Description and Understanding of Complex Fault Block Reservoir Geology

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Abstract. Reservoir description is an important step in oilfield development. Before mining, using various technical means to analyze and study oilfield structure can achieve the purpose of fully understanding the reservoir and provide theoretical basis for reservoir development. In this exploration, the background of description of complex fault block reservoir geology is analyzed, and X35 reservoir is selected as the research object to study the regional geological reservoir. By analyzing the fault distribution characteristics of X35 reservoir, the reservoir strata are divided. The three-dimensional (3D) geological model of the reservoir is established by using the method of facies-controlled modeling and numerical simulation. Finally, the 3D geological model is tested. The results show that the model has high accuracy and reflects the distribution of X35 reservoir, which has a certain guiding significance for the exploration and effective development of the remaining oil in the reservoirs distributed in this area.

Key words: reservoir description; complex fault block reservoir; 3D geological modeling; model verification.

1. Introduction
Generally speaking, the reservoir with oil-bearing area less than 1km2 and geological reserves accounting for more than 50% of the total reserves is called complex fault block reservoir [1]. The complex fault block reservoir is characterized by serious internal fault cutting, broken fault block, multiple independent reservoir development units, unclear distribution of oil-water relationship and prominent vertical upper layer contradiction [2], which leads to the difficulty of exploration and production in the later stage, and the oil and gas resources cannot be fully explored. If the geological distribution is not well understood before development, it will directly lead to the incomplete injection-production system during mining, and the recovery degree and recovery rate will be greatly restricted. Therefore, to ensure smooth production, maximize the mining value, and reduce the development cost, it is particularly important to study the reservoir description of complex fault block reservoir [3-4].

Reservoir description refers to a comprehensive description of the geological characteristics of an oil reservoir before its development, with the purpose of formulating a reasonable development measure for later reservoir development [5-6]. At present, reservoir geological description has become the main content of oil and gas development. As the core of reservoir description, three-dimensional (3D) geological modeling is the basis for further exploration of reservoir [7]. A complete reservoir model includes three parts: conceptual model, static model and prediction model [8]. The establishment of a
3D geological model is of great guiding significance to the reservoir parameters, internal structure and remaining oil prediction of complex fault block reservoirs [9].

X35 reservoir is a typical complex fault block reservoir, which is still in the initial stage of development. In this exploration, its reservoir geology is explored, and the 3D geological model of X35 reservoir is established. This model has a good guidance for the subsequent development of this reservoir.

2. Research status

2.1. Research status at home and abroad

As early as the middle of last century, Guthrie and Greenberger studied the water injection development of oilfields. They used multiple regression analysis method to carry out experiments in sandstone oilfields with partial or complete water drive, and obtained the calculation equation of recoverable reserves of water injection oilfield. Wright established the semi logarithmic linear relationship between water oil distribution ratio and oil production by studying the actual development data. Later, this water drive curve has become the basic way to predict the reserves of oil fields with water driven technology [10].

Zhang et al. studied the feasibility of water injection development in the section of Beizhongnan reservoir, aiming at the difficult development of low permeability and complex fault block reservoir. Based on the analysis of pore structure, the numerical models of pressure variation with time during oilfield production under different schemes were drawn. It was found that the water driving energy was fully utilized in the early stage of production, and the artificial nine-spot water flooding pattern was adopted in the later stage to keep the reservoir pressure at a high level. At the same time, viscosity stabilizer was used to restrain the damage of underground reservoir caused by water injection. The results show that compared with the traditional production method, the artificial water injection method has faster oil recovery rate and higher single well production [11].

In the construction of fine reservoir geological model, Chang studied the complex reservoir geology of Tankou oilfield. First, trend analysis and mini-oil layer comparison technology was used for paleogeomorphology analysis and marker bed identification; low order fault comprehensive identification technology was used to carry out regional structural mechanics analysis, and a new reservoir fault distribution model was constructed, which clearly showed the reservoir plane distribution law; finally, the remaining oil description technology was used to analyze the distribution law of remaining oil and high-yield area, and make clear the development direction of tapping potential strategy in Tankou oilfield [12].

