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# Hydrocarbon charging histories of the Ordovician reservoir in the Tahe oil field, Tarim Basin, China*

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**Abstract:** The Ordovician reservoir of the Tahe oil field went through many tectonic reconstructions, and was characterized by multiple hydrocarbon chargings. The aim of this study was to unravel the complex charging histories. Systematic analysis of fluid inclusions was employed to complete the investigation. Fluorescence observation of oil inclusions under UV light, and microthermometry of both oil and aqueous inclusions in 105 core samples taken from the Ordovician reservoir indicated that the Ordovician reservoir underwent four oil chargings and a gas charging. The hydrocarbon chargings occurred at the late Hercynian, the Indo-Sinian and Yanshan, the early Himalaya, the middle Himalaya, and the late Himalaya, respectively. The critical hydrocarbon charging time was at the late Hercynian.

**Key words:** Tahe oil field, Ordovician reservoir, Fluid inclusion, Hydrocarbon charging
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## INTRODUCTION

Researches on hydrocarbon charging history are essentially important to exploration and development, especially for the reservoirs subject to multiple hydrocarbon generations, discharges, migrations and accumulations, as was the case of the Ordovician reservoir of the Tahe oil field located at the southwest slope of the Akekule uplift, Tarim Basin, China. Regarding the hydrocarbon charging histories of the Ordovician reservoir, previous studies based on burial histories (Ye *et al.*, 1995), regional tectonic movements (He and Li, 1996) and geochemistry of source rocks (Gu *et al.*, 1998) led to different conclusions. In this research, for the first time 105 core samples from 10 wells were used to carry out systematic analysis of fluid inclusions, so that the complex hydrocarbon charging histories could be unraveled.

## FLUORESCENCE OBSERVATION

Flamboyant, yellow, orange and pearl opal fluorescing oil inclusions were commonly found in the Ordovician reservoir of the Tahe oil field, and some transitional fluorescence colors were also observed (Table 1). On the basis of the theory and application of fluorescence colors of oil inclusions discussed by some other scholars (Tsui, 1990;

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Burruss, 1991; Goldstein and Reynolds, 1994; Stasiuk and Snowdon, 1997; Munz, 2001), our observation results indicated that there were four oil inclusion generations, and that the entrapped oils were weakly matured (WM), moderately matured (MM), matured (M), and highly matured (HM), respectively (Table 1).

MICROTHERMOMETRY

**Oil inclusions**

The microthermometry of oil inclusions resulted in four populations with different homogenization temperature (*Th*) ranges (Fig.1a). The first population ranged from 61.0 °C to 75.6 °C, the second from 82.5 °C to 95.9 °C, the third from 107.8 °C to 112.5 °C, and the fourth from 122.0 °C to 134.9 °C. This oil generations result matched the fluorescence observation.

**Table 1 Characteristics of oil inclusions trapped in the Ordovician reservoir**

| Well | Depth (m) | Fluorescence colors | Translated API | Average *Th* (°C) | Maturity | Charging |
|---|---|---|---|---|---|---|
| S73 | 5271.74−5570.5 | Yellow | 20~30 | $Th_2$=89.1 | MM | Second |
| | | Blue | 40~45 | $Th_4$=124.0 | HM | Fourth |
| S78 | 5319.06−5520.05 | Orange | 15~20 | $Th_1$=67.3 | WM | First |
| | | Yellow | 20~30 | $Th_2$=94.0 | MM | Second |
| | | Green | 30~40 | $Th_3$=112.5 | M | Third |
| | | Pearl opal | 40~50 | $Th_4$=128.8 | HM | Fourth |
| S74 | 5468.80−5729.90 | Light yellow | 20~25 | $Th_1$=66.9 | WM | First |
| | | Yellow | 20~30 | $Th_2$=82.5 | MM | Second |
| T302 | 5404.40−5635.00 | Yellow | 20~30 | $Th_2$=87.2 | MM | Second |
| T403 | 5407.59−5627.55 | Flamboyant | 10~15 | $Th_1$=68.5 | WM | First |
| | | Yellow | 20~30 | $Th_2$=90.0 | MM | Second |
| | | Light yellow | 30~35 | $Th_3$=110.6 | M | Third |
| | | Pearl opal | 40~50 | $Th_4$=122.0 | HM | Fourth |
| S65 | 5470.02−5733.00 | Flamboyant | 10~15 | $Th_1$=61.0 | WM | First |
| | | Light yellow | 30~35 | $Th_2$=87.8 | MM | Second |
| | | Pearl opal | 40~50 | $Th_4$=130.1 | HM | Fourth |
| S75 | 5497.52−5739.30 | Flamboyant | 10~15 | $Th_1$=64.2 | WM | First |
| | | Dark yellow | 20~25 | $Th_2$=92.5 | MM | Second |
| | | Yellow | 20~30 | $Th_3$=109.2 | M | Third |
| S69 | 5453.70−5698.55 | Orange | 15~20 | $Th_1$=72.6 | WM | First |
| S79 | 5530.84−5703.64 | Orange | 15~20 | $Th_1$=72.0 | WM | First |
| S76 | 5559.30−5744.65 | Orange | 15~20 | $Th_1$=75.6 | WM | First |
| | | Yellow | 20~30 | $Th_2$=95.9 | MM | Second |
| | | Light yellow | 30~35 | $Th_3$=107.8 | M | Third |
| | | Pearl opal | 40~50 | $Th_4$=134.9 | HM | Fourth |

