

## Tectonic evolution of Cretaceous in 401 block, Sanzhao Depression, Songliao Basin

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### Abstract

**This paper takes Sanzhao Depression in Songliao Basin as the research target, analyzes the tectonic evolution features of Cretaceous. This paper proposes: San Zhao Depression of Song Liao Basin experienced three tectonic evolution stages, ①Fault depression stage (K<sub>1h</sub>–K<sub>1yc</sub>), ②Depression stage (K<sub>1d</sub>–K<sub>2n</sub>), ③Tectonic reversal stage (K<sub>2s</sub>–Q). Depression tectonic layer is the most important layer with longest duration and larger thickness of sediment. Source rock, reservoir and cap rock are all in this layer.**

### Keywords

**Songliao Basin, Sanzhao Depression, Fuyu oil layer, tectonic evolution.**

### 1. Introduction

Songliao Basin is one of the oil & gas richest continental sedimentary basins all around the world. Sanzhao Depression is the secondary tectonic units of Songliao Basin which is also part of a first-order tectonic unit-the central depression. Sanzhao Depression of Songliao Basin experienced three tectonic evolution stages: Fault depression stage (K<sub>1h</sub>–K<sub>1yc</sub>), Depression stage (K<sub>1d</sub>–K<sub>2n</sub>), Tectonic reversal stage (K<sub>2s</sub>–Q) [1]. The main expulsion stage of the source rock in Qingshankou Formation was the over-pressured releasing period after the hydrocarbon generation threshold was achieved. The over-pressured release took place once in late Nenjiang deposition and once during later Mingshui deposition [2].

This paper deeply analyzed the tectonic evolution features during depression period. The study provides strong supports and directions for future exploration of Fuyu oil layer.

### 2. Geological setting

The target layer is in 4th member of Quantou formation in lower Cretaceous. The lower Cretaceous is composed of Huoshiling, Shahezi, Yingcheng, Denglouku and Quantou Formations in the study area, while the upper Cretaceous is composed of Qingshankou, Yaojia, Nenjiang, Sifangtai and Mingshui Formations. From late Jurassic to Quaternary, the biggest tectonic deformation happened during the sedimentary period between Nenjiang formation and Mingshui formation (Fig. 1).

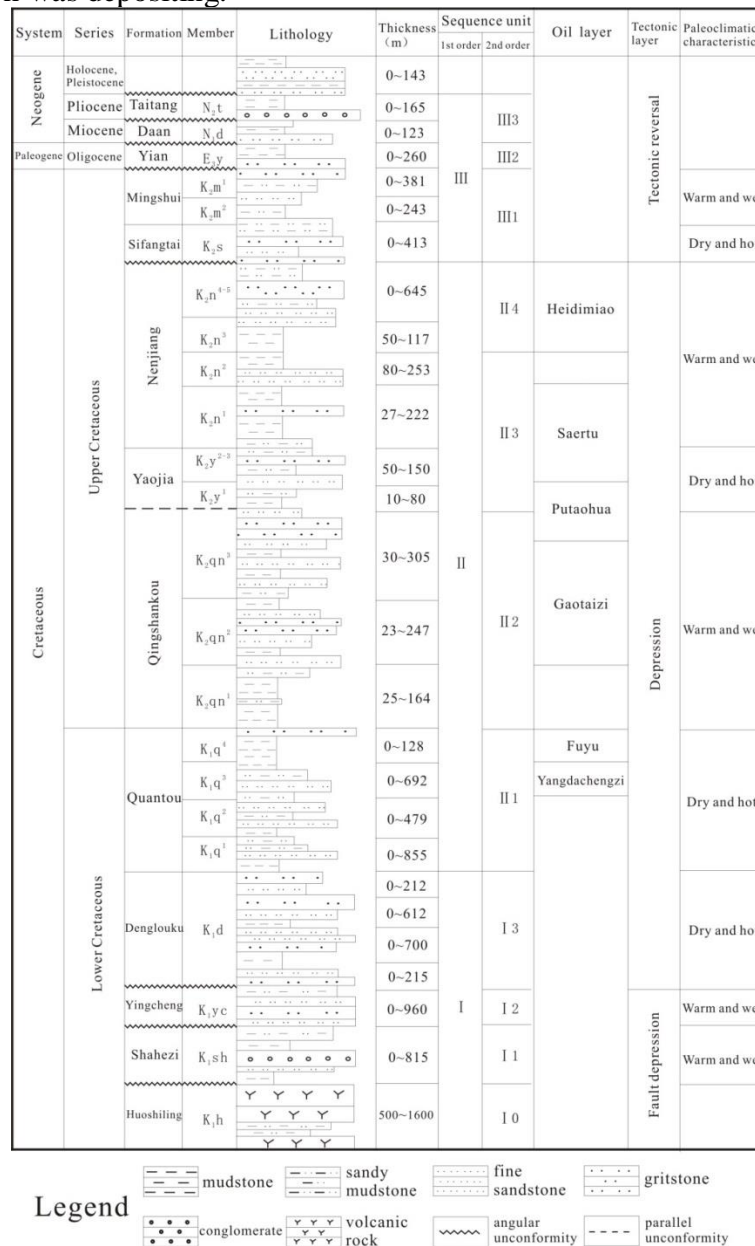
### 3. Tectonic Evolution Characteristics

