Global Academic Frontiers, Vol. 2, Issue 1, 2024, pp. 19-26 Print ISSN 2995-5688 Online ISSN 2995-570X

Target enhancement interpretive processing techniques and their application in B area

ZHANG Li[1]

[1]Sinopec Geophysical Corporation, Beijing 100020, China

*Corresponding author Email: zli_sgc@yeah.net

Abstract: The Ordovician reservoir in Area B is a carbonate fracture- controlled fractured-vuggy reservoir. The distribution of the reservoir is controlled by the slip fracture zones, with large differences in three-dimensional space and strong heterogeneity, which makes it difficult to identify the geological target body. Methods to improve the accuracy of fracture prediction through improved algorithms work well, but are difficult for ordinary interpreters. Therefore, a characteristic interpretive processing approach oriented to geological problems is proposed. In this paper, the geological target body in Area B is processed by the target-enhanced interpretive processing approach, and suitable key parameters are selected to highlight the geological target features. By these methods, improve the interpretation accuracy of the layers and fractures, and effectively support the later reservoir prediction.

Keywords: Carbonate reservoirs, fractured-vuggy reservoir, target enhancement, dip-steering filter, fracture characteristics

Introduction

Carbonate reservoirs occupy an extremely important position in oil and gas exploration. 47.5% of the world's remaining recoverable oil-gas reserves come from carbonate reservoirs[1-2]. The Ordovician reservoir in Area B is a carbonate fracture-controlled fractured-vuggy reservoir. In this area, the imaging effect of its 3D data on fractures and fractured-vuggy is poor, the imaging accuracy of seismic data on fractures and fractured-vuggy is low. Multiple waves are developed[3-4]. The in-event dislocation of small and medium-sized scale fractures is small and the breakpoints are not clear, which can't accurately portray the Ordovician fracture. On the one hand, the large difference in wave impedance between the Upper Ordovician and Middle Ordovician has a great shielding effect on the underlying target layer. On the other hand, it is difficult to identify the fractures by conventional methods because of the unclear imaging, which leads to the lack of understanding of fault property, scale, and tectonic evolution, and restricts the further development[5].

Seismic fracture prediction techniques can be broadly divided into three categories[6]. The first method is to use specific seismic attributes, such as curvature and stress field, to characterize fractures based on post stack seismic data. The second is based on pre-stack multi-directional seismic data, which uses anisotropic characteristics of longitudinal wave orientation to predict fracture orientation and density. The third is based on multi-component data using shear wave splitting, which is relatively limited due to the difficulty and high cost of obtaining high-quality shear wave data. The analysis techniques for coherence, curvature, and anisotropy are widely used [6-10].

Usually, people improve the accuracy of fracture prediction by improving algorithms. As many scholars continue to improve the third-generation coherence algorithm[3-4], their noise resistance and resolution are continuously improved. However, improving algorithms requires a high level of geophysical, mathematical, and computer programming skills, which is difficult for ordinary interpreters[11].

This proposes a characteristic interpretive processing technology method guided by geological problems, which improves the accuracy of fracture prediction through interpretive processing. Based on the characteristics of different fracture algorithms, interpreters use conventional processing and interpretation software to process the input data and output results separately before and after calculating fracture attributes, making the input data more in line with the needs of specific algorithms, further optimizing the output results, and achieving the goal of improving fracture prediction accuracy.

In this paper, the geological target features are highlighted through the target enhancement interpretive processing of the geological target body in Area B. The layer and fracture interpretation accuracy is improved, which lays foundation for reservoir meticulous depiction.

