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The Application of Geostatistics Inversion in Reservoir Prediction

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Abstract: A region of delta distributary plain distributary channel sand body development change fast, strong heterogeneity, small thickness of single sand body, sand body distribution, conventional deterministic inversion due to earthquake frequency limit, in the form of seismic inversion low vertical resolution, often it is difficult to identify. Geostatistical inversion method based on stochastic modeling technology, can effectively integrated geology, logging and 3 d seismic data, greatly improve the prediction results of vertical resolution, can more precisely describe reservoir slight change, can better identification of thin sand body. Using geostatistical inversion method for the thin layer of sand body is forecasted, through high resolution of geostatistics inversion of wave impedance and density inversion profiles can effectively identify the thin layer of sand body lateral distribution on the inversion profile.

Keywords: Geostatistical inversion ; Stochastic simulation ; Thin sand body identification ; Reservoir prediction.

INTRODUCTION

Geostatistical inversion theory

Geostatistical inversion method is presented in the 90 s, as a kind of effective inversion method, the method in seismic inversion as the initial model, starting from the well point, with inter well raw seismic data, seismic data would be set to a hard data (hard data), to establish a quantitative wave impedance of three-dimensional geological model[1-2], reservoir lateral prediction [3, 4]. Its characteristic is that a combination of the advantage of seismic inversion and reservoir stochastic modeling, take full advantage of the characteristics of the seismic data intensive, accurately calculate the variation function in different directions, the inversion results of multiple implementations can be used for the quantitative evaluation result uncertainty. This combining stochastic modeling technique and the conventional seismic inversion method can be effectively integrated geology, logging and 3 d seismic data, the model can accurately describe the change of reservoir. At present, post-stack inversion geostatistics has been widely applied in the seismic information integrated to the fine random geological model, can effectively predict the distribution of sand body.

Geostatistical inversion is a kind of stochastic simulation theory with combined inversion method of seismic inversion. It is made up of two parts, namely, the stochastic simulation process and optimizes the simulation results and makes it conform to the process of seismic data. Much random simulation method, the more mature of geostatistics inversion scheme is sequential Gaussian simulation combined with inversion based on model [5]. Give full play to the stochastic simulation technology in the process of inversion of the comprehensive ability of different scale data, such as can be integrated sequence stratigraphy study and contrast with the seismic interpretation results fine geological model is set up; Any random sequential stochastic simulation along the path, different random path to get different results and implementation, different implementation differences reflect the underground geological, heterogeneity and randomness of the difference, the greater the heterogeneity stronger. Inversion result can be realized through different differences in evaluation of risk; therefore, it is also a more effective solution to the earthquake. Although each is not identical, but each times the implementation to meet: in the well point consistent with logging data calculation of wave impedance; Between Wells in geostatistics characteristics of seismic data and the known data.

Geostatistical inversion algorithm

Post-stack inversion using strict geostatistics Markov Chain Monte Carlo algorithm (Markov Chain Monte Carlo, MCMC), will be constrained sparse pulse inversion and stochastic simulation technology, the combination of a new stochastic inversion algorithm. By seismic lithology and logging curve, the probability density function and information such as combining variational function, define the strict probability distribution model [6]. First of all, through the analysis of logging data and geological information to obtain the

probability density function and variation function; Secondly, complex MCMC method according to the probability distribution function (PDF) in statistical sense correct sample point set, namely according to the probability distribution function can be what kind of results, the built-in constrained sparse pulse inversion engine to ensure the effective bandwidth in seismic data within the scope of the simulation results and post-stack sparse pulse inversion results at least as accurate; On the basis of "information", the inversion results is clear, at the right location has a sharp edge of the lithologic body and more details to reproduce a real reservoir. Because of geostatistics inversion provides a lot more than the details of the seismic data band width trend and is identical to that of the seismic data at the same time, this makes the explanation and quantitative qualitative waveform based on the theory of the modern karst reservoir interpretation between got a perfect balance.

THE ACTUAL APPLICATION

Work area

The 94 block is located in chaoyang ditch oil field of the axis of arch structure, river delta sedimentary system, the main channel sand body is distributary channel of delta distributary plain deposits, block area of 50m^2, currently a total of 834 oil and water Wells, main development 557 Wells in fuyu oil layer. Overall development in the area after the production effect is good but the local existence question, the main problems for fracture development, the fracture characteristic is not obvious; Sand body development changes quickly, sand body distribution is not clear; Development potential is not clear. To find out in fuyu reservoir sand body sedimentary characteristics, improve the understanding of inter well sand body, using geostatistical inversion method for the thin layer of sand body is forecasted, through high resolution of geostatistics inversion of wave impedance and density inversion profiles, can effectively identify the thin sand body transverse distribution on the inversion profile, provide the basis for development plan establishment and favorable area prediction.

