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Study on Reservoir Characteristics and Main Controlling Factors of Chang-7 Reservoir in the Southwest of Wuqi Oilfield

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Abstract

This paper focuses on the problems of unclear oil and gas enrichment laws and difficult prediction of favorable zones in the tight reservoir of the Chang-7 member in the southwest of Wuqi Oilfield. It conducts research on reservoir characteristics and main controlling factors to provide a geological basis for efficient exploration in this area. By comprehensively applying technical methods such as detailed core observation, cast thin sections, scanning electron microscopy, high-pressure mercury intrusion, and basin simulation, the petrology, pore structure, and physical properties of the reservoir are systematically analyzed, and the controlling mechanisms of tectonism, sedimentation, and diagenesis are deeply discussed. The results show that the Chang-7 reservoir in the study area is an ultra-low porosity and ultra-low permeability lithic arkose sandstone, with intergranular pores and feldspar dissolution pores as the main pore types. The reservoir quality is controlled by multiple factors: sedimentary facies zones control the distribution of high-quality reservoirs such as sandy debris flows and turbidite sand bodies; in diagenesis, strong compaction and cementation lead to reservoir densification, while dissolution effectively improves the reservoir space; most importantly, the tectonic uplift and denudation since the Late Cretaceous have significantly improved the seepage capacity of the reservoir through elastic rebound and pressure reduction expansion mechanisms. Tectonic uplift is the key acquired constructive factor for improving the physical properties of the reservoir in the study area, and the paleotectonic high areas and areas with strong uplift and denudation are the favorable targets for further oil and gas exploration.

Keywords

Southwest of Wuqi Oilfield; Chang-7 Reservoir; Tectonism; Sedimentation; Diagenesis.

1. Introduction

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As the second largest continental sedimentary basin in China, the Ordos Basin is rich in oil and gas resources. The Upper Triassic Yanchang Formation is the most important oil-bearing series in the basin, among which the Chang-7 member is one of the main target intervals for tight oil exploration and development. In recent years, with the in-depth exploration and development,

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the Chang-7 tight oil has become an important replacement area for oil and gas reserve and production increase in the basin [1]. Although the characteristics and hydrocarbon generation potential of this interval as a high-quality source rock have been deeply studied [2], its own reservoir performance has long been insufficiently valued. In fact, the tight sandstones and mudstones developed in the Chang-7 member form an interbedded assemblage, and various types of sandstones show good oil-bearing properties, forming an important "source-reservoir integration" unconventional reservoir system [3]. However, the reservoirs in this area generally have the characteristics of low porosity, low permeability, and strong heterogeneity, and the oil and gas enrichment laws are complex, making it difficult to predict favorable zones, which has become a key problem restricting the exploration effect.

Existing studies have initially revealed the basic characteristics of the reservoir, but there are still obvious weaknesses in the main controlling factors of high-quality reservoir development: first, the later transformation mechanism of tectonic evolution on reservoir physical properties is not clear; second, the quantitative contribution of different diagenetic processes (compaction, cementation, dissolution) to pore evolution lacks systematic evaluation [4]; third, the coupled reservoir-controlling relationship among sedimentation, diagenesis, and tectonism has not been effectively revealed [5]. Therefore, this study takes the Chang-7 reservoir in the southwest of Wuqi as the research object. On the basis of finely characterizing the petrology, pore structure, and physical properties of the reservoir, it focuses on analyzing the controlling mechanisms of tectonism, sedimentation, and diagenesis on reservoir quality, aiming to clarify the development laws and main controlling factors of high-quality reservoirs, and provide a theoretical basis for the "sweet spot" prediction and efficient development of tight oil reservoirs in this area.

2. Organization of the Text

2.1. Geological Setting

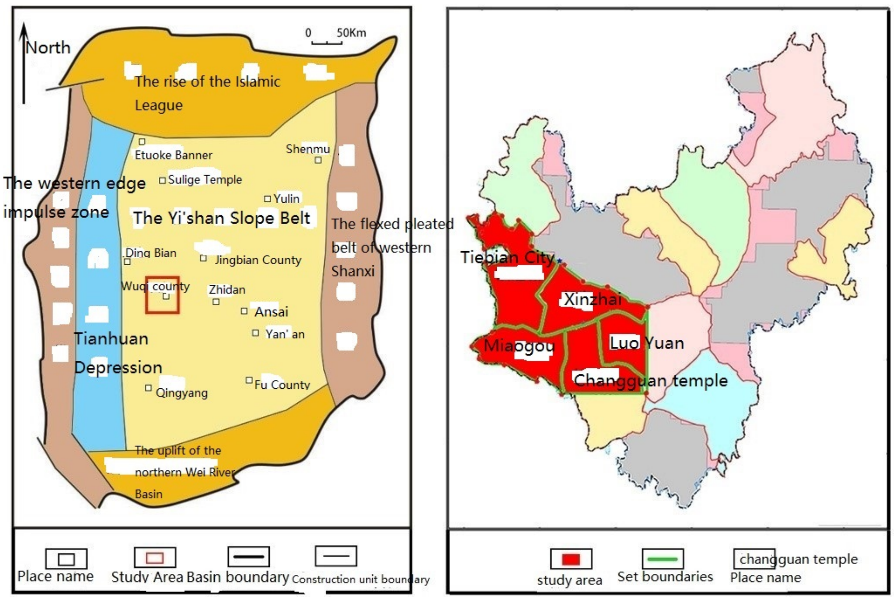


Fig 1. Location Map of the Study Area

The Ordos Basin is located in the Shaanxi-Gansu-Ningxia region of China. From the perspective of geological characteristics, it is a large-scale polycyclic cratonic basin with overall uplift and subsidence, depression migration, and simple structure [6]. It can be further divided into 6 first-order tectonic units: the Yimeng Uplift, Weibei Uplift, Western Margin Thrust Belt, Jinxi Flexure Belt, Tianhuan Depression, and Shanbei Slope Belt [7]. The basement is composed of Archean and Lower Proterozoic metamorphic rocks. The southwest of Wuqi is located in the central and western part of the Yishan Slope in the basin (Figure 1). Tectonically, it is a gentle monocline tilting to the west, including the Tiebiancheng Oilfield Area, Miaogou Oilfield Area, Xinzhai Oilfield Area, the western part of the Luoyuan Oilfield Area, and the northern part of the Zhangguanmiao Oilfield Area, with an area of 746 km^2 (Figure 1).

