Reservoir Heterogeneity Study of Chang 7 Formation in an 83 Block

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Abstract. The Chang 7 Formation of An 83 Block is typical tight reservoir, it is important for law of oil production and distribution of oil and water to study reservoir heterogeneity. Based on analysis of sedimentary characteristics of the study area, the foundation petrography and pore throat characteristics, the heterogeneity of reservoir has been discussed according to the core data and logs fruit. Results have shown that: the heterogeneity of reservoir layers behave as "homogeneous whole, local heterogeneity". The larger reservoir heterogeneity differences in the vertical direction. In the plane, the reservoir have a good continuity along the river, but is poor continuity vertically.

Keywords: An 83 Block; Chang 7 reservoir; tight reservoir; heterogeneity.

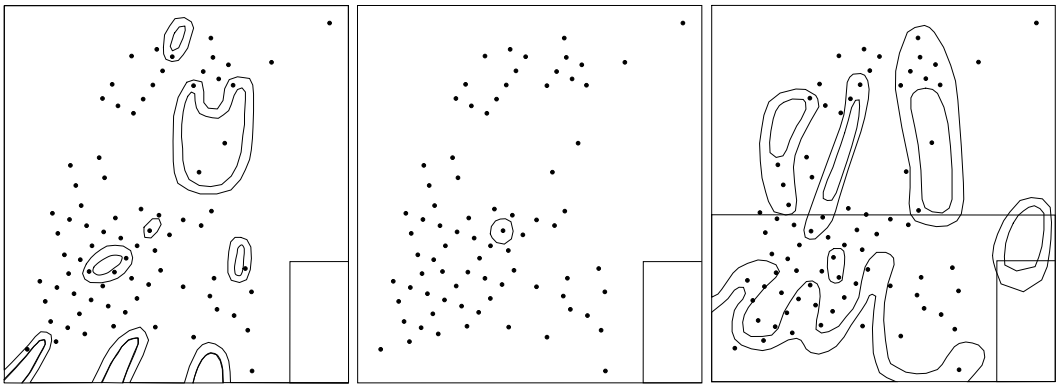
1. Introduction

Anbian of the Ordos Basin area is typical of tight reservoirs. The permeability of Chang 7 Formation of An 83 Block is very low, generally less than 0.1 ~ 0.2 × 10-3um2, which should be classified as the typical tight reservoir. On the structure, this area belongs to the southwestern tip of North Shaanxi Slope, Chang 7 was the largest expansion of the lake, and the lake water was obviously deepened, developed dark gray as well as dark gray shale and oil shale, forming a rich source of oil, where is the important distribution sector of source rocks of the raw. Currently, well production in the region was low, and the production decline was quickly. The reservoir heterogeneity study has important implications to ascertain the yield variation and distribution of oil and water relationship of the region, but also to further guide the rational development of oil fields.

2. Reservoir Characteristics

2.1 Reservoir sedimentary characteristics

Chang 7 sand groups of An 83 of Anbian area are delta front sub-facies sedimentary, which can be subdivided into three micro-facies including the underwater distributary channel, underwater distributary channel flanks and underwater distributary inter-channel. Ficture1 showed the distribution of sedimentary micro-facies from different layers, where mainly developed the underwater distributary channel sand, following by which was underwater distributary channel flanks sand, and the development of underwater distributary inter-channel sand was least, with mainly thin layers. The analysis results of coring and logging curves showed that: the sediment source of Chang 7 is the North-East; it can be further subdivided into Chang 71, Chang 72, and Chang 73, according to the lithology changes, in which Chang 72 small layer is the most developed body; Chang 71 small layer mainly developed underwater distributary channel sand bodies, controlling by the source direction; Chang 72 mainly developed underwater distributary channel sand, the thickness of which is greater; Chang 73 mainly developed underwater distributary channel sand, the distribution of which was the North East - SW direction as strips (Fig. 1).



(Chang 7_1) (Chang 7_2) (Chang 7_3)

Fig.1 The sedimentary micro-facies distribution of Chang 7 of An 83 block

2.2 The Petro physical Characteristics

Chang 7 formation of An 83 area mainly developed lithic Feld spathic fine sandstone. Among the detrital components, the quartz accounted for 17.5% ~ 40.5%, feldspar accounted for 52.5% ~ 24%, lithic accounted for 2% to 17.5%. Heteroaryl-based is mainly composed by mud, which may also include small amounts of fine sand, and whose content is generally 1 to 5%. Some of cements are developed with the same time of generating sediments, but most are developed at the period of digenesis and the subsequent sediments generated. There are many types of sediments, the content of which is higher, with an average of 14.1%.