For oil resource prediction and exploration, Ma et al. analyzed the geological conditions of Jizhong depression, explored the oil enrichment rules and predicted the oil resources in Jizhong depression. Finally, according to the geological conditions and resource potential of the area, the future exploration direction in the Jizhong depression was planned. Ma thought that it was necessary to continue to deepen the exploration work in the oil-rich depression area to ensure the continuous increase of oil reserves; at the same time, it was necessary to look for favorable areas of deep and medium shallow high-quality reserves, and take Hexi and Sicundian as the main direction of further exploration; finally, it was necessary to strengthen the prediction of surrounding storage sites and develop tight oil exploration target areas to realize resource replacement in the oil field [13].

Aiming at the problem of low modeling accuracy of complex fault block reservoir, Qiao et al. analyzed the structural reservoir of inner-sag uplift block in the Agadem block in Niger, and established a 3D structural model of oil-bearing series by well-seismic method. The model was verified by using oil-water interface and oil-gas interface model, which proved the reliability of the 3D model based on the well-seismic method. The results show that this model can well solve the problem of identifying the upper break point location in drilling, greatly improve the recovery factor of complex fault block reservoir, and also has a good guiding role in well pattern deployment and remaining oil acquisition [14].
For geological modeling, Chen et al. first analyzed the geological structure and sedimentary characteristics of a steam test area in the western depression of Liaohe basin, established sedimentary facies models of different layers, and drew sedimentary microfacies plans of different monolayers. By summarizing the sedimentary model of the target layer in the study area, 3D geological training images were made. Through comparative analysis with traditional modeling, it is found that it has better advantages in crosswell prediction [15].

Wang et al. took hundreds of development units of medium and high permeability thin oil sandstone fault block reservoirs as research objects, and divided fault block reservoirs into four types: edge and bottom water fault block reservoirs developed by natural energy development, simple fault block reservoirs with oil-bearing area greater than 0.5km² developed by water injection, complex fault block reservoirs with oil-bearing area generally 0.3-0.5km² developed by water injection, and quite complex fault block reservoirs with oil-bearing area less than 0.1km² developed by water injection. Analyzing the relationship between different reservoirs and water drive recovery can provide the decision-making basis for the exploration of fault block reservoirs [16].

2.2. Summary of research progress
At present, there are some studies on the establishment of reservoir geological model, remaining oil distribution and reserve prediction in China and foreign countries. In the complex fault block reservoir, the geological reservoir and remaining oil are numerically simulated and the exploration method is established through the analysis of porosity, permeability, recovery factor and other aspects. However, due to the diversity of complex fault block reservoir geology, the current technology is still unable to take into account all geological types, and there are still some implementation difficulties in geological modeling analysis, which will undoubtedly cause great difficulties for reservoir development.

3. Research method
X35 block reservoir is a fault block reservoir, mainly located in complex fault zone, with complex geological characteristics and relatively broken fault block, which leads to complex oil-water relationship, unclear distribution law and great difficulty in development. At present, there is no perfect 3D geological model of reservoir, so it cannot be successfully explored and developed. Combined with the previous research results and the excellent research experience in China and foreign countries, the stratigraphic and structural characteristics of X35 fault block reservoir are analyzed, and a new 3D digital model is established by using complex fault block structural modeling technology. According to the model, the corresponding development mode is proposed, and the purpose of accurate and reasonable development of reservoir is achieved.

