Reservoir prediction and application of multi-attribute fusion

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Abstract. Under the existing well pattern density conditions, there are still uncertainties in the understanding of reservoir distribution in XX Oilfield. The main reasons are that the different sedimentary environments and complex and changeable sedimentary models lead to uncertainties in reservoir prediction under the guidance of sedimentary models; Second, the sedimentary mechanism of different types of sand bodies is different, and there are multiple solutions in cross-well prediction. Therefore, other means must be used for auxiliary analysis in reservoir prediction, so as to improve the accuracy of sand cross-well prediction. This paper focuses on the basic method of reservoir prediction based on seismic multi-attribute fusion, which can further improve the accuracy of cross-well prediction in the cross-well prediction of thick oil layers. In addition, the sand body distribution characteristics corrected by multi-attribute fusion slice are applied to measure well selection and layer selection, and comprehensive analysis of remaining oil is carried out by integrating various disciplines, and relatively high-quality potential tapping horizons are determined, which further improves the coincidence rate of potential tapping by measures.

Keywords: XX oilfield, Multi-attribute fusion, Combination of well and earthquake.

1. The raising of questions
Under the existing well pattern density, there are still uncertainties in the understanding of reservoir distribution in XX Oilfield. The main reasons are: First, the sedimentary environment is different, and the sedimentary model is complex and changeable, which leads to the uncertainty of reservoir prediction under the guidance of sedimentary model; Second, the sedimentary mechanism of different types of sand bodies is different, the local migration mode and scale change greatly, and there are multiple solutions in cross-well prediction. Therefore, other means must be used for auxiliary analysis in reservoir prediction, so as to improve the accuracy of sand cross-well prediction. However, in the past application of reservoir prediction in XX Oilfield, a single technical method was used to carry out reservoir prediction research, and each method has certain adaptability, without combining various technical advantages.

In order to further improve the injection-production effect, it is necessary to describe the geological characteristics and sand body connectivity, enhance the river sand body boundary identification and combination certainty, and realize the accurate and effective description of cross-well sand bodies. Therefore, it is necessary to put forward new research ideas, combine well-based reservoir identification
technology, seismic attribute prediction technology and waveform inversion prediction technology for different types of reservoirs, and give full play to the comprehensive prediction function among the above technologies, so as to further improve the reservoir prediction accuracy and provide more reliable research results for accurately implementing injection-production relationship and finely tapping potential. This paper focuses on the basic method of reservoir prediction based on seismic multi-attribute fusion, which can further improve the accuracy of cross-well prediction in the cross-well prediction of thick oil layers. In addition, the distribution characteristics of sand body corrected by multi-attribute fusion slice are applied to measure well selection and layer selection. Mainly aiming at the plane distribution characteristics of sand body under the control of sedimentary units and its injection-production connectivity, the injection-production relationship of single layer is further implemented, and the comprehensive analysis of remaining oil is carried out in combination with vertical development characteristics, new well flooding interpretation results, numerical simulation results and relevant dynamic data, and the relatively high-quality potential tapping horizon is determined.

2. Prediction of sand bodies by sedimentary facies guided by multi-attribute fusion

Combining well and earthquake to depict sedimentary facies belt map is to use geophysical methods, mainly seismic results to make up for the lack of cross-well information, and combine drilling information to jointly depict the spatial distribution of sand bodies in different sedimentary facies belts. First, complete the facies belt map based on well data, and then refer to seismic attribute slices, guide the description of inter-well sand bodies from the plane seismic trend guidance and well point microfacies control, and modify the facies belt map based on well.

![Diagram](image)

**Figure 1.** Modification and improvement of sedimentary facies flow chart based on seismic attribute slice

(1) The continuity of the river course changes-continuous and discontinuous

Compared with the logging facies belt map, the well-seismic facies belt map was originally recognized as a continuous river channel sand body, which was divided into intermittent river channel combination relations through re-recognition of well-seismic facies belt map. As shown in Figure 2,
slice shows that the channel sand body between the two wells is not developed, so the channel sand body here is continuously modified to be discontinuous.

Figure 2. Based on well sedimentary facies map and attribute fusion slice

(2) The continuity of the river course changes from discontinuous to continuous
Compared with the old facies belt map, some of the well-seismic combination facies belt maps were originally recognized as unconnected river sand bodies, which were recognized as connected by well-seismic combination. Between Well A and Well B of Sa II9 sedimentary unit, the slice shows that channel sand bodies are developed between the two wells, so the unconnected channel sand bodies here are modified to be connected (Figure 3).

Figure 3. Based on well sedimentary facies map, attribute fusion slice and well-seismic combination

(3) Change of river scale
The change of river channel scale mainly refers to the change of the development range of river channel facies, mainly including the expansion and contraction of the development range of river channel facies. The following figure shows Well C and Well D of Pu I1 sedimentary unit.