The Triassic Yanchang Formation in the Ordos Basin belongs to an inland lacustrine sedimentary environment, which is divided into 10 oil-bearing intervals from Chang-1 to Chang-10 from top to bottom. Generally, it is a set of assemblages of grayish-green, gray medium-thick layer medium-fine sandstones, silty fine sandstones, gray mudstones, and dark shales [8].

The sedimentary period of the Chang-7 oil-bearing interval was the heyday of lacustrine basin development, belonging to a shallow lake-deep lake sedimentary environment, with semi-deep lake-deep lake subfacies and shore-shallow lake subfacies developed [9]. The Chang-7 member is further divided into Chang-7^1, Chang-7^2, and Chang-7^3 sub-members from top to bottom. During the sedimentary period of the Chang-7^3 sub-member, the scope of the lacustrine basin in the basin gradually expanded to the peak, and the water depth increased. During this period, a set of semi-deep lake-deep lake mud was developed, depositing the most important set of source rocks for tight oil in the Yanchang Formation. Later, the coverage area of the lake water gradually decreased and the water depth became shallow. From the sedimentary period of Chang-7^2 to Chang-7^1, there were repeated transgressions and regressions [9]. Affected by the northeastern provenance, gravity flow sedimentary sand bodies were widely developed in the study area.

The reservoir sand bodies and black shales are interbedded, forming a sedimentary environment where gray mudstones are developed at the top of the Chang-7^1 sub-member, silty fine sandstones are developed in Chang-7^2, black shales are developed in Chang-7^3, and sand-mud interbeds are locally developed in a large area [10]. From the Chang-7^1 sub-member to the Chang-7^3 sub-member, it presents a sedimentary characteristic of "source-reservoir-source" (Figure 2). The reservoir is in direct contact with the source rock, but its physical properties are poor, making it a typical tight reservoir [11].

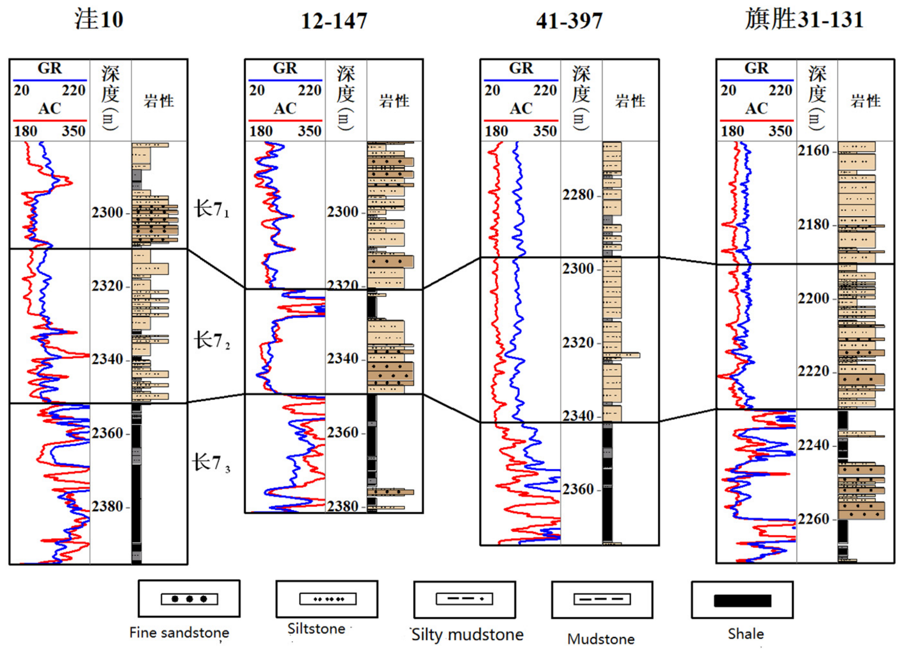


Fig 2. Correlation Section of Chang-7 Member in Wells Wa10-12-147-41-397-Qisheng31-131 in the Southwest of Wuqi Oilfield

3. Characteristics of Chang-7 Reservoir

3.1. Petrological Characteristics of the Reservoir

Through the observation and identification of ordinary thin sections and cast thin sections, the tight oil reservoir of the Chang-7 member in the southwest of Wuqi area is mainly composed of fine-grained lithic arkose sandstone, followed by arkose sandstone and feldspathic lithic sandstone. The clastic components generally have a high content of rigid particles, showing the characteristics of the northeastern

