Reservoir classification and evaluation of Yan'an formation in Xifeng Oilfield

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Abstract. According to reservoir lithology and the combination of pore throat, this paper takes porosity, permeability, pore throat diameter and displacement pressure as evaluation parameters to classify and evaluate the reservoir. Yan'an Formation reservoir in Xifeng Oilfield is divided into four types, I, II, III and IV, which correspond to four types of good, medium, poor and non reservoir respectively. From class I to class IV reservoir, the reservoir performance changes from good to bad, the porosity and permeability decrease, and the heterogeneity increases. The results of geological analysis show that the classification results are reasonable and have certain guiding significance for the exploration and development of oil and gas in the oilfield.

1. Introduction

Xifeng Oilfield is located in the joint of the Northern Shaanxi Slope and Tianhuan depression in the southwest of the Ordos Basin (Figure 1). It is located in Qingyang City, Gansu Province. It is a large self-contained low permeability reservoir with reserves of more than 100 million tons. The structure of Xifeng Oilfield is relatively simple, and it is generally a monoclone structure inclined to the west, with a gentle gradient of 5-10m per kilometer. Although there is no large structural fluctuation, there are five nose-like structures that are consistent with the region in the background of the West monoclone, with a nose axis length of 50-60 km, a width of 3-5 km, and a rise height of 3-8m. These nose-like structures play a certain role in controlling oil and gas enrichment[1].
2. classification and evaluation
Reservoir comprehensive evaluation is the comprehensive result and knowledge of reservoir research, and one of the main bases of oil and gas exploration. Correct reservoir evaluation is of great significance for oil and gas exploration. According to the analysis of lithology and grain size, medium-grained arkose is a good reservoir, fine-grained arkose is a medium reservoir, and very fine-grained arkose is a non-reservoir [2-3].

2.1 reservoir evaluation criteria
The evaluation criteria of reservoir in the study area are established by taking the physical parameters, sedimentary microfacies, cement content and grain size as the parameters of reservoir evaluation. Based on the reservoir evaluation standard, according to the existing thin section data analysis, combined with logging interpretation results, the reservoir evaluation is carried out. In the evaluation process, considering the limitations of coring section, based on the calibration of coring section, the oil layer, water layer and dry layer of logging interpretation level are combined [4].

According to the criteria of reservoir evaluation and the results of well logging interpretation, the evaluation model of sandstone reservoir in the study area can be established. Good reservoirs are developed in the upper part of underwater distributary channel or estuary bar, with shale content less than 10%, porosity greater than 15% and permeability greater than 1md. The result of logging interpretation is oil or water layer.

The middle reservoir is developed in the upper part of mouth bar, the underwater distributary channel and the middle part of the distal bar, with porosity of 10% ~ 15%, permeability of 0.1 ~ 1md, and shale content less than 15%. The result of logging interpretation is oil or water layer.
The poor reservoir is developed in sheet sand, interdistribatory bay and lower part of sand bar. The shale content is higher than 15%, porosity is 5% ~ 10%, permeability is 0.1 ~ 0.01md, and logging interpretation is mostly dry layer.

The non reservoir is mainly developed in the distributary Bay and shallow lake—semi deep lake mud area, most of which are mudstone and argillaceous siltstone, with porosity less than 5%, permeability less than 0.01md, and most of them are tight layer.

2.2 reservoir classification of Yanan Formation

Referring to the previous results of reservoir classification, combined with the characteristics of this area, as well as the research on sedimentary facies, diagenesis, pore structure type, reservoir physical properties, pore structure parameters, etc[5-6]. according to the reservoir lithology, pore throat combination relationship, porosity, permeability, pore throat diameter, displacement pressure characteristic parameters are taken as the evaluation. According to the index, the reservoir components of Yanan Formation in the work area can be divided into four categories (Table 1).

(1) Class I reservoir: it mainly consists of medium porosity and high permeability coarse throat reservoir, with general porosity greater than 15%, average throat radius of 6.03 μm, permeability greater than 10md, and general lithology of medium coarse sandstone. It mainly develops channel sandbars, branch channel deposits, with large reservoir thickness and certain production capacity. It is the upper class reservoir in this area.