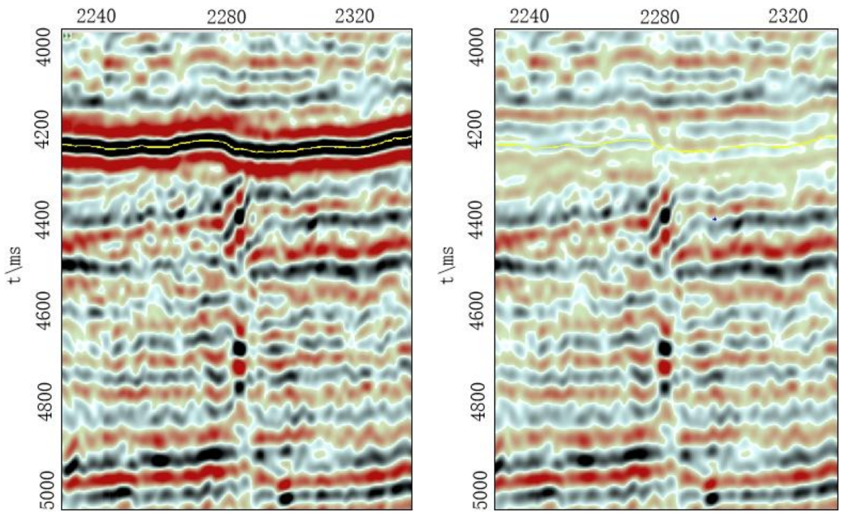
1. Main method

In order to highlight the target body in a targeted way, this paper makes use of high-resolution 3D seismic data to carry out research on target-enhanced processing techniques to improve the signal-to-noise ratio and resolution of the seismic data, so as to enhance the accuracy of seismic imaging of different types and scales of faults in B area. According to the characteristics of spectrum, amplitude and signal-to-noise ratio of the data, we will carry out comparative analysis of the key parameters of seismic data target-enhanced interpretive processing technology, determine the corresponding processing methods and parameters, and improve the seismic response characteristics, so as to establish an interpretive processing and imaging process suitable for the area, and highlight the fracture characteristics hidden in the seismic signals.

1.1 Strong reflection separation

The strong reflection separation technique adopts a match-tracking algorithm. It takes the input layer as the reference, matches the local optimal wavelet according to the best matching criterion, extracts the strong reflection features consistent with the optimal wavelet and realizes the adaptive decomposition of the original seismic record. The method blurs the position information in the matching trace, which leads to the good continuity of the identified strong reflection events. The effective reflections in the reservoir is highlighted after the strong reflections are stripped.

There are obvious strong reflections of clastic and carbonate rocks in Area B. The problem of strong reflections shielding weak signals of the reservoir has brought great difficulties to fine reservoir prediction. Figure 1 is a comparison of the effect before and after the separation of T_7^4 by using the above separation method. We can see that the strong reflection layer of T_7^4 at the top of the Ordovician, which is made up of limestone, has a strong shielding effect on the underlying fractured-vuggy reservoirs before the separation, and the characteristics of the fractured-vuggy bodies in its vicinity and underneath are blurred. After the strong reflection separation, the strong reflection interface is well weakened, which is helpful for fine interpretation and attribute extraction in the later stage.



Before After

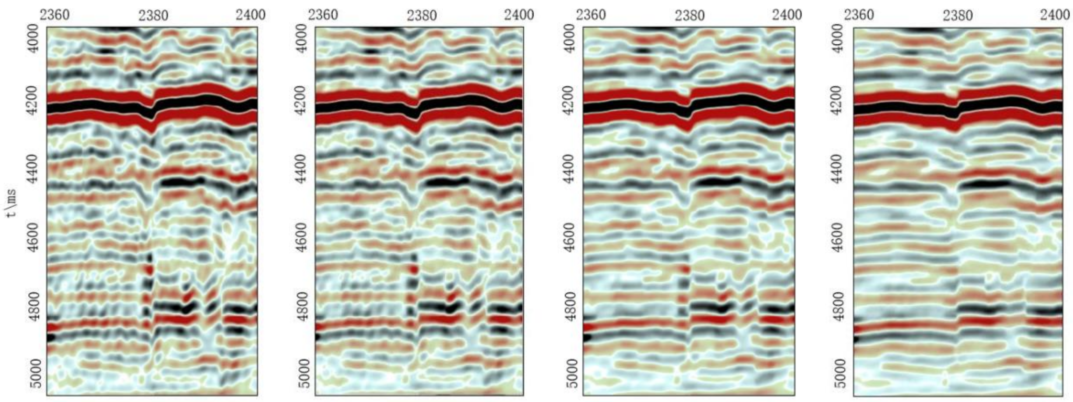
Fig. 1 Strong reflection separation effect diagram

1.2 Dip-steering filter

Dip-steering filter is a common method in interpretive processing flow. The application of dip-steering filter generally improves the signal-to-noise ratio of seismic data significantly. Dip-steering controlled enhancement technology uses the changes in inclination and azimuth to calculate the similarity of neighbouring channels, the results of which have significantly enhanced seismic lateral signal-to-noise ratio and the ability to delineate faults. This facilitates the subsequent study of faults and fractures.

