

# Fault Vertical Segmentation Growth and Determination of Oil Source Fault in Fuyang Oil Layer in Sanzhao Depression

Li Yilin<sup>1</sup>, Yu Tianrui<sup>2</sup>

<sup>1</sup>College of Earth Science of Northeast Petroleum University, Daqing, Heilongjiang, China, 163318,

<sup>2</sup>Wireline Logging Company, Daqing Drilling & Exploration Corporation, CNPC, Daqing, Heilongjiang China, 163412

## Abstract

*It is proved that fault possesses a typical characteristic of vertical segmentation growth if there is competent difference according to field observation, typical seismic analysis and physical modeling. Fault evolution can be divided into three stages by competent difference: formation of lower fault, segmentation of upper and lower fault and formation of thoroughgoing fault. Taking Sanzhao depression as an example, rock mechanical properties and fault-related fold theories prove that there widely exists faults in sandstone layer of Fuyang oil layer, whose propagation is stopped by mudstone in Qingshankou formation member, leading to the formation of fault vertical segmentation growth. Combining reservoir careful anatomy, it can be indicated that the main oil source faults of the "reversed" migration in Fuyang oil layer must keep active in hydrocarbon migration and accumulation period connect oil source and reservoirs, and segment vertically growth in Sanzhao depression.*

**Keywords:** Sanzhao depression; segmentation growth; "reversed" migration; oil source fault; Fuyang oil layer

## I. Introduction

Sanzhao depression of the central part of Songliao Basin secondary structural unit, after a rift period, inheritance of depression and inversion of tectonic depressions, with a typical rift basin "at fault on Au" dual structure<sup>[1]</sup> lower Cretaceous Quantou Fuyang reservoir is Sanzhao combination of the lower part of the main oil-producing layer<sup>[2]</sup> according to buoyancy-driven oil and gas migration principle, this should lead to a large number of oil and gas were lost Putaohua oil, but the oil source correlation results confirm Qingshankou generated a considerable part of the oil gathered on the underlying Fuyang reservoir, presented "intrusion" vertical migration mode<sup>[3]</sup> Sanzhao green source rocks down." intrusion "migration conditions sufficient source rock, communication source - faults and reservoir overpressure, and green oil source sufficient period, and generally have overpressure characteristics, overpressure formed during the deposition of Nenjiang period from early stage to help Yang Youcheng possession<sup>[4]</sup>, which is a section of source rocks generated green oil down V Fuyang reservoir migration and conductivity provided the impetus. Therefore, the key Sanzhao Fuyang reservoir oil accumulation is overlying Qingshankou source rock breaking down the types of oil along faults Fuyang reservoir "intrusion" migration. currently, oil on down to fix migration source fault injection there are two views, one off wearing T2 (Qingshankou bottom) to T06 (three paragraphs at the end Nenjiang) fault Fuyang reservoir for the oil source fault<sup>[5]</sup>; the other is the fault disappears only the upper section of the source rocks in the green of the T2 interface Fuyang reservoir is the main source fault<sup>[6]</sup> in fact, this oil and gas. species migration patterns and an often overlooked important geological phenomena are closely related-segmentation fault vertical growth, which can not be accurately determined Fuyang reservoir oil source fault of the key Therefore, this study is trying to Sanzhao depression. target, with field instances, physical simulation, rock mechanics characteristics and three-dimensional seismic, combined with fine reservoir anatomy, accurate calibration of Fuyang reservoir's main oil source fault, thus providing a favorable guidance for the exploration of Fuyang reservoir in Songliao Basin.

