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Fine inversion prediction of sand body in the Fuyu reservoir in Yumin area

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Abstract:- Fine inversion prediction of reservoir is one of the effective method to realize the sand body all the time. Space distribution of sand bodies in Fuyu reservoir of Yumin area is not clear, which restricted the further exploration and development in the area is seriously. The prediction inversion results is consistent with drilling results through sparse pulse inversion which is loyal to the original seismic data and Stochastic inversion which is loyal to the well data and seismic data, participate Inversion well'error and verify well'error is very small.

Keywords:- Yumin area Fuyu reservoir prediction of reservoir Inversion

Ⅰ. INTRODUCTION

Yu Min area is located in Zhaoyuan of Heilongjiang Province, which is in the southeastern of Songliao Basin in china. It go across one grade tectonic unit in the central depression area and the southeast uplift area, same across the two tectonic units Sanzhao sag, Chaoyanggou terraces and Changchun ridge anticline belt, has realizated 3D seismic full coverage in the area of 547km^2[1,2].

At present, Fuyu reservoir is the main development horizon of Yumin area, proven reserves and controlled reserves concentrated in the two third level structure which is the western Yumin nose structure and Eastern mint sets nose structure, At present, in the study area, 125 wells have been drilled evaluation, oil test obtained industrial oil flow in 49 wells, the low production of oil flow in 16wells, oil-gas exploration potential in this area shows good; Because of the small scale of sand body, reservoir effective thickness, Spatial distribution of sand body is not clearly, oil scale and area are difficult to implement. Therefore, need to carry out prediction of reservoir sand body of grape flower based on existing geological theory and exploration results, to provide an important theoretical basis for the assessment of potential resources of the study area blank of Fuyu reservoir in block and select advantageous zones.

II. THE SINGLE DRILLING WELL SANDSTONE CHARACTERISTIC STATISTICS

First of all, we must have a clear understanding of the sedimentary characteristics and sand body size, type of study area, on the basis of that, then we can choose proper inversion method. Fuyu oil layer in the study area is the mainly the shallow water delta，The facies in sand change speed、unstable lateral, profiles are usually lens[1]. The max single sand body thickness up to 10m, The min single sand body thickness is down to 1m, The thickness of single sand body distribute between 2-5m (Fig.1); The longitudinal every sand group development scale of sand bodies of different single sand at the group of FⅡ up, FⅠ middle and FⅠ down with the maximum probability to the formation of single sand body beyond 4m, While the F Ⅲ every sand group development than 4m single sand body of the minimum probability; Thin layer sandstone (h<2m) mainly distributed in F Ⅲ and F Ⅲ in sand groups (Table 1); Overall, the reservoir sand body in distributary channel sand, monolayer thickness greater than 4m sandstone accounted for more than 50%.

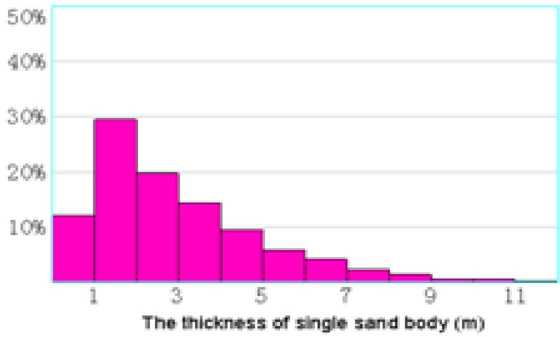


Fig.1: The histogram of the thickness distribution of single sand body in Fuyu formation

Table 1: Different sandstone thickness distribution of single sand layer

Sand group	The proportion of the different scale single sand body（%）						The proportion of the single sand body greater than 4m（%）
	0m<h<2m	2m≤h<3m	3m≤h<4m	4m≤h<5m	5m≤h<10m	10m≤h	
FⅠup	17.8	17.3	14.3	14.6	31.0	5.0	**50.6**
FⅠmid	14.8	9.3	12.9	11.0	36.4	15.6	**63.0**
FⅠdown	14.7	15.0	14.4	9.3	33.8	12.8	**55.9**
FⅡup	6.1	6.8	7.1	8.4	41.0	30.6	**80.0**
FⅡdown	16.6	14.6	14.6	11.2	33.2	9.7	**54.2**
FⅢup	26.7	17.2	14.9	9.5	30.8	0.9	**41.2**
FⅢmid	23.8	11.7	19.4	13.6	22.3	9.2	**45.1**
FⅢdown	**31.0**	**15.5**	**10.3**	**13.8**	**20.7**	**8.6**	**43.1**