The dip control enhancement can improve the quality of seismic data for better interpretation of stratum and fault . In calculation process, the dip change of each sampling point is fully considered. The comparison window is selected centered on the calculation sample points., and the corresponding calculation weights are defined for each sampling point involved in the calculation. Each correlation initial value is defined as 1 to ensure that all the results are positive. A perfect correlation will produce a weight of 2. We calculate the amplitude and weight of each dip-controlled sample point first , then average the weighting process for the sample points of all the comparison windows.

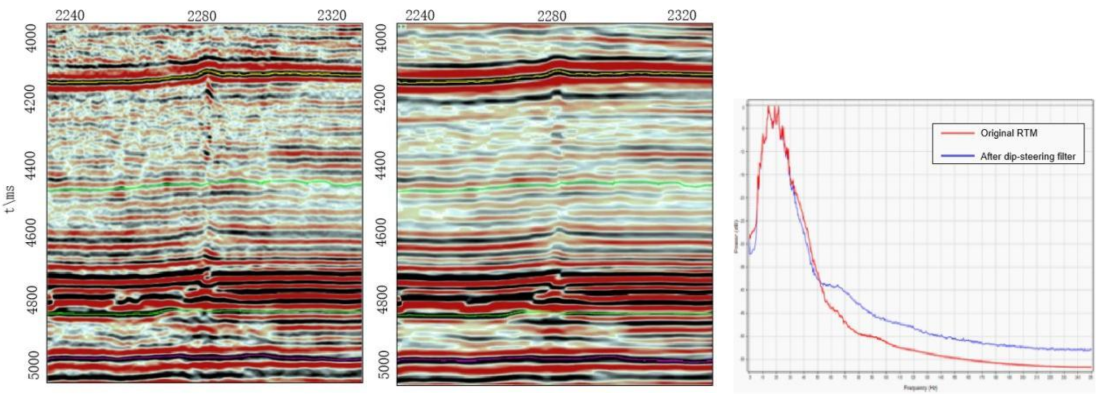
In the denoising processing and the selection of key parameters for filter, it is not only necessary to effectively suppress the noise and improve the signal-to-noise ratio, but also to maximize the protection of target body information such as faults and fractured-vuggy bodies. Find the balance between the protection of the fault information and the noise attenuation, so as to achieve the purpose of effective enhancement of the target. The RTM results data were tested and analyzed for key parameters, and the test effects of different parameters were compared. It was found that the fracture convergence is better and the fracture characteristics are more obvious by using the dip-steering filter parameter of 3_3_5 (Fig. 2).



1_1_5 3_3_5 5_5_10 9_9_10

Fig. 2 Comparative analysis of dip-steering filter processing test parameters

The characteristics of the seismic profiles after processing have been significantly improved, the noise has been suppressed, the strong amplitude characteristics of beads are maintained better, and the breakpoints of fractures are clear. Meanwhile, the amplitude spectrum of the data basically does not change. indicating that the processing follows the original amplitude and change rule, which has a high fidelity (Fig. 3).

