Geological Modeling with Petrel Software

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Abstract

Schlumberger Petrel seismic visualization interpretation system integrates geology and reservoir engineering, quickly realizes seismic data profile interpretation and three-dimensional interpretation, solid modeling, superstack processing and attribute extraction of seismic data, velocity analysis and time-deep relationship conversion, structural analysis and fault data extraction, transient attribute plane mapping, etc., and establishes seismic entity models through seismic data network resampling to predict favorable targets. In this paper, the solid geological modeling of the Junggar Basin is carried out by using Petrel software, so as to intuitively display the geological characteristics and various reservoir properties of the three-dimensional underground space in the study area, which provides the possibility for fine oil and gas description and oil and gas distribution prediction.

Subject Areas

Petroleum Geology

Keywords

Petrel Software, Geological Modeling, Three-Dimensional Interpretation

1 Regional Overview

Five oil and gas fields have been discovered in the abdomen of the Junggar Basin, Luliang, Shixi, Chenan, Mobei and Mosuo Bay, and six sets of reservoirs with the Jurassic Sangonghe Formation (J1s) and the Xishan Kiln Formation (J2x) as the main oil-bearing system and three sets of hydrocarbon source layers of the Lower Permian Fengcheng Formation, the Lower Wuerhe Formation of the Upper Permian and the Jurassic Coal System have been found, and the views of "source control theory" and "Liang aggregation theory" of oil and gas distribution were proposed [1]. In the past five years, its new proven oil and gas reserves

have accounted for 60% of the new proven reserves in the whole basin, and it has become a key area for increasing reserves and production in Xinjiang oilfield.

Basal faults and capsular faults develop in the abdominal area of the Junggar Basin, and the previous exploration and research results show that the faults and disintegration surfaces in this area are good channels for oil and gas transport. However, the fine structural characteristics of the abdominal region are limited by the data and research methods, and there are multiple solutions, and its structural characteristics and evolutionary characteristics are not well understood. Therefore, this paper will use PETREL software to model the 3D solid in the belly area of the Junggar Basin, restore the characteristics of underground faults and unintegrated surfaces, and then predict the favorable area more accurately, which provides a new basis for oil and gas exploration [2].

2. Data Entry

2.1. Seismic Data Body Input

Open the Petrel software, click on the blank space of the explorer, and select Import File. Select the location of the file, select the target file in.sgy format, select SGY-Y seismic data as the file type, and finally determine the import to successfully import the seismic data body, which is the basic condition for the establishment of geological models.

2.2. Wellhead File Input

The content of the file includes the basic information of the well, such as well name, well type, well depth, and well coordinates:

well name	well type	X	Y	Z
L1	proposed	18567589.7	6756432.5	6823
L2	proposed	19567589.7	6978521.2	6325

The import steps are: click the blank space of Software Explorer, select Import File, select the target well head file, and the import format is well head. After confirming the import, click select CRS to select the Coordinate reference system (CRS) corresponding to the target area and click OK to perform the next step of data processing, and determine the type and order of input data according to the order of the original data in the data column, the original data is visible in this step, which is convenient for users to choose the format of the imported data. After completing the above steps, the well location data is successfully imported into petrel, and you can select the well in the explorer to display the 3D distribution of the well position in the visual interface, and you can directly see the distribution of the well position (Figure 1).

