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The Relationship Between Thrust Faults and Structural Fractures in the Tarim Basin, China

Jianfa Han[1]; Guiting Hou[2,*]; Bing Jing[1]; Yan Ju[1]; Le Li[2]; Wei Ju[2]

[1]Institute of Exploration and Development, Tarim Oil Filed Company, Kular, China
[2]School of Earth and Space Sciences, Peking University, Beijing, China
[*]Corresponding author.
Email: gthou@pku.edu.cn

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Abstract
It is a problem that how thrust faults control the distribution of structural fractures in the exploration and development of fracture oil-reservoirs. One section of fracture outcrops in Ordovician carbonites is measured in the north margin of Tarim Basin, and two sections cross the Fault I in the central Tarim Basin are measured and processed in the paper. The development rule of structural fractures can be depicted by the fracture density, and the fractures near fault can be divided into two regions: the fracture zone controlled by fault and the fracture zone controlled by regional stress field. The ratio of fault-controlled fracture zone width to the throw of thrust fault is a very important parameter to depict the development of fractures influenced by thrust fault. The ratio is related to the mechanism, scale and throw of the thrust fault. The width of fault-controlled fracture zone can be predicted based on the mechanism and throw of the thrust fault. It is very helpful to the exploration and development of fault-controlled fracture reservoirs.

Key words: Structural fractures; Fault-controlled fracture zone; Thrust fault; Fracture density

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INTRODUCTION

The development of structural fractures in carbonites plays an important role in the fractures-oil-reservoirs in carbonite field. The research of fractures is still a frontier problem in structural geology and petroleum geology. The quantitative research of fractures were introduced by the French geologist Van Golf Lacht (1989), including the measurement of the orientations of fractures, density and width of fractures. The thrust faults are dominant structural type in the Tarim Basin and the northern margin of the basin (Qu et al., 2003; Song et al., 2007). It needs further research how the thrust faults constrain the development of structural fractures. In this paper, the mathematic statistics is used to search for the rule that how the thrust faults constrain the distribution of fractures density.

It is very difficult to find the rule that how the thrust faults constrain the distribution of fractures densities in the basins due to the absent of continued cores and outcrops. Otherwise, it is convenient to establish the geological models of the development of fractures in the outcrops of the margin of basin, for example, the carbonite outcrops in the Bachu area, the northern margin of the Tarim Basin in the northwestern China.

The Tarim Basin is very important petroleum basin in which the fracture reservoirs are found in the carbonites of Early Ordian Yingshan Formation (O1y) and Yijianfang Formation (Oyif) (McKnigh et al., 1989; Nishidai and Berry.,1990; Allen et al., 1999; He et al., 2002). It is very useful to establish the geological models that how the thrust faults constrain the distribution of structural fractures in the outcrops of the north margin of Tarim Basin, and the models will be used to compare with the fractures zones in the seismic sections in the central Tarim Basin.

1. METHODOLOGY

The Tangwangcheng Fault that is a thrust fault is developed in the Bachu area, the north margin of Tarim Basin, which can be compared with the seismic sections L1 and L2 cross the thrust fault "Fault I" in the central Tarim Basin (Fig. 1). The density of fractures in six spots of section "Tangwangcheng Fault" are measured, the density of fractures in six spots of section "L1 of Fault I" are measured, and the density of fractures in six spots of section "L2 of Fault I" are also measured in the same method. The density of fractures is the fracture length per area, which unit is 1/m.

$$f = \frac{\sum \text{Li}}{ab}$$

f is the density of fracture, *L*i is the length of fractures, *a* is the length of measured spot, *b* is the width of measured spot.

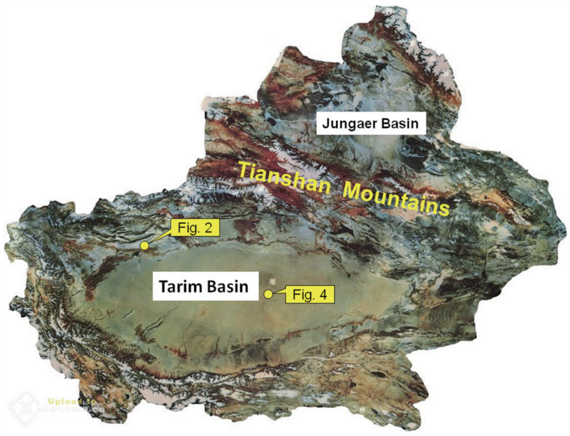

Figure 1
Locations of Research Areas in Xinjiang, Northwest China

2. RESULTS AND ANALYSIS

The Tangwancheng thrust fault is developed in the southeastern Bachu, Xinjiang, and in the Early Ordian Yijianfang Formation carbonites (Fig. 2). The throw of the thrust is about 100 m and the width of fault zone is 35 cm. The attitude of the thrust fault is 10°∠45°. How does the thrust fault control the distribution of fractures near the fault? Six spots are arranged in the footwall carbonites of the Tangwangcheng Fault (Fig. 2). The density of fractures in each spot is measured and processed in this paper.

