Fracture Types and Its Control Factors in Tight Oil Reservoirs

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Abstract. Fractures are well developed in tight sandstone reservoirs, which are the main reservoir space and important seepage channel. Fractures control the migration, accumulation, preservation and single well productivity of tight oil and gas, and affect the drilling and completion methods, fracturing reconstruction measures and production effect of tight oil exploration and development. This paper mainly studies the genetic type, development characteristics and control factors of fractures in tight reservoirs. According to the geological origin of fractures, there are two types of structural fractures and diagenetic fractures in the study area, among which high angle structural fractures are the main one, and it is layer controlled fracture. The degree of fracture development is controlled by lithology, formation thickness, sedimentary micro and other rock heterogeneity factors.

Keywords: Tight Oil, Natural Fracture, Genetic Type, Development Characteristics

1. Introduction

Due to the influence of sedimentation, diagenesis and later structural process, the heterogeneity of tight sandstone reservoir is very serious. Due to the influence of lithology, grain arrangement, single layer thickness, sand body combination, structural shape and structural stress and other factors, the natural fracture development degree is very high [1]. On the one hand, the tight reservoir framework is dense, resulting in the ultra-low permeability of the framework; it is difficult for the fluid to flow. The ultra-low permeability reservoir relies on natural fractures to control the seepage system, thus affecting the development plan deployment and development effect of Fractured Oilfield [2, 3]. Therefore, it is very significance to study the development law of reservoir fractures for the correct deployment of overall planning and enhanced oil recovery of ultra-low permeability oilfields [4, 5].

2. Geological Background

Ordos Basin ranks the second in China's sedimentary basins by size. Historically, it is known as the ShaanGanNing basin, which spans five provinces and regions. It starts from Yinshan in the north, Qinling in the south, Helan Mountain in the West and Luliang in the East, with the whole area of $37 \times 10^4$ km$^2$ and the main area of $25 \times 10^4$ km$^2$. Based on the understanding of the present structural form, the basin’s basement properties and structural characteristics, combined with the evolution history of the basin, it is mainly differentiated six regional structural units, Yimeng uplift, Weibei uplift, western
margin thrust belt, Jinxi fold belt, Tianhuan depression and Northern Shaanxi slope [6, 7]. The faults and folds are developed on the basin’s edge, while the internal structure of the basin is relatively simple, the stratum is gentle, and the dip angle is usually not greater than 1°. In terms of structural division, a place in the southwest of the Northern Shaanxi Slope is the main study area (Figure 1).

3. Fracture Type and Distribution Characteristics
According to the geological origin of the fractures, the fractures in the study area can be differentiated into two types: the structural fractures formed under the action of the structural stress field and the diagenetic fractures produced in the process of reservoir deposition or diagenesis.

Because the strata in the basin are nearly horizontal, faults and folds are not developed, so the structural fractures related to local structural events such as folds and faults are not developed, mainly manifested as the fracture system in the weak structural deformation area controlled by the regional structural stress field. According to the study of similar outcrops, cores and thin sections in the field, structural fractures are the main fracture types of tight reservoirs in the study area. They are widely distributed in various lithologies, with obvious regularity and directionality. Within a certain range, the strike of fractures is relatively stable, often in echelon arrangement or in the form of conjugate shear fractures. Calcite, quartz and other minerals are common in fractures filling phenomenon (Figure 2). In the argillaceous rocks, there are also low angle slip fractures formed by structural compression, which have obvious scratch and mirror features along the fracture tendency. In the surface outcrop...
area, the structural fractures are perpendicular to the rock surface, usually in the form of two groups of orthogonal fractures, which have the distribution characteristics of regular distribution, wide spacing, good equal spacing, wide development range, relatively stable occurrence, and can form a good fracture network system.