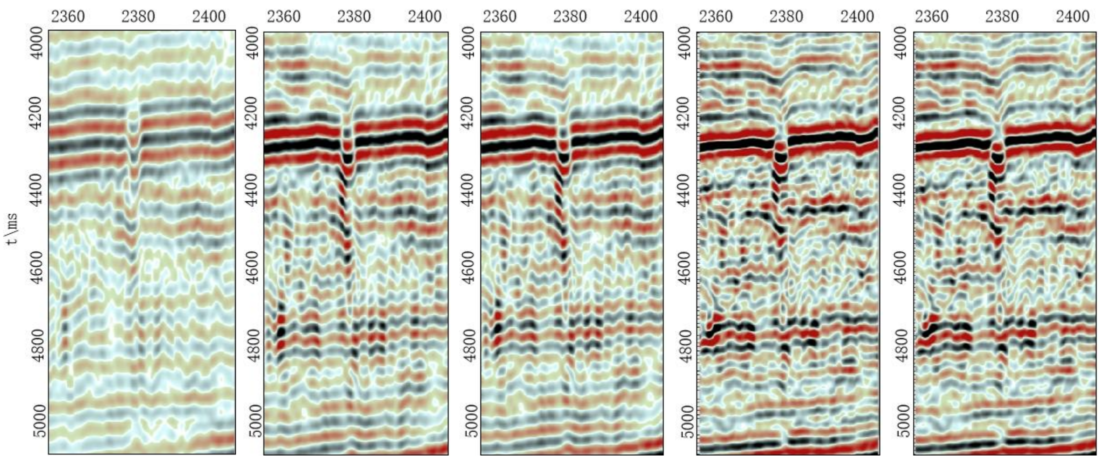


Before After Spectrum comparison

Fig. 3 Dip-steering filter processing effect diagram

1.3 Band-pass filter

Band-pass filter is a frequency-specific filtering method that preserves the frequency components in a certain frequency range while attenuates the frequency components in other ranges to a very low level. Band-pass filter is performed on the original data based on the DSG. Five filter ranges of 8-15Hz, 8-20Hz, 8-25Hz, 8-30Hz and 8-35Hz are selected to compare and analyze the filter effect. By comparison, we can see that after 8-30 Hz filter the signal-to-noise ratio of the Ordovician layer is moderate. The fracture convergence and bead imaging effect are better, and the fidelity is high(Fig. 4).

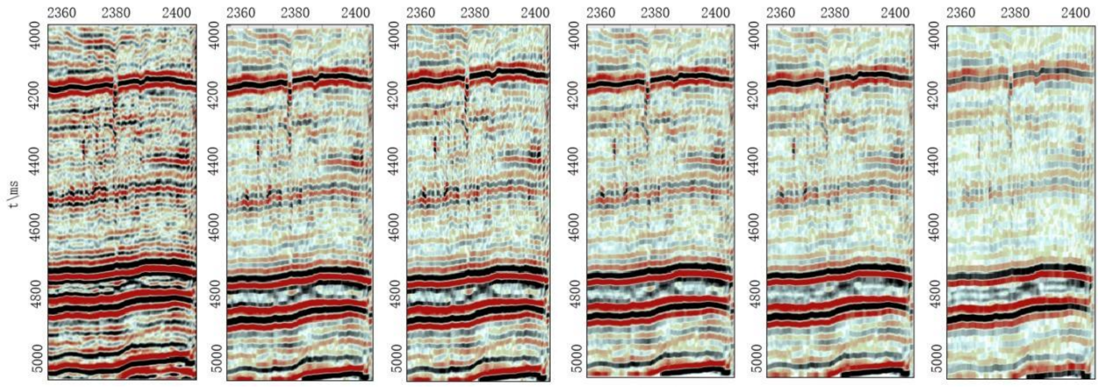


8-15Hz 8-20Hz 8-25Hz 8-30Hz 8-35Hz

Fig. 4 Comparative analysis of band-pass filter test parameters

1.4 Median filter

Median filter is a nonlinear smoothing technique. It is able to protect the edges of the signal from blurring while filtering out noise, whose excellent characteristics are not available in linear filtering methods. In addition, the algorithm of median filter is relatively simple and easy to implement in hardware. Median filter is performed on the original data based on the DSG. The parameters of filter length are selected as 11, 13, 15, 17 and 21 to compare and analyze the filter effect. Comparison shows that the fracture characteristics are gradually clear, and the focus of the cavern is improved with the increase of filter length 11, 13, 15. With the increase of filter length 15, 17, 21, the continuity of the layer is slightly better, but the effect of the fracture carving and the bead imaging is getting worse gradually (Fig. 5). It is believed that the median filter is effective in the fracture convergence and the part of layers tracking, while the parameters of filter length should not be too large. 13 is more suitable for this area.