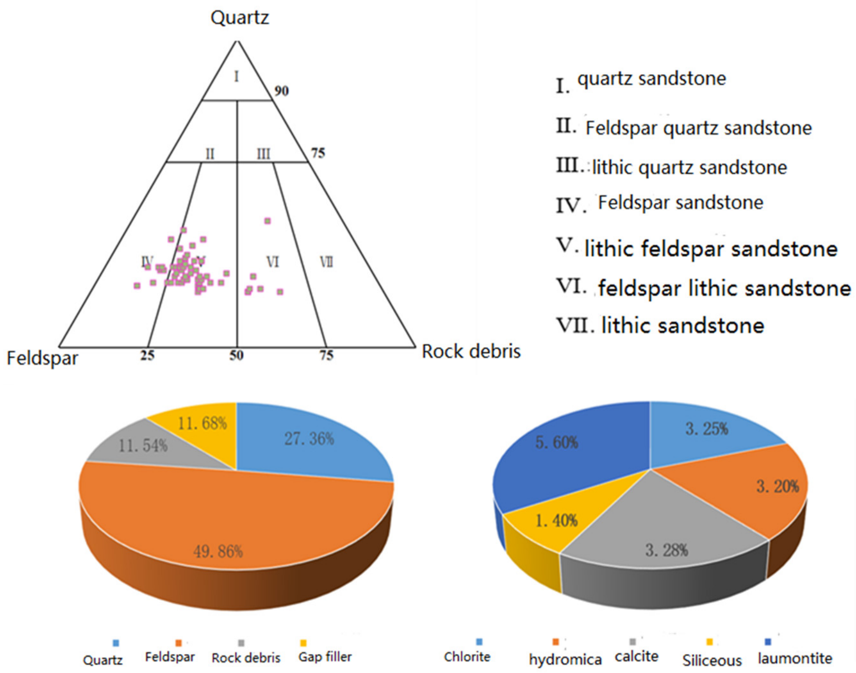


Fig 3. Reservoir Rock Types of Chang-7 Member in the Study Area

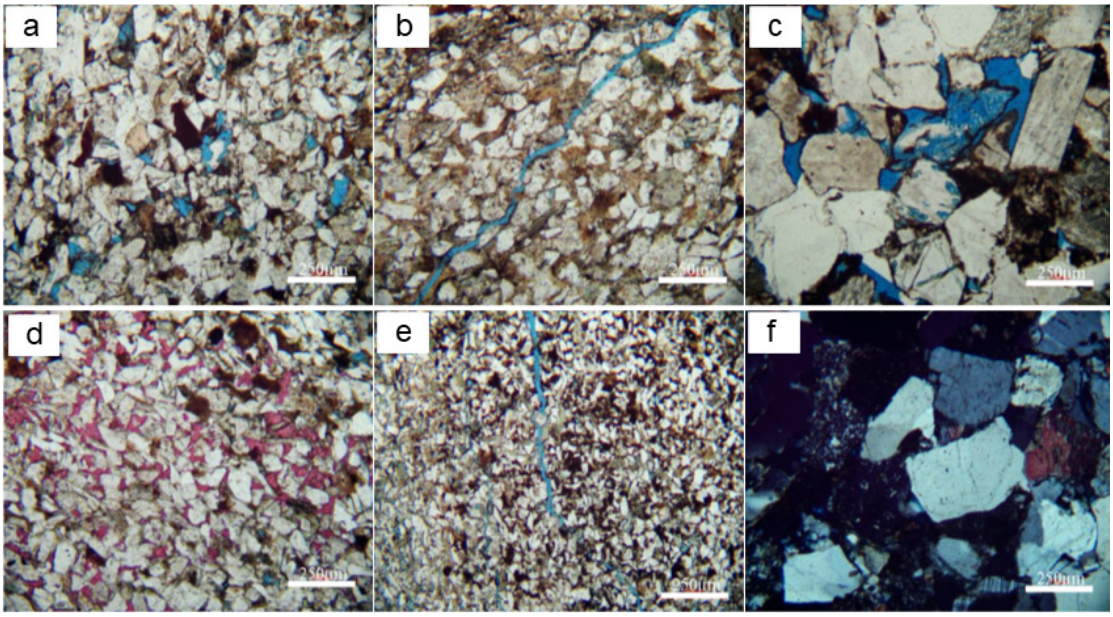
provenance with high feldspar and low quartz. The average content of quartz is 27.36%, feldspar is 49.86%, and lithic is 11.54%. Among the lithic components, the content of metamorphic rock lithic is 5.19%, igneous rock lithic is 1.77%, sedimentary rock lithic is extremely low (0.71%), and other types of lithic are 5.19%. The content of interstitial materials is 11.68%, mainly including chlorite, hydromica, calcite, and siliceous minerals, with a small amount of laumontite. Among them, the content of chlorite is 3.25%, hydromica is 3.20%, calcite is 3.278%, siliceous minerals is 1.40%, and laumontite is 0.56% (Figure 3).

Petrological characteristics indicate that the reservoir in the study area has inherent disadvantages in physical properties. The high feldspar content and relatively high lithic content mean that the proportion of unstable components and plastic components in the rock is high, which is prone to strong compaction deformation and dissolution-recementation during the burial process.

3.2. Pore Characteristics of the Reservoir

3.2.1. Pore Types

By sorting out the observation data of thin sections in the target interval, it is found that the surface porosity of the Chang-7 reservoir in the southwest of Wuqi ranges from 2.18% to 9.77%, with an average of 3.51%. Primary pores are mainly intergranular pores, and secondary pores are mainly feldspar dissolution pores and lithic dissolution pores (Figure 4a), with microfractures commonly seen (Figure 4b). Cast thin sections show the morphology of intergranular pores and lithic dissolution pores (Figure 4c). Local dissolution is obvious, and it can be observed that calcite cement fills most of the pores (Figure 4d). Mica is distributed in strips and flakes (Figure 4e), and quartz overgrowth occurs (Figure 4f).