(2) Class II reservoir: it is mainly composed of low porosity, low permeability and fine throat reservoir, with general porosity of 13% ~ 15%, average throat radius of 0.44 ~ 1.63 μm, permeability of 5 ~ 10md, lithology of medium fine sandstone, mainly developed branch channel and flood plain deposit, with certain thickness and production capacity, which is the medium reservoir in this area.

(3) Class III reservoir: mainly low porosity, ultra-low permeability and fine throat reservoir, with porosity of 11% ~ 13%, average throat radius of 0.22 ~ 0.41μm, permeability of 1 ~ 5md, lithology of siltstone, developed crevasse fan and river swamp deposit, thin reservoir thickness, poor reservoir in this area.

(4) Class IV reservoir: mainly low porosity, ultra-low permeability and fine throat reservoir, with porosity less than 11%, average throat radius between 0.05-0.21 μm, permeability less than 1md, lithology mainly siltstone and argillaceous siltstone, developed river swamp and lake marsh deposits, which are non effective reservoirs.

| level | Por, % | Per, mD | r₅₀, μm | C, Pₐ | Evaluation result |
|-------|--------|---------|---------|-------|------------------|
| I     | >15    | >10     | >2      | >0.3  | Good             |
| II    | 13~15  | 5~10    | 0.45~2  | 0.23~0.3 | Medium         |
| III   | 11~13  | 1~5     | 0.25~0.45 | 0.13~0.23 | poor          |
| IV    | <11    | <1      | <0.25   | <0.13 | non              |

2.3 reservoir evaluation of Yanan Formation

Evaluation of yan10 oil-bearing formation: it is mainly composed of medium and fine sandstone reservoirs. According to the above standards, it is mainly composed of class II and class III reservoirs, which are medium porosity and low permeability reservoirs. In addition, there are medium permeability reservoirs. The average thickness of sandstone is about 50m, which is in the early diagenetic stage B. the diagenesis degree is low, and the cement is calcite. If acidizing and fracturing measures are taken, the physical properties will be greatly improved[7].

Yan9 reservoir group evaluation: it mainly consists of braided river medium grained sandstone reservoir, which is of class III physical property, medium porosity and low permeability type, with an average reservoir thickness of 13.5m. It is in the early diagenetic stage B, with strong dissolution and relatively developed secondary pores in the late stage.
Yan8 reservoir group evaluation: it mainly consists of braided river medium fine sandstone reservoir, with physical properties of class III-IV, medium porosity and low permeability reservoir. The average reservoir thickness is about 10 m.

Yan7 reservoir group evaluation: it is mainly composed of braided river medium fine sandstone reservoir, with physical property of class III, medium porosity and low permeability reservoir. The average reservoir thickness is about 8m.

Yan6 reservoir group evaluation: it is mainly composed of braided river medium fine sandstone reservoir, which is of class II-III physical property. It is of medium porosity and high permeability reservoir type, with high permeability and more effective than porosity. The reservoir thickness is about 10 m. although it is of late diagenetic stage A, there is no connected crystal calcite cementation, part of it has gypsum cementation, but the distribution of gypsum is uneven, and there are still many secondary pores.

3. conclusion
According to the above standards, Yan10 reservoir group is mainly composed of class II and class III reservoirs, which are medium porosity and low permeability reservoirs. Yan9 reservoir group is mainly composed of braided river medium grained sandstone reservoir, which is of class III physical property and of medium porosity and low permeability type. Yan8 reservoir group is mainly composed of braided river medium fine sandstone reservoir, with physical properties of class III-IV, medium porosity and low permeability reservoir[8]. Yan7 reservoir group is mainly composed of braided river medium fine sandstone reservoir, which is of class III physical property, medium porosity and low permeability reservoir. Yan6 reservoir group is mainly composed of braided river medium fine sandstone reservoir, which is of class II-III physical property and of medium porosity and high permeability reservoir type.

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