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Acquisition Practice of High Signal-to-Noise Ratio in YTB Block of Sichuan Basin

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Abstract

YTB block in Sichuan basin is a favorable area to exploit oil and gas in shallow tight rock. 3D seismic project of this zone has two characteristics. Firstly, it has high requirements for the tolerance rate of the construction process and the acquisition of high signal-to-noise ratio seismic data; Second, there are widely obstacles and noises that lead to difficult acquisition construction organization. In acquisition practice, high signal-to-noise ratio seismic data was obtained by reasonable design of construction scheme, optimization of excitation parameters, improvement of receiving conditions and optimization of obstacle crossing observation system.

Keywords

Tight Oil and Gas, Tolerance Rate, High Signal-to-Noise Ratio, Obstacle

1. Introduction

YTB block of Sichuan basin is located in Mianyang City and Suining City, Sichuan province. J_2s of Jurassic and T3x of Triassic both are favorable areas to exploit oil and gas in shallow tight rock. Some wells in the adjacent areas have obtained high-production. Petro China Southwest Oil & Gasfield Company thus deploy a 3D seismic prospecting project to confirm the sturctures and faults, to describe the favorable facies and reservoir distribution, to detect fractures and fluid and to support well drilling.

The project requires high quality data from Jurassic to simian. In order to receive high resolution and high signal-to-noise ratio reflection data from J_2s to T3x, reasonable organization, optimized parameter configuration, improved excitation and reception conditions and suppressing various noises are ma- nipulated.

2. Seismogeological Characteristics of the Target Area

Geography of YTB block is typical hill-mountain with low elevation between 380 - 680 m. Outcrops are siltstone in upper of J3p of Jurassic and K_2c of Cretaceous and gravel of Quaternary. 96% of the survey area covers sand and shale of Jurassic and Cretaceous formations. So, those are better conditions for seismic prospecting.

The near surface has 2 or 3 layers and its thickness is within 10 m. Velocity of low velocity layers is about 1200 m/s. Lateral variation of the velocity of high velocity layers is smooth. The velocity range is between 2000 and 3200 m/s. The structure is smooth too. Wave field is simple. The seismic reflection is continuing and the wavepacket characteristic is clear and typical.

3. Design of 3D Acquisition Construction

3.1. Analysis of Former Data

YTB block and adjacent areas had finished several 2D and 3D seismic prospecting projects. Last two projects targeted to T_3x - T_2l and lower Paleozoic-Sinian reservoirs. The two designs apply 20 m × 20 m bin size and 400 m receiver line interval while applying 6000 m and 7500 m maximum offset respectively.

According to 2D and 3D data, shot records excited in J_3p, K_2c and gravel of Quaternary are better. The data have 10 Hz - 70 Hz frequency band. As for cretaceous and Jurassic formations, the records excited in shale are better than those in sand. While shooting in high velocity layers, type of rock for shooting has more important influence to the data quality than shot well depth.

Figure 1 is frequency scan of records excited in J_3p shale and sand rock in adjacent area.

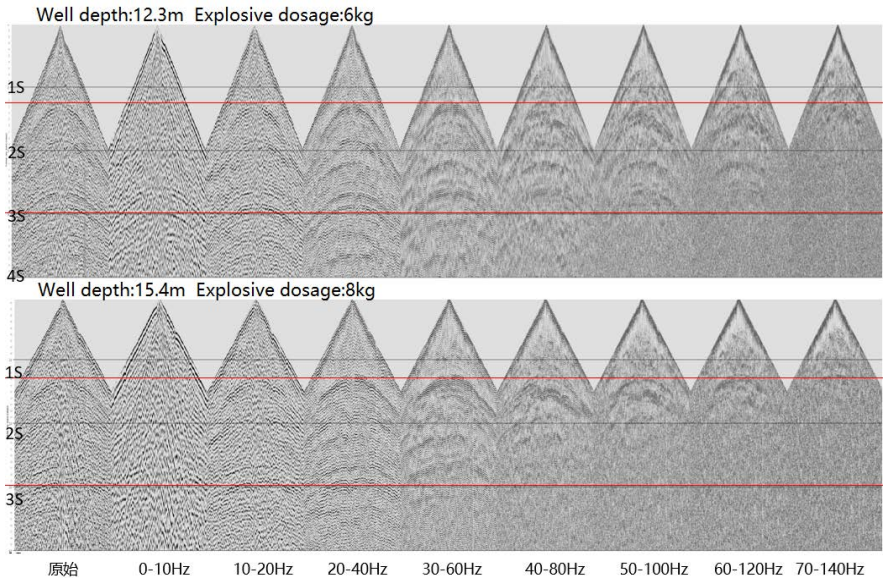

Figure 1. Frequency scan of records excited in J_3p shale (above) and sand (below) rock in adjacent area.

