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Fluid inclusion characteristics and significance of the QZ7 Well in eastern Qiangtang Basin

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Abstract: *The Upper Triassic is one of the most important oil and gas exploration targets in the Qiangtang Basin, and it is also the main target of the upcoming oil and gas battle in the Qiangtang Basin, but the oil and gas charging period and accumulation process of the target layers are still unclear. Therefore, in this paper, the upper Triassic Bagong Formation and Borilla Formation of Qiangzi 7 well with good oil and gas display were studied, and the fluid inclusion measurement and microfluorescence were carried out. The results show that the host minerals of Bagong Formation and Borilla formation contain two kinds of quartz and calcite, and five kinds of fluorescence are orange yellow, yellow green, green, light blue and blue, showing the characteristics of hydrocarbon charging at different mature stages. The homogenization temperature ranged from 23.4 ℃ to 343.4℃, and the three phases of oil and gas charging fluid were divided into 30~70℃, 110~120℃, 140~180℃ and the first phase &gt. Hydrothermal fluid activity at 210°C. Combined with the buried history, it is inferred that the area experienced three stages of oil and gas charging and accumulation in the Middle Jurassic Batong (about 165Ma), Oligocene to early Miocene (about 30-20Ma) and early Pliocene (about 5Ma). The multi-stage oil and gas charging and accumulation of Qiangzi 7 well further indicates that the Upper Triassic oil and gas target layer in the Qiangtang Basin has a very broad oil and gas exploration prospect.*

Keywords: *Qiangtang Basin, Fluid inclusions, Bagong Formation, Borilla Formation*

1. Introduction

Fluid inclusions are substances that diagenetic and metallogenic fluids are trapped in mineral lattice defects during the process of mineral crystallization and growth, and are still preserved in the main mineral and have phase boundaries with the main mineral [1~2]. The formation conditions of various deposits and rocks, as well as the data of accumulation, migration and evolution of oil and gas [3] can be obtained from the study, which is an important branch of geochemical research with rich geological information and an important means to study the period of accumulation [4-5]. The systematic study and measurement of individual inclusions can obtain high-precision data, which can be used for various mathematical processing and physicochemical theoretical interpretation of the data obtained from the inclusions, providing extremely important qualitative and quantitative evidence for understanding the hydrocarbon accumulation process and the distribution law of oil and gas reservoirs [6~8].

Qiangtang Basin, located in the northern part of Xizang Region, is one of the few undeveloped large-scale oil-gas basins in China [9]. In the eastern part of the basin, a set of fine clastic rocks and carbonate rocks of the Upper Triassic Bagong and Borila formations were deposited in the Boerzanglongba area, and well-developed source rocks, reservoirs and oil and gas show great potential for oil and gas resources [10~11]. However, due to the strong weathering of the surface outcrop, the process of deep oil and gas charging and accumulation in this area has been unclear. In recent years, the Qiangzi 7 well in this area has been continuously drilled into two sets of formations, namely Bagong Formation(T_3bg) and Borilla Formation(T_3b), creating a very good condition for revealing the Upper Triassic oil and gas charging and accumulation.

The lithography, homogenization temperature, microfluorescence and laser Raman composition of Upper Triassic T_3bg and T_3b inclusions in Well Qiangzi 7, Qiangtang Basin are studied in this paper, and

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then the oil-gas charging period and reservoir-forming process are discussed, hoping to provide important reference for the upcoming oil-gas battle in Qiangtang.

2. Regional Geology

Qiangzi 7 Well (Fig. 1) is located in the core of the Polzanglongba anticline in the Polzanglongba area of the Qiangtang Basin, which is located in the eastern margin of the North Qiangtang Depression and close to the eastern Qiangtang uplift belt. The deformation of this trap structure is influenced by the interaction of two major tectonic units, and it is an important oil-gas bearing structure in the eastern Qiangtang Basin [12]. Qiangzi 7 well is a geological shallow drilling project arranged by Chengdu Geological Survey Center of China Geological Survey in the Qiangtang Basin in 2014. The total drill depth is 402.5 meters. The drilling formation is Upper Triassic T_3bg, and the drilling formation is Upper Triassic T_3b. The Bolzanglongba anticline is located between Quemoco and Guladandongshan. The exposed strata of the anticlinal core are the Upper Triassic T_3b, and the exposed strata towards the two wings are successively T_3bg, T_3b, J_1q, J_2b, J_2x, J3s, J3x.