III. DATA PREPROCESSING

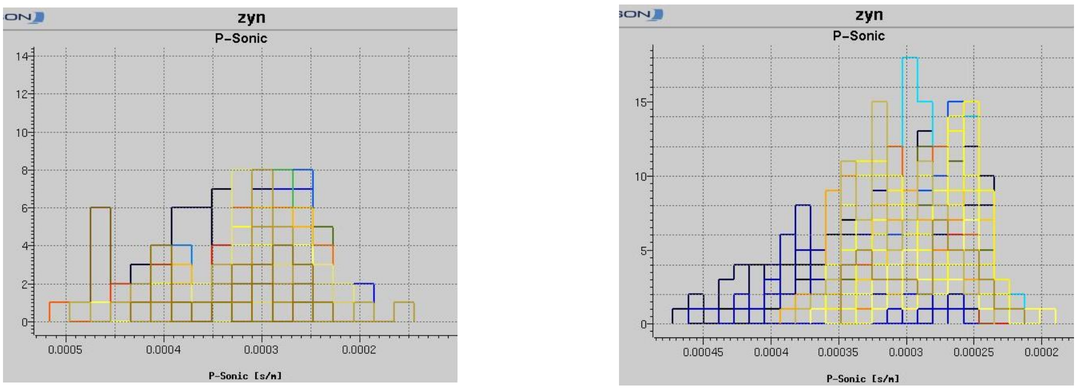
a The standardization and interpretation of logging Editing and correcting of logging curve

Due to the influence of wellbore expansion and other factors,in the measuring process, the measurement value of sonic logging curve and density logging curve often deviate from the actual value, therefore, it is necessary to edit the abnormal logging value and make depth error caused by logging curve of different times of well production depth correction. The methods of mean filter and manual editing are generally used to correct the curves to make them in the reasonable range[3].

Normalization of logging curve

In fact logging data normalization uses the same layer of the same field or area which often has similar geological-geophysical characteristics of self-similar distribution patternTake an overall analysis of logging data of oil wells and correct the inaccuracy of calibration to achieve the standardization of Logging data in the whole oilfield[4,5].The logging curves are normalized by the histogram method. To process the acoustic curve (AC) , by using the standard interval histogram as the logging data normalization analysis scale mode, and then through analyzing the distribution of the same standard layer frequency per well, compare it with the standard model to determine the offset correction required.

The whole area has a total of 460 wells, the process of normalization is carried out .It can be seen from the acoustic frequency distribution histogram before standardization (Fig. 2a), although frequency distribution of most wells is in good consistency, but the AC values of individual wells offset, if data like this are directly used in multi well process or the inversion, it will cause large errors,what`s more, wrong conclusions may be obtained. It can be seen from the frequency distribution histogram after normalization (Fig. 2b)that the relevency of normal distribution histogram correlation is very well.



a.Statistical histogram before sonic curve correction **b. Statistical histogram after sonic curve correction**

Fig.2: Before and after the sonic logging curve standardization

b The analysis of seismic spectral characteristics

South Zhaoyuan seismic work area is new seismic data acquired in recent years, belongs to production seismology data volume, the binning is 20m*20m，seismic vertical resolution is higher. Spectral analysis shows（Fig.4），the basic frequency of seismic data is about 55-60Hz,distribution of the frequency band is 10—220Hz,the width of frequency band of the seismic data is more suitable for high-precision inversion needs.

