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Reservoir characteristics of Donghe well No.1 in Tarim Basin

Liao Taiping [a], Hu Jingjing [b], Lai Fuqiang [a,*], Duan Yonggang [c]

[a] School of Petroleum Engineering, Chongqing University of Science and Technology, Chongqing 401331, China
[b] National Oil and Gas Exploration and Development Corporation, Beijing 100034, China
[c] Well Completion Center, Southwest Petroleum University, Chengdu 610059, China

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ABSTRACT

Based on the techniques of X-ray diffraction analysis, identification of the thin sections of core cast, physical analysis and scanning electron microscopy analysis, this paper studied the reservoir characteristics of the Carboniferous strata in Donghe well No.1 of Tarim region. The results show that the reservoir lithology is mainly the fine-grained quartz sandstone with ferrocalcite and pyrite, mud cement-based, the permeability concentrated in 5–40 × 10–3 μm^2, a small part of the high permeability up to 150–327 × 10^{-3} μm^2 and porosity ranged from 10% to 20%. The most part of the reservoirs is low permeability with a small part of the layer in moderate-high permeability. The types of reservoir space include intergranular pores, intra particle-molding pores, micro-pores and cracks, which mainly are intergranular pores with the pore diameter of 15–200 μm, 95.5 μm on average. And the types of the throats are complex with the main type of constricted throats in this area and large contribution to the permeability.

1. Geology of oil field

Donghetang structure is located in the southern slope of the North Tarim Uplift Belt, and is nose-shaped uplift derived from Shaya fault with the formation declining to the south, east, and west, which extends and plunges from northeast to southwest [1]. The nose-shaped uplift of northwest part is broken by Shaya fault, with a short axial anticline in the front part with the area of 10.5 km^2 (Fig. 1).

Donghe Well No.1 was drilled at the short axial anticline with the closed height of 131.5 m and the closed area of 56.5 km^2 of whole trap. The planned depth of Donghe Well No.1 is 6300 m with the target stratum of Ordovician. The well was drilled into the Carboniferous System in June, 1990, and oil layer was discovered in the Lower Carboniferous sandstone section with the depth of 5726 m on July 11, 1990 [2]. The apparent thickness of Carboniferous system is 423 m, shown in the well section of 5565–5988 m in Donghe Well No.1, which is divided into three lithologic groups [3]. The upper part is brown mudstone (the lagoon system). The middle part is limestone, dolomite and sandstone interbedded section (tidal flat system) and the lower part is fine-grained quartz sandstone in gray (barrier island system) [4]. There are 4 layers of oil reservoir: 1 layer of dubious oil reservoir and 1 layer with oil and water. The total thickness of the oil layer is 106 m.

The halfway test was conducted in the well section of 5755.4–5782.8 m. The test result shows that it is roughly equivalent to daily oil production of 389 m^3 and gas of 700 m^3. During well completing test, the daily oil production is 11 m^3 in the first layer of 5810–5819 m, the maximum daily oil production is 837 m^3 and daily gas production is 5532 m^3 in the second layer of 5756–5800 m; the daily oil production is 233 m^3 and gas of 2783 m^3 in the third layer of 5726–5746 m; the daily oil production is only 110 m^3 and gas of 778 m^3 in the fourth layer (time) of 5726–5746 m and 5756–5800 m by combined well completing test; the fifth once more test, daily oil production is 369 m^3 in the fifth layer (time) of 5726–5800 m by re-drilling for oil testing.

The geothermal gradient is 2 °C/100 m and the formation pressure (in the middle of strata) is 62.4 MPa in Donghe Well No.1. The Donghetang Carboniferous strata can be compared with those of Bachu Xiaohaizi section, Tazhong well No.1 in the low uplift desert zone of the central part of the Tarim Basin, wells in Rennan area and Manxi well No.1 in Manjiaer recessed area. The bimodal limestone with obvious characteristics is widely distributed above Donghe sandstone, which is an important marker for Carboniferous stratigraphic correlation in this area [5]. The Donghe sandstone is corresponding to the lower part of Bachu group (C_{1b}) in Bachu Xiaohaizi section.

The direct cap rock of sandstone reservoir is limestone, interbedded sandstone and mudstone section, with the thickness of 72.5 m in this area, which contains oil layers I and II and the dubious oil reservoir III [6]. Carboniferous brown mudstone with the

* Corresponding author. Tel.: +86 23 65023851.
E-mail address: laifq1982@163.com (F. Lai).