Sanzhao Depression of Songliao Basin experienced three tectonic evolution stages: Fault depression stage (K<sub>1h</sub>–K<sub>1yc</sub>), Depression stage (K<sub>1d</sub>–K<sub>2n</sub>), Tectonic reversal stage (K<sub>2s</sub>–Q) [1]. Depression tectonic layer is the most important structural layer with longest duration and thickness of sediment. Source rock, reservoir and cap rock are all in this layer. The main research of this paper is focused on Depression stage which is closely to target layer (Fuyu oil layer).

#### 3.1 Fault depression stage

Fault depression stages (K<sub>1h</sub>–K<sub>1yc</sub>) began in the Houshiling period, early Cretaceous. In this period, subduction of oceanic plate caused upwelling of hot mantle, resulting in a large number of volcanic eruptions in the study area. Songliao basin had both the characteristics of continental rift and active continental margin. During Shahezi formation sedimentary period, basin was in the stretch settlement

and strongly chasmic stages. And entered atrophy stage of the fault depression during the period of Yingcheng formation was depositing.



Legend: mudstone, sandy mudstone, fine sandstone, gritstone, conglomerate, volcanic rock, angular unconformity, parallel unconformity

Fig. 1 Stratigraphic column of Sanzha Depression

### 3.2 Depression stage

After the deposition of Denglouku formation started, Songliao basin entered Depression stage. In this period, gradually cooling down of lithosphere caused stratum shrink, which resulted in uneven sinking of the crust. In the early, the cold shrink of stratum was relatively fast, and basement faults which controlled depression sedimentary were still active and growing. Its sedimentary has already exhibited the characteristics of Depression stage. So the stratum below Denglouku formation showed the features of Fault Depression, while those above Denglouku formation exhibited the characteristics of Depression. This stage was the transition period from Fault Depression to Depression. At the end of Denglouku formation sedimentary period, the basin entirely entered Depression stage, until Nenjiang formation sedimentary period. In this period, stratum showed a slight tensile stress environment, and the effect became smaller and smaller. Sanzha sag in the center depression of Songliao Basin was formed during this period. Tectonic evolution history of the study area showed that the tectonic evolution between the 4th member of Quantou formation and Nenjiang formation can be divided into four stages (Figs. 2~3):

