

Prediction of sedimentary facies of x-oilfield in northwest of China by geostatistical inversion

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Abstract. In the early stage of oilfield development, there are only a few wells and well spacing can reach several kilometers. For the alluvial fans and other heterogeneous reservoirs, information from wells alone is not sufficient to derive detailed reservoir information. In this paper, the method of calculating sand thickness through geostatistics inversion is studied, and quantitative relationships between each sedimentary micro-facies are analyzed by combining with single well sedimentary facies. Further, the sedimentary facies plane distribution based on seismic inversion is obtained by combining with sedimentary model, providing the geological basis for the next exploration and deployment.

1. Introduction

The heterogeneity of alluvial fan reservoirs is strong, and it is necessary to study the sedimentary facies in the development stage of oil and gas fields^[1-5]. In recent years, a great deal of research has been done on alluvial fan reservoir, and more understanding has been made on the distribution of the configurational units and depositional characteristics of alluvial fan. Wu Shenghe (2013) discussed the inner layer division system of alluvial fan in the Lower Triassic Kelamayi oil field in Xinjiang, and established the corresponding "general connecting sand body" as the characteristics of the sedimentary configuration model. Chen et al. (2015) established the seismic identification method of alluvial fan reservoirs. Feng et al. (2015) thought that the fan-root reservoirs were mainly flow-channel systems, forming a "tree-branch" combination.

X field is located in the northwest margin of Junggar Basin. The reservoir is about 17.5km away from the Guai-5 area of the Xiaoguai Oilfield in the north and 15.8km away from the south area of the No.45 well. The administrative area is under the jurisdiction of Karamay City. Work area are mostly desert and sandbags.

The X field is a triangular fault block formed by two fractures, and the target zone(P2X3) is divided into three sand groups P2X31, P2X32 and P2X33 from the top to the bottom, and the top structural is a west-to-east dip of the monoclinic.

2. Geostatistical seismic inversion prediction

Seismic data, logging, and cores are the most important sources of information for the analysis of sedimentary facies. Although logging can provide information only near well trajectories, this information often has high resolution and accuracy. Seismic data is not as accurate as logging data and core data. However, seismic data could cover a wider area and have three-dimensional characteristics. Seismic inversion technology can make full use of information provided by logging and seismic data to predict the lithology and properties of reservoir, and which also could provide more macro-information for sedimentary facies analysis.



The constrained sparse spike inversion—CSSI could obtain the wave impedance data volume at the seismic resolution, which is faithful to the response of the seismic data, but its horizontal resolution is limited by seismic resolution. For the further geological study, when the seismic data can not meet the needs of reservoir study, it is necessary to integrate the well information and the seismic data, then realize the high predictability of fully utilizing the seismic data in the horizontal direction and fully utilize the high resolution of the well in the vertical direction.

The geostatistical seismic inversion workflow fully utilizes logging data and geostatistical data to generate high-resolution impedance models and lithology bodies, and the geostatistical inversion can also solve the problems of low seismic resolutions and have certain help to solve the lithology multiplicity of single seismic attribute superposition [6-8].

As is shown in Fig.1, the trend of geostatistics inversion and post-stack CSSI inversion is consistent, which indicates that both inversion are faithful to seismic information and the two inversion results support each other. The geostatistical inversion has a significantly higher resolution in the vertical direction, and generates a relatively reasonable impedance by means of the statistical PDF parameters, therefore, the sedimentary facies research depends mainly on the analysis results from geostatistical inversion.

The study of sedimentary facies carried out by the well distribution characteristics of reservoirs and the plane and profile of geostatistical inversion results, the warm represents the low impedance, the cool color represents the high impedance, the warm of the well profile represents the low shale content, and the cool color represents high clay content. By analyzing the characteristics of well reservoirs, the values of well impedance and the distribution of well logs are obtained, then could calculate the sand time thickness distribution (Figure 2), that lay the foundation for the study of sedimentary facies.

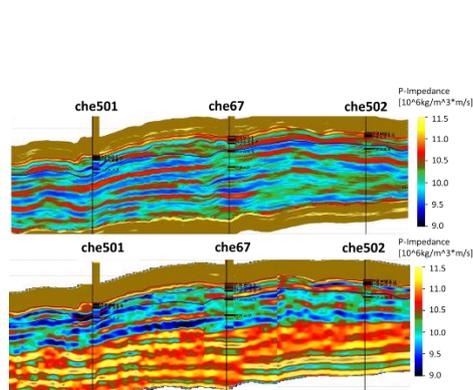


Figure 1. (Upper)Geostatistical inversion profile
 (Lower)poststack acoustic impedance inversion(Lower)