The fracture densities decrease while the distance of measured spots to fault increases (Fig. 2).

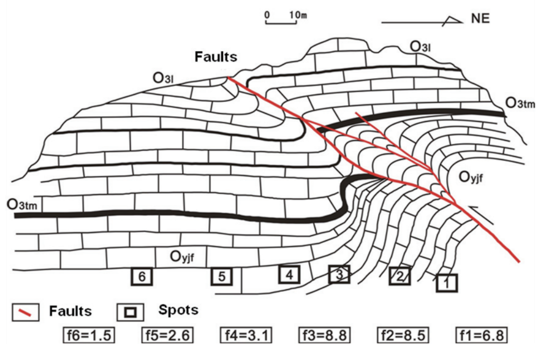

Figure 2
Distribution of the Measured Spots in the Footwall of Tangwangcheng Thrust Fault (f1~f2 Are Density of Fractures)

The fracture densities are 6.8, 8.5, 8.8, 3.1, 2.6, 1.5 while the distance of measured spots to fault from 0 to 260 m. Within the distance of 150 m to the thrust fault, the fracture density is above 6 (1/m), but the fracture density is less than 3 (1/m) beyond 150 m (Fig. 3). The 150 m-wide fracture zone is called as "Fault-controlled fracture zone" which density is much higher than other area that is beyond 150 m. The fracture density in the area beyond 150 m varies slightly and is stable, which is called as "Fracture area controlled by regional stress field". The fracture zone controlled by thrust fault is related to the mechanism, scale, displacement and attitudes of the fault (Table 1). The ratio of the fracture zone width to the thrust fault throw is 1.5 (Table 1).

Table 1
Ratio of Fault-Controlled Fracture Zone Width to Throw of Different Faults in the Tarim Basin

Sections of faults	Mechanism of faults	Throw of faults(m)	The width of fractures constrained by faults (m)	The ratio of fracture zone width to fault throw
L1 of Fault I	Compressional	1440	2000	1.4
L2 of Fault I	Compressional	1440	2500	1.7
Tangwangcheng Fault	Compressional	100	150	1.5

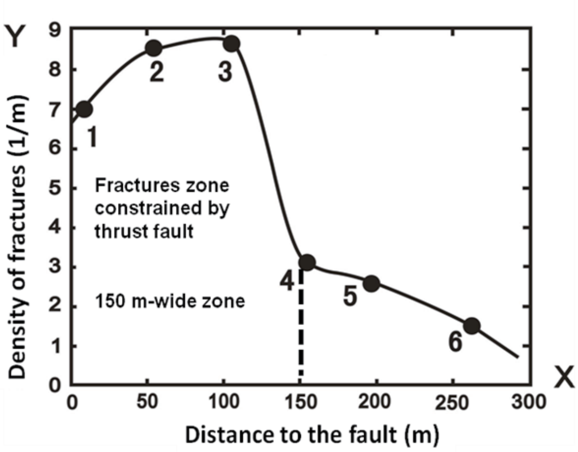

Figure 3
Distribution of Fractures Densities in the Footwall of Tangwangcheng Thrust Fault

The ratio that is gotten in the outcrop can be applied to the central Tarim Basin? We compare the ratio gotten in the outcrop to the ratio gotten in the central Tarim Basin in this paper.