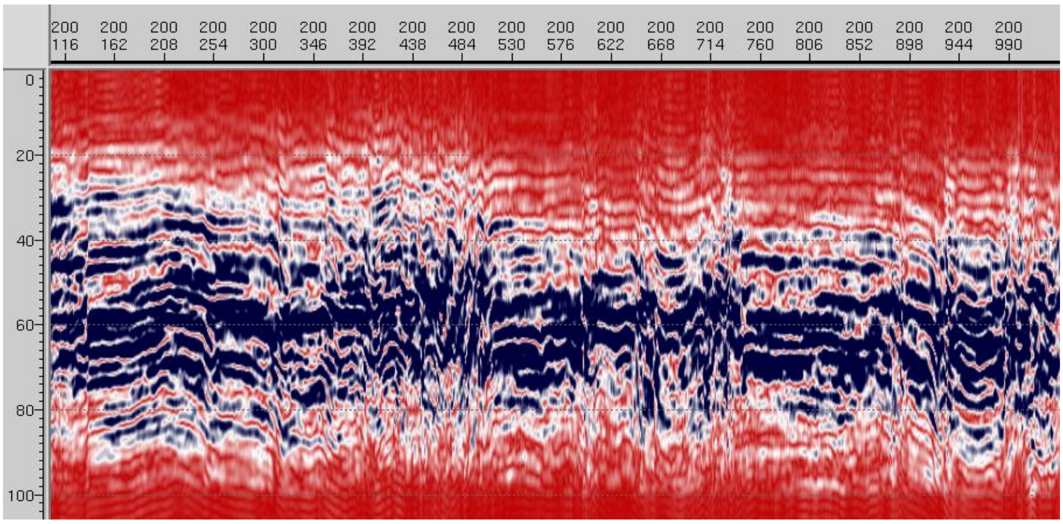
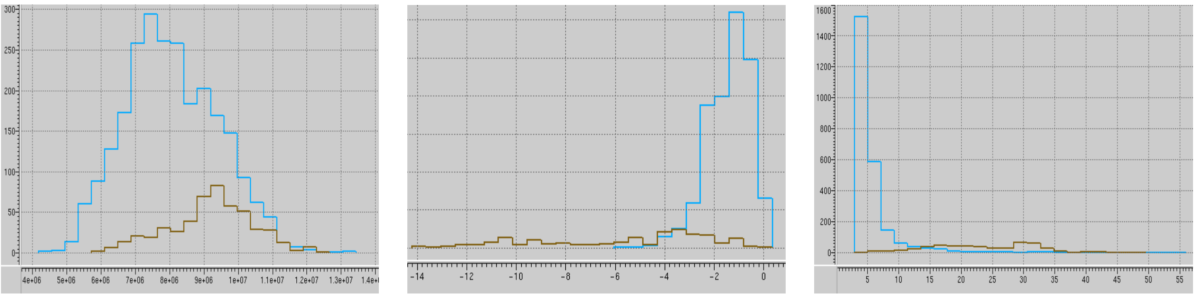


Fig.4: Spectrum profile section of production seismology in South Zhaoyuan

IV. PARAMETER ANALYSIS FOR RESERVOIR SENSITIVE LOGGING

By analyzing the response characteristics of the curves of sandshale in Fuyu oil layer,to define log parameter which are sensitive to sandshale; From the statistics of reservoir sensitivity in Fig.5 can be seen, the distinguish ability to sandshale of acoustic is poor,while SP and R_{LLD} can both identify sandshale well; but many wells of the study area cannot acquire SP, while R_{LLD} curves are collected over the whole, so R_{LLD} curves are used for impedance fitting, and then improve the resolution of reservoir prediction.



AC **SP** **R_{LLD}**

Fig.5: Histogram of reservoir sensitivity statistics

V. ACCURATE CALIBRATION OF HORIZONS AND WAVELET EXTRACT

The thickness of Fuyu oil layer is about 250m, divides into 3 oil layers, FI、FII and FIII, 17 sublayers in total, in order to predict spatial distribution of every sublayer sand, accurate horizon calibration appear to be very important; to seismic inversion based on model, Wavelet is a bridge connecting seismic record and initial model,the result of model inversion is related closely to seismic record, initial model and wavelet.How to acquire right wavelet is one of the keys to inverse successfully. The process of define optimal wavelet is as follows: First, the effective frequency band of seismic data can be known as 10～90Hz by spectrum analysis,the main frequency can reach as high as 60Hz,so extract theoretical Ricker wavelet whose main frequency is 90Hz,use the theoretical wavelet and log impedance curve to create seismogram synthesis,make the main wavelet group of the seismogram synthesis and the actual synthesis aligned,choose a right time window to extract seismic trace wavelet, and use the new extracted wavelet to create new seismogram synthesis, regulate the time-depth curve to make the seismogram synthesis gradually approaching the actual seismic trace, repeat the process above until the acquired synthesis and the seismogram synthesis reach the best adaptation (Fig.6).By the work above, coordinating the control of wavelet quality and the analyze of matching of seismogram synthesis,must ensure the best matching of the seismogram synthesis and the seismic data (Fig.7),to make a less residual value,as soon as the correlation coefficient is above 65%,the calibration of this well is basically stereotypes, the best time-depth relation is acquired, best-completed horizon calibration establishes the foundation of lateral extrapolation of log message, provides ideal wavelets for the later inversion at the same time.