2.3. Entering Data Input

Layer data includes: Inline, Corssline, X, Y, Z coordinates, and layer names.
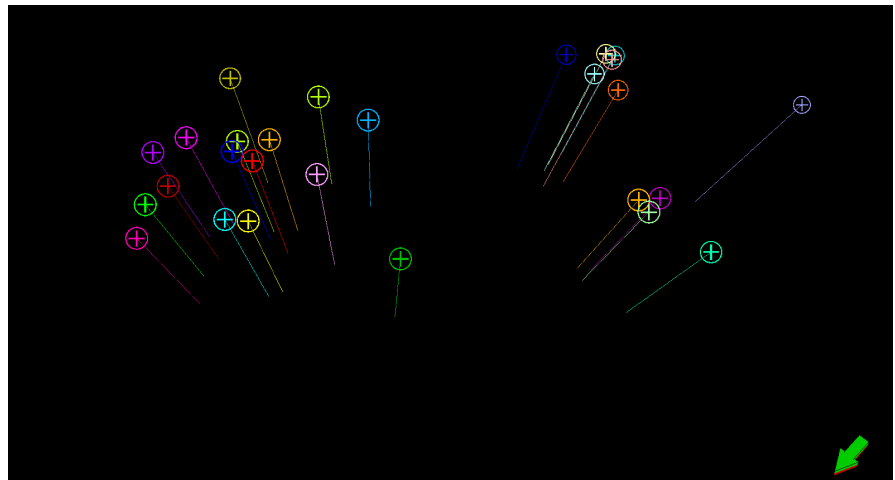
Figure 1. Three-dimensional well distribution interface in the abdomen of the Junggar Basin.

INLINE	XLINE	X	Y	Z	NAME
1010	1190	17453622.0	6258656.05	6587.252	Z1
1010	1190	17589677.38	6587429.47	6582.54	Z1
1010	1200	18587145.38	6358740.21	6957.629	Z1
1010	1200	18525256.05	6587412.05	7258.587	Z1
1010	1200	19427416.72	6587422.88	8526.36	Z1

Click on the blank area of the resource manager, select the Import File, select the target file, the file type is selected according to the original file format. The selection type of this article is Kingdom 3D Interpretation Lines (ASCII) to confirm the opening file. In the next step, select the data body and data type (time or depth) corresponding to the introduction of layer data (**Figure 2**).
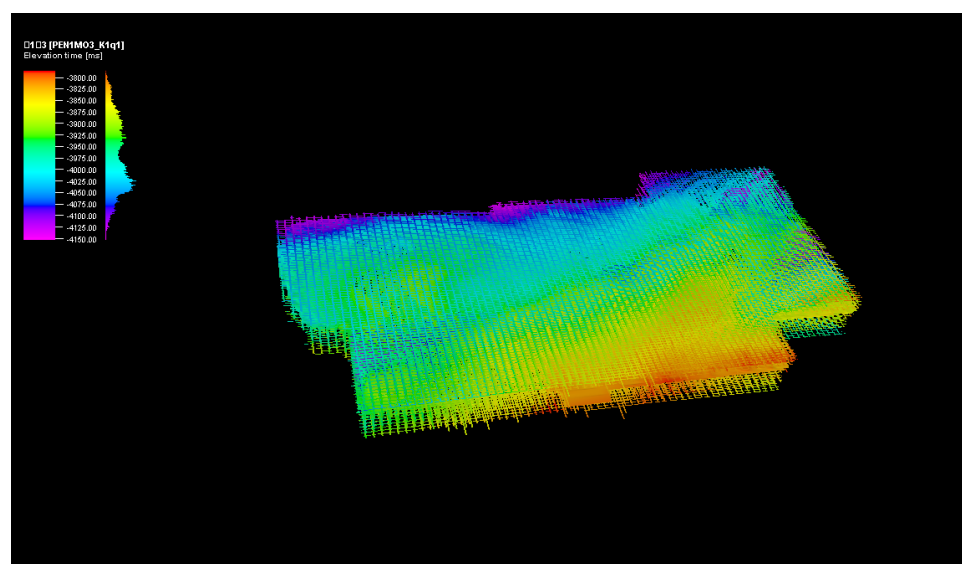

Figure 2. Data Display at the 5th region of the Basin of the Basin in the Basin of the Basin.

2.4. Introduction to Tables Data

Fault data includes: X, Y, Z coordinates, fault name, fault point and other information.