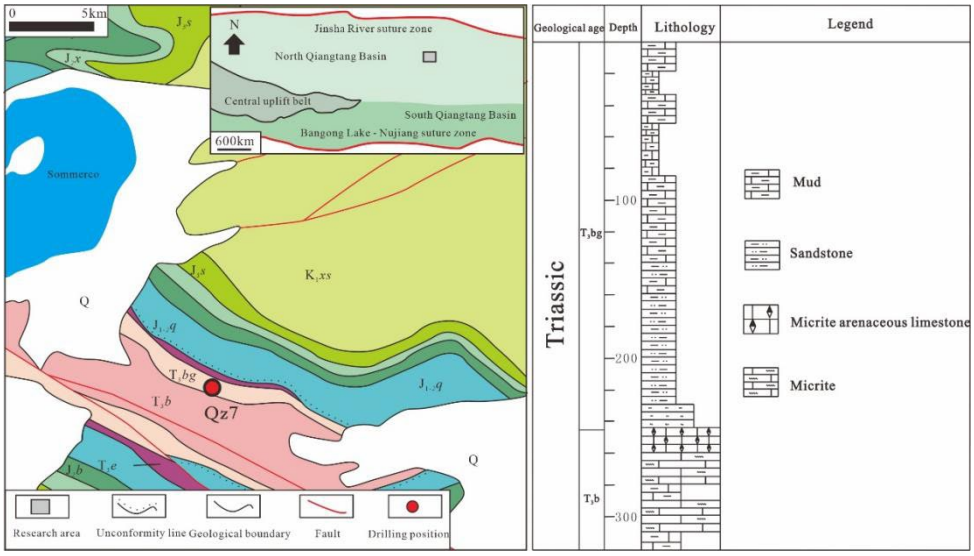

Fig.1 Comprehensive bar chart of location and lithology and stratigraphy of Well Qiangzi 7 (Revised from Song Chunyan, 2018)

3. Sample and analytical test methods

The samples were taken from the T_3bg and the $T_3bg$of Qiangzi 7 well (Fig. 2), including 4 pieces from the T_3bg and 10 pieces from the T_3b. All the samples were taken from the drilling core. The distribution of samples along the depth was shown in Fig 2. 14 pieces of polished fluid inclusions were sent to the Southwest Mineral Resources Supervision and Testing Center of the Ministry of Land and Resources for fluorescence, temperature measurement and Raman analysis of inclusions. The temperature analysis of fluid inclusion was carried out in the Southwest Mineral Resources Supervision and Testing Center of the Ministry of Land and Resources using the LINKAM THMS600 cold and hot platform. All the analyses were carried out in the laboratory with room temperature 23℃ and humidity 35%, and the results were corrected [13]. The measurement was based on SY/T 6010-1994 method for the homogenization temperature and salinity of sedimentary rock inclusions. The laser Raman spectroscopy analysis of inclusions was completed in the Southwest Mineral Resources Supervision and Testing Center of the Ministry of Land and Resources. The detection instrument model is Renishaw in Via Reflex microscopic laser Raman spectrometer. Experimental conditions: laser wavelength 514nm, laser power 20mW, exposure time 20 seconds /1 superposition. The temperature in the laboratory is 23℃ and the humidity is 40%.