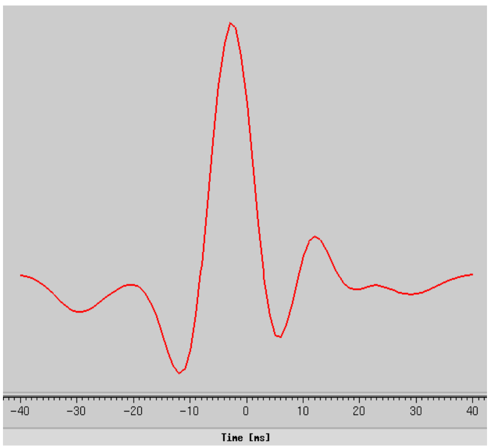


Fig.6: The actual trace wavelet beside the well

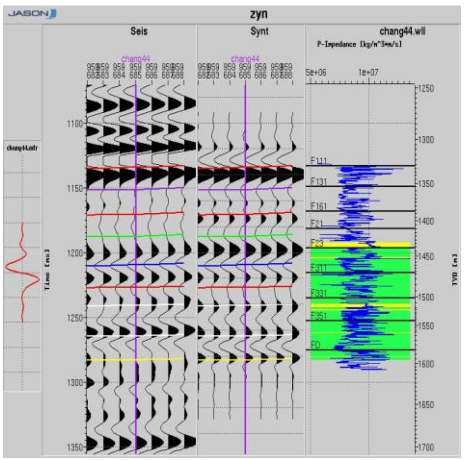


Fig.7: Accurate calibration of seismogram synthesis

VI. INVERSION EFFECT EVALUATION

Considering the actual geological conditions of study area (area belongs to the low well district), main geological task is to identify the external area of sand body distribution law, but these areas drilling is relatively less and the distribution is not uniform, but both broadband constrained inversion model or multi parameter lithologic seismic inversion has higher requirements on well spacing density based on theinversion accuracy, have very high correlation with the well spacing density, so these methods are not applicable in this area, inversion has multi solutions has not test, on the other hand also has risk exploration. Therefore, we choose the constrained sparse spike inversion in the area (seismic inversion method based on) combined with geostatistics inversion, constrained sparse spike inversion can more reflect the original features of the seismic data, has high reliability in sparse or no well area, but because of the limited seismic data, the vertical resolution ability is limited, therefore, of geostatistical inversion on the basis of it, using CO kriging technique, I Chumi Ima Chumi from logging data, seismic wave impedance, effective integrated seismic and well log data, vertical wells with higher resolution, better reflects the characteristics of seismic data, reservoir prediction and inversion research.

a sparse pulse wave impedance inversion

Using standardized acoustic time to generate the wave impedance curve make synthetic seismogram, extracting each well of wavelet, using wavelet though sparse pulse wave impedance inversion, the Fig.8 is a well profile with method to extract after inversion,getting a low vertical resolution, it is very difficult to meet the accuracy requirement with the method on the study area purpose layer of fine reservoir characterization , but the results can be used as a subsequent stochastic inversion constrained background.