(a) Mainly intergranular pores, followed by feldspar dissolution pores and lithic dissolution pores, 2114.82m, Tie17 Well, Chang-7 Member; (b) Microfractures, 2137.63m, Zhai13 Well, Chang-7 Member; (c) Intergranular pores and lithic dissolution pores, 2141.75m, Zhai13 Well, Chang-7 Member; (d) Calcite cement filling large pores, Tie17 Well, 2136.72m, Chang-7 Member; (e) Mica distributed in strips and flakes, Zeng217 Well, 2033m, Chang-7 Member; (f) Quartz overgrowth, Zhai13 Well, 2034.98m, Chang-7 Member)

Fig 4. Pore Types of Chang-7 Member in the Southwest of Wuqi Oilfield

3.2.2. Classification of Pore Structure

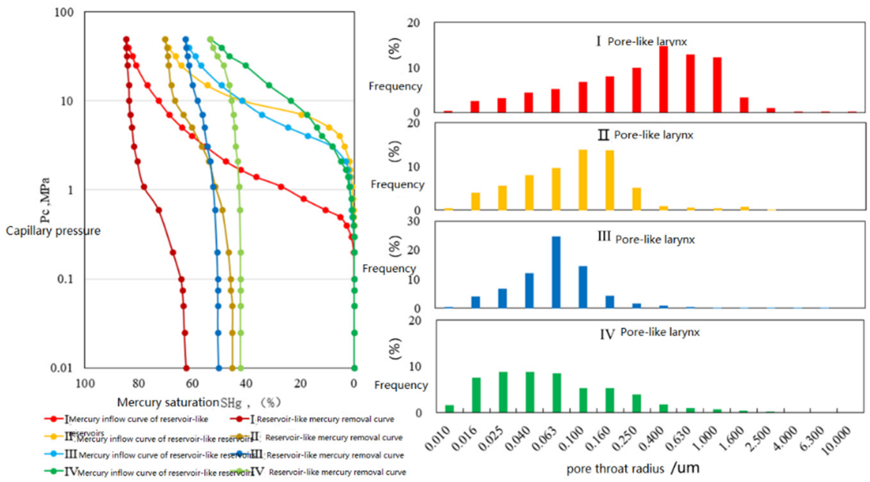


Fig 5. Mercury Intrusion Curves and Pore Size Distribution Characteristics of Sandstones in the Chang-7 Member of the Study Area

By integrating physical property tests, cast thin section observation, mercury intrusion experiments, and other methods, this study deeply explores the relationship between pore-throat sorting, pore-throat scale, and reservoir physical properties. On this basis, combined with the actual oil-bearing data, the potential connection is further revealed, and the pore structure in the southwest of Wuqi is classified into four types (Figures 5).

(1) **Type Ⅰ Pore-Throat Structure (High-Quality Reservoir)**

It has the significant advantages of high porosity (porosity > 8%) and high permeability (permeability > $0.5\times10^{-3}\mu m^2$). Its pore-throat structure is excellent, showing coarse skewness (skewness mean 2.15) and large pore-throats (median radius > 0.5μm). The capillary pressure curve shows extremely low displacement pressure (< 0.5MPa) and high mercury withdrawal efficiency (> 45%), indicating that fluid can flow and be produced easily in it.

(2) **Type Ⅱ Reservoir (Medium Reservoir)**

It has medium porosity (porosity 5-8%) and medium-low permeability (permeability 0.01-$0.5\times10^{-3}\mu m^2$). The pore-throat structure is medium, with a median radius between 0.1-0.5μm. The relatively low displacement pressure (0.5-1MPa) and medium mercury withdrawal efficiency (20-45%) indicate that it has a certain reservoir and seepage capacity.

Table 1. Statistical Table of Pore-Throat Classification of Sandstone in Chang-7 Member of the Study Area

Reservoir Classification	Porosity (%)	Permeability ($10^{-3}\mu m^2$)	Skewness Mean	Median Pressure (MPa)	Median Radius (μm)	Displacement Pressure (MPa)	Mercury Withdrawal Efficiency (%)
Type Ⅰ Pore-Throat	>8	>0.5	2.15	<1	>0.5	<0.5	>45
Type Ⅱ Pore-Throat	5-8	0.01-0.5	4.64	1-10	0.1-0.5	0.5-1	20-45
TypeⅢ Pore-Throat	5-8	0.005-0.01	9.38	10-30	0.05-0.5	1-5	20-45
TypeⅣ Pore-Throat	<5	<0.005	7.17	>30	<0.05	>5	20-45

(3) **Type Ⅲ Reservoir (Poor Reservoir)**

Although it has medium porosity (porosity 5-8%), it is an ultra-low permeability reservoir (permeability 0.005-$0.01\times10^{-3}\mu m^2$). Its pore-throat distribution shows fine skewness (skewness mean 9.38) and small pore-throats (median radius 0.05-0.5μm). The relatively high displacement pressure (1-5MPa) and low mercury withdrawal efficiency (20-45%) indicate that the fluid flow resistance is large.

(4) **Type Ⅳ Reservoir (Tight Reservoir)**

It is a tight reservoir with ultra-low porosity (porosity < 5%) and ultra-low permeability (permeability < $0.005\times10^{-3}\mu m^2$). The pore-throats are fine (median radius < 0.05μm), the displacement pressure is high (> 5MPa), and the mercury withdrawal efficiency is low (20-45%). Its reservoir and seepage performance is poor, and it usually needs to be reformed to form industrial productivity.

3.3. Physical Properties of the Reservoir

Through the detection of porosity and permeability of core samples in the study area, the Chang-7 reservoir in the study area is generally an ultra-low porosity and ultra-low permeability reservoir. The porosity of the Chang-7 member ranges from 0.59% to 14.56%, with an average of 7.7% (Figure 6); the permeability ranges from $0.003\times10^{-3}\mu m^2$ to $2.49\times10^{-3}\mu m^2$, with an average of $0.54\times10^{-3}\mu m^2$.

The porosity of the Chang-7^1 sub-member ranges from 1.2% to 14.56%, with an average of 7.6%; the permeability ranges from $0.006\times10^{-3}\mu m^2$ to $2.49\times10^{-3}\mu m^2$, with an average of $0.57\times10^{-3}\mu m^2$.

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The measured porosity of the Chang-7^2 oil-bearing interval ranges from 0.9% to 14.12%, with an average of 7.9%; the permeability ranges from $0.004\times10^{-3}\mu m^2$ to $2.44\times10^{-3}\mu m^2$, with an average of $0.53\times10^{-3}\mu m^2$.

