

The Study and Application of Underground 3D Modeling Based on Yelmand Gold Mining Area

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Abstract-Because of the exhaustive exploitation of the surface minerals and the shallow ones, people have to explore the minerals in the deeper layers of the earth. However, it seems always uncertain that how much storage of the minerals and where the minerals are distributed in the deep earth. Petrel software combines the strong functions of 3D modeling and numerical simulation together, which can efficiently develop and manage the study area. This paper introduced the main modeling procedure, the stages of modeling of Petrel. Furthermore, Petrel forecasted the distribution and reserves of gold mineral using facies modeling, which provided strong support for the decision of the exploration and development. As an innovation point, this paper explored the technological realization of the transplantation of the 3D model between the Petrel software and the 3DMAX software for the first time, and achieved perfect effect. At last, the Yelmand gold mining case study indicated that Petrel could quickly build tectonic model, stratum model and lithofacies model with the help of the function of stochastic facies modeling algorithm and powerful human-machine interaction in 3D modeling, which was helpful to the recognition and further extraction of the study object.

Keywords-Underground 3D modeling, Petrel, Facies modeling, Kriging algorithm, 3D model transplantation

I. INTRODUCTION

It is urgent to study the minerals of the deeper earth because of the exhaustive exploitation of the surface minerals and the shallow ones. Many countries have arranged major projects for deep earth exploration at home and abroad. Such as France's GEOSCOPE (in 1982), Australia's Glass Earth (in 1999)[1], Japan's triton plan, America's EarthScope (in 1998), China's transparent plan for underground four kilometers (in 2009), etc. Facing the problem arises, Petrel software takes full advantages of its functions of 3D modeling, which brought great benefits for the areas of the oil reservoir engineering, geology and seismology.

Petrel is a software that integrates many subjects together such as geophysics, geochemistry, geology and drill hole, etc. It is a digitally explored and developed decision-making platform which is centered on geological modeling. Its functions cover 2D visualization, 3D visualization, wells correlation, pillar gridding, creating geological datum, workflow management, fault modeling, making horizons, facies modeling, etc. It synthesizes seismic data interpretation, log analysis, comprehensive geological research, geological modeling and numerical

simulations together. Using sufficient and comprehensive analysis of data, petrel can calculate the reserves, quantitatively estimate risk, select the optimization models, design the well placement and find the rest reserves. With the help of petrel, development costs can reduce obviously.

II. OVERVIEW OF RESERCH AREA

Yelmand gold field is located in the southwest of the Pigeon Hole of Yining county, Xin Jiang province. It is beside the Yelmand River, about 700 meters long from south to north and 550 meters wide from east to west. The elevation of the ore body ranges from 1417 meters to 1812 meters. Its rocks contain tuff, tuff breccia, melting breccia, sandstone and conglomerate in the lower carboniferous of the big hara junshan group of the second lithologic section.

It has fracture structures largely, while there is rarely folded structure. The complex tectonic framework results from the overlying of the fracture structure of different times, different kinds and different scales. This fracture system contains about 5 groups of fracture, namely NNW, NW, SN, EW, NE, etc. Among them, NW and SN that is always active before mineralizing plays an controlling role in the formation of tectonic structure, which decides the generation of the rocks and ore; The fracture of NE and EW and the part fracture of NWW that cracks after mineralizing controls the preservation, buried depth, exposure and erosion of the ore body.

III. 3D MODELING DESIGNING PROCESS [9]

A. Preparation for required database

Judging from the modeling content, the types of the fundamental data can be divided into five categories [5] [8]:

1) 153 well tops data, which is used for describing the 3D geographic coordinates of the well horizons [7]; 2) 153 well deviation data, which is used for describing well trajectory information; 3) 5 horizons data, used for the stratification of the study area. Extract the main rock types which have markedly guiding significance for gold prospecting and regard these rock types as layering targets. These targets are lc (loess and collapse product layer), tuff, breccia, supported conglomerate and limestone. 4) 5 main fault zones, used for constructing the tectonic model. They are F2 reverse fault, F4 normal fault, F5 reverse fault, F7 transcurrent fault and F8 normal fault. This information is collected from geological documents without wells breakpoints' controlling and seismic interpretations. Its

arguments such as geographic coordinates, dip angle, inclination are got from vector process of geological documents. And the 3D geographic coordinate of the fault lines are calculated by Matlab software. Because of lack of wells earthquake joint materials, the faults can only qualitatively describe the fracture structure. 5) Remote sensing data, covering satellite imagery, DEM and contour lines. As the auxiliary data, it can initially check on the quality of 3D model.

B. Tectonic modeling

Tectonic modeling reflects the spatial distributive framework of reservoir stratum [4], which is made up of fault model, pillar gridding model, horizon model, etc. The type of faults can be adjusted by horizon-fault lines [9]. Pillar gridding uses regular polygon to fix study area, carry out gridding and set up faults' key pillars to control the quality of the 3D model by adjusting the wrong related key pillars. This model uses orthogonal angular point grid system. It steps out 10 meters and is divided by 146 multiplying 120 grids horizontally, while vertically it is divided by 5 horizons. The number of the total grids is up to 88935. The horizons model reflects the 3D distribute of the Yelmand gold body underground.

C. Facies modeling

Facies modeling is the key step in reservoir modeling. It provides 3D skeleton for reservoir parameter simulation. This process fully reflects the geological knowledge and thinking. Furthermore, it makes full use of geological parameters to control attribute model.