X	Y	Z	fault name	fault point
18514758.01	6355896.12	5687.580078	F1	2
18515758.01	6586859.08	5698.979981	F1	2
18514438.01	6586387.05	5236.080078	F1	2
18536758.01	6986987.05	5689.139893	F1	3
18784758.01	6356555.08	5674.350098	F1	3

Click the blank area of the PETREL resource manager, select Import File, select the target file, the file type is selected according to the original file format. The selection type of this article is Seisworks FaultSticks (ASCII), and click to open. Enter the data columns corresponding to X, Y, Z value and the corresponding data of Point Number, Name, and click OK to successfully import the broken data. In the next step, the break can be successfully displayed on the 3D visual window. As shown in Figure 3, the nature and direction of the breakthrough in the abdomen area are complex and changeable.
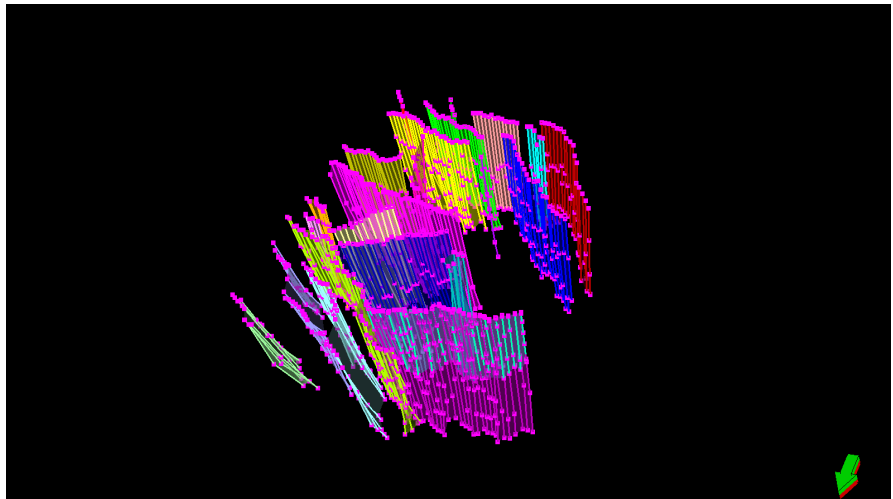
Figure 3. Three-dimensional display of fault distribution in the abdominal area of Junggar Basin.

3. Establish a Construction Model

The structural model is an important basis for 3D geological modeling, and the skeletal model of the entire 3D geological model can reflect the distribution form and distribution outline of the entire work area in 3D space. Only when the correct construction model is established can the phase model and attribute model be constructed. A construction model generally consists of two parts, namely a fault model and a plane model.

3.1. Establish a Fault Model

Fault models are generated by using Petrel to import faults according to the above steps or manually and finely interpret them based on seismic data. In the process of manual interpretation, it should be noted that open the Fault interpretation tool option of the Tool Palette tool box, and correctly activate the corresponding fault name for editing, otherwise the result of fault disorder will occur, which will affect the subsequent fault interpretation and three-dimensional fault display (Figure 4).

Figure 4. Fracture manual interpretation interface.

3.2. Layered Model

The establishment of the level model can directly import the level data into the software or manually interpret the three-dimensional seismic structure, supplemented by well-seismic combination, and use the mathematical interpolation method to generate the top and bottom surface structural maps of each layer, and then superimpose the generated top and bottom surface structural maps to finally establish a complete spatial level structural model (Figure 5).
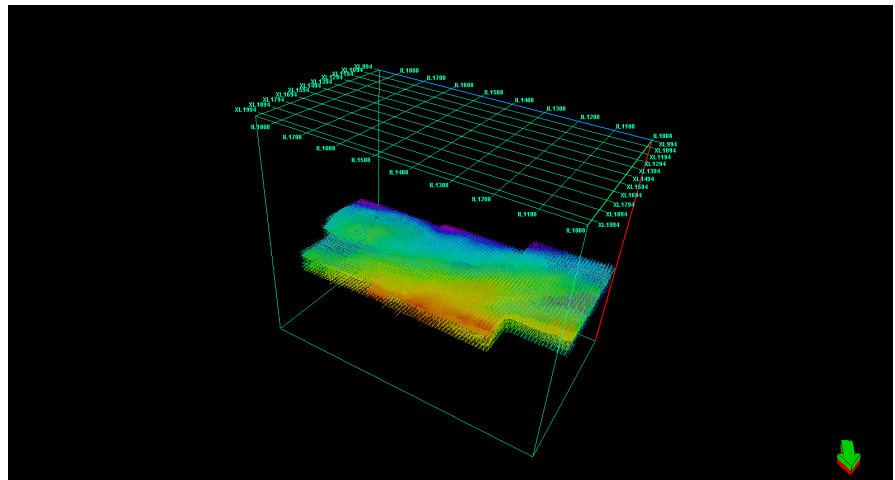
Figure 5. 3D data body and layer display interface.