Sedimentary period of 4th Member of Quantou Formation

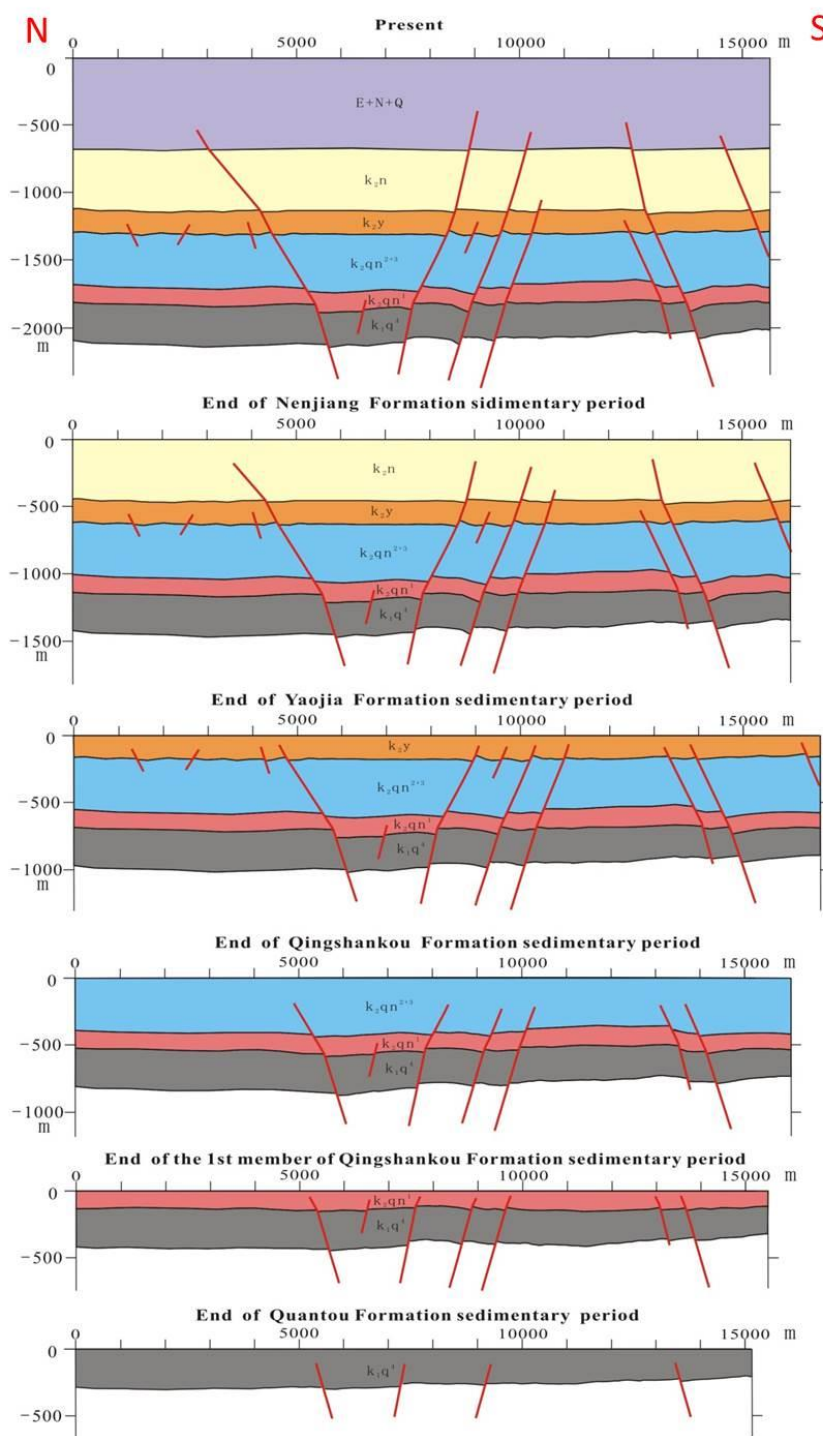


Fig. 2 Tectonic evolution section(north-south)

This period was in the stage of stable sedimentation. In the late of the 4th member of Quantou formation, Songliao Basin occurred a large-scale extensional movement. During this period, numerous normal faults which broke the top surface of the 4th member of Quantou formation ( $T_2$  axis) exhibited the structural style of graben alternate with horst. In the study area, the thickness of the stratum gradually increase from WS to EN, and so as the fault throw. Due to the large number of faults and their characteristic of development, faults formed in the late of Quantou formation not only changed the original structural framework, but also controlled the sedimentary features of the upper stratum in the study area (Figs. 2~3).

Sedimentary period of Qingshankou Formation

In the Qingshankou formation sedimentary period, the study area accepted thick dark shale depositional under the new structure framework. The deposition process was consistent with Songliao Basin in the same period, getting rapid no compensate sediments. The thick shale depositional of this period also provides a good cap rock for Fuyu oil layer. The faults formed in the end of the 4th member of Quantou formation continued growing in this period (Figs. 2~3).