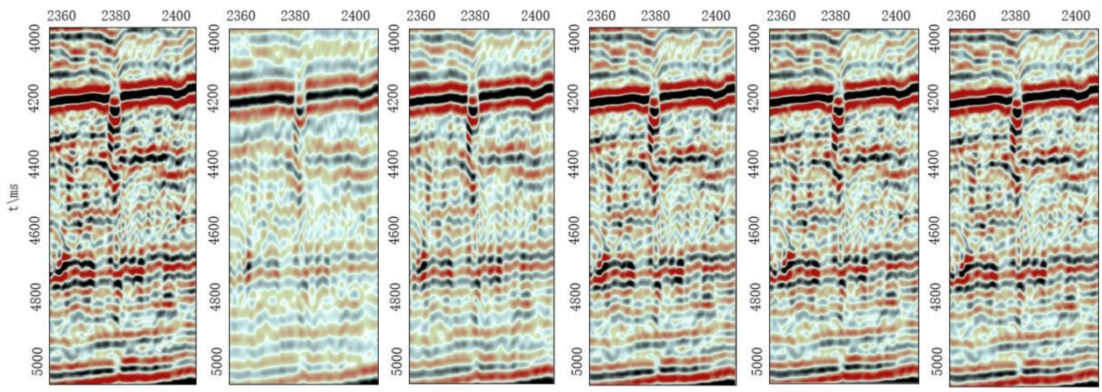


Original RTM 11 13 15 17 21

Fig. 5 Comparative analysis of median filter test parameters

1.5 Butterworth filter

Butterworth filter is performed on the original data based on the DSG. It is necessary to analyze the filter gradient and range parameters, which are selected as 8-10-15-18, 8-10-20-24, 8-10-30-36, 8-10-40-48, and 8-10-50-60. The result shows that that the signal-to-noise ratio of the layer after 8-10-30-36 filter is higher, the continuity is better, and the effect of fracture carving and bead imaging is relatively better, too (Fig. 6). Butterworth filter is effective in tracing the continuity of the fracture and part of the layer, and the 8-10-30-36 filter parameters are more appropriate for this area.

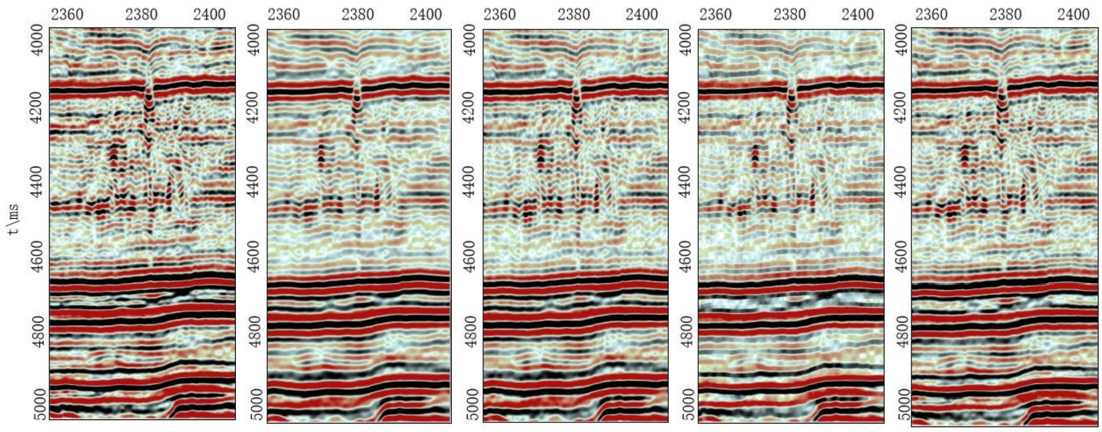


Original data 8-10-15-18 8-10-20-24 8-10-30-36 8-10-40-48 8-10-50-60

Fig. 6 Comparative analysis of butterworth filter test parameters

3 Application effect

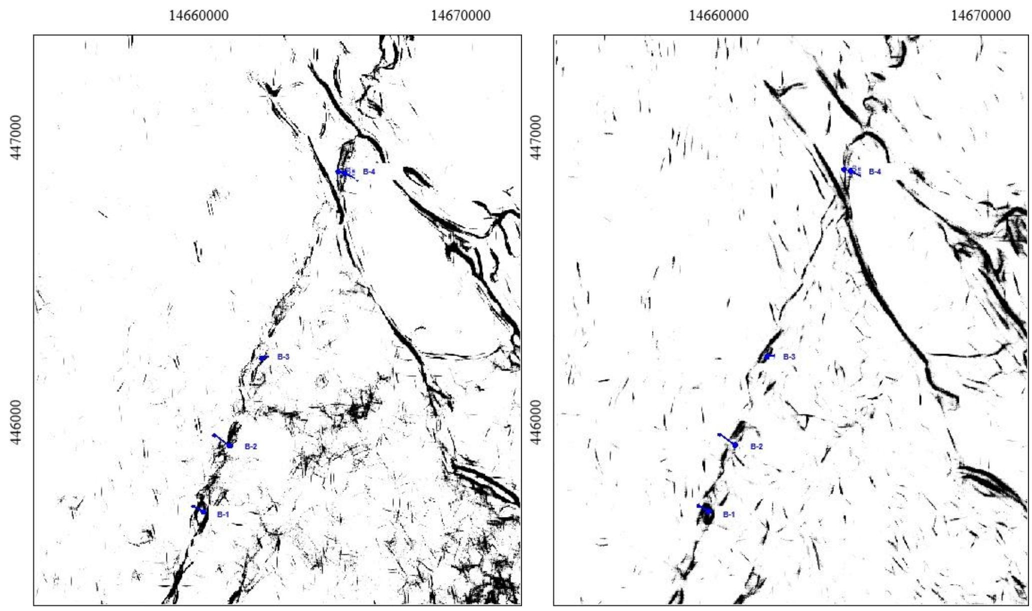
In summary, the filter parameter test and analysis are carried out around dip-steering, band-pass, median and butterworth after strong reflection separation. The signal-to-noise ratio of dip-steering filter data has been greatly improved, the main fracture breakpoints and sections are clear, and the bead response is prominent, followed by band-pass filter and butterworth filter (Fig. 7). This could provide reliable interpretive processing resultant data for the later fine interpretation.