4. Phase Modeling

Phase modeling means the distribution of discretized data into the entire model network, and Petrel provides several deterministic and random phase modeling techniques that characterize the phase band distribution characteristics in detail, such as indicating Chris, sequential indication simulation, truncated Gaussian simulation, neural network methods, etc., and can be used interactively. Users can accurately describe the spatial distribution of facies zones in each sedimentary period and analyze the history of sedimentary evolution [3]. Generally, the phase model of sequential indication simulation (A stochastic algorithm based on phase elements sets its own variation function and proportion for each phase, and establishes a sedimentary facies model under the constraints of the sedimentary conceptual model and the seismic attribute model) is used to calculate randomly, using the data analysis results, and adding the sedimentary facies distribution map of each layer to constrain.

5. Build Property Models

To establish the attribute model of the reservoir, each element in the 3D grid is assigned an attribute value, and the deterministic and random attribute modeling in the working area is carried out by using logging data and drilling data and trend graphs at each attribute level, and the sequential Gaussian simulation algorithm is used [4].

In the actual attribute modeling process, there are two types: phased model and earthquake control model. The phased model first establishes a sedimentary facies model, constrains porosity in the sedimentary facies model, and then constrains permeability with sedimentary facies and porosity, while the seismic control model directly constrains porosity and permeability with seismic properties [5]. Generally, the phased model is mostly used when there are many wells in the study area. In this study area, there are more well location data and complete data, so the phased model is selected for modeling.

6. Conclusion

The abdomen of the Junggar Basin mainly develops the tertiary fault, and the third-stage fault is reduced through accurate fault interpretation, and the fault system, sand body drainage layer, unintegrated surface and other elements constitute a variety of oil and gas transmission combinations, through accurate structural model, petrographic model and attribute model, a geological model in line with the actual reservoir is established, the detailed characteristics of the reservoir are finely and accurately described, and the three-dimensional visualization of the underground reservoir is realized, which provides a basis for better understanding the characteristics of the reservoir and proposing more feasible development schemes. Establishing accurate 3D geological models and accurately depicting underground faults, fractures, and sand body connectivity are the key to the numerical simulation of reservoir engineering [6].

Conflicts of Interest

The authors declare no conflicts of interest.

References

[1] Sun, T.B., Wang, L. and Chen, G.Q. (2023) The Digital Teaching Practice of "Geology of Oil and Gas Field Development" Course under the Background of Global Digitalization. *Heilongjiang Education* (*Theory and Practice*), 61-63.

[2] Jiao, G.H., Zhang, W.P., Xie, L.H., *et al.* (2023) Sedimentary System and Its Controlling Factors in the Lower Jurassic Sangonghe Formation in southern Junggar Basin. *Journal of Palaeogeography*.
http://kns.cnki.net/kcms/detail/11.4678.P.20230301.1801.002.html

[3] Zhang, G.Q. and Yu, Z.G. (2015) Establishment of Reservoir Geological Model Using Petrel Software. *Groundwater*, **37**, 208-210.

[4] Li, S.S. (2014) Application of Petrel Software in Geological Modeling. *Neijiang Science and Technology*, **35**, 58-59.

[5] Hu, S.Y., Wei, Y.J., Dong, D.Z., *et al.* (2006) Control Effect of Abdominal Fault Activity on Oil and Gas Accumulation in Junggar Basin. *Acta Petrolei Sinica*, 1-7.

[6] Chen, F., Bian, B.L., Li, X., *et al.* (2021) Transport System and Its Control on Reservoir Formation of Jurassic-Cretaceous in Hinterland of Junggar Basin. *Lithologic Reservoirs*, **33**, 46-56.