

## Application of Petrel Software in Reserve Estimation in Xinli-Xinbei Oilfield, Jilin Province, China

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**Abstract.** Volumetric estimates provide a valuable check on the estimates derived from material balance and decline analysis methods. Xinli-Xinbei oilfield, Jilin Province-China is an ascertained and developed oilfield. It is affluent in geological reserves, and has greatly development potentiality. Based on the high precision of tridimensional reservoir geological model, this study calculated the reserves of the Xinli-Xinbei oilfield by Petrel, which deal with the issue that the reserves parameters are difficult to correctly acquire when estimate complex reservoir's reserves in terms of traditional volume method. In addition, the achievement maps made by Petrel show the distribution of reserves more accurately. Consequently, the results indicated that application of Petrel in reserve estimation reflects the true nature of the reservoir more accurately and more objectively which can better be applied to oilfield development and adjustment.

### Introduction

Reserve volume is the comprehensive evaluation of oil-gas field exploration and development, as a consequence, the rationality of reserves calculation definitely affect the decision of oil field prospecting and exploitation. The reserves calculation method based on the high precision of tridimensional reservoir geological model, can be used to deal with the issues that the reserve parameters are difficult to correctly acquire when estimating complex reservoir's reserves in terms of traditional volume method. Reservoir evaluation utilizing reserves value and reserves abundance value which has been calculated before, with other related parameter provide geological basis for oil field development and adjustment.

With the rapidly development of computer, three-dimensional modeling technology of petroleum reservoir has been the prime methods of petroleum industry making reservoir description[1]. Three-dimensional geology modeling of the reservoir can reflect the characters of distribution and regularities of variation in reservoir geology space attribute. That provides geology basis for petroleum pool development[2].

Oil and gas reservoir is the ultimate accomplishment of oil and gas field exploration or exploitation. It is the essential target that the petroleum industry purposes. Reservoir assessment can be guidance to the development of an oil and gas field. It is also an important basis for determining the investment scale. Therefore, whether the appraisal results of petroleum and natural gas geological reserves are accurate is extremely important[3]. At present, the main calculation methods of reserves appraisal include: analogy method, volume method, material-balance method, water driving characteristics curve method, statistical simulation method and so on[3].

The objectives of this paper were to estimate the amount of oil and gas in place and to establish three-dimensional geological modeling for Xinli-Xinbei oilfield using seismic data and well logs data. Fig. 1 shows the geological map of Xinli-Xinbei oilfield in the Jilin Province, China.

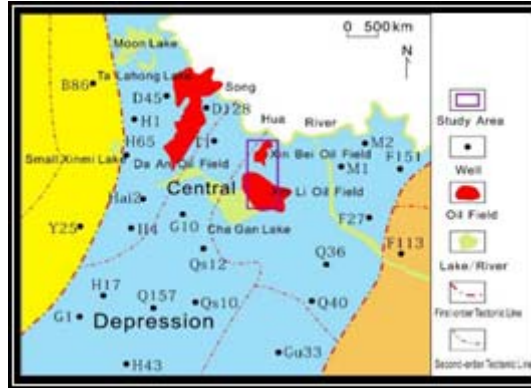


Fig. 1: Geological map of the study area

**Geologic Characteristics.** Research area located in Xinli-Xinbei in the south of Songliao basin. Tectonic location is at west of the Fuxin uplift in the central depression belt of the Songliao basin, which is a south-north anticline with fault complication. The north of the reservoir is controlled by tectonic from the horizontal scale while the south controlled by lithology. From the vertical scale the lower reservoir is controlled by lithology and the upper is controlled by structural. Consequently, the research reservoir is a lithologic-tectonic complex one. The area of research is 300 square-kilometer covers and target interval is the third member of Nenjiang of Heidimiao oil group. The facies types are delta facies and shallow lake facies.

**Attribute Model.** Lithofacies-controlled model aimed at establishing parameter models which exactly reflected porosity, permeability under the earth and the special distribution of effective reservoir [4]. Attribute model employed analysed variogram and made Prior Choice of Stochastic Modeling, using the method of sequential Gaussian simulation method which was based on collocated cokriging established Porosity model and permeability model[5,6,7].

## Methodology

Seismic data and well logs date were employed in Petrel to estimate the reservoir reserves and also to establish the 3-dimensional model for Xinli-Xinbei oilfield. The structural and attribute models were first obtained and were used in Petrel to calculate the reserves and the value compared to the reserves value using the traditional method. In order to achieve the stated objectives, the following methods were employed.