![Figure 2. Photos of structural fractures](image)

Diagenetic fracture refers to the near horizontal fracture caused by compaction and pressure dissolution in the process of diagenesis. Bedding fracture is a common form of diagenetic fracture, which is mainly developed on the lithologic interface, especially in argillaceous rocks and sandstones. It is usually distributed along the micro level, and has the distribution characteristics of bending, intermittent, pinching, branching, etc. Locally, it has dissolution phenomenon and good oil-bearing property, which is an important factor affecting single well productivity.

4. Control Factors of Fracture Development

4.1. Lithology
Lithology is the most basic factor affecting the fracture development of tight reservoir [8-11]. Due to the different mineral composition, structure and structure of different rocks, the mechanical properties of different rock types are very different. Therefore, under the same tectonic stress, the development degree of fractures is diverse. Based on the information of similar outcrops, cores and thin sections in the field, the influence of lithology factors such as grain size, mineral composition, separation and physical properties on fracture development is analyzed.

The hard rock stratum has a high elastic modulus, which is generally brittle. Before the rock fracture and deformation, it can not withstand more strain, and its fracture development degree is greater than that of the weak rock stratum. Under the same tectonic stress, the development degree of fractures in the rocks with high brittle components such as calcite, dolomite and quartz is relatively high, while the development degree of fractures in the rocks with high plastic mineral components such as argillaceous and gypsum is relatively low (Figure 3); the fractures in the shale with high carbonate mineral content are often completely filled, while the shale with quartz, feldspar and other minerals is mainly composed of shale The degree of fracture filling is weak.
Figure 3. Relationship between rock mineral composition and fracture density

4.2. Bed Thickness
According to the field outcrop and core fracture observation, the fractures in the study area are obviously dominated by the rock mechanics layer, developed in the layer and terminated at the lithologic interface or bedding plane [12-15]. The fracture is nearly vertical to the bedding plane, and the fracture height is equivalent to the thickness of the stratum. It is mainly distributed in 5-20cm, generally no more than 80cm, and some of the cross layer fractures can reach 3.7m. The fracture has a good linear relationship with the rock stratum’s thickness. When the thickness of the rock layer increases, the fracture spacing increases, and the fracture density decreases. When the thickness of the rock stratum is more than 3m, the fracture is generally not developed (Figure 4).

Figure 4. Relationship between bed thickness and fracture spacing (left), fracture density (right)

4.3. Sedimentary Microfacies
Because of the different rock combination and thickness of different sedimentary microfacies, the fracture density is obviously different. Sedimentary microfacies mainly control the fracture development degree by controlling the distribution of the reservoir in different parts, such as rock composition, grain size, single layer and accumulated layer thickness. For example, according to the statistics of core fracture density of different sedimentary microfacies in the study area, the fractures are the most developed between waterways and at the front of waterways, with the average fracture
linear density of 2.49 m^{-1} and 2.65 m^{-1} and the average fracture surface density of 5.10 m/m^2 and 5.30 m/m^2 respectively; The second is braided channel and turbidite sand, with the average fracture linear density of 1.58 m^{-1} and 1.28 m^{-1} and the average fracture surface density of 3.30m/m^2 and 3.35m/m^2 respectively; the channel and semi deep lake mud fractures are relatively undeveloped, with the average fracture linear density of 0.96 m^{-1} and 0.49 m^{-1} and the average fracture surface density of 2.00 m/m^2 and 1.20 m/m^2 respectively.

5. Conclusion
According to the geological origin of fracture, it can be differentiated two types: structural fracture formed under the action of structural stress field and diagenetic fracture produced in the process of reservoir deposition or diagenesis, among which high angle structural fracture is the main one. The degree of fracture development is controlled by lithology, formation thickness and sedimentary micro equal factors. The higher the brittle minerals’ the content, the finer the particles and the denser the rocks are, the higher the degree of fracture development is. The fracture and the rock stratum’s the thickness are a good linear relationship at mathematics. When the thickness of the rock stratum increases, the fracture spacing increases and the fracture density decreases. Sedimentary microfacies mainly control the fracture development degree by controlling the distribution of the reservoir in different parts, such as rock composition, grain size, single layer and accumulated layer thickness.

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