2.3 Characteristics of Pore Throat

Pores have a closely relationship with hydrocarbon migration and accumulation, controlling the reservoir heterogeneity. The main reservoir pore types of Chang 7 formation of An 83 area are intergranular pores, feldspar dissolved pores and debris dissolved pores, part of which can be seen intercrystal pores, micro cracks and so on. Among them, feldspar dissolved pores and debris dissolved pores of intragranular corrosion pore are the main types, intergranular pores are less than those, and intercrystal pores as well as micro cracks are the least. Types of throat are main developing punctate throat and flaky throat. Whose connectivity is poor, as well as coordination number of throat is low. The average radius of throat is about 0.6μm, and the average radius of pores is about 56μm, so the combination of reservoir pores and throats is partial small. The value of reservoir displacement pressure and median pressure are partial high, the value of median radius is partial small, the sorting is better, median and rough throats are generally not development, and the combination of pore structure belongs to small pores with fine throats(Table 1).

Table 1 the mercury parameters of Chang 7 reservoir of An 83 block

position	wells	numbers of samples (piece)	XP	SK	CS	CC	displacement pressure (MPa)	median pressure (MPa)	the maximum saturation of intake mercury (%)	the efficiency of retire mercury (%)	median radius
Chang7_1	4	4	12.76	1.04	1.58	0.13	1.92	19.32	67.99	26.96	0.06
Chang7_2	13	13	12.98	-0.39	1.28	0.1	2.94	19.13	65.7	26.82	0.07
Chang7	17		12.87	0.33	1.43	0.12	2.43	19.23	66.85	26.89	0.06

3. The Interlamination Heterogeneity of Reservoir

The heterogeneity of layers within reservoir refers to the changes of reservoir properties in the vertical, having an important impact on the effect of water flooding and the distribution of remaining oil on the development of reservoir, but also being inner causes of conflicts between layers. The heterogeneity of layers within reservoir can be analyzed from the process of deposition and diagenetic,

or can be characterization by particle size, permeability and the other rhythms of the reservoir properties in vertical.

Generally, the variation of debris size in the single sand layer shows a certain rhythmic. The existence of rhythm is related to the strength of hydrodynamic during the process of sedimentary and the distribution of deposition. Through analyzing the core observed data and logging curves of Chang 7 reservoir groups, the patterns of rhythm commonly include positive rhythms, counter-rhythms, and complex rhythms, wherepositive rhythms are more common seen (shown as Fig. 2).