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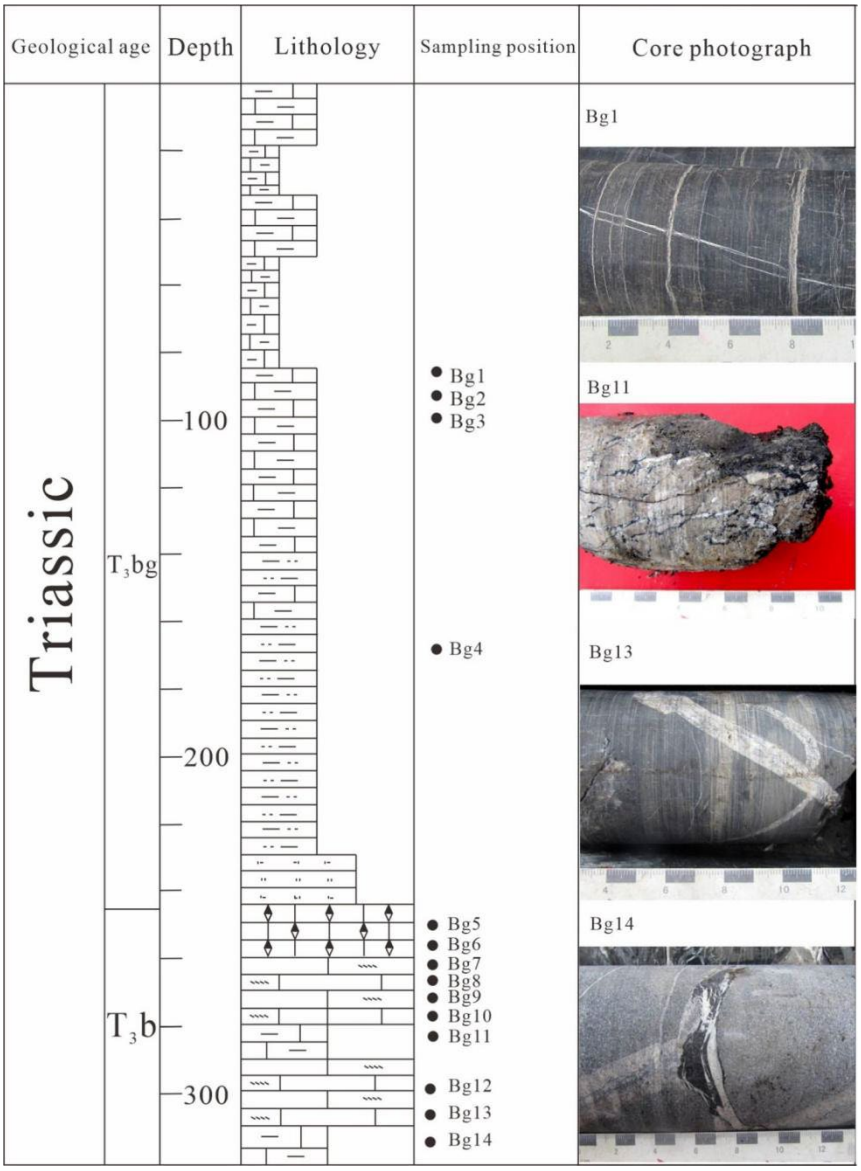

Fig.2 Histogram and sampling location of Well QZ 7

4. Fluid inclusion characteristics

4.1. Inclusion fluorescence characteristics

The fluid inclusions of the T_3bg and the T_3b in Qiangzi 7 well have rich fluorescence displays, with five types of fluorescence, orange yellow, yellow green, green, light blue and blue, respectively, showing hydrocarbon charging characteristics at different maturation stages, as follows:

(1) T_3bg: two phases of oil and gas charging events were developed. The first phase was the light oil stage with yellow-green fluorescence (Fig. 3b, c, e), which was found in both inter crystalline pores and structural fractures. The fluorescence in inter crystalline pores was distributed in a star-point pattern, showing charging characteristics. The fluorescence in the tectonic fracture is distributed along the fracture in a band, showing migration characteristics. The second phase is the condensate phase, which shows blue fluorescence (Fig. 3e), indicating that it has a high maturity and is distributed in the inter crystalline pores in a dot pattern, with the characteristics of oil and gas charging.

(2) T_3b: Three stages of hydrocarbon charging events were developed. The first stage was the light oil stage with orange-yellow fluorescence, which mainly existed in the secondary enlarging of calcite (Fig. 3a), indicating early hydrocarbon charging; The second phase is also light oil, emitting green fluorescence, filling in the inter crystalline pores, and covering the early orange-yellow fluorescence to

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some extent (Fig. 3a). The third stage is the condensate stage, with light blue and dark blue fluorescence, which develops in the inter crystalline pores and between structural fractures respectively. The fluorescence in the fractures is in a beaded distribution, belonging to the hydrocarbon charging with medium to high maturity (Fig. 3 d, f).