4. Research contents and results
4.1. Data analysis and model establishment
After a long period of plate movement, X35 oil reservoir has gradually become an asymmetric anticline with gentle East-West trend, high in North and low in South. The structure of the whole area is cut into several small blocks by faults, and the differences among them are large. The number of fault blocks in the south is large and complex, and most of the blocks have a certain height difference. According to the analysis of the strata encountered in drilling at present, the reservoir strata can be divided into four strata from top to bottom: Quaternary, Tertiary, Cretaceous and Jurassic. According to the related laboratory data of the expression of region center and the original stratigraphic division, X35 reservoir is divided into 4 sandstone formations and 14 small layers. At the same time, with the reference of the formation thickness and combined with the characteristics of vertical lithologic association, the 13 small layers are further divided into 20 subdivision layers (Table 1).
Table 1. Table of X35 subdivided single sand layer

| Group | Sandstone group | Small layers | Subdivision layers | The number of the subdivision layers |
|-------|----------------|--------------|--------------------|--------------------------------------|
| S1    | S11            | S11          | 1                  |
|       | S12            | S12          | 1                  |
|       | S13            | S13          | 1                  |
| S2    | S21            | S21          | 1                  |
|       | S22            | S2^1−2, S2^2−2 | 2                  |
|       | S23            | S23          | 1                  |
| X35   | S31            | S3^1−2, S3^1−2 | 2                  |
|       | S32            | S3^2−2       | 2                  |
|       | S33            | S3^3         | 1                  |
|       | S34            | S3^4−2       | 2                  |
| S4    | S41            | S41          | 1                  |
|       | S42            | S4^1−2, S4^2−3 | 3                  |
|       | S43            | S4^3−1, S4^4−2 | 2                  |

To accurately reflect the spatial distribution of reservoir physical parameters, accurately define the spatial scope of each reservoir, and provide theoretical basis for oilfield development, it is found that X35 reservoir is affected by sand body distribution changes, and its reservoir porosity and permeability have a high correlation. The 3D geological model drawn by random simulation method is difficult to conform to the previous geological understanding. Therefore, in this exploration, facies-controlled modeling and numerical simulation are used to create 3D geological model.

Combined with fault data and top surface structure data of sandstone group, Petrel modeling software is used to model the main section of X35 reservoir by studying the elevation and small layer coordinates of each layer in X35 area. Based on the existing drilling data and fault information, the accuracy of 3D modeling data is ensured. According to the size, distribution characteristics and plane distribution of sand bodies, the lithofacies model of each single sand layer of each oil formation in X35 reservoir is established (Figure 1). This 3D model can well reflect the distribution of sand body layers on the plane, which is very important for reservoir numerical simulation in the future.

Figure 1. Lithofacies model of X35 reservoir geology

4.2. Model checking

In the process of modeling, the source of original data is different, and the models obtained by different modeling methods are also different. Therefore, in order to ensure that the 3D model can be better used for future oilfield development, probability distribution test method and well pattern dilution test method are used to test the 3D geological model of X35 reservoir.

When the probability distribution test method is used to analyze the 3D model, the reservoir parameter data of the 3D geological model is drawn. Combined with the probability distribution histogram of the original drilling data, it is found that the probability distribution of the simulation data...
is roughly consistent with the original data, which proves that the established 3D geological model has high accuracy and accurately reflects the variation law of reservoir attribute parameters.

In reality, there are 215 wells in X35 oilfield. In the exploration, 20 wells are randomly removed. By comparing the remaining wells, it is found that the new data model is basically consistent with the data before extraction, and the error of permeability and porosity is small, which proves that the modeling is reliable and has certain practical significance.

5. Conclusion

By describing the geology of X35 complex fault block reservoir, combining with data analysis of sand distribution in the whole area, the 3D geological model of reservoir is established by means of facies-controlled modeling and numerical simulation. Through the study and test of geological modeling, it is concluded that before modeling, it is necessary to fully understand the pre reservoir geology, determine the regional reservoir sand body distribution, analyze the geological stratification data and fault data, and improve the accuracy of the model; after the completion of the model, the data model should be checked to ensure the reliability. The established model represents the distribution characteristics of sand body, which is consistent with the geological characteristics of reservoir. It is proved that the model is true and reliable, and can be used in the follow-up production of X35 reservoir. Moreover, it has certain reference value for later reservoir numerical simulation, remaining oil distribution and oil-water movement law.

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