Study on the Characteristics of Physical Property and Oil-bearing of the Es3~Z Member of Niuzhuang Sub-Sag of Shengli Oilfield

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Keywords: Niuzhuang Sub-Sag; Lithologic reservoir; Porosity; Permeability.

Abstract. The Middle Submember of Member Three of Shahejie Formation of Paleogene (Es3~Z Member) in the west of Niuzhuang Sub-sag of Shengli Oil Field is the research object of this article. In this article, the porosity and permeability of the Es3~Z Member are statistically analyzed and calculated from well sampling of 19 typical wells in the Niuzhuang Sub-sag. Then the relationship between the physical property and oil-bearing of reservoir are studied. Finally, Studies suggest: ① Secondary Interstice are the main interstice and Original Interstice develops not well. The distribution of the pore throat is uneven and partial small. So the rock porosity and permeability is not well. ②The average value of porosity is approximately 15.4%. And there is mostly middle-low porosity, some extra-low porosity and few high porosity reservoir. ③Extra-low and low permeability reservoir is the main reservoir(71.9%) and middle permeability occupy a certain proportion of 27.5%, but high-permeability reservoir are rare. The average value of permeability is 0.65-17.8×10^{-3}μm^2. ④ Lower limit of physical properties are as follow: In oil-bearing reservoir the bottom limit of porosity is 7% and permeability is 0.1×10^{-3}μm^2. While in oil reservoir and better reservoir the bottom limit of porosity is 12.5% and bottom limit of permeability is 1×10^{-3}μm^2.

Introduction

Niuzhuang Sub-sag is a secondary sub-sag of Dongying sag of Jiyang depression in Shengli Oilfield, Which locates in the southeast of Dongying depression. It is adjacent to the Wangjiagang-Chenguanzhuang fault belt of south slope of Dongying sag in the south and the central anticline of the Dongying sag in other direction. Thus formed a rhombus depositional unit which is controlled by the near EW trending faults. the relationship between formation pressure and reservoir distribution of study area(Fig. 1) was studied in detail[1,2], but the reservoir physical characteristics and oil bearing relation of Es3~Z Member has not corresponding research, seriously restrict the further oil and gas exploration. Therefore a preliminary study has been conducted on the reservoir characterization such as porosity, permeability and oil-bearing condition.

Based on drilling data analyses, the strata of study area are mainly developed the Pingyuan Formation of Qaternary, the Minghuazhen Formation and Guantao Formation of Neogene, the Shahejie, Dongying and Kongdian Formation of Paleogene. Among them, the Shahejie Formation is an important oil and gas bearing unit with massive thickness and uniform distribution. According to the feature of sedimentary cycle and lithology characteristics, Shahejie Formation is made up of its Member 1, Member 2, Member 3 and Member 4 from top to bottom, Thereinto, Member 3 can be divided into three sub-member with obvious differences[3,4]. The middle third sub-member is a set of heavy film which main part is massive grey mudstone and is mingled with micropsammite and siltstone deposition, which is delta front facies and the the main oil-bearing layers.

Therefore, it is meaningful to deeply and systematically analyze the relationship between reservoir physical characteristics and oil bearing for further oil exploration in this district.