## Types And Characteristics Of Fuyang Reservoir Oil Source Fault

Traditional view is that oil source fault accumulation of active faults is the main reservoir of Fuyang oil source fault<sup>[7]</sup>, due to the oil along the fault dynamic "intrusion" migration not only to overcome the resistance

of the capillary rocks, but also to overcome buoyancy and formation pressure oil itself, while accumulation of fault activity near the pressure lead to the release, can not form a downwardly V Fuyang reservoir "intrusion" transport Therefore this kind of fault is not all Fuyang reservoir oil "intrusion" migration channels. based on this view, presented only the upper disappear in the blue section of the source rock is the fault of Fuyang reservoir major oil source fault despite the accumulation of such faults in the crucial moment there is no obvious dislocation activity, but it still was turned on, the output become hydrocarbon migration pathways in the region under the influence of tensile stress field green section of the source rocks generated oil along the class fault can not be migrated upward, only in the role of over pressure, to overcome the formation pressure, capillary resistance and buoyancy of oil and gas itself down volts Fuyang reservoir of "intrusion" migration .

Both views were ignored an important geological phenomenon, The tomographic vertical segment growing accumulation of the active fault is not all Fuyang reservoir "intrusion" migration mainly oil source fault, such fault is divided into vertical to segment growth fault and the through faults; for through faults, since the accumulation of intense activity, broken open, some green oil source rock in the buoyancy of the advantages of covering up Putao hua oil transported by the same time through sex fault near the pressure lead to the release, can not form a down wardly V Fuyang reservoir "intrusion" dynamic migration, that is not through the fault of Fuyang reservoir oil "intrusion" migration channels. in fact, only accumulation of activities, storage and communication source vertical segment is growing fracture Fuyang reservoir major oil source fault. such faults upper and lower segment outgrowth oil to Fuyang, Putao hua reservoir filling the channel up and down different for the same fault section under over pressure role as the main fault segment under downward path of the oil-volt Fuyang reservoir "intrusion" migration .

### **Vertical Segmentation Fault Growth Earthquakes, Geological Evidence**

#### **Vertical Segmentation Fault Growth Universality**

Due to differences competent rock, faults in the brittle layer (competent rock formations: sandstone or chalk) nucleation, rather than plastic or shale interbedded sand and shale, that is covered with laminated plastic developed in the most typical rock formations, especially mudstone, shale and gypsum rock, etc., resulting in the plastic layer fault vertical segment outgrowth<sup>[8]</sup>with cumulative fault activities segment growth faults in plastic layer (non-competent rock formations) are connected by fault<sup>[9]</sup> a typical seismic profiles show Oseberg area: the upper and lower segments showed vertical fault phenomenon, and overstep area Mainland layer dip obvious change in rotation<sup>[10]</sup> ; from Siping area Yaojia outcrop features, the fault vertical overstep with typical growth characteristics of the upper and lower segments ; at the same time fault segment growth characteristics are constantly being physical simulation , numerical simulation and drilling<sup>[11]</sup> confirmed .

#### **Fault-Propagation Folds Growth Guidance Fault Vertical Segments Seismic Interpretation**

Most fold rift basin formation and normal faults, in general, the formation of brittle widely developed traction (drag) folds up and fault propagation process, the formation of strata encountered in plastic mandatory (forced) fold, the overall performance characteristics of rock upward monoclinic widens differences competent decisions fault evolution through three stages . lower part of the fault formation, breaking through the vertical fragmentation and fracture the formation. Sanzhao Xujiaweizi typical three-dimensional seismic profiles show: most faults Qingshankou (especially green section) within the dip change significantly, while the development of fault-bend part of a typical small micro-amplitude anticline, further confirmed that the fault the vertical segment is experiencing growth gradually formed today's connected through fracture (Figure 1).