**Reserves Calculation.** The method of reserves calculation is a volumetric method in Petrel. Based on 3D geological model having a high degree of accuracy, reserves of each grid cell was calculated, followed by calculation of the accumulated grid cell. The total reserves of the whole reservoir were obtained from the Eq 1.

$$N = \sum_{k=1}^n 100Ah\phi S_{oi}\rho_o / B_{oi} \quad (1)$$

Parameters of the formula:

N ——Oil geological reserves,  $10^4$ t;

A ——oil-bearing area,  $\text{km}^2$ ;

h ——effective thickness, m;

$\phi$  ——effective porosity, f;

$S_{oi}$  ——primitive oil-bearing saturability, f;

$\rho_o$  ——oil density,  $\text{t/m}^3$ ;

$B_{oi}$  ——oil formation volume factor, non-dimensional quantity

With the calculation of reserves in Petrel, it was very important to define the associated parameters, but not merely determine the parameters of average constants. There are several differences between the method of reserves calculation in Petrel and the traditional one. The parameters used in reserves calculation module in Petrel were all based on the 3D modeling result, such as sandstone percentage, reservoir oil saturation, effective porosity, etc. The oil-bearing area

was determined by the single layer plans, oil density was defined by analysis data of crude oil and the oil formation volume factor was defined by the data of high pressure analysis. After the determination of each parameters, the reserves of Heidimiao reservoir was then calculated with the function of reserves calculation in Petrel.

**Reserves Evaluation.** After the reserves calculation, the reserves value and property were obtained by observing reserves abundance value and planning reserves abundance distribution. These reserves evaluated parameters assessed the reservoir storage. Reservoir storage evaluated parameters is the product of reservoir net pay thickness of the unit volume, average effective porosity, primitive oil bearing saturability, oil density and oil formation volume factor. This parameter explained oil reserves abundance and expressed the oil reserves in unit volume given in Eq. 2

$$rep = \sum_{k=1}^n \frac{100 \times A(i) \times he(i) \times \varnothing(i) \times S_o(i) \times \rho_o \times he(i)}{A(i) \times he(i) \times B_{oi}} \quad (2)$$

Where  $rep$  = the reserves evaluated parameter.

The meaning of other parameters is the same as Eq. 1

The reservoir storage parameters such as reservoir size, oil group size, sand group size, layer size and even single sand body size were then evaluated.

## Results and Discussion

**Reserves Calculation.** Petrel was used to establish layer scale 3D geological model of research area by seismic data and well data of Xinli-Xinbei oilfield, Jilin Province. The area of the model was 300km<sup>2</sup> and contained 9 layers with the grid precision of 25m × 20m in horizontal scale and 0.5m of the vertical scale. The total number of grids is 2 × 10<sup>8</sup>.

This high precision 3D geological model guaranteed accurate and reasonable result in subsequent reserves calculation. From the simulation result, it was observed that both porosity and permeability had high value, so the target reservoir was of high porosity and permeability.

The modeling method of research used facies-controlled principle. In the process of facies and property modeling, deterministic and stochastic modeling technology was applied and combined with the realities of research area. The high precision 3D geological model was established by well data and seismic data. Facies is the constraint of the model, when processing the property modeling and Sequential Gaussian Simulation was adopted. This simulated method was based on sequential simulation principle. In the first step, the model was scaled up to grid system. In the second step, the computer handled each grid cell sequentially, because the random variable of each grid cell followed the conditioned Gaussian distributions, so the value of each grid cell was determined by the mean value and variance. By solving Krigin equation set, both the mean value and variance of the grid cell was obtained and the normal distribution of the grid cell was determined. The sample of the cell was obtained by the use of the corresponding sample method, which was the last step.

The problems caused by fast facies change and serious heterogeneity were solved by the reservoir geological model established by this method as reasonable.

Finally distribution character of reservoir property in different facies was achieved and therefore the high precision geological model established formed the basics of the reserves calculation. Figs. 2 to 5 show the structural, facies, porosity and permeability models for the Xinli-Xinbei oilfield.