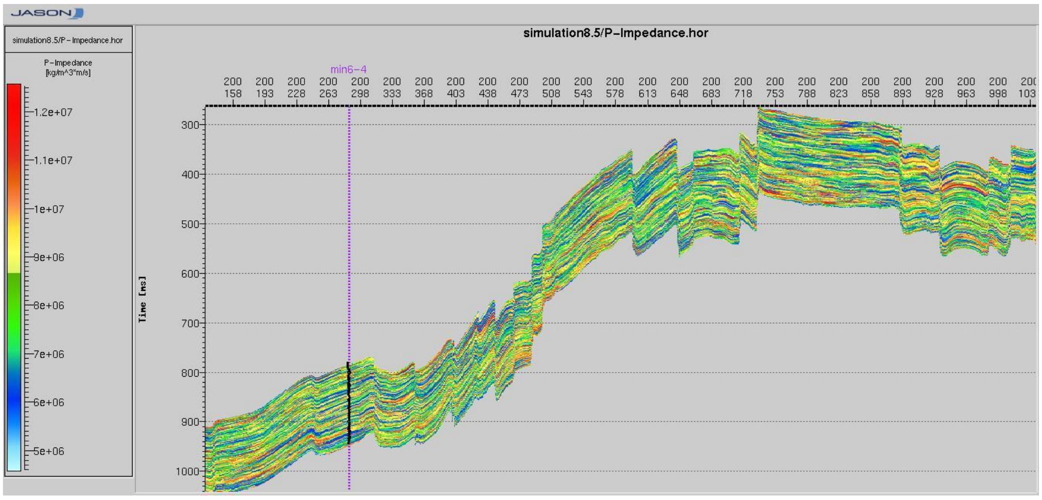


Fig.8: original wave impedance inversion profile in the study area

b random inversion of resistivity

Through inversion section (Fig.9), the accuracy is higher on the longitudinal recognition of the inversion profile , lateral on sand body distribution is discontinuous, and sand body boundary is clear.

c The longitudinal resolution

Contrasting between inversion profile curve of even well and resistivity curve(Fig.10), on the whole, well curve and inversion profile alignment is higher, especially, it is higher for thin sandstone identification precision; it is fast to change on lateral of Inversion section , and it takes the lenticular sand body distribution on sand body east-west interwell inversion profile.

d posterior well validated

The example is in ZhaoYuanNa work area, part of the well whose curve and stratification is complete, quality is good are used , and the curve is not complete or incomplete well as posterior well,it is a means to test the reliability of inversion. Finally, there are 267 well which take participate in the inversion of the well (part of the slope is not involved in),61 Wells which are continuous data in inversion Wells, the distribution is shown in Fig.11, blue is not involved in the well, red to take participate in the well in ZhaoYuanNa work area.

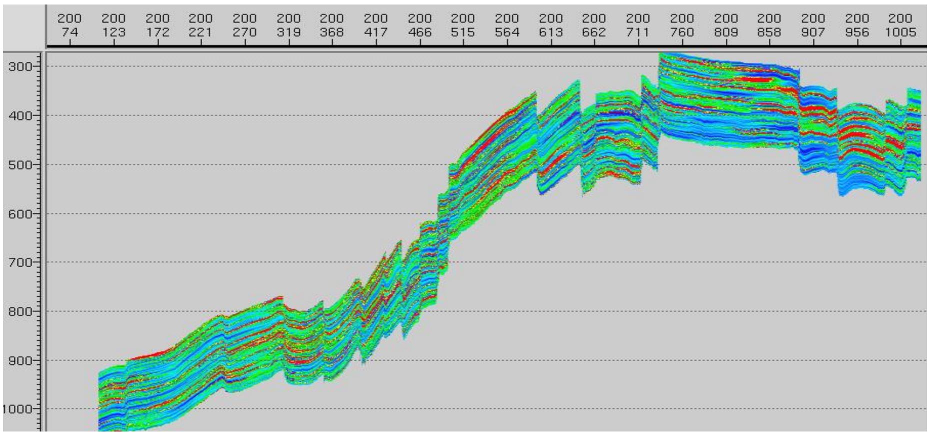


Fig.9: resistivity stochastic inversion profile in the study area

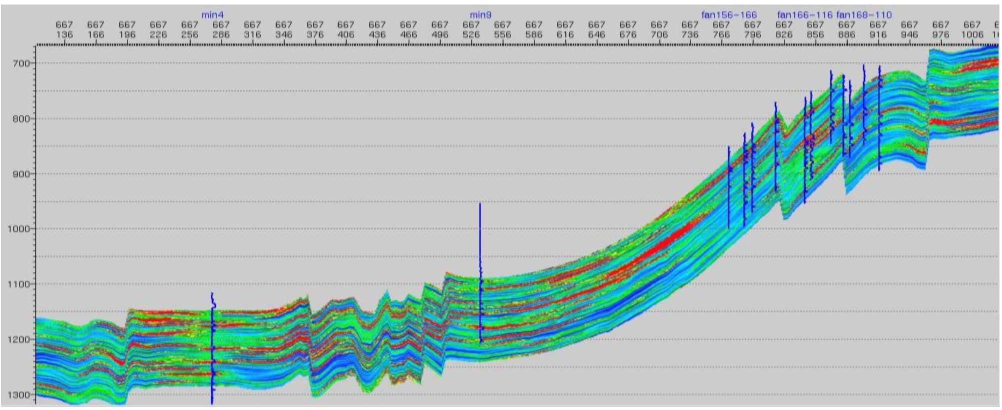


Fig.10: well inversion profile and well curve (RLLD)comparison

Contrasting between Posterior Wells and seismic section anastomosis (Fig.11:), it coincides on sandstone thickness of >3m , with distribution for multiple thin interbed sandstone, vertical can only identify 1 set; In the area which well is dense, the inversion accuracy is higher, posterior well anastomosis ideal.