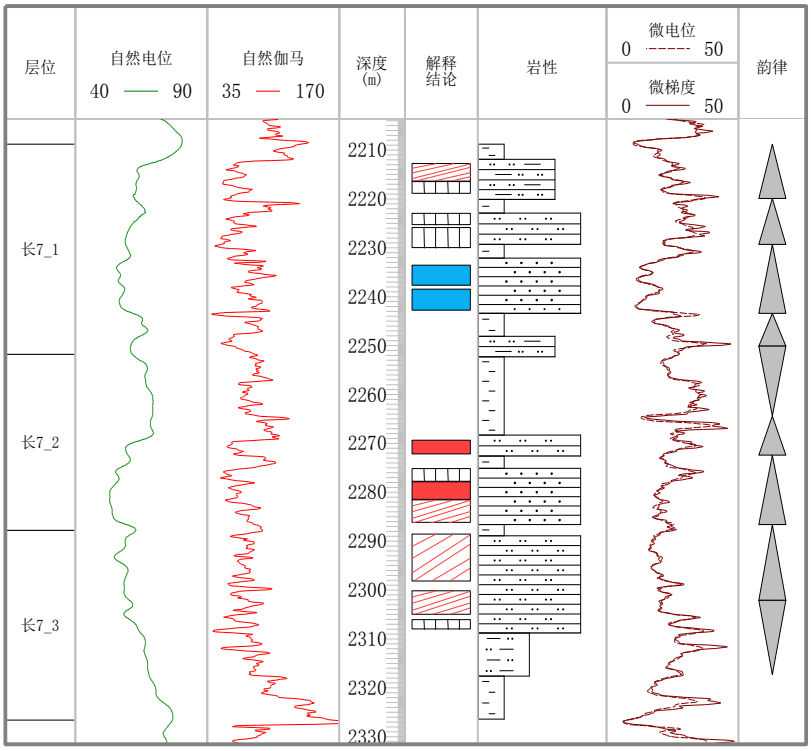


Fig. 2 The reservoir rhythm distribution of An229-42 well of Chang 7

Integrated using the analysis of drilling data, coring data logging data, Chang 7 reservoir groups of An 83 area mainly distribute muddy intercalation. The statistics of the intraformational beds of Chang 7 reservoir shows that: the intraformational beds are not developed, with an average of 1.11, the distribution frequency of which is 0.10/m, and the density is about 9%, intraformational homogeneity is better. The intraformational beds of main layer Chang 722 is more developed than the other layers, but because of its greater thickness, the smaller the average interlayer frequency, thereby, the impact of interlayer on the heterogeneity of reservoir is less. From the plane view, the interlayer barrier is mainly developed between the river subject and the underwater river diversion.

The statistics data of coefficient of variation, onrush coefficient, permeability contrast of Chang 7 reservoir of An 83 area are shown in Table 2. The heterogeneity of Chang 7 reservoir with these statistics is conducted comprehensive evaluation shows: the heterogeneity of reservoir is better overall, belonging to homogeneous - medium heterogeneous reservoirs. In contrast, due to the development of interlayer in Chang 72, the heterogeneity is slightly stronger, but it still belongs to heterogeneous reservoir. From the distribution of the heterogeneity parameters of each layer, the layers basically reflecting the reservoir is of "heterogeneity", that in the homogeneous background, there is still existing individual stronger heterogeneity area.

Table 2 the heterogeneity of interlayer permeability of Chang 7 reservoir

position	coefficient of variation		onrush coefficient		permeability contrast	
	average	maximum	average	maximum	average	maximum

Chang 7_1	0.07	1.31	0.58	2.85	1.88	74.0
Chang 7_2	0.23	1.93	0.94	5.73	3.78	97.0
Chang 7_3	0.18	1.08	0.86	2.52	3.06	76.0
average	0.17	1.93	0.83	5.73	3.09	97.0

4. The In Layer Heterogeneity of Reservoir

As Chang 7 reservoir of An 83 area developed delta front intrafacies, and mainly developed underwater distributary channel; due to changes in hydrodynamic conditions at two sides of underwater distributary channel, easily developed sheet sand and other micro-phases; because of water power of deposition channel became smaller from medium channel to two sides, reservoir properties became worse from center to two sides, resulting in heterogeneity. The changes frequently of underwater distributary channel in longitudinal was so fast, river and depression alternating, so that the radius of sedimentary particles in vertical constantly alternating and evolution, resulting in layer heterogeneity. Due to the impact of depositional environment, the vertical heterogeneity of reservoir serious, the in layer heterogeneity of reservoir can be quantitatively characterized through stratification factors and sand density.

Stratification factor is defined as the number of reservoir sands contained within a reservoir, the ratio of the total number of layers that wells drilled through to the total number of wells in the study area is available to represent. The size of stratification factor reflects the severity of reservoir heterogeneity, the larger the stratification factor and the smaller the reservoir layer, the poorer the exploitation. The stratification factor of Chang 72 reservoir groups of An 83 area is largest, 5.61; Chang 71 followed by that, 4.46; Chang 73 is least, 3.11.

Barrier refers to the non-permeability layers those distribute between two sands, having good plane continuity, and a large distribution range, such as mudstone, shale and so on. Studies showed that the main barrier were mud rocks, the developmental situation of Chang 7 reservoir barrier was shown in Figure 3. Barrier was more developed in the study area, with an average thickness greater than 10m.The barrier had a good role of separating. Since the control of the hydrodynamic conditions of river, barrier performed a law of becoming thicker from center to two sides of the river.

