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Study on Geological Modeling of Heidimiao and Fuyang Oil Layer in Da'an North Area

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Abstract. In this paper, through the study of reservoir geological modeling, the reservoir modeling software is used to establish the reservoir 3D geological model; combined with the sedimentary microfacies research results, the reservoir sedimentary microfacies model is established; using geostatistics and stochastic simulation methods, the small layer performs stochastic modeling of porosity, permeability and oil saturation properties, and establishes a three-dimensional model of the properties under the control of reservoir sedimentary facies.

1. Fundamental

In the process of reasonable sand body phase control modeling, there should be three levels of constraints: the distribution of the skeleton sand body should conform to the geological law, that is, the characteristic parameters of the sand body should conform to the empirical characteristic parameters and the plane phase trend; the sand body interior The vertical and lateral contact relationship of the lithofacies unit is consistent with the phase sequence change; the distribution probability of the attribute parameters of each sedimentary facies unit is consistent with the hard data (well point data). In the modeling process, the sand body skeleton model should be established first, and the sedimentary facies model should be established under the constraints of the skeleton model. Finally, the attribute model is established under the constraint of the sedimentary facies model, i.e. multi-level phase control modeling. Of course, the division of formation units must follow the isochronous control principle before multi-level phase control. The influence of the change of the base surface cycle on the sediment distribution should be analyzed, instead of simple mathematical statistics. If the sediments of different time periods are used as one layer, when the unit is simulated, it may confuse the actual geological laws of different isochronous units, resulting in the model not being able to objectively reflect the geological reality. This modeling firstly uses the principle of high-resolution sequence stratigraphy to determine the isochronous interface, divides the reservoir into multiple modeling units according to the isochronous interface, and establishes the sand body skeleton model with multiple information constraints, which is strict in the sand body skeleton model. The sand body sedimentary facies model is established under constraint. Finally, the sequential indication simulation and sequential Gaussian simulation method are used to integrate the above various types of information through the variogram function, so as to establish a high-precision reservoir parameter model by sedimentary phase model.
constraints. Then the phased attribute model is used as the input data, and the multi-level phase-controlled attribute model is established on the condition of the reservoir type.

2. General steps for reservoir modeling

Reservoir modeling can generally be divided into three steps: reservoir structure modeling, sedimentary microfacies modeling, and reservoir property modeling.

2.1. Reservoir structure modeling

The structural model consists of a layer model and a fault model. The fault model responds to fault planes in three dimensions. The layer model reflects the three-dimensional distribution of the stratigraphic interface, and the superimposed layer model is the stratigraphic framework model. The reservoir description should select the appropriate scale. The fine reservoir description is to establish the reservoir geological model at the level of single layer or single sand body (or quasi-sequence or small cycle). The stratified data must be converted to the level of true altitude after the correction of the center of gravity and the correction of the well to be used for structural modeling. The two-dimensional formation interface model in the fine reservoir description is generally generated by the inverse square method. If the inter-well interpolation prediction is performed by the geostatistical Kriging method, the layer microstructure will not be reflected due to its smoothing effect. The fault model can be built using interpretation data based on seismic data. It is also possible to combine the single-layer interrupt layer polygons in the existing single-layer plan view in the vertical direction, and use them to constrain the shape and position of the fault plane at the interface interface to establish a fault plane. Different fault geometries have different characterization methods in geological models, so the amount of data required to establish different types of fault models is different. With the formation interface and fault plane, the reservoir structure model can be established according to the ground stacking method.

2.2. Sedimentary microfacies modeling

The macroscopic heterogeneity of the sedimentary facies control reservoir determines the thickness, geometry, variation law and physical properties of the reservoir. Due to the decisive role of sedimentation relative to macroscopic heterogeneity of reservoirs, phased reservoir modeling is generally used in fine reservoir descriptions. Phase-controlled modeling is more accurate than traditional one-step modeling—that is, the three-dimensional distribution model of reservoirs is established by interwell interpolation based on well reservoir parameters. The study of sedimentary facies in the stage of fine reservoir description involves not only the study of sedimentary systems, sedimentary facies, but more importantly, the study of sedimentary microfacies. The logging phase-sedimentation phase analysis is based on the analysis of the sedimentary facies of the core, and analyzes the relationship between the log shape and the sedimentary microfacies. It is necessary to first establish a reservoir structure model and a sedimentary facies model, and then according to the quantitative distribution rules of different phase reservoir parameters, phase separation for inter-well interpolation or stochastic modeling, and establish a reservoir parameter distribution model. Reservoir modeling software provides interactive phase modeling and stochastic phase simulation for sedimentary microfacies modeling.

Each deposited microphase in the model. The stochastic phase simulation technique uses the sedimentary microfacies as discrete variables and uses stochastic simulations to fit known conditions. Stochastic simulation methods for commonly used discrete variables are punctuation and truncated Gaussian simulation. According to the probability law of the point process, the punctuation process determines the spatial center position of the object distribution according to the distribution law of the geometric objects in the space, and then matches according to the geometric properties of the object and the known conditions. It is a target-based stochastic simulation technology. The truncated Gaussian simulation is a stochastic simulation technique based on phase elements. It establishes a three-dimensional distribution of type variables by establishing a series of thresholds and truncation
rules to cut off three-dimensional continuous variables. The so-called threshold value means that once the independent variable exceeds this value, it will change, even if the property changes the critical value of the independent variable. The independent variable in the modeling of sedimentary microfacies is the value of the logging curve reflecting the characteristics of the sedimentary microfacies, and the function value corresponds to a certain sedimentary microfacies. To establish a sedimentary microfacies model of a reservoir, the corresponding relationship between the well logging phase and the sedimentary facies should be analyzed based on the study of the sedimentary facies of the sedimentary system. Logging curves can be used to identify logging sedimentary facies with logging phase-deposited phase plates.