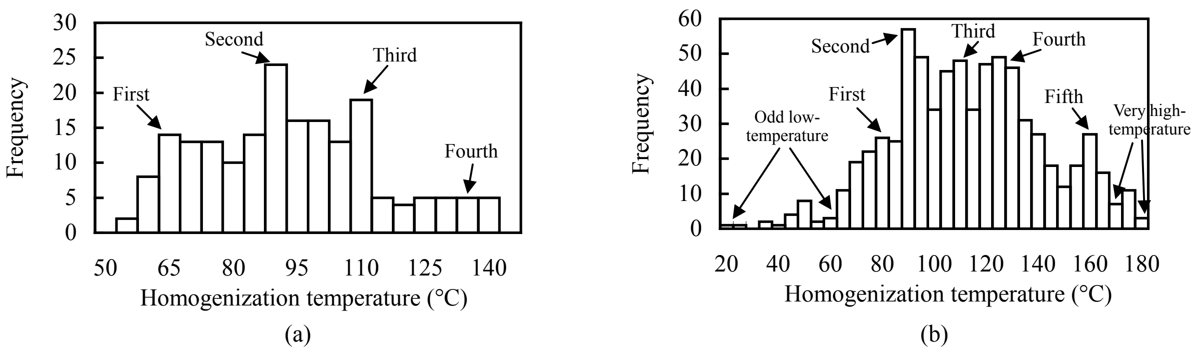


**Fig.1 Histogram of homogenization temperatures of fluid inclusions**
(a) Oil inclusions; (b) Aqueous inclusions

**Aqueous inclusions**

Fig.1b of the aqueous inclusions microthermometry results shows that besides some inclusions with odd low-temperatures (*Th*<50~60 °C) and some inclusions with very high temperatures (*Th*>170 °C) and gas to liquid ratios (*G/L*>15%), five major populations with different *Th* ranges were detectable. The former two types had no geological implications in this research, and the latter five groups represented five thermal fluid activities related to the hydrocarbon chargings of the Ordovician reservoir. The inclusion recorded temperature ranges of the five thermal fluid activities were 60~85 °C, 85~100 °C, 100~115 °C, 115~150 °C and 150~170 °C, respectively.

## CONCLUSION

Results from the systematic analysis of fluid inclusions indicated that the Ordovician reservoir underwent four oil chargings. It is noteworthy that the fifth aqueous inclusion generation gave rise to ice melting temperatures beyond 0 °C, which was proved hydrocarbon-bearing by additive Laser Raman analysis. Therefore, we came to the conclusion that the Ordovician reservoir underwent a later gas charging. By coupling with the conventional tests indicating that the main part of the reservoir was composed of the weakly matured oil (Zhang, 2001), we can conclude that the dominant hydrocarbon charging was the first oil charging.

Furthermore, by projecting the homogenization temperatures of the oil inclusions onto the burial curves, the time for every hydrocarbon charging was determined (Fig.2). The four oil chargings occurred during the late Hercynian, the Indo-Sinian and Yanshan, the early Himalaya and the middle Himalaya, respectively; and the gas charging occurred during the late Himalaya. The critical hydrocarbon charging time was at the late Hercynian.

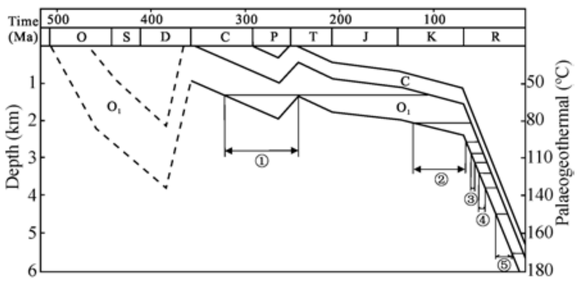


**Fig.2 The time for hydrocarbon chargings of the Ordovician reservoir in the Tahe oil field**
1: the first during the late Hercynian, from 61.0 °C to 75.6 °C; 2: the Second during the Indo-Sinian and Yanshan, from 82.5 °C to 95.9 °C; 3: the third during the early Himalaya, from 107.8 °C to 112.5 °C; 4: the fourth during the middle Himalaya, from 122.0 °C to 134.9 °C; 5: the fifth during the late Himalaya, from 150 °C to 170 °C (burial curves after Ye Desheng *et al*., 2000)

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