The NW-trending Fault I is the huge thrust fault that is developed in the central uplift of Tarim Basin. Two sections cross the Fault I in the central Tarim Basin are arranged for the measurement of the fracture density (Fig. 4). Six measured spots along each section are arranged in the Fig. 4. The first spot is closest to the Fault I in the central Tarim Basin, the sixth spot is most far to the Fault I. These measured fracture densities in these spots are objected and processed by the exponential regression analysis (Fig. 5). The regression equations follow the exponential distribution. The high fracture densities decrease sharply within the distance of 2~2.5 km to the Fault I, but the low fracture densities decrease slightly beyond 2.5 km. The 2.5 km-wide fracture zone is called as “Fault-controlled fracture zone”, and the area beyond 2.5 km is called as “Fracture area controlled by regional stress field” (Fig. 4 and 5). The throw of Fault I in the central Tarim Basin is about 1.44 km, so the ratios of fault-controlled fracture zone width to the throw of Fault I arrange from 1.4 to 1.7. The ratios between the Tangwangcheng Fault and Fault I are compared, it is obvious that the ratio of Tangwangcheng Fault is within the ratios of Fault I. It suggests that the ratio of Tangwangcheng Fault in outcrop of north margin of Tarim Basin is consistent with the ratio of Fault I in the central Tarim Basin. The exponential distribution of fracture densities vs. the distantces to the thrust faults proposed in the outcrops in the north margin of Tarim Basin can be applied to the analysis of the distribution of fracture densities in the central Tarim Basin, and predict the fracture distribution in the central basin based on the ratio of fault-controlled zone width to fault throw.

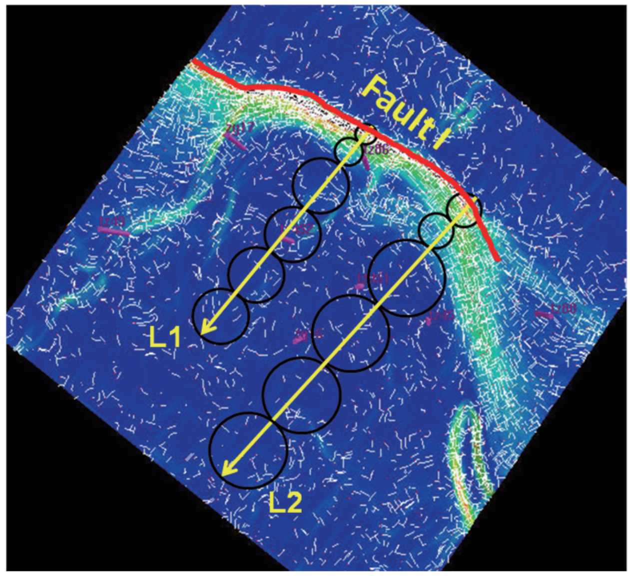

Figure 4
The Locations of Sections L1 and L2 in the Central Tarim Basin

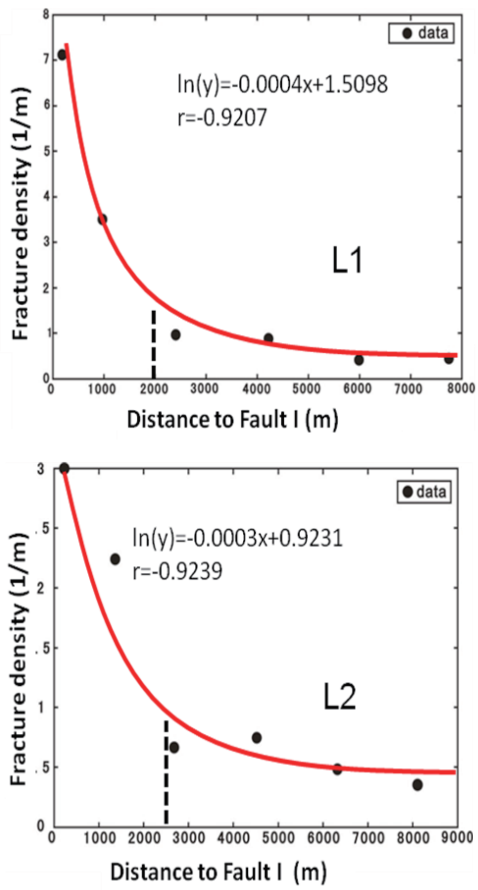

Figure 5
Distribution of Fractures Density in Sections L1 and L2 in the Central Tarim

CONCLUSIONS

(1) The development of fractures can be depicted by the fracture density, and the fractures near fault can be divided into two regions: Fault-controlled fracture zone and Fracture zone controlled by regional stress field

(2) The ratio of fault-controlled fracture zone width to the throw of thrust fault is very important parameter to depict the development of fractures that are constrained by the mechanism, scale and throw of thrust fault. The width of the fracture zone can be predicted based on the ratio, mechanism and throw of the thrust fault. It is very helpful to the exploration and development of fracture reservoirs.

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