

Characteristics of the Permian Reservoirs From Taiyuan Formation in Shenmu Gas Field

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Abstract- The petrographic, physical and pore throat characteristics and heterogeneity of the reservoirs from the Taiyuan Formation in the Shenmu gas field, comprehensive application mainly on core observation, cast section, scanning electronic microscope, grain-size analysis and mercury-injection curves. There are the lithic quartz-sandstone, quartz sandstone, and lithic sandstones with high compositional maturity and medium textural maturity. The reservoir has low porosity and low permeability. The average porosity is 7.8% and the average permeability is $0.64 \times 10^{-3} \mu\text{m}^2$. The pore space of the reservoir mainly includes the secondary dissolved pores between grains, and rock fragment-dissolution pores plays a vital role in dissolved pores. The main factors influencing the reservoir capacity include sedimentary environments and diagenesis. Sedimentary environment is the root cause of poor reservoir property, peat diagenesis and cementation are responsible for poor physical properties of the reservoirs, and dissolution led to the modification of the reservoirs.

Keywords- characteristics of the reservoirs; controlling factor; reservoirs assessment

I. INTRODUCTION

Ordos Basin is the second largest sedimentary basin in China, where abundant reserves of oil, gas and coal have been discovered and it has become China's largest natural gas production area with increasing oil and gas production in many parts of the basin. As a craton basin developed on the base of North China block, the Ordos Basin is characterized by its very stable structural setting. Shenmu gas field at the northeast of Yishaan slope in Ordos basin, on the west side near Yulin gas field (Fig.1). In sedimentary research, Lan Chao-li et al [1,2] study Taiyuan formation sedimentary characteristics, think of Taiyuan formation is tide-dominated delta and tidal flat sedimentary, and provides a wealth of core analysis data, the main reservoir is underwater distributary channel, with low porosity and permeability, the shape of sand complex, great thickness variations, strong heterogeneity. Research on reservoir characteristics is basis of oil and gas development, reasonable classification of reservoir is the basis for quantitative evaluation of reservoir [3,4,5]. Therefore, study on the comprehensive evaluation of Taiyuan formation has become a core issue in Shenmu gas field development.

II. PETROLOGIC CHARACTERISTICS OF RESERVOIR

A. Physical Property of Reservoir

Through the statistical of conventional petrophysical data, the distribution of porosity in study area range from 4% to 10%, the average of porosity is 7.8%; and also the distribution of permeability range from 0.01mD to 1.0mD, the average of permeability is 0.64mD. According to oil industry standard [6], the reservoir of study area has characteristic with low porosity and low permeability.

B. Pore Structure of Reservoir

According to the statistics of casting thin sections, the pore type of study area is primary secondary pore, consisting of dissolving pores in the volcanic detritus and feldspathic sandstone (Fig.1). The average of facial porosity is 3.41% in Taiyuan formation reservoir, and the facial porosity of secondary pore is 3.35%, the facial porosity of primary pores is 0.06%, the facial porosity of microfissure pores is 0.01%. Compared with other reservoir of upper palaeozoic in ordos basin, the space of sandstone reservoir in study area more dependent to secondary to porosity, thus dissolution controlled the reservoir space formed and evolved in study area during rock-forming process.

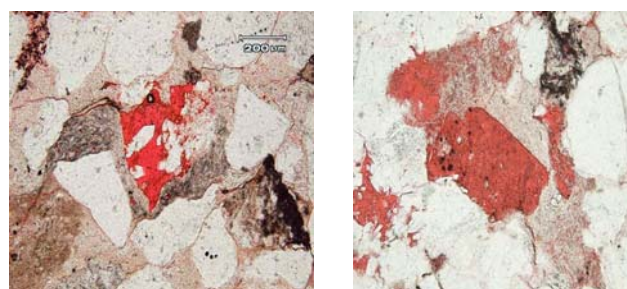


FIGURE 1. POROSITY TYPES OF THE RESERVOIR SANDSTONES IN THE SHENMU GAS FIELD.

