HP19-JP10)
24 Jiaomuchaka (PL0)
25 P05
26 Xiaochaka (P02)
27 South Bandao Lake (BP)
28 Bandao Lake (BNP)
29 Dongba (DP)
30 Niudu Lake (NP)
31 North Jiantou Mountain (JBP)
32 Jiantou Mountain (JP)
33 Beileicuo (BCP)
34 Biluocuo (POG)
35 Luxiongcuo (LXP)
36 South Luxiongcuo (LNP)
37 Riasa (RAP)
38 East Bank of Donggecuoren
39 Duoersuodongcuo
40 Chibuzhangcuo
41 Suobucha
42 Songker
43 East Mingjing Lake Mountain (MP)
44 East Wulanwulacuo Mountain (WJP)
45 Zuerkenwula Mountain (ZP)
46 Zhamuna (ZHP)
47 Zhuoqing (ZPP)
48 Tuotuo River (PG)
49 Tuotuo River (PF)
50 Tuotuo River (PH)
51 Tuotuo River (PA)
52 Tuotuo River (PB)
53 Tuotuo River (PN)
54 Tuotuo River (PJ)
55 Duogaerqu (PC)
56 Duogaerqu (PI)
57 Anduo (PA)
58 Dongqu
59 Yicangma
60 Baikamushouma

Fig. 1a. Geotectonic divisions in the Qiangtang Basin, Tibetan Plateau.

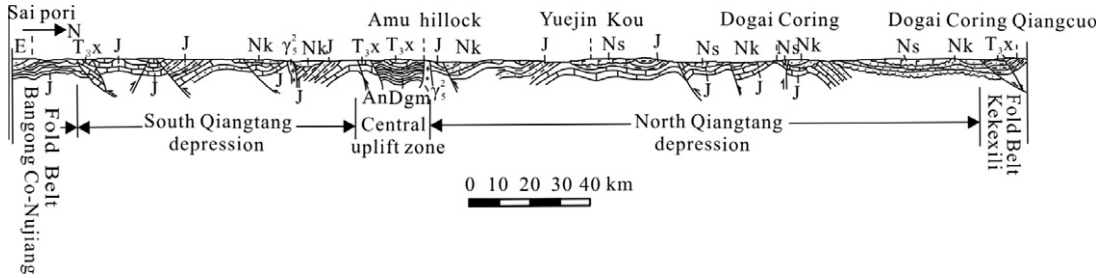

Fig. 1b. Schematic cross-section of the Qiangtang Basin, Tibetan Plateau.