RTM Dip-steering filter Band-pass filter Median filter Butterworth filter

Fig. 7 Comparison of interpretive processing effect

The comparative analysis of the extracted AFE attributes before and after the interpretive processing also shows that there is a significant improvement in the clarity of the faults and fractures after the interpretive processing (Fig. 8).



Before interpretive processing After interpretive processing

Fig. 8 Comparison of the AFE attributes of the main destination layer

4 Conclusion

The target enhancement processing using a combination of strong reflection separation, dip-steering filter, and bandpass filter with different frequency bands can significantly improve the interpretation accuracy of the layers and fractures in this region. It would effectively improve the subsequent seismic imaging effect of fractures at different levels and fractured-vuggy in the target layer, and lay a solid foundation for the fine engraving of the reservoir.

Reference

[1] Tong XG, Zhang GY, Wang ZM, et al. Potential and distribution of global oil and gas resources[J]. Petroleum Exploration and Development, 2018, 45 (4):727-736.

[2] Chen HX, Kang ZH, Kang ZJ. Stratified Structure and Formation Mechanism of Paleokarst Cave in Carbonate Reservoir of Tahe Oilfield. Geoscience. 2022, 36(2):695-708.

[3] Ma YS, Cai XY, Yun L, et al . Practice and theoretical and technical progress in exploration and development of Shunbei ultra-deep carbonate oil and gas field, Tarim Basin, NW China[J]. Petroleum Exploration and Development,2022,49(1):1-17.

[4] Huang C, Yun L, Cao ZC, et al . Division and formation mechanism of fault-controlled fracture-vug system of the Middle-to-Lower Ordovician， Shunbei area， Tarim Basin[J]. Oil & Gas Geology, 2022,43(1):54-68.

[5] Deng GX, Hu WG, Wang Z. Quantitative characterization of fractured-vuggy carbonate reservoirs[J].Xinjiang Petroleum Geology, 2021,42(2):232-237.

[6] Liu ZF, Qu SL, Sun JG, et al. Progress of seismic fracture characterization technology[J]. Geophysical Prospecting for Petroleum,2012,51(2):191-198

[7] Liu J, Li W, Gong W, et al . Seismic identification and description of ultra-deep fault-controlled reservoirs in Shunbei area[J]. Xinjiang Petroleum Geology, 2021,42(2):238-245.

[8] Liu HY. The improvement of C3 coherence algorithm and the application in fault identification[D]. Jilin: Jilin University, 2013.

[9] Liao MH, Liu J, Gong W, et al .Discussion on reflection characteristics and prediction technology of faultcontrolling fractured-vuggy reservoir in Shunbei area[J].Chinese Journal of Engineering Geophysics, 2020,17(6):703-710.

[10] Yang P, Liang XH, Li HY, et al. Seismic methodology for identification of highly profitable wells in fractured-vuggy carbonates in the Tarim Basin[J].Expanded Abstracts of 83rd Annual Internat SEG Mtg, 2013, 2490-2494.

[11] Yang P, Li HY, Hu L, et al. Interpretative processing techniques and their applications in improving fracture prediction accuracy [J]. Geophysical Prospecting for Petroleum, 2015, 54(6):681-689.