When there are no enough detailed sedimentary microfacies materials, people can use well logging interpretation results or shale content curve to calculate facies model[2][3]. In this paper, Facies modeling used sequential simulation method and Kriging algorithm [10] [11] to create facies model by inputting trend constraints under the control of the main direction of the variogram. This model adopted both of the stochastic modeling and determinable simulation modeling to generate the reservoir model.

In the condition of detailed geological materials, Petrel can predict the probably distribution of gold and estimate potential unexploited gold reserves. With these results, Petrel can guide the further exploration and development and huge human resources can be saved.

IV. MODEL TRANSPLANTATION

Though Petrel brings benefits for geophysics, geology and seismology, there is still a long way to go model transplantation between Petrel and other 3D software. This paper explored the technology realization of model transplantation between Petrel and 3DMAX for the first time and gained good result with the help of ArcGIS.

In this paper, I took the LC horizon as an example. First, Petrel exported model to notepad format; Then ArcGIS converted this format to 3D feature class and turned the feature class to raster format using built-in interpolation algorithm; Next, used built-in interpolation algorithm to turn the raster into contour lines; Added the elevation of contour

lines to the elevation field of CAD format and exported the contour lines to DWG format which 3DMAX could distinguish; Last, In 3DMAX software, the contour lines were turned to surface using its built-in interpolation algorithm.

V. SUMMARIES

A. Petrel can build fine 3D geological model for Yelmand gold body by the process of fault modeling, horizon modeling and facies modeling. The model can exactly describe the characteristic of gold distribution in an amazing speed. The establishment of fault model can be used for check the accuracy of the current fault geological data.

B. The facies model generated by actual variogram can not only play a restriction role in geology, but also describe the heterogeneity of the reservoir and reduce the uncertainties of the physical parameter. It provides powerful support for practical exploration and development.

C. This paper explored the new technological method for the model transplantation between Petrel and 3DMAX for the first time, which is a good example for the enhancement of the Petrel extendibility.

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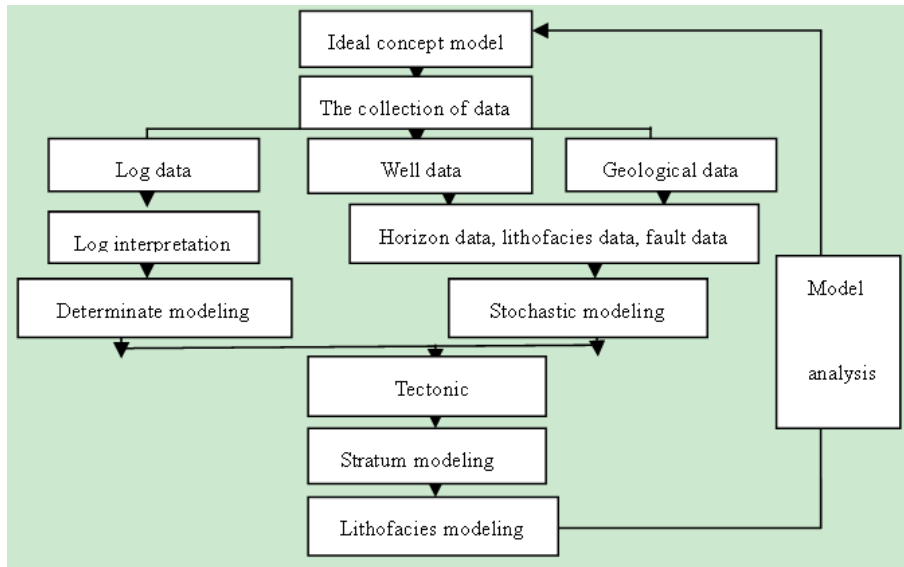


Figure 1. the flow diagram of Petrel 3D modeling

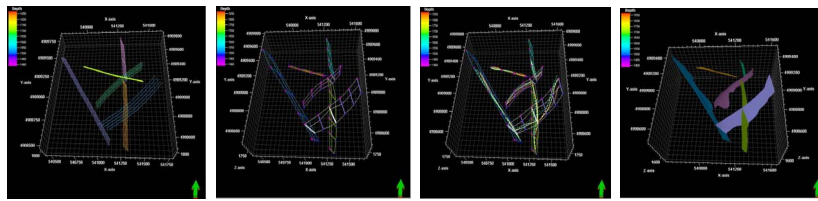


Figure 2. the build process and adjustment of fault model

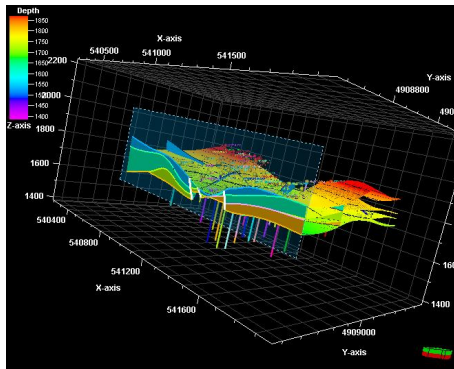


Figure 3. the vertical cutting plane of the tectonic model

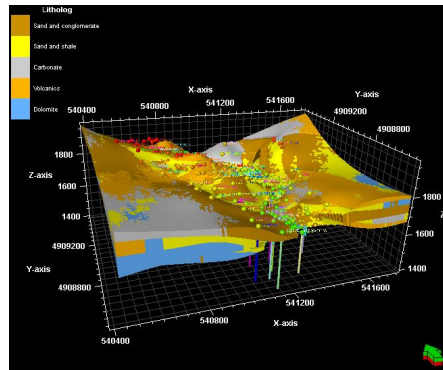


Figure 4. the facies model generated by well logging interpretation of shale content curve.



Figure 5. the model transplantation from Petrel to 3DMAX using ArcGIS