Main parameters of the test

In order to find out all kinds of pattern on the degree of control in fuyu reservoir sand body, 546 Wells in the research process is divided into three patterns, according to different well pattern to carry out seismic inversion inter well sand body prediction research.

Factory zone fuyu reservoir rule in the row of horizontal vertical well intervals (every) such as smoke analysis as the first set of pattern (figure 1), a total of 179, the largest spacing is 615 m, the most short distance is 94 m, the average spacing of 500 m. Factory area of law in the row to select all well as a second set of well pattern (figure 2), 359, the largest spacing is 497 m, the most short distance is 68 m, the average spacing of 353 m. Select all work area well 535 as the third set of well pattern (figure 3), the largest spacing is 497 m, the most well spacing to 10 m, the average spacing of 289 m.

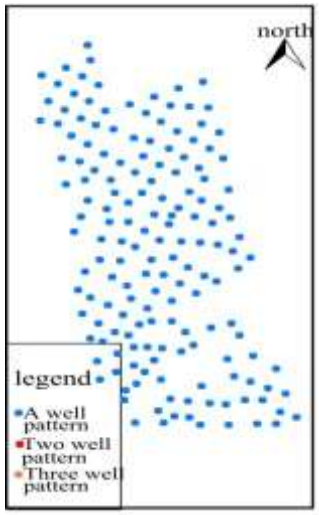

Fig. 1：Fuyu a set of well pattern

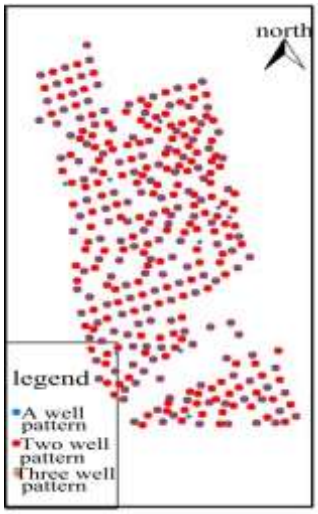

Fig. 2：Fuyu two sets of well pattern

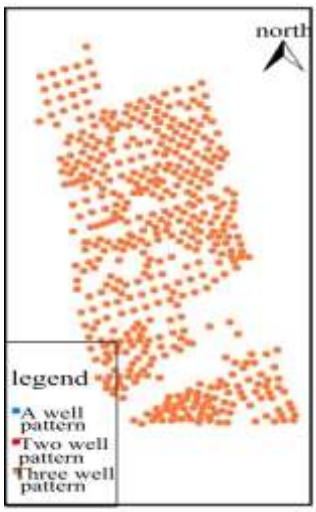

Fig. 3：Fuyu three sets of well pattern

Seismic inversion for logging curve sample match the sample of the earthquake, the conventional approach is to put the logging curve resampling, and earthquake match, this leads to logging curve coarsening, resulting in lost reservoir effective information, the inversion results distinguish thin layer ability reduce [8]. This study tests first sampling to seismic data into ms 0.08, 0.25 ms and 0.5 ms, ms 2 test, the logging curve match, according to different sampling interval and the earthquake in the computer operation ability and the inversion precision of target requirements within the scope of the earthquake point as close as possible to sample and well samples, in order to improve the resolving power of actual

inversion curve. Test four sampling rate, discover 0.5 ms resolution inversion results than 1 ms sampling rate, to meet the demand of geological, ultimately determine the application of 0.5 ms sampling interval (figure 4).

