Exploration and Application of Seismic Attributes Fine Combination in Reservoir Prediction

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Abstract. In view of the problem that the reservoir prediction of well-seismic combination used to be mainly inversion, supplemented by seismic attributes, inversion needs external cooperation and expensive funds, and conventional attributes prediction are not accurate enough to depict the boundary of sand body, we continue to use the I-Geoseis seismic software provided by our company, to give full play to the advantages of well-seismic combination. The conventional amplitude attributes and coherence attributes fusion method are used to accurately depict the boundary and the trend of channel sand bodies, to guide the drawing of sedimentary facies, improving the prediction accuracy of channel sand bodies. The applied research results not only deepen the geological understanding but also guide the adjustment of water-driven scheme.

Introduction

Since2008, our factory has carried out well-seismic combination reservoir description technology in five blocks, mainly using reservoir inversion as the main method and attribute prediction as the auxiliary method. The results show that the two methods can be used to a certain extent enhance the prediction accuracy of cross-well sand bodies in high distributary plain and inner front reservoirs,It is very important for channel sand body description and reservoir modeling. In the near future, although the prediction accuracy of inversion technology is higher than that of seismic attributes, our factory does not have the software and hardware equipments and related technologies for seismic inversion, and can not complete it independently. It needs external cooperation and expensive funds [1]. The application conditions of seismic attributes prediction technology are relatively mature. Oilfield companies have equipped our factory with I-Geoseis seismic Software and technicians also master the relevant operation technology [2]. Under the condition of considering economic benefits, seismic attribute prediction technology is the main means of reservoir description in our factory in the near future. But at present, the conventional seismic attributes are not accurate enough to describe the boundary of sand bodies, and the prediction accuracy needs to be further improved. Therefore, it is necessary to continue to carry out seismic attribute prediction [3]. The method of merging amplitude attributes and coherent attributes is explored.

Reservoir Prediction Using the Fusion Method of Amplitude Attribute and Coherence Attribute

Block Profile. A is located in the middle and west of B development area and between two NW trending faults with an area of 5.3km^2 and a total of 533 wells, including 258 new wells and 100.5 wells/km^2 well pattern density. The seismic data used in this study, from the top of C to the bottom of D, the reflection time is 750-1030 ms, the difference between top and bottom reflection time is generally about 130ms, the actual top-to-bottom depth difference is about 200m; the main frequency is about 50Hz,the effective bandwidth is 20-100Hz [4].

According to the front densified facies map, the distributary plain facies and inner front facies are the main facies in Di2 layer, and the channel sand is mainly distributed in main or narrow strips. Among them,Di21、Di 22、Di 23、Di 24、Di 25 are mainly developed 250-1500m River host zone, and Di 26、Di 27、Di 28 are mainly developed 50-200m narrow channels.

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According to the frequency histogram of sandstone thickness distribution and the cross-section of sand body in Di2 layer, the sandstone thickness of single channel sand body in the target layer is mainly 1-5m, and the effective thickness is mainly 1-3m.Vertically, the sandstone-mud thin interbedded structure is developed.

Fine Selection of Amplitude Attributes and Coherence Attributes. Fine Selection of Conventional Amplitude Attributes. take an example of Di26,extracting n slices of amplitude attributes of corresponding horizons(Chart1), using I-Geoseis software to calculate the correlation coefficient between the attribute values of well points and the thickness of sandstone for primary selection, this time research 8 sedimentary units, using old seismic data and reinterpretation of seismic data, from the correlation coefficient, the correlation coefficient is better using the later data(Table1) .And using seismic attributes lithology probability analysis optimization technology to select attributes with high correlation coefficient (correlation coefficient can not be less than 0.2). The probability curve of lithology/microfacies is drawn to optimize the seismic attributes. The optimal amplitude attributes are selected by judging whether the probability of sand-mudstone/microfacies has a high probability interval with large area ratio (Chart2). And the best one is selected. This time select 8 units of amplitude attributes [5].