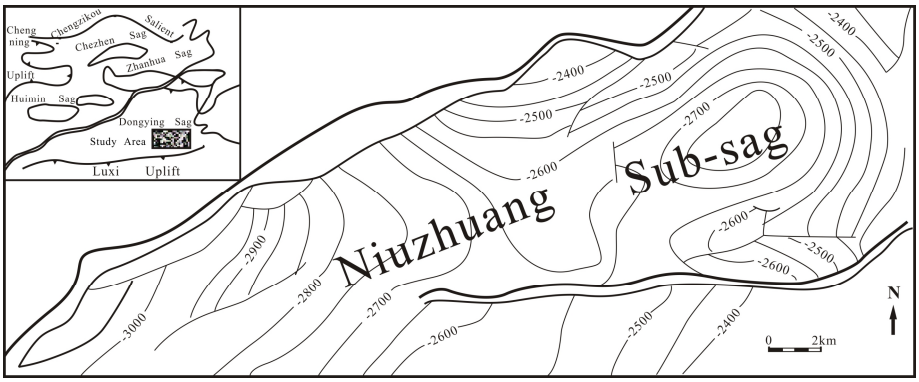


Fig.1 The location of research area

Physical properties of reservoir of Es3~Z

Pore structure and Porosity. Owing to the deep buried depth and suffering from the intense diagenesises, the turbidity sand of Es3~Z has more secondary pore and less primary pore, with the former being mainly of residual original intergranular pore and micropores in clay mineral matrix while the latter being mainly of intergranular dissolved pore, intragranular dissolve pore and microfracture resulting from comprehensive process of diagenesis and tectonics[5]. ①Intergranular dissolved pore(Fig. 2a) is formed from the dissolution of partially mudstone matrix and early carbonate cement. Most of the edges present irregularly saw-toothed or bay-like. ②Intragranular dissolve pore(Fig. 2b) is formed from feldspar, intermediate-basic debris and carbonate. Potassium feldspar come into being intragranular dissolve pore along one or two groups of crystal planes, when the particle dissolution is strong, it will manifest honeycomb or debris. ③Microfracture(Fig. 2c) has great influences on physical properties, it not only offers favorable channels for petroleum's migration,but is favorable for the migration and accumulation of oil and gas[6,7,8].

With mercury injection capillary curve and thin section, hole porosity and throats with their shapes and distributions are studied. Mercury injection data shows that pore throat structure is poor and thin throat is the main types. In generel, the shape of capillary pressure curve measured by mercury intrusion method appear as fine distortion(Fig. 3), the porosity of 1257 core samples from 19 wells in west area of Niuzhuang sag was studied in detail, it is suggested that the average porosity is around 15.4 percent; ultra-low porosity samples(17.7%), low porosity samples(23.3%), medium porosity samples (58.7%) and rare in high porosity samples (0.3%).

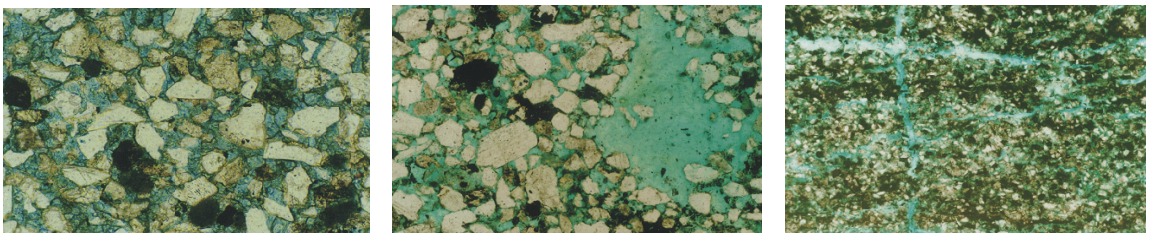
Permeability. According to classification and evaluation criteria of clastic reservoir physical property in China, the permeability of 317 core samples from 7 wells of Niuzhuang sag was studied in detail[9], it is suggested that the average permeability is 0.65~17.8×10^{-3}μm^2; ultra-low permeability samples(29.9%), low permeability samples(42.0%), medium permeability samples (27.5%) and rare in high porosity samples (0.6%). Above knowable, the reservoir characteristics of study area mainly consists of ultra-low and low permeability(71.9%) with sand bodies of bad conjunction and high heterogeneity.

Physical property and oil-bearing of reservoir

As an important part of reservoir evaluation, physical property will obviously control the oil-bearing properties of reservoirs. The relationship between physical property and oil-bearing can use porosity and permeability of the two main physical parameters to show[10].

By making statistical quantitative analysis with the core samples of oil marks from 19 wells of study area. The paper draw a sample statistical bar chart of porosity and permeability with oil marks(Fig. 4). As is shown in Fig. 4, The higher level the rock samples show, the higher the corresponding of porosity and permeability are. Among them, The porosity of fluorescence and staining level mainly focus on the range of ultra-low and low porosity, the permeability mainly focus

on the range of ultra-low and low permeability; While the samples of oil and gas have higher level, especially rich in oil samples, within the scope of ultra-low porosity and permeability.



a.Intergranular dissolved pore(×100) b.Intragranular dissolve pore(×40) c. Microfracture(×40)

Fig.2 Secondary porosity style of turbidite sandbody of middle Es3 in the Niuzhuang Sag