The measured porosity of the Chang-7^3 oil-bearing interval ranges from 0.59% to 14.5%, with an average of 7.5%; the permeability ranges from $0.003\times10^{-3}\mu m^2$ to $2.46\times10^{-3}\mu m^2$, with an average of $0.52\times10^{-3}\mu m^2$.

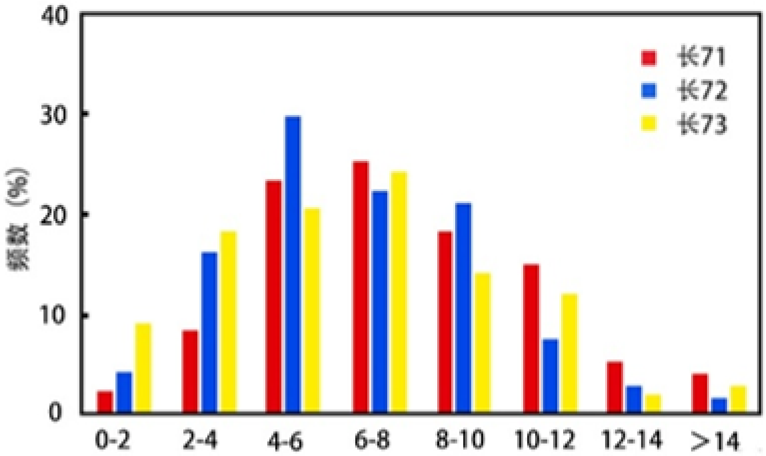

Fig 6. Histogram of Measured Porosity in the Southwest of Wuqi Oilfield

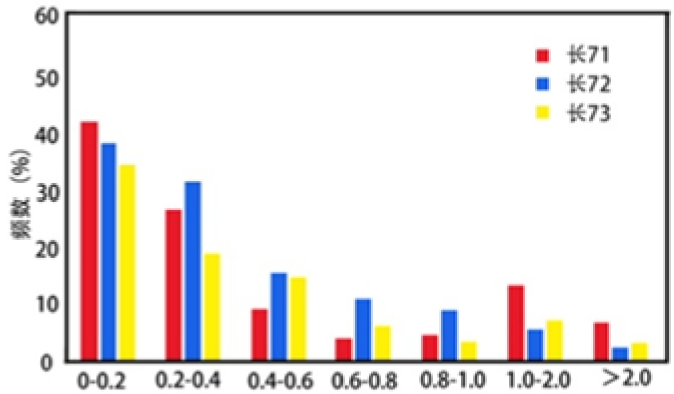

Fig 7. Histogram of Measured Permeability in the Southwest of Wuqi Oilfield

Table 2. Statistical Table of Measured Physical Properties of Chang-7 Member in the Southwest of Wuqi Oilfield

Interval	Porosity (%) - Maximum	Porosity (%) - Minimum	Porosity (%) - Average	Permeability ($\times10^{-3}\mu m^2$) - Maximum	Permeability ($\times10^{-3}\mu m^2$) - Minimum	Permeability ($\times10^{-3}\mu m^2$) - Average
Chang-7	14.56	0.59	7.7	2.49	0.003	0.54
Chang-7^1	14.56	1.2	7.6	2.49	0.006	0.57
Chang-7^2	14.12	0.9	7.9	2.44	0.004	0.53
Chang-7^3	14.5	0.59	7.5	2.46	0.003	0.52

4. Main Controlling Factors

4.1. Tectonism

To reveal the controlling effect of tectonic evolution on the physical properties of the Chang-7 reservoir, the PetroMod basin simulation software was used to reconstruct the single-well porosity evolution history based on Well 41-427 (Figure 8). The stratigraphic sedimentary age and denudation uplift refer to previous studies [12][13][14]. The simulation results show that the Chang-7 reservoir experienced 4 stages of stratigraphic uplift and denudation events from the end of the Triassic to the Quaternary, and the porosity changed dynamically with the burial history and tectonic uplift history. The first stage was affected by the Indosinian movement from the end of the Triassic to the early Jurassic; the second stage was affected by the early Yanshan movement at the end of the Jurassic Yan'an Formation; the third stage was affected by the main episode of the Yanshan movement from the end of the Late Jurassic to the early Cretaceous; the fourth stage was between the Late Cretaceous and the Quaternary, affected by both the Yanshan movement and the Himalayan movement, with a denudation amount of up to 1000 meters. The influence of uplift and denudation on the porosity of the study area can be roughly divided into three main stages: continuous compaction and porosity reduction (early diagenetic stage A), stable porosity reduction (early diagenetic stage B), and uplift and porosity increase (middle diagenetic stage A).