Table1 The correlation coefficient between the attribute values of well points and the thickness of sandstone

Sedimentary units	old seismic data	reinterpretation of seismic data
Di21	0.23	0.44
Di22	0.22	0.41
Di23	0.18	0.35
Di24	0.21	0.45
Di25	0.4	0.46
Di26	0.21	0.35
Di27	0.26	0.32
Di28	0.25	0.34

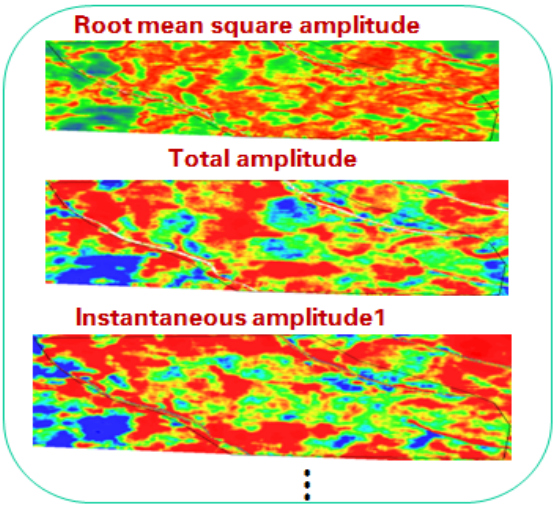

chart 1 Slices of amplitude attributes

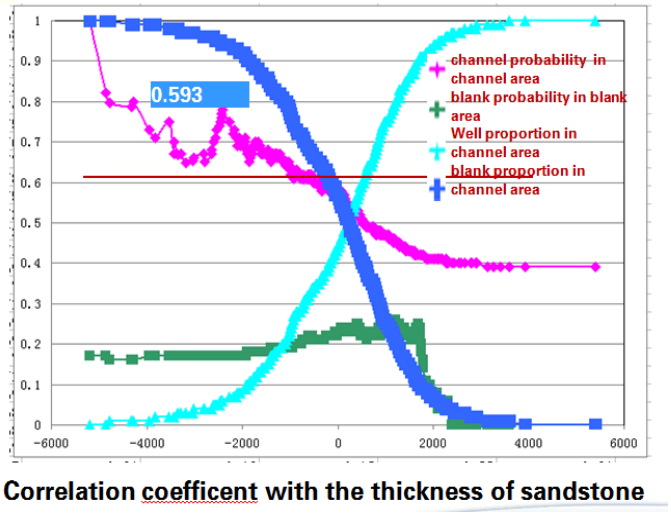

chart 2 The Di26 probability curve of lithology

Fine Selection of Coherence Attributes. coherence attributes have certain advantages in describing the boundary of sand body, too large or too small coherence parameters will affect the accuracy of identifying the boundary of sand body; through calculating 47 coherence data volumes with different combinations of parameters, more than 1000 slices along the layer are extracted and optimized through clarity preliminary selection and actual wells verification [6]. According to the parameter combination with the highest coincidence rate, it is concluded that the number of coherent seismic traces in the study area is orthogonal 5, and the time window is 7ms, the coincidence rate is up to 97.87%,and the sand boundary is most accurately depicted (Table2) [7].

Forming the Fusion Technology of Amplitude Attribute and Coherence Attribute. Aiming at the problem that the prediction of sand boundary is not clear by the optimized slices of conventional

amplitude attributes, the characteristics of strong boundary identification ability and instantaneous amplitude attributes reflecting lateral variation trend are fully utilized by the coherence technique. The data of these two seismic attributes are processed and fused with each other. After fusing, the two seismic attributes are fused on a slice of seismic data. There are trends and boundaries, which make up for the use of conventional attribute slices to not accurately identify river boundary conditions [8]. Among them, the specific fusion process is to determine the optimal amplitude attributes of sand boundary coherence threshold value and range of distribution; to determine the optimal coherence attributes of sand and mudstone threshold value, because the coherence value range is 0-1, the value range is linearly proportional to expand; to deal with the coherence data points larger than the threshold value for a single value, and Remove the amplitude attribute value range distribution, replace the coherent boundary value to the amplitude attribute, and reconstruct the map according to the value range[9].