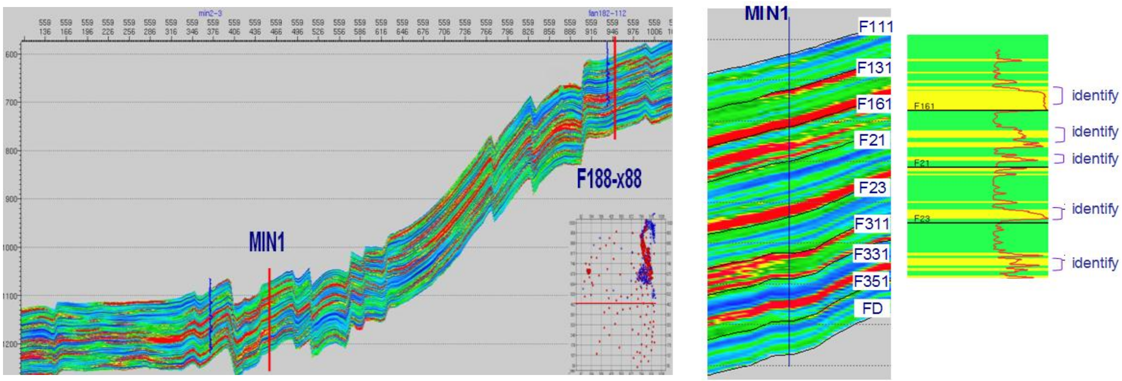


Fig.11. posterior well effect

VII. THICKNESS OF SAND BODY PREDICTION AND ERROR ANALYSIS

a sandstone thickness prediction

According to the above methods and processes, it gets 8 sandstone thickness in Fuyu reservoir sand groups each (FI, up,middle and down, FII up, down, FIII, up,middle and down),3 the sandstone thickness on the reservoir group (FI, FII and FIII) , on this basis, combining with the research of sedimentary characteristics, Fuyu reservoir area which we study and Putaohua reservoir sand body space distribution have fine description.

b Error analysis

Error statistics to predict the thickness of sand (Fig. 12), the relative error of sandstone thickness of<0.5% are mainly within the scope,the second distribution between 5% to 15%,the relative error of >15% is relatively small, accounts for 14% of the proportion of the total;

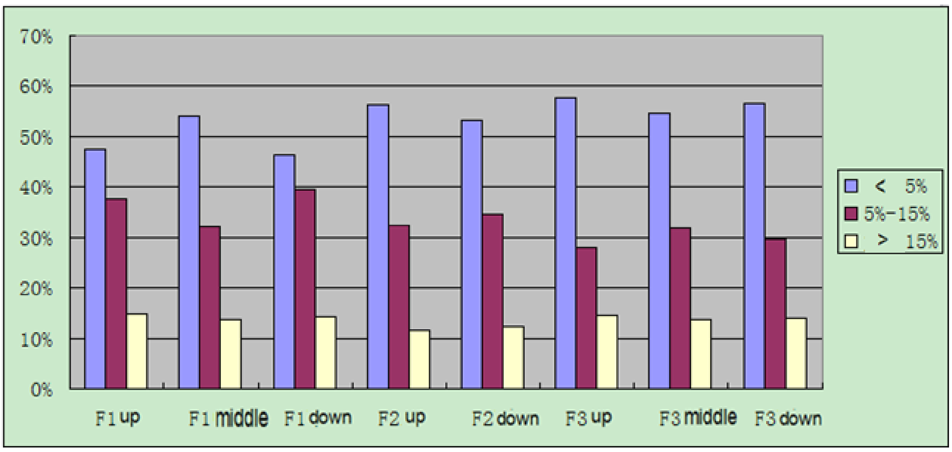


Fig.12: each group of sand layer thickness of sand body prediction accuracy of statistics

VIII. CONCLUSION

a Well seismic inversion has become an important means of reservoir description of reservoir;

b Sparse pulse inversion and stochastic inversion combination has better application effect in thin and poor reservoir, the sparse and uneven area.

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