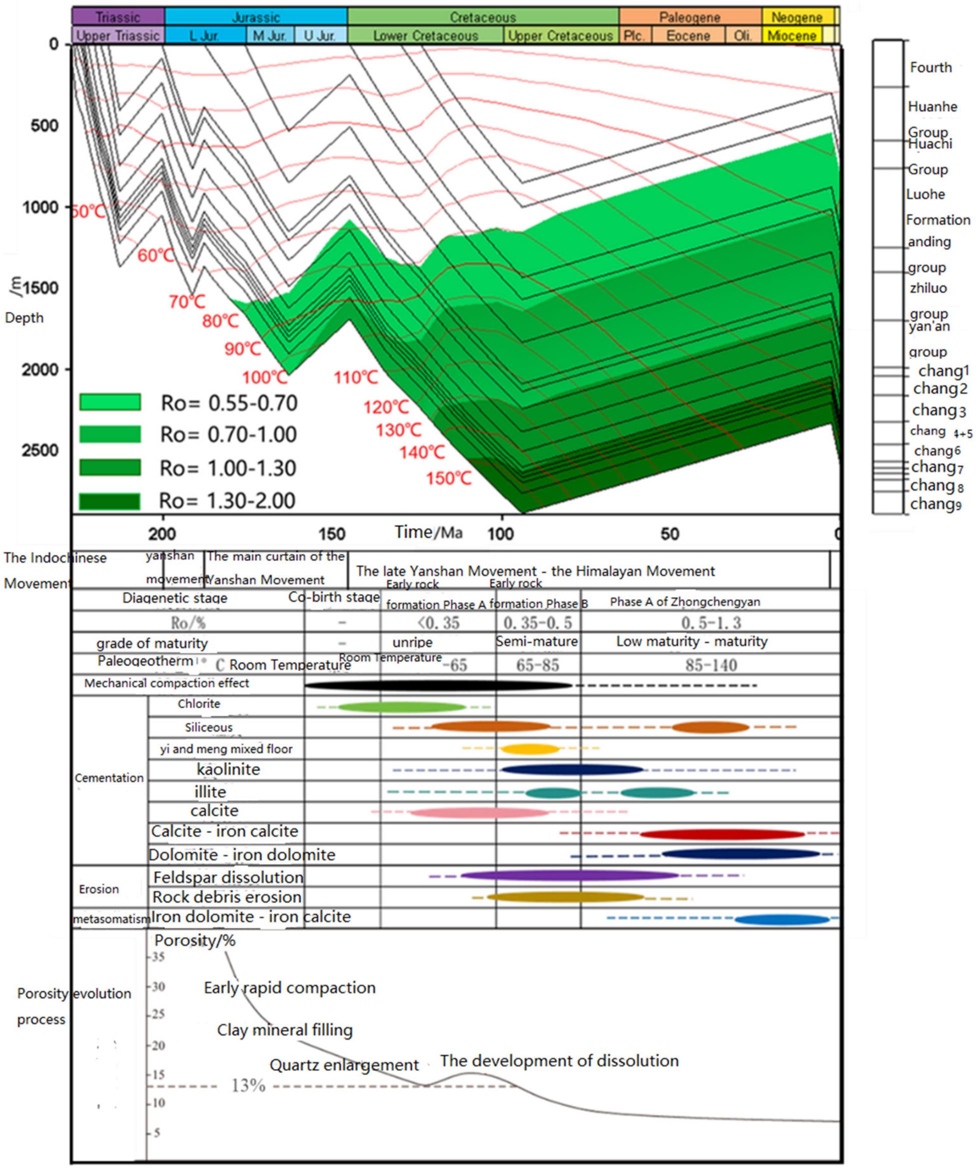

Fig 8. Comprehensive Diagram of Hydrocarbon Generation Burial History, Thermal History, Diagenetic Sequence and Porosity Evolution History of Chang-7 Reservoir in Well 41-427 in the Southwest of Wuqi Oilfield

Before the intense burial in the Early Cretaceous, the Chang-7 member in the study area continued to subside and be buried. With the rapid deepening of the stratum, mechanical compaction was the dominant factor leading to the sharp loss of primary porosity, and the porosity decreased rapidly from the original 35%-50% to about 13%. During this period, although early clay mineral filling may have occurred, the physical compaction caused by the overlying stratum static pressure was the primary reason for the decrease in porosity. In the Early Cretaceous, the basin entered the thermal subsidence stage [13][14], and the Chang-7 member reached the maximum burial depth of 2985m. At this time, the mechanical compaction effect weakened, but with the increase of geothermal gradient, affected by the peak period of thermal events in the Ordos Basin in the Early Cretaceous, diagenetic effects such as dissolution and metasomatism were enhanced, becoming the main factors for the further slow decline of porosity. In the Late Cretaceous, a significant tectonic uplift event occurred in the study area, resulting in stratigraphic denudation. After the stratigraphic uplift and denudation, the effective overlying stress decreased, reducing the confining pressure, and the rock framework underwent slight elastic expansion [12], leading to a rebound increase in the porosity of the study area, which then slowly decreased to the current measured value under diagenesis.

4.2. Sedimentation

Based on previous studies and core observation and recording of 13 wells in the study area, it is determined that semi-deep lake-deep lake facies are developed in the southwest of Wuqi, and gravity flow deposits are developed in the sand bodies. Sedimentary facies zones control the distribution and original physical properties of the sand bodies, and sandy debris flows, sliding slump, and turbidite sand bodies become favorable reservoir facies zones. However, the gravity flow sedimentary system can not only form thick and widely distributed sand bodies to provide sufficient reservoir space for oil and gas, but also lead to great changes in the internal physical properties of the reservoir due to its complex sedimentary process and strong later diagenetic transformation, showing duality in the control of reservoir quality[15].

4.2.1. Constructive Role: Material Basis for High-Quality Reservoir Development

Gravity flow deposition forms large-scale deep-water reservoirs, breaking through the limitations of reservoir distribution. In the semi-deep lake-deep lake sedimentary environment of the study area, terrigenous clastics enter the deep-water area through gravity flow, forming large-scale sand bodies in or around the deep-water area where source rocks are developed, which evolve into reservoirs, forming a high-quality "near-source" or "intra-source" reservoir-forming assemblage; high-density turbidity currents can deposit to form thick-bedded massive medium-fine sandstones. These sand bodies usually have low mud content, uniform particle size, and medium to good sorting, with good original intergranular porosity. Although they become tight after diagenetic transformation, their original "good framework" retains the basis for later dissolution transformation; the kerogen in the source rock undergoes low-temperature pyrolysis, generating a large amount of organic acids containing carboxyl groups that enter the adjacent permeable sand bodies, dissolving unstable components such as feldspar and lithic, and forming secondary dissolution pores.