Pore structure is mainly composed of pore and throat, throat for connecting two narrow channel, affecting the permeability of reservoir. Size and shape of throat are mainly depend on contact among grains, the cemented type, size and shape of grains [1]. The compaction of study is strong, there are the necking throat, the laminated throat, the curved lamellar throat, and the control shape throat, dominated by the curved lamellar throat and the control shape throat (Fig.2). According to statistics of mercury injection parameters in all

layers of sandstone, the displacement pressure of reservoir range from 0.12MPa to 6.00MPa, average of displacement pressure is 0.85MPa, median pressure range from 0.94MPa to 38.56MPa, average median pressure is 7.75MPa, reflecting that the permeability of reservoir is poor. Median radius of throat range between 0.02 μ m with 0.78 μ m, the mean value is 0.21 μ m, and they are mainly distributed between 0.1 μ m and 0.3 μ m, reflecting that throat radius is generally small. The maximum mercury saturation is higher, it's between 52.9% to 94.6%, the mean value is 77.51%; the efficiency of mercury withdrawal is low, it is mainly between 18% and 50%, the mean value is 39.08%, reflecting that the pore is macropore, throat radius is small, connectivity between pore and throat is poor. Based on the previous classification standard [1], the pore throat texture belong to small pore and micro throat type; the platform of mercury injection curve is not obvious, the sorting of pore throat is poor, it's extra permeability mercury injection curves(Fig.3).

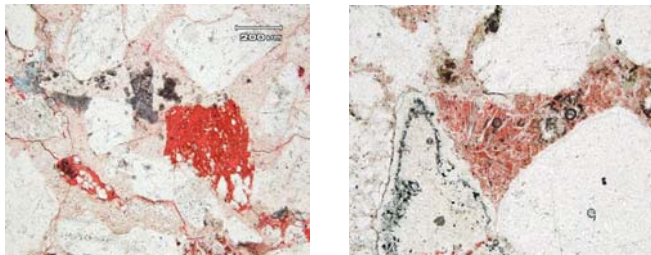


FIGURE II. PORE THROAT TYPES OF THE RESERVOIR SANDSTONES IN THE SHENMU GAS FIELD.

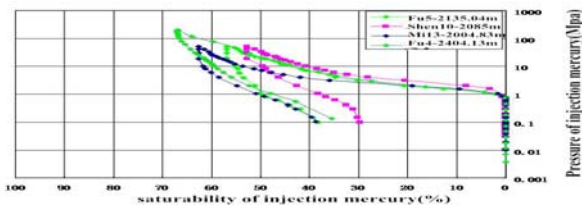


FIGURE III. CAPILLARY PRESSURE CURVES IN THE SHENMU GAS FIELD.

III. THE MAIN CONTROL FACTORS OF RESERVOIR PROPERT

A. The Influence of Sedimentary Environment

Sedimentary environment is the basic geological factors affecting the reservoir physical properties, different sedimentary environment for different grain size, thus it leads to different physical property characteristic, and controlling the difference of reservoir physical property [7]. The period of Taiyuan formation are mainly delta facies of clastic-dominated deposition in study area. The grain size of sandstone is coarse grain, sorting and roundness is medium,; the average of porosity is 7.8%, the average of permeability is 0.64mD; throat types of reservoir are mainly the curved lamellar throat and the control shape throat, considering the above factors that lead to poor physical properties in the study area.

B. The Influence of Diagenesis

The sandstone reservoir in study area experienced long diagenetic process, through the casting thin sections observation by microscope and scanning electron microscope,

it shows that the main diagenetic are compaction, pressure solution, cementation, cavity filling, metasomatic alteration and dissolution. For sandstone reservoir, the most important factor of influenced diagenesis are compaction, cementation and dissolution. According to the improvement or damage on reservoir physical property for diagenesis, it can be divided into constructive and destructive diagenesis. The compaction and cementation as the main destructive diagenesis, while the solution as the main constructive diagenesis.

1. Compaction and Pressure-solution

The lithology of sandstone in study area is dense, the sandstone is mainly particle-supported, the contact between grains are mainly line contact, the cementation type is mainly porous cementation, they all show that the compaction is strong. A lot of evidence to illustrate the mentioned above, for example, plastic grains along the long axis direction of directional arrangement, so it formed directional fabric of compaction, plastic deformation of plastic particles(Fig.4-a); the fracture of quartz debris(Fig.4-b). Through the casting thin sections of sandstone in study area, pressure-solution is partial phenomenon. The contact between grains is concavo-convex contact, even it maybe stylolite structure, so a significant of primary porosity. Stylolitic structure are mainly discovered in quartz grains with clay minerals or slab-flaky phyllite debris, so they were found in the lithic quartz sandstone and lithic sandstone (Fig.4-c)

2. Cementation

Cementation is common in the reservoir of Taiyuan formation, for the study area, the main cementation are siliceous cementation, carbonate cementation and clay cementation.