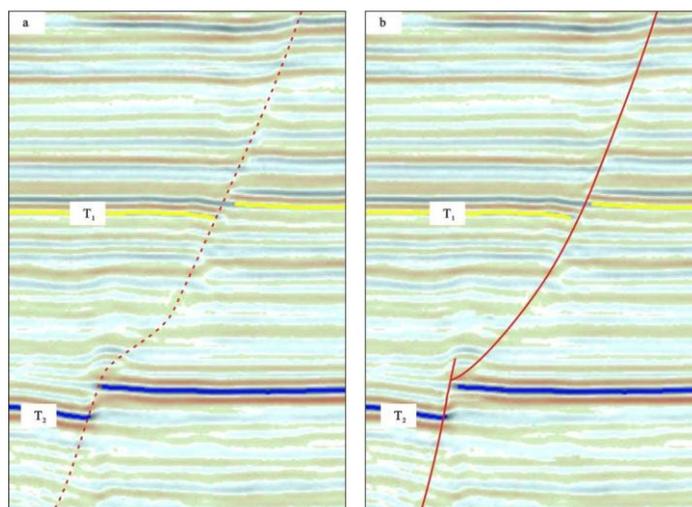


Fig. 1 Typical seismic section of Xujiaweizi area in Sanzhao depression

### **Mechanical Fault Vertical Segment Growing Evidence**

Sand-mud (p) shale sequences, as long as the existence of competent rock poor general segmentation fault in cap growth segment; for consolidation diagenetic rock, mudstone competent<sup>[8]</sup>. of sandstone and limestone competent than weak; that is, in the same deformation conditions, mudstone and sandstone than limestone are more prone plastic flow measured vitrinite reflectance  $R_o$  may well reflect. evolution of geothermal history and diagenetic history, Sanzhao green mudstone source rocks for some vitrinite reflectance ( $R_o$ ) 0.6% -1.2%, the majority of between 0.75% and 1.0%; History shows that the thermal evolution of organic matter: Qingshankou source rocks vitrinite reflectance in Mingshui group at 0.71% -1.12%, in the middle diagenetic stage a period of consolidation diagenetic stage; Fuyang the main reservoir sandstones in the middle diagenetic stage A2 sub-period, the performance of the consolidation diagenesis<sup>[9]</sup>.

Experimental studies confirmed: Poisson's ratio is smaller, brittle rock the stronger the greater the Young's modulus, the greater the degree of brittle rock, While the Poisson ratio is greater than 0.25 and the Young's modulus of less than  $5 \times 10^4$ MPa region, the general performance of the plastic deformation of rock, shale Barbett North Texas also confirmed this phenomenon. Therefore, it can apply the Poisson's ratio and Young's modulus comprehensive determination of rock differences between the relative capable of Songliao Basin Yao period sandstone, mudstone and Qingshankou Quantou (Fuyang reservoir) sandstone Poisson's ratio relationship : Yao period of sandstone and sandstone Quantou Young's modulus less than  $5 \times 10^4$ MPa, Poisson's ratio generally less than 0.25; and Qingshankou shale Young's modulus generally less than  $5 \times 10^4$ MPa, Poisson's ratio is generally greater than 0.25, somewhat plastic deformation, capable of sandstone that is significantly stronger than mudstone capable of having a clear competent poor. Therefore, Yang Sanzhao depression reservoir sandstone section generally formed fracture, green mudstone period up to prevent the spread of the lower portion of the fault, thereby forming a vertical fault segment growth phenomenon.

Key Time Activities vertical fracture growth segment Fuyang Reservoir is the main source fault. Combination of volcanic cycles, unconformity characteristics and tectonic evolution confirms help Yangsan Zhao recess through seven intense period of activity<sup>[5]</sup>, according to the faulting of times, Fuyang reservoir divided into four categories fault system: First rift depression period of the formation of active faults (T5, T4 off to T1, T2); the second is the formation of rift depression period and continued activity of reverse faults (T5, T4 to T06 off above ); the third is the fault of the depression formed (T3 off to T2, only broken T2, T2 down to T1); Fourth, the depression of the formation of inversion of active faults (T3, T2 to T06 off above) Sanzhao homogenization temperature and burial history still Oilfield show: Qingshankou source rocks in the late Mingshui large quantities of hydrocarbon generation and expulsion, Fuyang reservoir that is a critical moment for the oil accumulation Mingshui deposition stage combined. hydrocarbon accumulation period, from the broken system into perspective, the rift depression period of the formation and reversal of active faults and continued depression of the formation of the active fault is reverse Fuyang reservoir oil source fault<sup>[5]</sup>, that communication source storage, accumulation of active and off through T06 fault Fuyang reservoir is the main source fault on this basis, combined with seismic interpretation and reservoir fine fine dissection confirmed: (1) out of water sedimentary late due to the fault segment growth, oil along the "segmented" oil source fault segment up and down "two-way" migration, namely oil and gas sub-section along growth faults under the Fuyang reservoir "intrusion" migration, the foot wall Fuyang reservoir is the main gathering site, and along the fault segment Putao hua oil conducting oil and gas, typical examples Hajime 113, 114 and Hajime Fang 481 wells. Therefore, the "fault segment growth." "oil and gas vertical migration" and decided to Fuyang reservoir