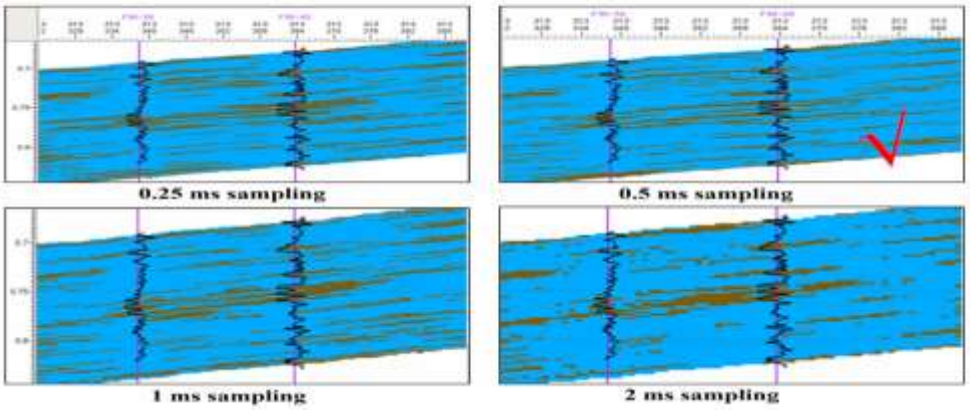

Fig. 4：Effect of different sampling of inversion analysis

Geostatistics after statistical analysis, to obtain various lithology PDF distribution, in addition to the establishment of stratigraphic framework, control of main parameters of the mechanical parameters are lithologic proportion, vertical variation, horizontal variation, and signal-to-noise ratio.

(1) The vertical variation of variation can be determined by geological statistical analysis combined with test results, the discrete attributes (lithology) and continuous attributes (longitudinal wave impedance) vertical variation of 2ms (3m), but given the thin reservoir in the study area (less than 3 m), need a smaller vertical variation test. Test results show that the vertical sampling interval 1 ms than 2 ms higher resolution (figure 5).

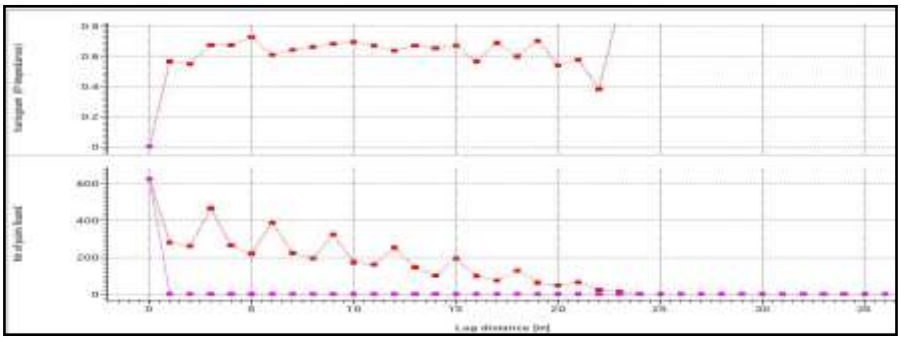

Fig. 5：The vertical variation analysis results

(2) the lateral variation of transverse distribution of the control sample, the greater the speed of the slower, due to the effect of constraints of the earthquake, the inversion result affected by lateral variation in general is not big, mainly affect the thin layer of sand body distribution, comprehensive consider optimizing codomain 2000*2000.

(3) the figure 6 is SNR test results, the signal-to-noise ratio is to control the inversion of the relevance of the synthetic records and actual seismic data, the SNR is mainly decided to the earthquake in the proportion of inversion, the signal-to-noise ratio, the greater the proportion of inversion of seismic is larger; Signal-to-noise ratio in the hours, the proportion of inversion of seismic is lesser, interwell prediction accuracy by [9]. Low signal noise ratio (SNR), the basic seismic inversion is given priority to with interwell interpolation, signal-to-noise ratio is too big, too dependent on interwell uncertainty caused by the earthquake. Mainly based on the signal-to-noise ratio in the deterministic inversion quality analysis, on the basis of the test different signal-to-noise ratio inversion result, the signal-to-noise ratio of seismic data distribution area in 8 to 16 db, after the test, choose 12 db as the signal-to-noise ratio in the process of inversion.

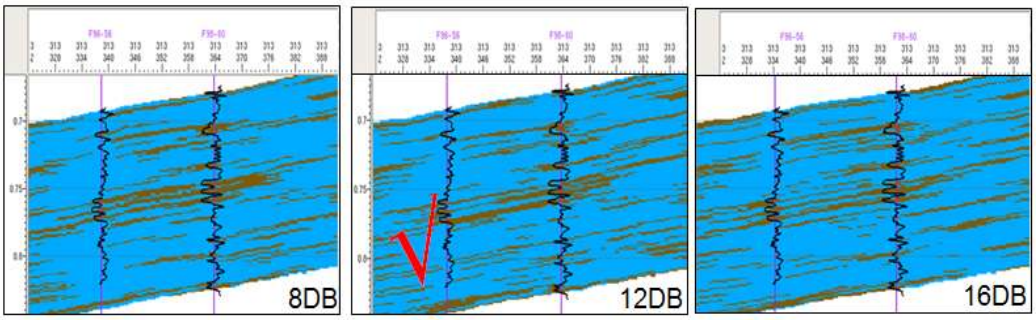

Fig. 6：Signal-to-noise ratio test results figure

Geostatistical inversion result evaluation

In one, two, three sets of well pattern of geostatistics inversion of resistivity profile on body, net inter well sandstone continuity is good, natural sandstone distribution, and illustrates the rationality of the inversion parameters. Through comparing three sets of well pattern more profile browsing, the third set of well spacing density is big, the Wells, more in line with the details. Instructions for fluvial facies sedimentary formation, participate in the inversion of the logging, the more the more can control the size of the sandstone and the boundary, the more accurate prediction results, so the final application of the third set of well pattern sand body of the inversion results of the quantitative prediction and correction of sedimentary facies belt graph, fuyu oil layer of different well pattern inversion result is shown in figure 7-in figure 9.