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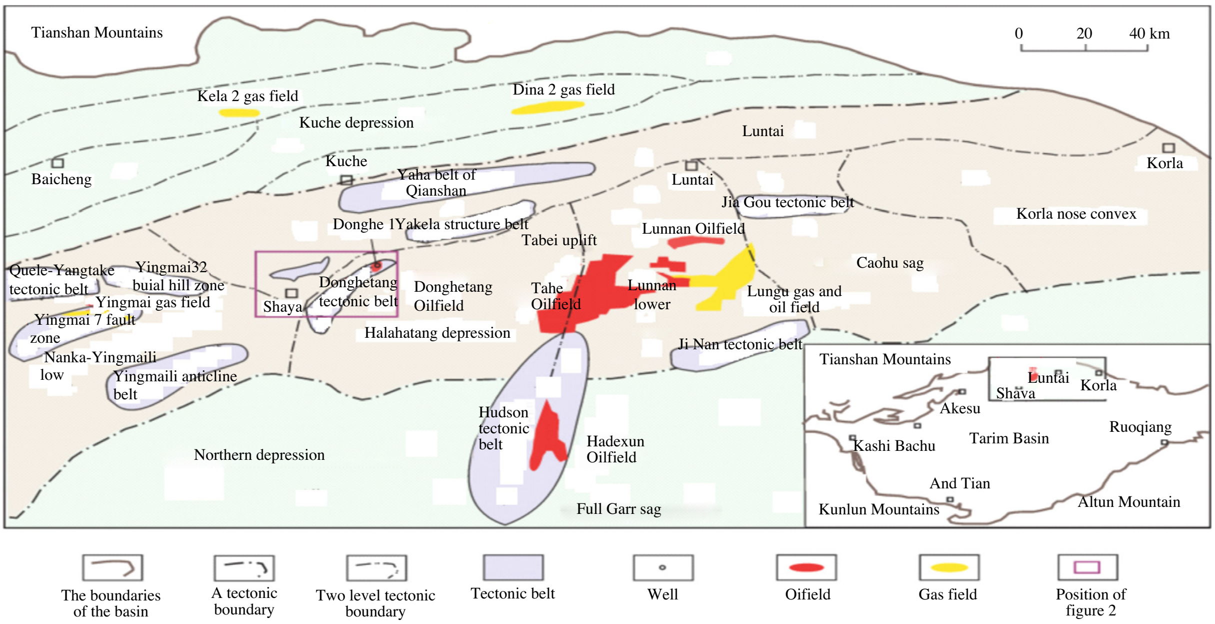

Fig. 1. Map of Donghetang oilfield structure.

thickness of 88.5 m that is above limestone, interbedded sandstone and mudstone section is a good regional cap rock. There is an unconformable denuded zone in the northeast parts of reservoir and there may be an asphalt-heavy oil belt at the top of Carboniferous and the bottom of Jurassic in this unconformity zone, which can create asphalt sealing. There is fault sealing with the length of about 5.5 km in the northwestern section of reservoir. That the upper punched north side of the Shaya fault to the lower Palaeozoic Erathem carbonate rocks contacts directly with the Donghe sandstone formation can take shape of barrier [7] (Fig. 2).

2. Lithology characteristics of reservoir

The reservoir lithology is fine grained quartz sandstone with ferrocalcite and pyrite, and mud cement-based. The shale content is 2.16%-9.53% with the mineral composition in kaolinite and illite, and contains a small amount of mixed layer of illite/smectite. Table 1 lists the results of the clay core analyzed by X-ray diffraction.

2.1. Authigenic quartz

Authigenic quartz content is in commonly 0.5–3% in this area, which is below the 5–16% in Wushi zone, therefore the precipitation of quartz makes little damage to the pore. In contrast, it is beneficial to the preservation of pores. Authigenic quartz occurrence includes oversize, quartz overgrowths and grain filling euhedral quartz.

The oversize and overgrowth of quartz are affected by clay mineral [8]. The quartz overgrowth is relatively important in this area.

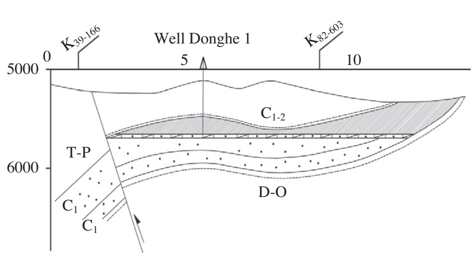

Fig. 2. Schematic diagram of Donghetang structural reservoir profile.

The place that the thickness of clay cladding (main components: illite, I/S and kaolinite) is reduced or discontinuous is most suitable for quartz overgrowth, while the thicker clay cladding will block the nucleation sites and be not conducive to overgrowth. In addition, clay cladding also increases the areas of contact between granules, and reduces the intensity of pressure dissolution and the siliceous source [9]. For the samples of pore development, the dissolved phenomena of the oversized part of secondary quartz can be observed under the microscope, even involving quartz particles.

2.2. Carbonate minerals

In the study area, carbonate minerals are the most abundant cements with the content of 2%–15%, generally, some of them higher than 15%. The main components include calcite, ferrocalcite, siderite, dolomite and anchorite. Calcite shows xenomorphic filling intergranular pore mostly, with the minority in subhedral or even crystal stock form, and sometimes metasomatic alteration of feldspar, quartz, flint and so on. The ferrocalcite that surrounding the oolite is often shown radial absorbance, as well as dolomite, with a higher degree of idiomorphic grain and it also can be metasomatic alteration.

2.3. Clay minerals

Kaolinite is mainly clay minerals in sandstone, with minor illite and mixed illite/smectite and small amounts of chlorite.

(1) Kaolinite is as the major clay minerals with the content of 37.99–82.59%, generally in 60–80%. The relative contents of kaolinite are decreased from top to bottom, while illite and mixed illite/smectite are increased downward, which shows the transformation of kaolinite to illite [10].
(2) The content of illite is second only to that of Kaolinite, with the relative content of 8–20% and the maximum value in 39.06%. The contents of the mixed illite/smectite are low, with the range of 1.94–21.89% and generally in 10–15%. The mixed ratio of illite/smectite is lower than 15%, which belongs to the illite.