2.3. Reservoir property modeling

In order to evaluate the three-dimensional heterogeneity and hydrocarbon-bearing properties of the reservoir, a reservoir property model needs to be established. Effective thickness, porosity, permeability, and oil (water) saturation are important reservoir parameters for evaluating reservoir three-dimensional heterogeneity and hydrocarbon-bearing properties. The reservoir property model includes reservoir physical properties such as effective thickness model, porosity model and permeability model, and fluid property models such as oil (water) saturation. In the later stage of reservoir development, the well network density is large, the well spacing is small, and the uncertainty factor in the reservoir is small. Therefore, reservoir physical modeling is generally performed using deterministic reservoir modeling methods in reservoir fine description. The general reservoir property model can be generated from the log curve or from the single-layer reservoir physical parameters and oil-bearing parameters of each well.

3. Structural modeling

Construct a spatial grid of model response reservoirs. The structural model of reservoir structural modeling consists of a layer model (figure 1) and a fault model (figure 2). The fault model actually reacts to the fault plane in three dimensions. The layer model reflects the three-dimensional distribution of the stratigraphic interface, and the superimposed layer model is the stratigraphic grid model (figure 3).

The basic data of modeling is mainly stratified data, that is, the comparison data of the stratification of each well and the level data of the interpretation of seismic data. Generally, the interpolation method (which can also apply the stochastic simulation method) is applied to generate the top and bottom surface models (i.e., the layer structure model) of each isochronous layer, and then the layers of each layer are superimposed to form a grid.

It is sometimes insufficient to build reservoir models by relying solely on actual well data. Generally, in the location where the boundary and well points are sparse, the oilfield boundary areas are often the weak areas of exploration and the main direction of the next exploration. Appropriate increase of virtual wells can improve the description of the strata.
Figure 1 H23b level model of Heidimiao Temple oil layer

Figure 2 The fault model of the Heidimiao oil layer

Figure 3 H23b stratum structure model of Heidimiao oil layer

Accuracy can also enhance the credibility of the entire three-dimensional body, but the complement of the virtual well follows the general trend of the formation, but the reliability of the data is obviously much worse than the actual well. Therefore, virtual wells should not be used as much as possible, but only when the well pattern density is really insufficient.

After the initial model of the stratum is built, it should be based on the existing geological knowledge and experience, and make full use of the 2D and 3D interactive editing functions provided by the modeling software to make necessary repairs. Reservoir 3D modeling is a visualization of the reservoir geological concept model. Reliable and sufficient geological concept mode is a necessary prerequisite for modeling.

4. Create a phase model

The computer modeling of the reservoir realizes the visualization of the existing reservoir research results, and combines the qualitative research with the quantitative research to realize the numerical simulation of the reservoir and further scientificize the reservoir research. First build the phase model, and then perform phase-control physical simulation, thus providing four simulation methods, deterministic phase modeling + deterministic physical simulation (DD); deterministic phase modeling + random physical simulation (DS); random phase modeling + deterministic physical simulation (SD); random phase modeling + random physical simulation (SS). Get as many and reasonable models as possible, and the next step is to get a more accurate model. The D-S mode is introduced here. The artificial interpretation result in the sedimentary facies is deterministic. On the basis of this, the phase
model (figure 4) can be built and random simulation can be performed.

The significance of phased modeling: one is to narrow the target area, and the other is because the physical properties are highly correlated with the sedimentary facies type. Physical properties simulation for different sedimentary facies types can improve the accuracy of physical property simulation. Improve the accuracy of historical fits.

Figure 4 Sedimentary facies model of F7 small layer in Fuyu oil layer

5. Attribute modeling

On the basis of structural modeling, the top and bottom interfaces establish a three-dimensional mesh model of the geological body of a single sand layer, and calculate the physical property parameters of the reservoir in the three-dimensional mesh model for the modeling of the attribute body (Figures 5, 6). Reservoir three-dimensional attribute modeling can be divided into deterministic modeling and stochastic modeling. Deterministic modeling is the deterministic prediction of the unknown zone between wells, that is, from the control points with deterministic data (such as well points), the only reservoir parameters determined by unknown points (such as wells) are inferred. Stochastic modeling refers to the method of generating an optional, equal probability reservoir model based on known information and using a random function as a theory. Therefore, the reservoir model created by the stochastic simulation method has multiple solutions.

Figure 5 F7 small layer porosity model of Fuyu oil layer

Figure 6 Permeability model of F4 small layer in Fuyu oil layer

6. Conclusion

Based on the study of small-layer contrast and sedimentary reservoirs, the fine structure model, sedimentary facies model and fine petrophysical property model of Heidimiao oil layer, grape flower
oil layer and Fuyu oil layer were established by using Petrel software. Compared with the actual model, the model is built with high precision.

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