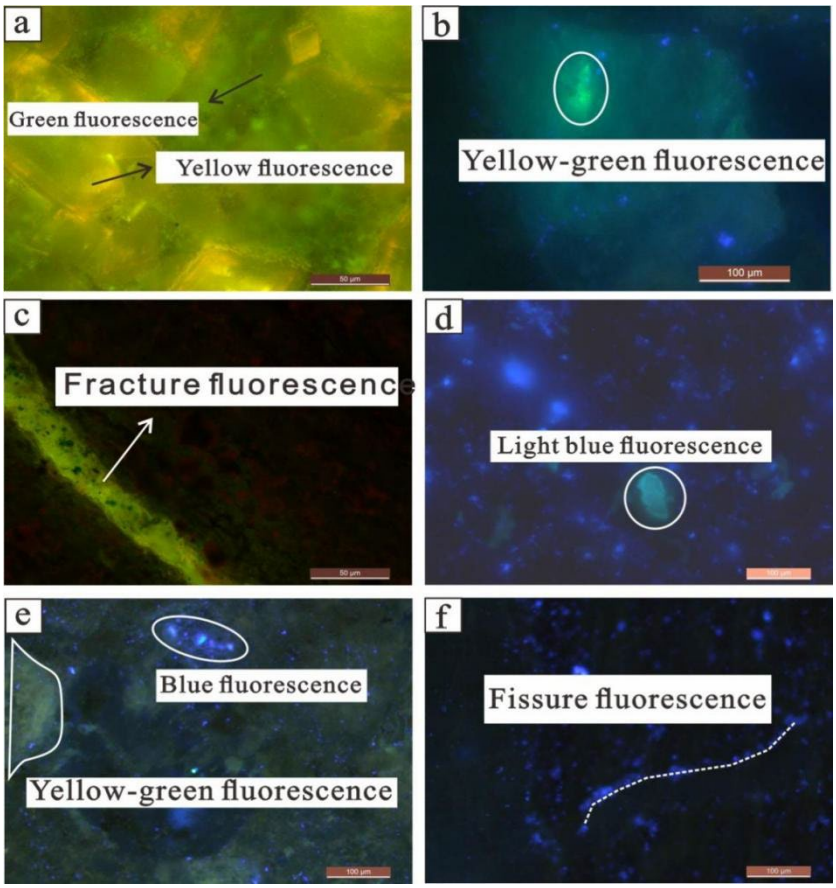

Fig.3 Fluorescence characteristics of fluid inclusions in Well QZ 7

4.2. Inclusion homogenization temperature and salinity characteristics

Temperature measurement of fluid inclusions is one of the commonly used analytical methods to study fluid inclusions and is the most important content in the study of fluid inclusions [14]. The homogenization temperature of saline inclusions is an important basis for classifying oil and gas accumulation [15]. Generally, well-developed inclusions with sufficient growth space are selected for temperature measurement. In this paper, the homogenization temperature of inclusions was determined by homogenization method. The specific characteristics are as follows:

The homogenization temperature of fluid inclusions in Bagong Formation ranges from 23.4 ℃ to 293.7℃, with an average of 82.67℃. According to the homogenization temperature histogram (Fig. 4a), the main peak is 30-40 ℃, accounting for 29.7%. The homogenization temperature of fluid inclusions in the Borilla Formation ranges from 40.7 ℃ to 343.4℃, with an average of 130.57℃. According to the homogenization temperature histogram (Fig. 4b), the main peak ranges from 110 ℃ to 120℃, accounting for 19.75%.

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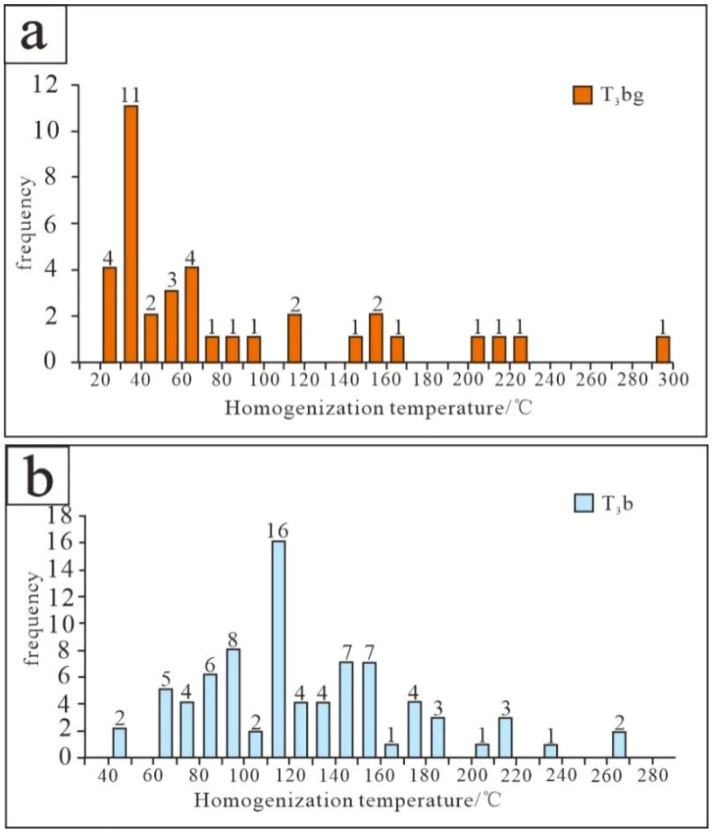