Figure 4. Well C and Well D of Pu I1 sedimentary unit
(4) Channel combination change

The combination change of rivers refers to the change of the combination form among the branches of rivers, such as the bifurcation of rivers and the merging of bifurcations between rivers. As shown in fig. 5, between well e and well f in Sa Ⅲ 4+5 sedimentary unit, from the section, the river channel sand is interrupted, which clearly indicates that there is a river channel with a dead mouth, therefore, the continuous river channel sand body here has been modified, and the river channel combination relationship has changed.

Figure 5. Sa Ⅲ 4+5

Compared with the original logging sedimentary facies belt map, the modified well-seismic sedimentary facies belt map describes the distribution pattern of river channel sand bodies more finely, the overall distribution law remains unchanged, and local river channel sand bodies change. After obtaining the well-seismic combination zone map, the reliability of the well-seismic combination zone map can be judged by mutual verification with the dynamic injection-production data, and only after the obtained results conform to the production data can the well-seismic combination zone map be considered to be more accurate.

3. Application of multi-attribute fusion results

Based on the distribution characteristics of sand bodies corrected by multi-attribute fusion slicing, we have applied measures to select wells and layers, mainly aiming at the plane distribution characteristics of sand bodies under the control of sedimentary units and the injection-production connectivity, and comprehensively analyzed the remaining oil in combination with vertical development characteristics, water flooding interpretation results of new wells, numerical simulation results and relevant dynamic data, thus determining relatively high-quality potential tapping horizons.

Take Well Y as an example. Well Y is a waterflooding infill production well located in a certain block of XX Oilfield. In February 2018, the average daily liquid production was 37.3t, the daily oil production was 1.27t, and the water cut was 96.6%. The production interval was high Ⅰ13 ~ high Ⅱ30. In March 2013, after fracturing, the oil production increased by 1t, the produced liquid increased by 24 m³, and the water cut increased by 1 percentage point. The effective period of the measures was short and the effect was not ideal. In order to further improve the productivity of this well, the measure potential of this well is analyzed. The Sa II group of this well is located on the production diversion line (as shown in Figure 6), and there is a certain potential for hole supplementation, so the sedimentary units of Sa ii group of this well are analyzed.
1. Multi-attribute fusion slice guides well facies belt map and optimization measures

In Sa II 5+6 sedimentary unit of Y well group, the continuity of river channel has changed after the well facies belt map is guided by attribute fusion slice, which changes the original injection-production relationship of this well group.

In Sa II 13+14 sedimentary unit and Sa III 1+2 sedimentary unit, the channel scale of well-seismic facies belt map has changed, which changed the original sedimentary facies combination of this well group.
2. Multi-attribute fusion slice enhances the understanding of phase diagram

In Sa II 15+16 sedimentary unit, the results of well sedimentary facies map are consistent with the results of attribute fusion slice, which strengthens the understanding of well sedimentary facies map.

Through the analysis of the well group in plane, the distribution of sand bodies is known. According to the analysis of the profile of this well group, the water injection wells w of this well group mostly form thick injection and thin production in the sand body of sa ii group, and the water well stratification test results show that the pressure is 8.6MPa and the water injection rate is 154m³/d, which has room for rising. According to the interpretation results of PS flooding near new wells, Sa II Formation is mostly unwatered or lowly flooded, and there is residual oil in the formation.
The reference numerical simulation results also confirm the existence of remaining oil in Sa II formation.

According to the above analysis, hole patching measures were carried out in this well in March 2018, and the interval was from Sa II 1+21 to Sa III 1+2 sedimentary units. At the initial stage of the measures, the oil increased by 3.2t, the liquid increased by 52t, and the water cut decreased by 1.6 percentage points, with good results. At the same time, water injection well w increased by 30m³/d in the corresponding interval. After a period of exploitation, the oil pressure of injection well la 5-162 gradually decreased by 0.2Mpa under the condition of constant water injection rate, which further confirmed the good production effect of supplementary well Y in sa II formation interval. Well-seismic combined with sedimentary facies belt map guided by multi-attribute fusion slices plays a good guiding role.

4. Conclusions
1. The attribute fusion technology improves the correlation coefficient between seismic attributes and stratigraphic attributes, and the seismic attribute fusion reservoir prediction method can realize the identification of intermittent river sand bodies meeting the thickness scale.
2. In the process of applying multi-attribute fusion results to facies belt map, we should take well point facies belt map as the foundation, combine with dynamic production data, and make comprehensive judgment on this basis.
3. Using the results of multi-attribute fusion, it plays an obvious role in optimizing the measure wells and improves the coincidence rate of tapping the potential of measures.

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