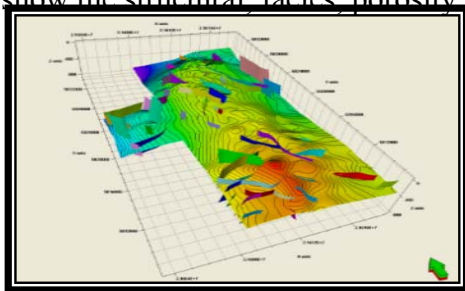


Fig. 2: Structural model of reservoir

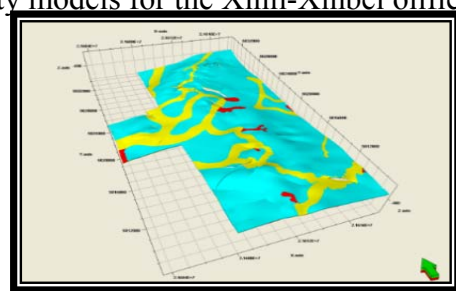


Fig. 3: Facies model of reservoir

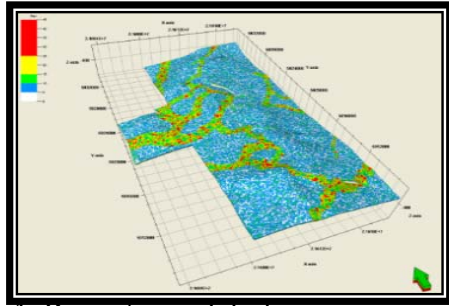


Fig. 4: Porosity model of reservoir

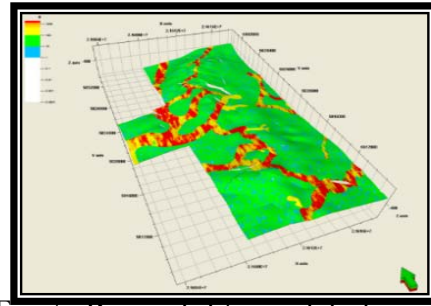


Fig. 5: Permeability model of reservoir

**Reserves Calculation.** The Volumetric method being one of the major ways by which reserves of reservoir was calculated was widely applied in different stages of exploration and development, different trap types and different reservoir types and drive modes. The reliability of the calculation results depended on the quality and quantity of data. There was high precision in calculating large and medium-sized structural sandstone reservoirs, however, results of the complex lithology oil reservoir was low in terms of accuracy. The main reason was that the geological reserves was calculated on the basis of the whole oil-field and the calculating parameters were of single average values. During the calculating process, the reservoir heterogeneity was ignored and as a result, the accuracy of the reserves was affected.

One important feature of Petrel is that it gives several possible and predicted results of the reservoir information and it is good to process uncertainty analysis of the heterogeneity of the reservoir. Based on the high precision 3D geological model, we calculated the reserves of structural-lithological reservoir and a good result was achieved.

When the property model has been established, the reserve calculated parameters were fitted in the model and reserves calculated according to Eq. 1. This process was accomplished by the module of “Volume calculation” in Petrel.

Parameters such as effective grid cell, effective porosity and oil saturation obtained from property model were set up. The primitive oil formation volume was also obtained and if the well blocks needed separate calculation, the boundary of each well blocks were imported and program run. Petrel then performed multiplication for each grid cell and reserve values of each single cell obtained. The sum of each grid cell and then the total reserve volume of the reservoir obtained. The oil density was then multiplied to the total reserve volume to estimate the reserves quality values shown in Table 1.

In order to examine the confidence level of the geological model, reserves quality value was calculated as  $1803.304 \times 10^4 \text{t}$  using the traditional method and was calculated as  $1724 \times 10^4 \text{t}$  using the Petrel. There was a difference in value of 4.6% between the traditional method and Petrel which was considered a little higher. In the analysis, it was considered that when calculating reserves in Petrel, the reservoir was subdivided into different scales on the request of the oilfield and a more reasonable parameter selected and as such the results obtained could be said to be accurate and better than the traditional method. Therefore, it was concluded that the Petrel approach was perfect, accurate and reflected the true value of reserves.

**Reservoir storage evaluation and favorable regions prediction.** When a series of reserve data had been calculated, the reserve abundance (Fig. 7) was obtained using the equations in Eq. 1 and Eq. 2. According to reserves evaluation coefficient histogram of Xinli-Xinbei (Fig. 6), reservoir reserves evaluation coefficient standard in layer scale was divided into four intervals of high, middle, low, lower.

High reserves storage interval: more than  $200 \times 10^4 \text{t}/\text{km}^2$ ;

Middle reserves storage interval:  $100 \sim 200 \times 10^4 \text{t}/\text{km}^2$ ;

Low reserves storage interval:  $50 \sim 100 \times 10^4 \text{t}/\text{km}^2$ ;

Lower reserves storage interval: less than  $50 \times 10^4 \text{t}/\text{km}^2$ .

From the reserves evaluation coefficient histogram of layer  $H_{II}^{2-1}$ , it was observed that the distribution of the evaluation coefficient was between  $0 \sim 424 \times 10^4 t/km^2$ ; the main interval was between  $48 \sim 210 \times 10^4 t/km^2$ . The distribution was nearly symmetric platykurtic and combined with reserves abundance contour analyzed that the layer  $H_{II}^{2-1}$  showed wide reserves distribution scope and continuously distributed along south to north. T had a relatively well reserves with lower reserves area about 10%, low reserves area about 20.5%, middle reserves area about 63%, and high reserves area about 14.5%. It was also observed the high reserves area were around J13-24 well block, low reserves area was around X+10-8 well block and middle reserves area was around X212 well block.