Table 2 optimal evaluation for coherent body parameters (part)

parameter							Optimal effect	
Number of channels	Number of channels	Time window /ms	Coherence slice number	Primary window area	Verifying layer	Verifying well number	Verify compliance well number	Verification coincidence rate
3	3	3	22		Di2	235	225	95.74
3	3	5	22		Di2	235	225	95.74
3	3	7	22		Di2	235	220	93.62
3	3	9	22	5-9	Di2	235	222	94.47
3	5	5	22		Di2	235	225	95.74
3	5	7	22		Di2	235	220	93.62
3	5	9	22		Di2	235	198	84.26
3	5	11	22		Di2	235	198	84.26
3	5	13	22	5-9	Di2	235	190	80.85
5	5	3	22		Di2	235	220	93.62
5	5	5	22		Di2	235	228	97.02
5	5	7	22		Di2	235	230	97.87
5	5	9	22		Di2	235	230	96.8
5	5	11	22	5-1	Di2	235	227	96.6
5	5	13	22	1	Di2	235	220	93.62
7	7	3	22		Di2	235	220	93.62
7	7	7	22		Di2	235	223	94.89
7	7	9	22		Di2	235	220	93.62
7	7	11	22	11-13	PI2-3	235	220	93.62

Mapping the Sedimentary Facies Maps with the Fusion Result Maps. Eight units of Di2 layer are plotted two sets of facies diagrams based on well data and the well- seismic combination data .In order to test the prediction accuracy, 50 reserved posterior wells are used to verify the prediction. Statistics show that the coincidence rate of channel sand is 8.1 percentage points higher by using attribute fusion method than by logging (Table3).

Table 3 Statistics of river sand conformity rate with different reservoir description methods

Sedimentary units	Well density (wells/Km^2)	Drilling (wells)	Logging data		Amplitude and coherence		
			Prediction channels (wells)	Coincidence rate (%)	Prediction channels (wells)	Coincidence Rate (%)	Coincidence rate difference (%)
Di21	100.5	22	17	77.3	18	81.8	4.5
Di22		19	13	68.4	15	78.9	5.3
Di23		14	11	78.6	12	85.7	0
Di24		19	14	73.7	16	84.2	5.3
Di25		10	5	50	7	70	10
Di26		49	47	95.9	49	100	4.1
Di27		13	8	61.5	10	76.9	7.7
Di28		15	11	73.3	12	80	6.7
Total		161	126	78.2	139	86.3	5.0

Application of Achievements

Deepen the Understanding of Geology. In the process of drawing sedimentary maps, it is concluded that: for large-area developed channel sand bodies, the fusion map can accurately locate the channel boundary and for the narrow channel sand bodies can locate the channel boundary and direction.According to the identifying boundary conditions of coherent attributes in each sedimentary unit, and referring to the geological conditions such as effective thickness, sand-layer ratio and barrier thickness, the suitable geological conditions for identifying channel sand boundary by coherent attributes are preliminarily defined.

Table 4 Geological conditions suitable for identifying sand boundary by coherent attributes

Reservoir type	barrier thickness	sand-layer ratio	Effective thickness difference
Main body with large boundary of channel sand body	>5m	>0.6	>2m
Narrow channel sand body	>10m	>0.6	>2m

Guiding the Adjustment of Water and Polymer Flooding Dynamic Program and Providing Technical Basis for Production and Injection of Block Polymer Flooding. All the new wells in the block are polymer flooding wells. In the process of application, the facies zone diagram mainly judges the influence of water flooding injection wells on new polymer flooding wells, adjusts the reasonable scheme of influential water flooding injection wells, stops injection in individual wells, and works out 9 schemes for water flooding wells, providing technical basis for polymer flooding. With the deepening of development, combined with reservoir development and the individualized design required by polymer flooding, the polymer flooding injection scheme adjusts 73ports and injection concentration scheme adjusts 186ports. Compared with before injection, the daily oil production increases by 161.8t, and good results have been achieved.

Conclusion

By using the method of fine combination of amplitude attributes and coherent attributes, the characteristics of strong boundary identification ability and instantaneous amplitude attributes reflecting lateral variation trend are fully utilized by the coherence technique and the prediction accuracy of channel sand body is improved by 8.1percentage points.

The coherence attribute mainly locates the boundary accurately in the main wide channel, and directs the sand direction and boundary in the narrow channel area. The geological conditions that can be identified by the coherence boundary are mainly related to the thickness of the barrier, sand-layer ratio and the difference of effective thickness.

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