4.2.2. Restrictive Role: Main Controlling Factor for Strong Reservoir Heterogeneity

The complexity and eventuality of gravity flow deposition also lead to strong heterogeneity of the reservoir, seriously restricting the uniformity of reservoir quality. First, the physical properties of different types of gravity flow sedimentary microfacies vary significantly. The main channel and the center of the lobe have the best reservoir performance, while the channel flank, lobe edge, and terminal facies zones have poor physical properties due to increased mud content and finer particle size. Second, the multi-stage superposition of gravity flow events leads to large changes in the thickness of single sand bodies, frequent sand-mudstone interbedding, and the development of interlayers and interbeds vertically. Macroscopically, it is a continuous sand body, but microscopically, it is multiple isolated reservoir units, resulting in complex vertical connectivity of the reservoir (Figure 9); a large number of soft lithic and mud content will undergo strong plastic deformation and compaction during burial diagenesis, greatly accelerating the loss of porosity. At the same time, lithic and feldspar are prone to alteration, forming clay minerals such as chlorite and illite, which block the throats, seriously damaging the primary pores and significantly reducing the porosity and permeability.

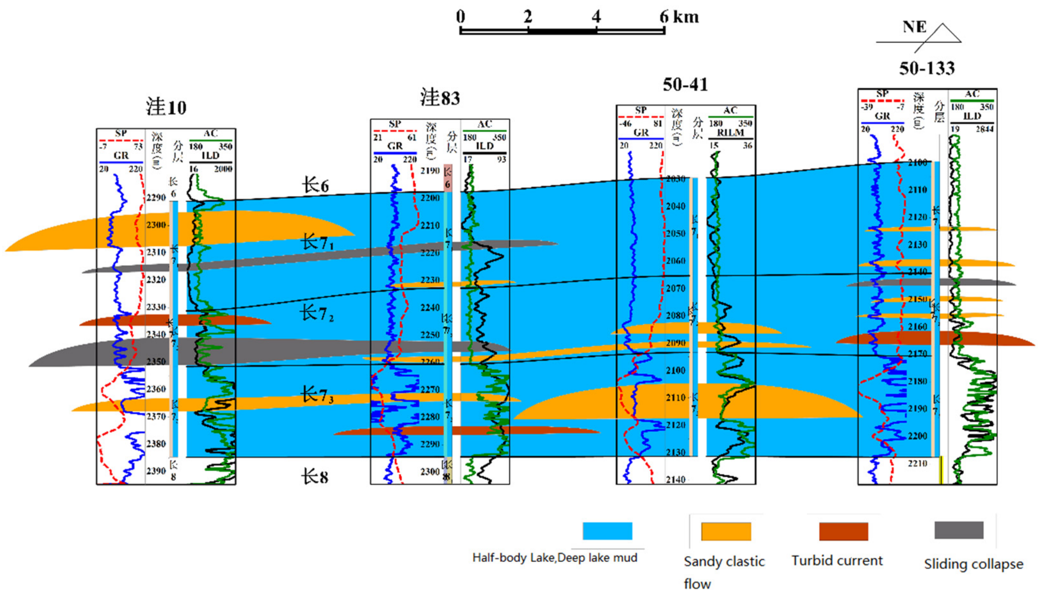

Fig 9. Sedimentary Correlation Section of Chang-7 Member in Wells Wa10-Wa83-50-41-50-133 in the Southwest of Wuqi Oilfield

4.3. Diagenesis

4.3.1. Compaction and Pressure Dissolution

During the diagenetic evolution of the reservoir, compaction affects the physical properties of the reservoir in the study area by reshaping the particle arrangement and pore structure (Figure 10a), making it more compact. The feldspar content in the study area is much higher than the quartz content, indicating that the proportion of plastic components in the rock is relatively large. This characteristic reflects that the reservoir evolution in the study area has the material basis and diagenetic conditions for strong compaction.

Under the action of overlying stratum pressure or tectonic lateral pressure, the stress is highly concentrated at the point contact or line contact between sandstone particles (Figure 10b), leading to local dissolution of SiO_2 at the stress concentration points. The dissolved substances migrate to the surrounding area through pore water and reprecipitate in low-stress areas to form quartz overgrowth edges (Figure 10c), filling the remaining intergranular pores and throats, and further damaging the reservoir physical properties.

4.3.2. Cementation

Cementation shows duality in the reservoir evolution of the study area. In terms of destructiveness, the precipitation of cement causes reservoir densification and reduces porosity, thus seriously affecting the reservoir capacity. In terms of constructiveness, under certain conditions, cement can instead improve the reservoir physical properties, slow down the damage of compaction to the pore structure, and provide a material basis for later dissolution. When the cement dissolves, secondary dissolution pores will be formed, further changing the pore structure and seepage characteristics of the reservoir, thereby improving the reservoir compactness to a certain extent and enhancing the reservoir quality.