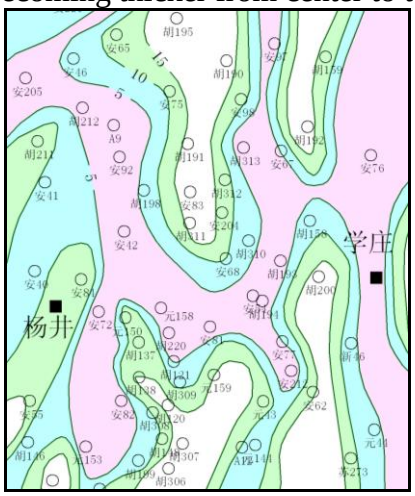


Fig. 3 The distribution of reservoir barrier

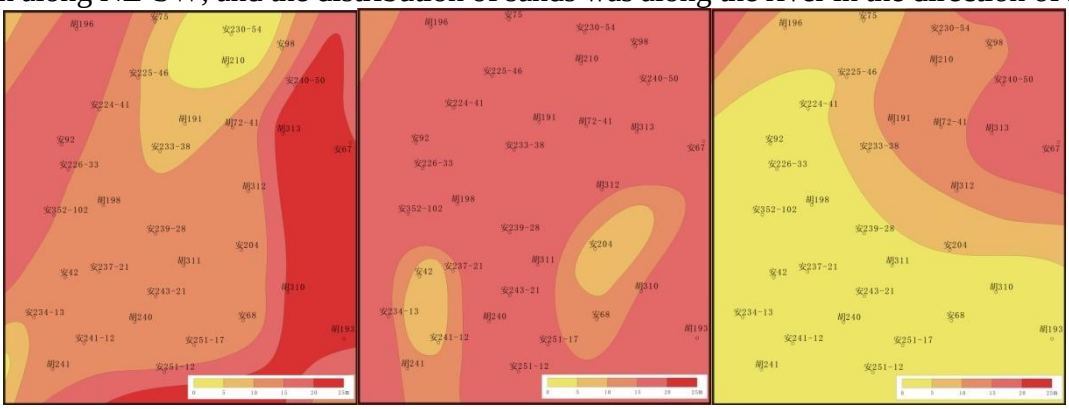
5. The Heterogeneity of Reservoir Plane

The heterogeneity of plane mainly refers to the degree of change in the physical properties of sand on a flat surface, which can be characterized through the geometry of sands, the degree of change in continuity and physical properties. The heterogeneity of plane has a greater impact on reservoir

development, which to a certain extent controls the types of development wells and the distribution of remaining oil. Chang 7 reservoir of An 83 is delta front - semi-deep lake sediments, the heterogeneity of which has the following characteristics:

5.1 The Geometry of Sands

Chang 7 reservoir of An 83 is delta front - semi-deep lake sediments, the geometry of sands is banded on plane, the sands of underwater distributary channel on profile are mostly having a lens body of a thick middle and thin wings, a flat top and convex bottom, as well as asymmetrical sides (Figure 4). The analysis of reservoir source showed that the source direction of Chang 7 reservoir was extension along NE-SW, and the distribution of sands was along the river in the direction of NE-SW.



(Chang 7_1) (Chang 7_2) (Chang 7_3)

Fig. 4 The distribution of sands of Chang 7 reservoir

5.2 The Continuity and Connection of Sands

The continuity of sands is used to describe the development size of sands on the plane, reflecting the geometry of sand bodies, generally characterized by drilling rates. Drilling rates indicates the degree of well network controlling on the sands, namely the percentage of the number of sands that wells drilled through to the total number of wells. The connection factor of sands is the ratio of the average thickness of every layer to the total number of wells in study area, which is used to reflecting the thickness changes of sands on vertical. The greater the connection factor, indicating the smaller the thickness changes, the more uniform the distribution of the plane, the lower the frequency of pitchout, the greater the likelihood of connectivity. The development degree of sands in every layer was shown as Table 3, which shows: the sands scale of Chang 71 is small, and the drilling rates are low; the lateral continuity of sands of Chang 72 is better, and the drilling rates are higher.

Table 3 the sand connection of every layer in study area

position	the average thickness of sands (m)	the number of wells drilled	the total number of wells	drilling rates (%)	the connection factor
Chang71	3.27	209	294	71	0.516
Chang72	3.32	232	294	79	0.603
Chang73	3.07	182	294	62	0.419

6. Conclusions

Chang 7 of An 83 area belongs to delta front - semi-deep lake deposition, the deposition is controlled by the source of North East, and its distribution characteristics are controlled by the distribution of channel sand bodies, mainly developing lithic, Feld spathic and fine sandstone, the structure combinations of pores are fine holes throat. The heterogeneity of layers within the reservoir expressed as “homogeneous whole, local stronger heterogeneity”; due to changes in hydrodynamic conditions during deposition, vertical barrier is developed, having strong heterogeneity; the homogeneity of reservoir plane along the direction of the source is good, while the heterogeneity of reservoir vertical along the direction of the source is strong.

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