According to 2D and 3D seismic profiles, reflection events have good continuity, seismograms have high signal-to-noise ratio. In addition，evaluate criteria of former 2D and 3D projects reveal that surface wave, sonic wave and external interference are the main factors to lower the field data quality. So, one of the important work is suppressing all kinds of noise to improve high signal-to-noise ratio. The proportion of the three types of main noises was tried to control under 12%.

3.2. Analysis of Work Conditions

It has been mentioned before that most of outcrops are Cretaceous and Jurassic sand or shale which are benificial to obtain good data. Meanwhile there are some disadvantageous conditions for seismic data acquisition. 1) Zi River and its tributaries pass through all receiver lines from west to east. 2) Extensive obstacles, such as rivers, city blocks, pipeline nets and expressway, spread all over the survey. These will affect geometry design. 3) There are many interference sources in survey area. For example, factories and power stations will degrade the seismic data quality. 4) Although the overall elevation of the survey area is low, it fluctuates frequently and has a high vegetation coverage rate, which poses certain difficulties for construction.

3.3. Key Points and Difficulties for Acquisition

The project aims to two shallow targets, J_2s buried 2760 meter depth and T_3x buried 4320 meter depth. Channel sands will be probed by using seismic data which require improving seismic resolution from J_2s to T_3x.

In summary, the key points are improving signal-to-noise ratio and resolution while the difficulties are how to suppress noises, to keep safe in wading across the rivers frequently, to guarantee shot and receiver distribution evenly and to perform the project successfully.

3.4. Construction Measures of Acquisition

The project takes some effective methods to solve the problems mentioned above. For example, testing the explosive to choose weight and planting geophones in tight coupling way to optimize shooting parameter and detecting condition. Investigating noises in advance to positioning interference sources and controlling based noise types to attenuate noises. Improving the ratio of accurate positions and reducing the negative impact from the obstacles to maintain shots and geophones symmetrical distribution (Bai et al., 2020).

Refer to experience from the former projects in adjacent area that the safe distance is 80 meters between source and house while using 6 kg dynamite. We reduce dynamite to 4 kg and shorten the distance to 50 meters to increase the ratio of accurate positions. 1151 wells were reduced dynamite and ratio of accurate positions is increased to 60.09%. The records with normal and reduced dynamite have the similar quality.

As for numerous obstacles, we adopt dynamical way to design geometry. That is designing indoor in advance, measuring in field, redesigning indoor (Wu et al., 2021a). In order to get a reasonable geometry, shot points were recovered in principle of nearby recovery in a grid. According to analysis, Zi River, county and a park are the most important factors to affect geometry design.

Zi River is 80 - 500 meters wide and cross the northern survey area. In theory, there are 948 shot and 786 receivers affected by the river from statistics. According to the investigation in field, the unacceptable points were abandoned during design. That results the minimum full fold number in some area is 132 which cannot meet the requirement, 85% of the full fold. By dynamical design, we migrate and recover those 948 shot points. Finally, the minimum full fold number is up to 157 which meets the design requirement.

County and the park area include 445 shot points. If abandoning all the points, the minimum full fold number in some area is 132. **Figure 2** is a diagram of abandoned shot location in the county and park. **Figure 3** is the simulation of the observation system after the survey line passed through the county and the park.

After migrating and recovering, the new geometry achieves the minimum full fold number up to 169, reaching 85% of the full fold. **Figure 4** is a diagram of recovered shots location in the county and park. **Figure 5** is the simulation of the recovered observation system after the survey line passed through the county and the park.