Fig.4 Histogram of homogenization temperature of fluid inclusion

5. Hydrocarbon charging period

The homogenization temperature histogram of inclusions shows that the inclusions in the T_3bg have one characteristic peak (30~40℃), while the inclusions in the T_3b have four characteristic peaks (60~70℃, 110~120℃, 140~160℃, 170~180℃)(Fig. 5). In summary, the fluid inclusions of well Qiangzi 7 are divided into three phases of hydrocarbon charging events and one phase of hydrothermal fluid activity according to the homogenization temperature. The homogenization temperatures of the three phases of hydrocarbon charging events are 30~70℃, 110~120℃ and 140~180℃, respectively.

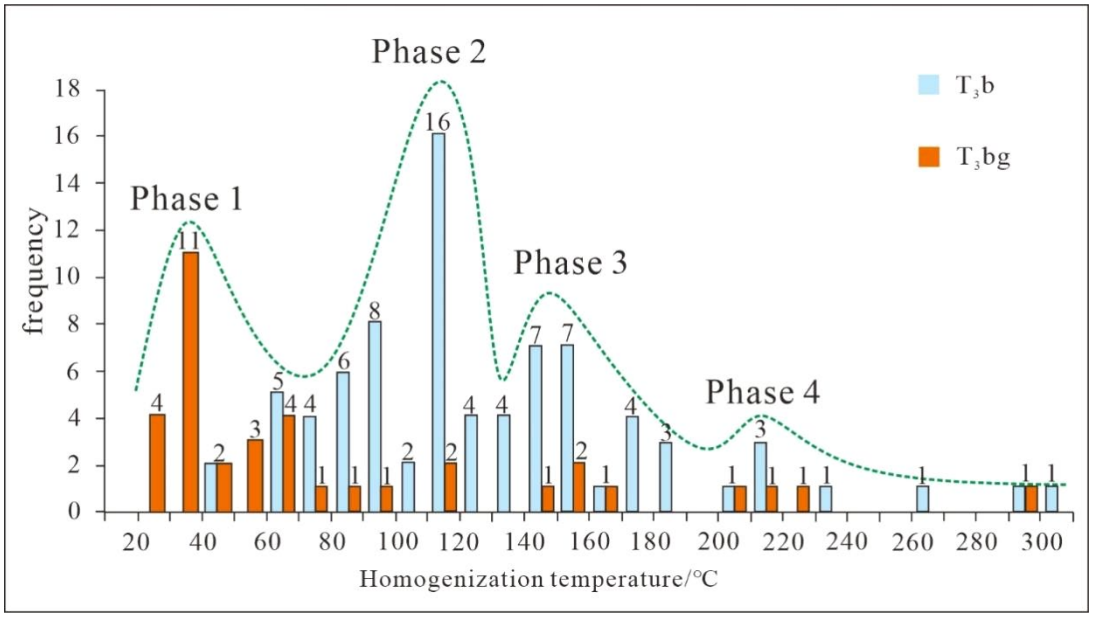

Fig.5 Histogram of homogenization temperature of T_3bg and T_3b

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According to the uniform temperature, the ancient burial depth of the inclusions is estimated to be 113 ~ 5140m. Combined with the burial history of Qiangtang Basin, the oil-gas charging periods of the T_3bg and T_3bg in Well 7 of Qiangzi can be concluded as follows(Fig. 6):

(1) In the first stage (about 165Ma), the Batong stage of the Middle Jurassic, Qiangtang Basin was in a relatively stable depositional stage, and the Bangong Hu-Nujiang ocean basin expanded to the maximum [16]. In the interior of the basin, the buried depth increased rapidly, the source rock reached the threshold of hydrocarbon generation, and the number of oil-bearing inclusions increased rapidly. The homogenization temperature of inclusions was between 110 and 120℃, indicating that the Qiangtang Basin was filled with light oil. The fluorescence is orange-yellow.