Putao hua oil and gas accumulation show "complementary" accumulation mode. (2) through-type oil source fault causing the pressure release oil along the fault to a small advantage convergence Putao hua oil resistance, can not form a down wardly V Fuyang reservoir "intrusion" dynamic migration , a typical example of an Fang 136 Xu and 22 wells. Therefore, only the accumulation of events, the source storage and communication sub-vertical fault is supporting the growth of the main oil source fault Yang reservoir.

## II. Conclusion

(1) Rock competent differences determine fault vertical growth through three stages of evolution: a lower fault formation, breaking through the upper and lower segments and faults formed.

(2) Fine interpretation of seismic, field observation, rock mechanics characteristics and drilling is based on application fault propagation fold theory that the traditional interpretation of the most penetrating of the oil source dip angle changes within Qingshankou formation, the actual performance is typical segment growth characteristics.

(3) Through faults Sanzhao Key Time activities not Fuyang Reservoir oil source fault, only the accumulation period of activity and growing segment of the fault Fuyang Reservoir is the main transport pathways; in overpressure the role, under section V of these faults become oil down Fuyang reservoir "intrusion" of the main channel migration.

## References

- [1]. Chi, Y. L. , Xiao, D. M. , Yin, J. G. , 2000. The Injection Pattern of Oil and Gas Migration and Accumulation in the Sanzhao Area of Songliao Basin. *Acta Geologica Sinica*, 74(4): 371—377.
- [2]. Chi, Y. L. ,Yun, J. B. ,Meng, Q. A. ,et al. , 2002. Deep Structure and Dynamics and Its Relation to Hydrocarbon Accumulation of Songliao Basin. Beijing: Petroleum Industry Press, 10—80.
- [3]. Diao, H Y. 2013. Rock mechanical properties and brittleness evaluation of shale reservoir. *Acta Petrologica Sinica*, 29(9): 3300—3306.
- [4]. Egholm, D. L. , Clausen, O. R. , Sandiford, M. , et al. , 2008. The Mechanics of Clay Smearing Along Faults. *The Geological Society of America*, 36(10): 787—790.
- [5]. Færseth, R. B. , 2006. Shale Smear Along Large Faults: Continuity of Smear and the Fault Seal Capacity. *Journal of the Geological Society*, 163(5): 741—751.
- [6]. Færseth, R. B. , Johnsen, E. , Sperrevik, S. , 2007. Methodology for Risking Fault Seal Capacity: Implications of Fault Zone Architecture. *AAPG Bulletin*, 99(9): 1231—1246.
- [7]. Fu, G , Wang, Y. G , 2008. Oil Migration Transporting Pathways in Nose Structure Region Outside Oil Source Area and their Controlling on Oil Accumulation: Example of Shangjia Region in the Songliao Basin. *Geological Review*, 54(5): 646—652.
- [8]. Fu, G , Wang, Y. G , Yuan, D. W. , 2010. Source Faults of Fuyang Oil Layer in Sanzhao Depression and its Control to Oil Accumulation. *Acta Petrolei Sinica*, 31(5): 762—766, 773.
- [9]. Fu, X. F. , Ping, G. D. , Fan, R. D. , et al. , 2009. Research on Migration and Accumulation Mechanism of Hydrocarbon "Reversed Migration" in Fuyang and Yangdachengzi Formation in Sanzhao Depression. *Acta Sedimentologica Sinica*, 27(3): 558—566.
- [10]. Fu, X. F. , Guo, X. , Zhu, L. X. , et al. , 2012. Formation and Evolution of Clay Smear and Hydrocarbon Migration and Sealing. *Journal of China University of Mining & Technology*, 41(1): 52-63.