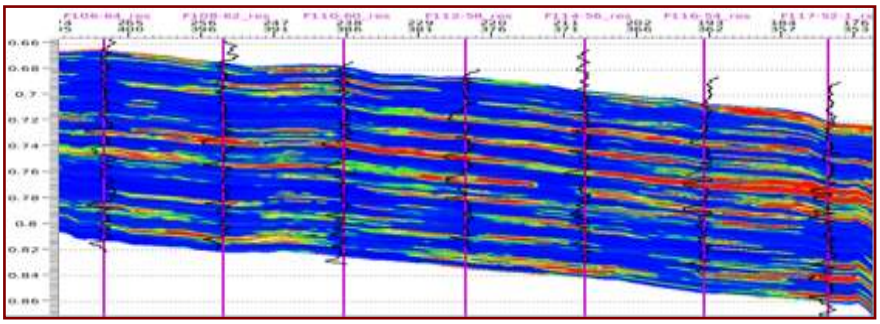

Fig. 7：Fuyu reservoir resistivity inversion section one pattern

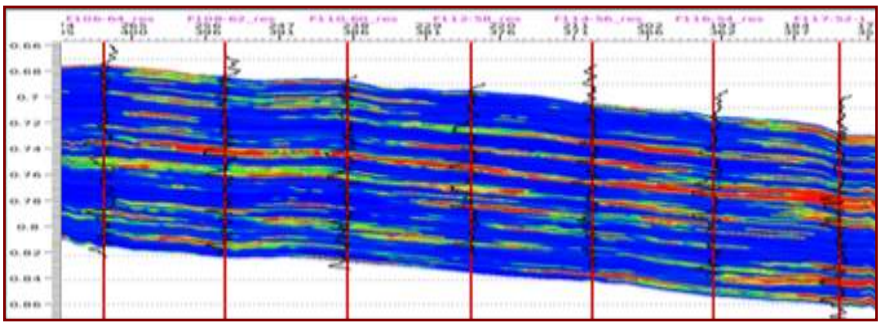

Fig. 8：Fuyu reservoir two sets of pattern resistivity inversion section

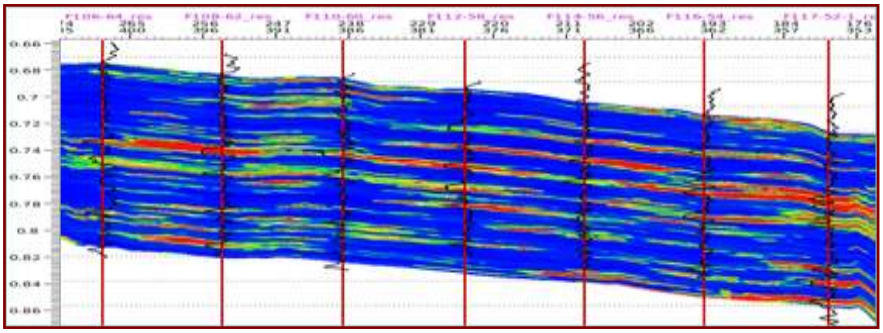

Fig. 9：Fuyu reservoir resistivity inversion section three sets of well pattern

Inversion result evaluation can be concluded that the geostatistical inversion in well point position and participate in basic perfectly well, the corresponding is good and the posterior, also has certain continuity between Wells, can better describe the main sedimentary sand body, confirmed that the predictability of post-stack inversion of geostatistics.

CONCLUSIONS

1. Post-stack inversion geostatistics interwell sandstone continuity is good, natural sandstone distribution, and the third set of well spacing density is big, the well, more in line with the details.
2. The fluvial facies sedimentary formation, participate in the inversion of the logging; the more the more can control the size of the sandstone and the boundary, the more accurate prediction results.
3. Geostatistics inversion can greatly improve the results of the longitudinal resolution, quantitative prediction sandstone thickness, surface to determine the distribution characteristics of the single sand body, fixed boundary of sand body.

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