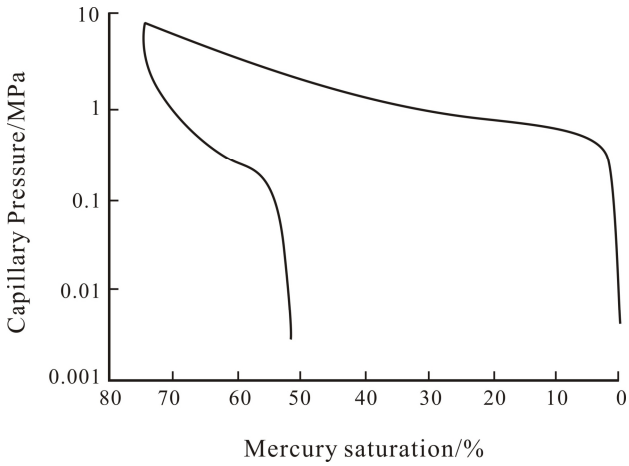


Fig.3 Characteristics of capillary pressure curves of turbidite sandbody in the Niuzhuang Sag

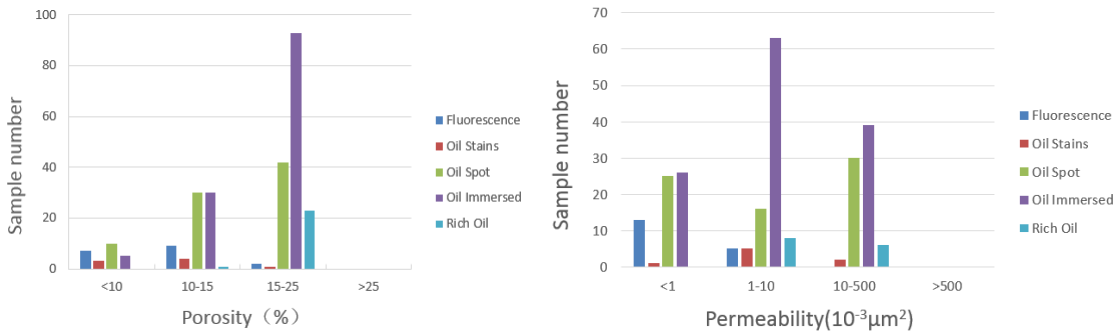


Fig.4 The bar chart of oil-bearing core samples' porosity and permeability

In a word, the physical property shows the good positive correlation with oil-bearing. That is to say that the higher the physical property of reservoir is, the better oil-bearing capacity of sand-body is. In order to achieve the oiliness of reservoir prediction and quantitative evaluation, it's necessary to define the physical property lower limit of oil-bearing grade, especially the higher oil-bearing grade[10].

The corresponding porosity and permeability values are the lower limit of reservoir physical properties when the cumulative frequency is 15%. Because the general cumulative frequency of <15%, the largest reserves lost <7%[11,12]. Due to the physical properties of Es3~Z behave strongly heterogeneity both in vertical and lateral directions, so in trying to include all of the oil and gas reservoirs with exploitation value to reduce the loss of reserves. This peper selects the cumulative frequency value of 10% as standard. The experimental data show that the lower limit of porosity of oil spot is 7% and the permeability is $0.1\times10^{-3}\mu m^2$. While the lower limit of porosity of oil-immersed and above levels of the reservoir is 12.5% and the permeability is $1\times10^{-3}\mu m^2$.

Conclusions

(1) Owing to the deep buried depth and suffering from the intense diagenesises, the turbidity sand of Es3~Z has more secondary pore and less primary pore. Mercury injection data shows that pore throat structure is poor and thin throat is the main types.

(2) the average porosity of sand of Es3~Z of Niuzhuang sag is around 15.4 percent; ultra-low porosity samples(17.7%), low porosity samples(23.3%), medium porosity samples (58.7%) and rare in high porosity samples (0.3%), The pore structure mainly consists of low-medium porosity and less high porosity.

(3)The reservoir characteristics of Es3~Z of Niuzhuang sag mainly consists of ultra-low and low permeability(71.9%) with sand bodies of bad conjunction and high heterogeneity.The average permeability is $0.65\sim17.8\times10^{-3}\mu m^2$.

(4) The experimental data show that the lower limit of porosity of oil spot is 7% and the permeability is $0.1\times10^{-3}\mu m^2$. While the lower limit of porosity of oil-immersed and above levels of the reservoir is 12.5% and the permeability is $1\times10^{-3}\mu m^2$.

Acknowledgements

Supported by the Scientific Research Foundation of Graduate School of Shandong University of Science and Technology (No.:YC150320).

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