(2) In the second stage (about 30~20Ma), from the Oligocene to the early Miocene, the uplift rate was slow, the study area entered the secondary hydrocarbon generation, the crust of the Qiangtang Basin was shortened, folding and thrust occurred, providing a good trap structure for the secondary hydrocarbon generation [17], and the oil and gas reservoirs could be well preserved. The homogenization temperature of inclusions is about 140~180℃, and the inclusions are mainly filled with medium-high mature hydrocarbon fluids. The fluorescence is yellow-green, green, light blue and blue.

(3) In the third stage (about 5Ma), the early Pliocene, the strata uplifted rapidly [18]. Oil and gas migrated, captured and charged in quartz and calcite particles along the fractures generated by tectonic movement. The homogenization temperature of inclusions was about 30-70 ℃, and the fluorescence was light blue and blue.

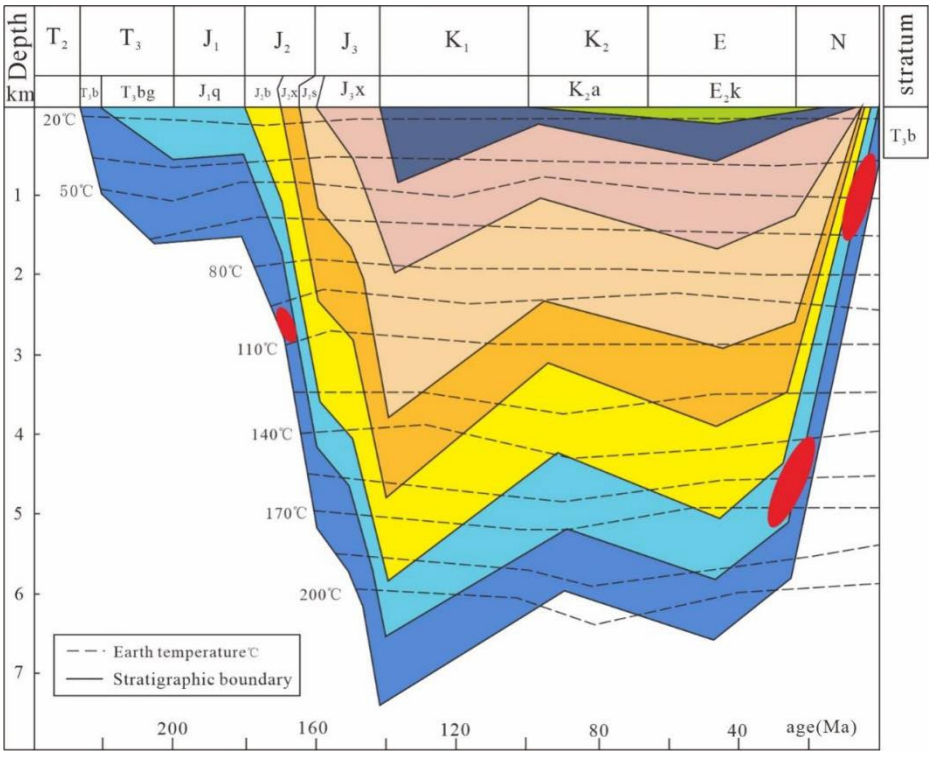

Fig.6 Burial history curve of QZ 7 well (modified after Wang Jian et al., 2009)

6. Conclusions

According to the fluid-inclusion fluorescence analysis, the host minerals of T_3bg and T_3b contain two kinds of quartz and calcite, and five kinds of fluorescence are orange yellow, yellow green, green, light blue and blue, showing the characteristics of hydrocarbon charging at different mature stages

According to microthermometry analysis of inclusions, the homogenization temperature of gas-liquid two-phase inclusions in quartz veins is mainly distributed at 30-40 ℃; The homogenization temperature of inclusions in calcite is mainly distributed in the range of 60~70℃, 110~120℃, 140~160℃, 170~180℃.

The history of oil and gas charging in the T_3bg and T_3b of Well Qiangzi 7 can be divided into three periods: the Batong of the Middle Jurassic (about 165Ma), the Oligocene to early Miocene (about 30-

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20Ma) and the early Pliocene (about 5Ma) respectively. The research results show that the eastern Qiangtang area has a large amount of oil and gas resources and a good prospect of oil and gas exploration and development.

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