a. **Carbonate Cementation**

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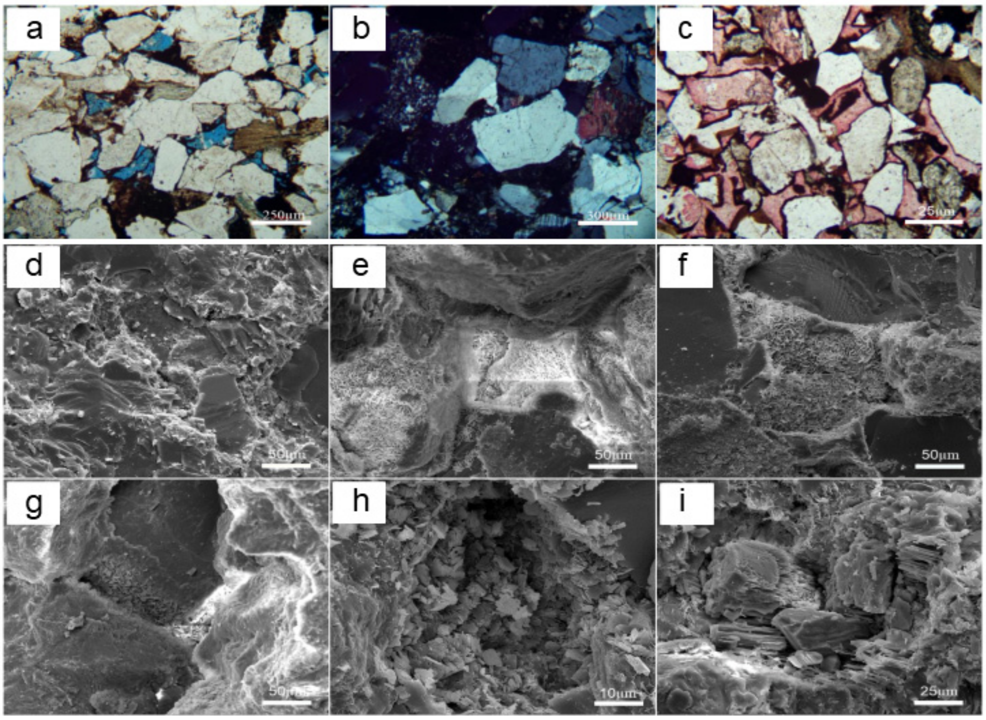
The carbonate cements in the study area are mainly ferrocalcite, which is often filled in the pores, leading to the blockage of pore-throat channels, seriously affecting the pore-throat connectivity, thus having an adverse impact on the reservoir physical properties and significantly weakening its reservoir and seepage capacity (Figure 10d).

b. **Siliceous Cementation**

It is mainly manifested as quartz overgrowth. This type of cementation is usually relatively stable and difficult to dissolve. However, the quartz overgrowth in this area is relatively weak and has a limited development degree. The main reason is that the chlorite film on the particle surface inhibits the formation process of quartz overgrowth, hinders the precipitation and recrystallization of siliceous substances, thus limiting the further development of siliceous cementation (Figure 10e).



(a) Well Z7: Clastic particles show point and linear concave-convex contact; (b) Well Z7: Quartz overgrowth, filling pores; (c) Well Z13: Calcite cementation; (d) Well S1: Siliceous cementation; (e) Well S1: Chlorite film covering the particle surface; (f) Well S1: Chlorite filling pores; (g) Well S1: Illite filling pores; (h) Well S1: Kaolinite filling pores; (i) Well S1: Feldspar dissolution)

Fig 10. Diagenetic Types of Chang-7 Member in the Southwest of Wuqi Oilfield

c. **Clay Mineral Cementation**

The clay mineral cementation in the study area mainly includes chlorite, illite, and a small amount of kaolinite. These cements are often present as pore fillings between pore-throats, hindering the pore connectivity, reducing the seepage capacity, and having different degrees of adverse effects on the reservoir physical properties.

1) Chlorite

Chlorite cementation in the study area mainly exists in two forms: one is film cementation, which covers the particle surface. This form can effectively slow down the damage of compaction to the particles, maintain the stability of the pore structure, and is conducive to the preservation of the pore structure (Figure 10f); the other is filling in the pores in the form of cement, which limits the fluid migration and has an adverse effect on the physical properties.

2) **Illite**

It has a certain diagenetic indicative significance. Illite is often filled in the pore space in the form of cement, blocking the reservoir pore-throat system, thus weakening the seepage performance of the reservoir and having a negative impact on the physical properties (Figure 10g).

3) Kaolinite

Kaolinite cementation plays a complex dual role in the reservoir. On the one hand, it helps to retain part of the pores by reducing the impact of compaction on the particle structure, alleviating the loss caused by compaction; on the other hand, when kaolinite fills the pores as cement, it significantly hinders the pore connectivity, thus greatly reducing the permeability of the reservoir and causing obvious damage to the reservoir physical properties (Figure 10h).

4.3.3. Dissolution

Dissolution is mainly manifested as the dissolution of cements and unstable particle components in the pores by acidic fluids, thereby optimizing the reservoir physical properties. The most typical dissolution in the study area is the dissolution of feldspar (Figure 10i). The acidic substances selectively dissolve the feldspar components cemented inside the particles, forming feldspar dissolution pores, which effectively improve the porosity and permeability of the reservoir.

5. Conclusion

(1) The lithology of the Chang-7 member reservoir in the southwest of Wuqi Oilfield is mainly arkose sandstone. The main pore types include intergranular pores, feldspar dissolution pores, and lithic dissolution pores, accompanied by a small number of microfractures. Through the correlation analysis between pore-throat structure parameters and physical properties, the reservoir is divided into four types, showing that the physical properties deteriorate gradually from Type Ⅰ to Type Ⅳ, reflecting that the reservoir quality is obviously controlled by diagenesis.

(2) Tectonic uplift and denudation is the most critical acquired factor for improving the physical properties of the tight reservoir of the Chang-7 member in the study area. Although the early compaction and cementation caused extreme densification of the reservoir, the late tectonic uplift effectively curbed the continued decline of porosity and restored it to a certain extent through elastic rebound and pressure reduction expansion mechanisms, providing the necessary reservoir space for oil and gas accumulation. Pressure dissolution is one of the core factors leading to its current low porosity and low permeability characteristics. The suture contact and concave-convex contact between quartz particles and the developed quartz overgrowth are commonly seen under the microscope.

(3) Sedimentation, diagenesis, and tectonism jointly control the final quality of the Chang-7 reservoir. Sedimentary facies zones are the basis, determining the original physical properties and distribution pattern of the sand bodies; diagenesis is the key, whose strong destructive effects tend to densify the reservoir, while constructive dissolution locally improves the pores; tectonic uplift is an important acquired improvement factor, which partially reverses the densification trend caused by early diagenesis through physical expansion, and finally determines the current physical property pattern of the reservoir. Therefore, finding areas with developed sedimentary sand bodies, strong dissolution, and obvious tectonic uplift is the key to predicting the "sweet spots" of high-quality reservoirs.

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