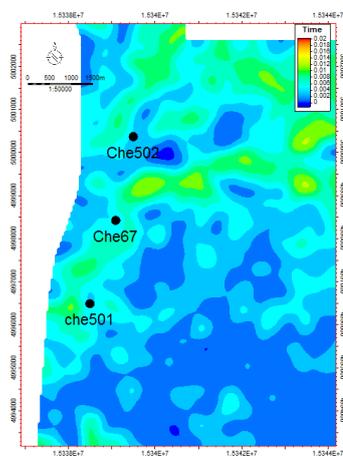


Figure 2. Sand thickness distribution

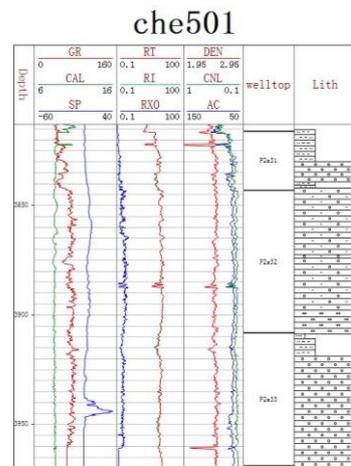


Figure 3. Single well histogram

3. Characteristics of sedimentary facies

3.1. The types of sedimentary facies

The fan-root facies is mainly developed in this area. The overall sediment grain size is coarse, and coarse conglomerates and macadamies are the main sediment, the percent of conglomerate rock is more than 90%. In the northern region close to the provenance, this fan-root deposition system is essentially not developed fan-mid facies, and thus reveal a high resistivity (20-408Ω·m or more) with

little fluctuation. The fan-root are subdivided into three sedimentary micro-facies, main channel, swale, and floodplain.

3.2. Single Well Sedimentary Facies

In the well Che501, the lithology and sedimentary facies are analyzed (Fig. 3), P2x31(the first sand group), gray-brown silty mudstone, the lower part is gray-brown fine conglomerate, the sedimentary facies is the main channel and floodplain micro-facies. P2x32(the second sand group), brown glutenite and small conglomerates, sedimentary facies is the main channel, swale micro-facies. P2x33(the third sand group), gray-brown fine conglomerate and sandy mudstone, sedimentary micro-facies are the main channel and floodplain.

3.3. Distribution of sedimentary facies

Based on the results of sand thickness distribution, the sedimentary facies maps of P2X31, P2X32 and P2X33 are analyzed (Figs. 4). On the whole, the sedimentary micro-facies of the main channel corresponds to the thickest part of the inversion sand thickness map with channel-shape. The swale is distributed around the main channle and begins to diverge in the lower part of the main channel, that is, with the direction of the main channel, the thickness of the swale is gradually thinning, and the scale becomes larger gradually. The floodplain micro-facies are the largest micro-facies in the region, which filling the interspace of the main channel and the swale micro-facies. The sedimentary micro-facies with the best reservoir properties are the main channel micro-facies and the worst ones are the floodplain micro-facies. From the top to the bottom, the main channels are the most developed in the P2X31 sand layer group, and the P2X33 sand group most developed the floodplain micro-facies, therefore, the best property layer is the upper P2X31 sand group.

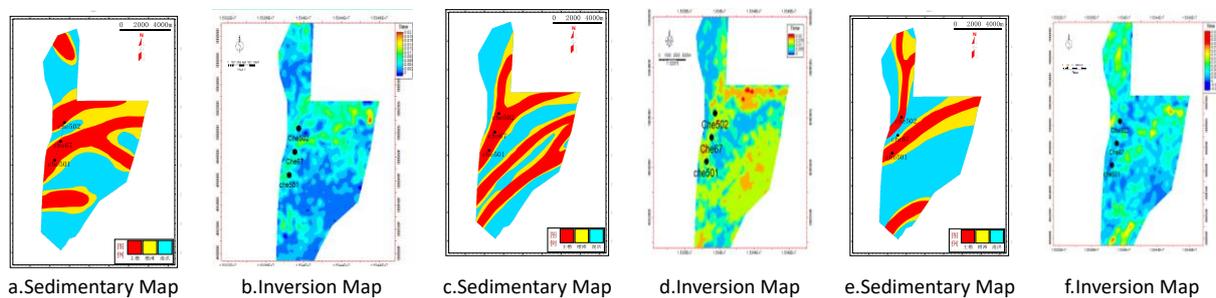


Figure 4. P_{2x31}¹ P_{2x32}² P_{2x33}³ Sedimentary Map and Inversion Map

4. Conclusion

- (1) As well data are relatively limited in the exploration area, seismic data can be used to assist the analysis of sedimentary facies. Both constrained sparse spike inversion and geostatistical inversion methods are tried. It has been proved that geostatistical inversion has a higher vertical resolution and will be used.
- (2) The Northwest X field belongs to fan-root sub-facies, which is subdivided into three kinds of sedimentary micro-facies, namely main channel, swale and floodplain micro-facies. The reservoir properties are better in main channel and worse in floodplain.
- (3) The inversion reservoir thickness map is used to analyze the plane distribution of sedimentary facies. The main channel corresponds to the thicker parts of the thickness map, while the floodplain micro-facies corresponds to the thinner parts. From top to the bottom zone, the main channel is more developed with better reservoir quality. Based on the statistical characteristics, the paper summarizes the sedimentary facies pattern of the X oilfield, and provides guidance for the sedimentary facies analysis of the similar reservoirs.

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