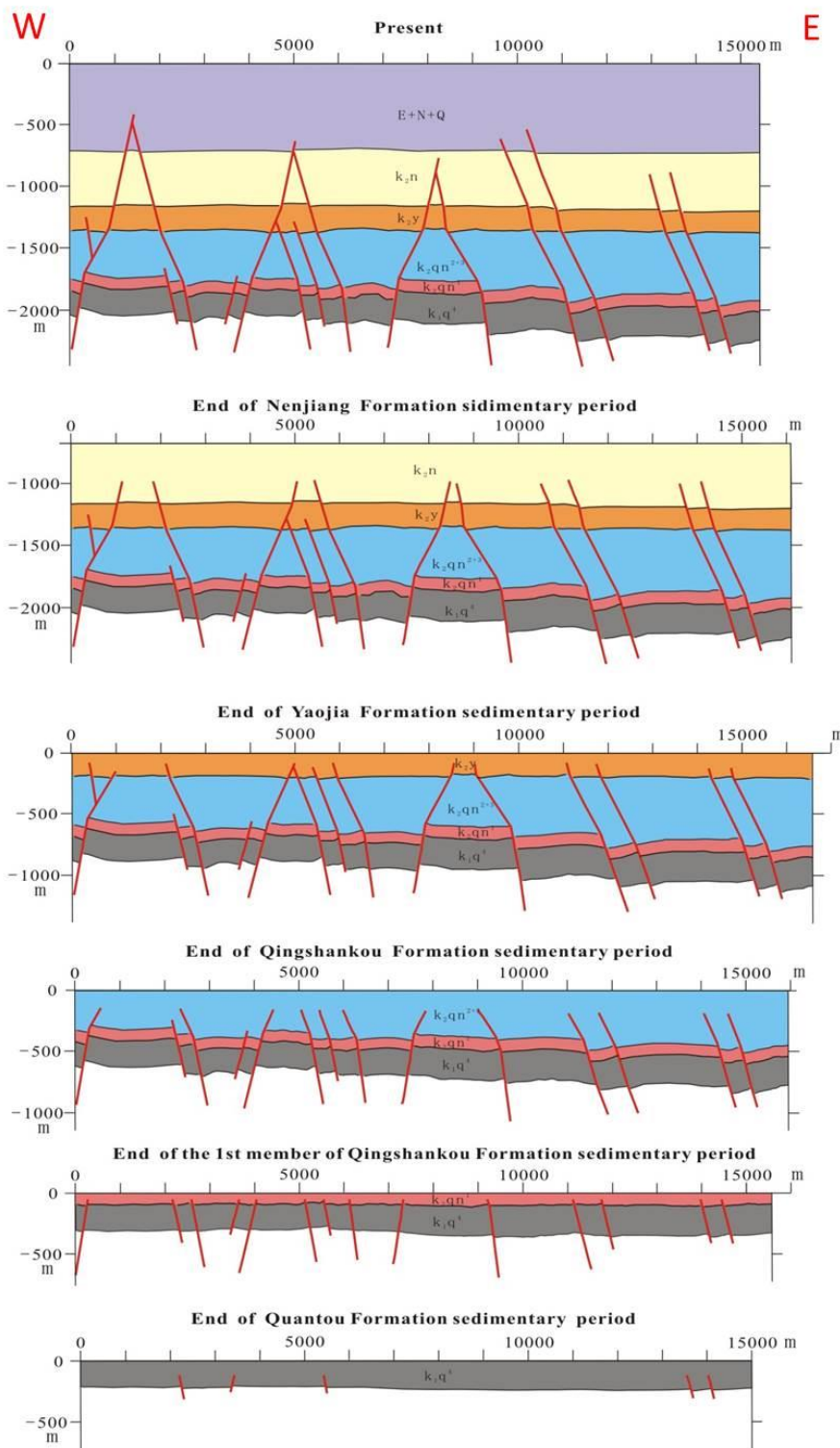


Fig. 3 Tectonic evolution section(west-east)

Sedimentary period of Yaojia Formation

Tectonic environment is relatively stable in Yaojia sedimentary period. This period mainly gets compensate sediments and the stratum tends to relatively flat. Thus the thickness difference of stratum

is significantly smaller than before. The 1st member of Yaojia formation developed small faults, due to the minor fault throw and short-length extension, the faults can not change the structure framework in this area, but have some impact to the deposition of Yaojia formation (Figs. 2~3).

#### Sedimentary period of Nenjiang Formation

Nenjiang Formation is mainly in continuing high-rate sedimentary period. In the late Nenjiang sedimentary period, intense tectonic reverse movement was occurred, changing from the background of extensional action to squeezing action. Thus the structure framework of Sanzhao Depression dramatically changed (Figs. 2~3).

### 3.3 Tectonic reversal stage

At the end of Nenjiang sedimentary period, Songliao Basin entered the tectonic inversion period ( $K_{2s}$ -Q) [3, 4]. The intensive tectonic reverse movement is mainly due to the expansion of the Sea of Japan, the subduction of oceanic plate to Eurasia and the shear extrusion of North Asia. At present, two times of tectonic reversal movement can be identified: end of Nenjiang sedimentary period and end of Mingshui sedimentary.

## 4. Conclusion

San Zhao Depression of Song Liao Basin experienced three tectonic evolution stages: Fault depression stage ( $K_{1h}$ - $K_{1yc}$ ), Depression stage ( $K_{1d}$ - $K_{2n}$ ), Tectonic reversal stage ( $K_{2s}$ -Q). And the Depression stage can be further divided into four stages, including: stable subsidence during Quantou Formation sedimentary period, intensive extension during Qingshankou Formation sedimentary period, stable subsidence during Yaojia Formation sedimentary period and rapid subsidence during Nenjiang Formation sedimentary period.

## References

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