(1) Siliceous cementation

SiO₂ cement is the most common cements in the study reservoir, the content of SiO₂ between 3%-10% in quartz sandstone, so it seriously affected the porosity and permeability of reservoir. SiO₂ cement has the following several kinds of output form:1)secondary concrescence of quartz edge(Fig.4-d); 2)automorphic quartz(Fig.4-e);3) SiO₂ healing cementation(Fig.4-f).

(2) Carbonate cementation

Carbonate cementation is one of the important diagenetic that reduce pore during the diagenetic process of clastic rocks, the mentioned above is common in study area, carbonate cementation are mainly ankerite and ferrocalcite, they happen after the formation of secondary pore, and they exist in the form of pore filling(Fig.4-g).

(3) Clay cementation

Through analysis by scanning electron and X-ray diffraction, it showed that the authigenic illite is mainly clay minerals, while the content of authigenic kaolinite is small. Observation of electron showed that authigenic illite mainly exist in intergranular dissolved pore and intragranular dissolved pore, especially in the intragranular dissolved pore, it moved along the pore and throat of particle surface, and they are more schistic, silk-thread and reticulation(Fig.4-h). So the

physical property is poor, they reduce the porosity and permeability of reservoir, it's more difficulty to develop tight sandstone gas [7].

strong, it could form moldic pore. Dissolution as a constructive diagenesis, while it also widespread in the study area, the formation of secondary pore has improved the physical porosity to some degree [8].

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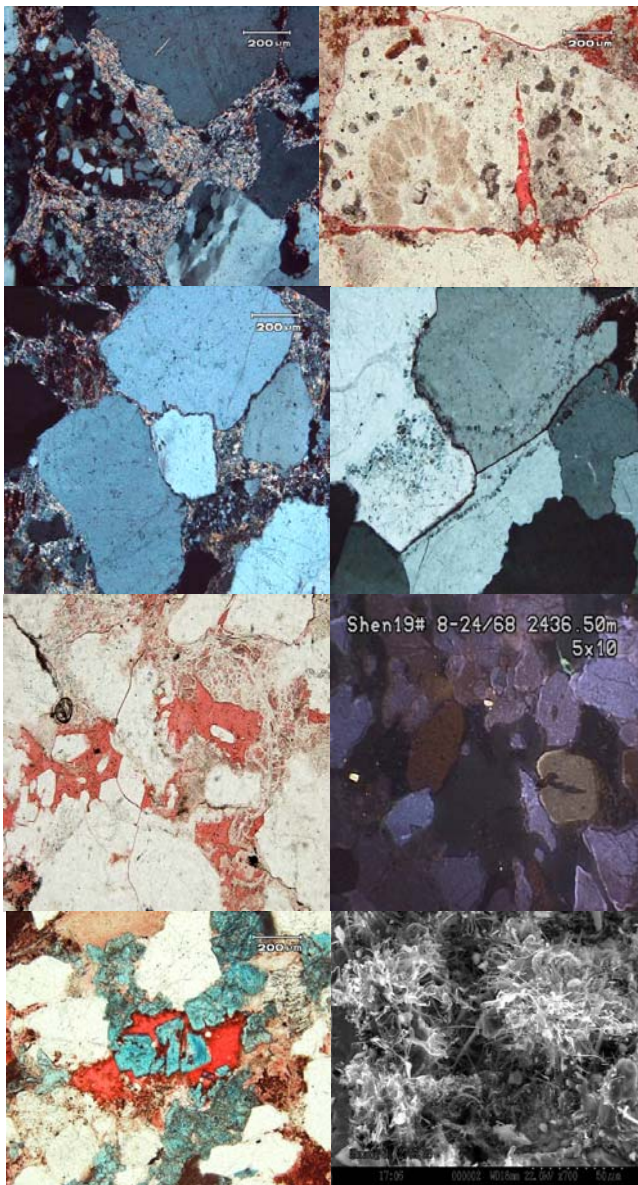


FIGURE IV. CAST SECTION AND SEM MICROPHOTOGRAPHS IN THE SHENMU GAS FIELD.

3. Dissolution

When the buried depth is more than 2200m, it will be early diagenetic, the organic matter will enter high maturation phase with the peak period of hydrocarbon generation, there are some formation water will be separated out [8], the dissolution is obvious, so it can improve the physical properties of reservoir in some degree. The type of pore is dominated by secondary pore in the study area, including dissolution of mineral particles that are feldspar, volcanic debris, clay and so on. Based on the morphology of detrital dissolution, if the pore is prismatic, so it reflect that the feldspar dissolution, followed by volcanic debris dissolution, if the dissolution is