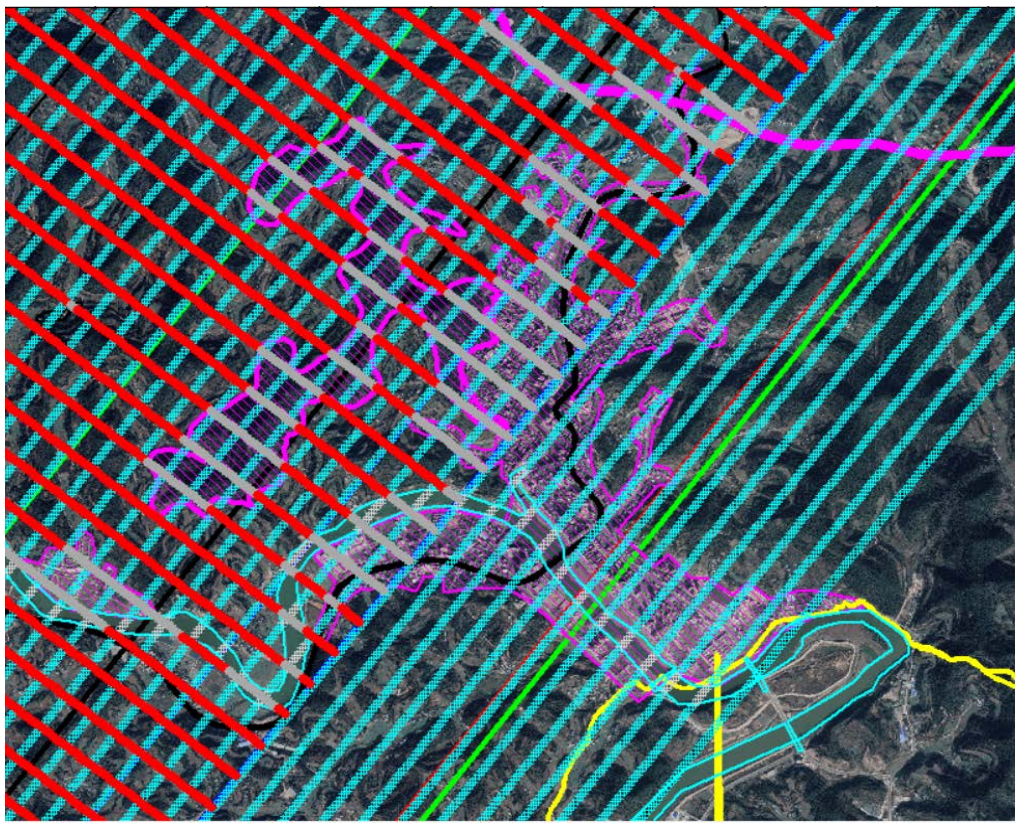

Figure 2. Diagram of abandoned shots location in the county and park.

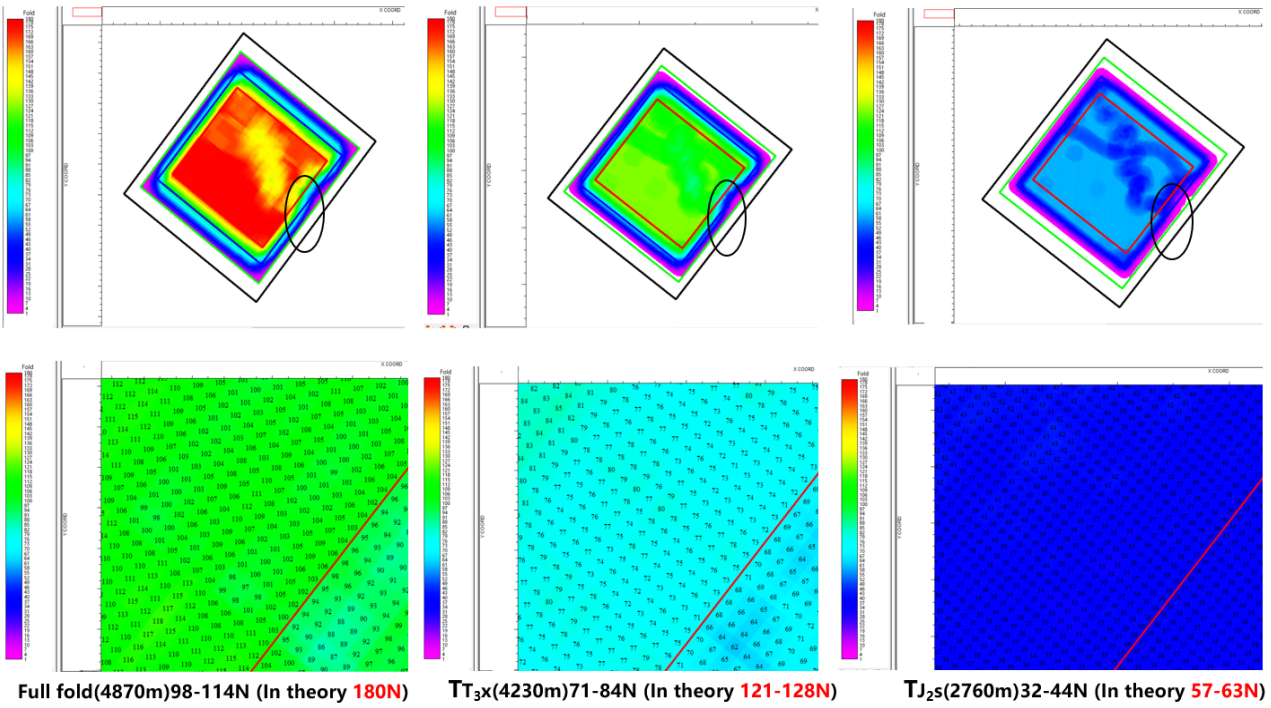

Figure 3. The simulation of the observation system.

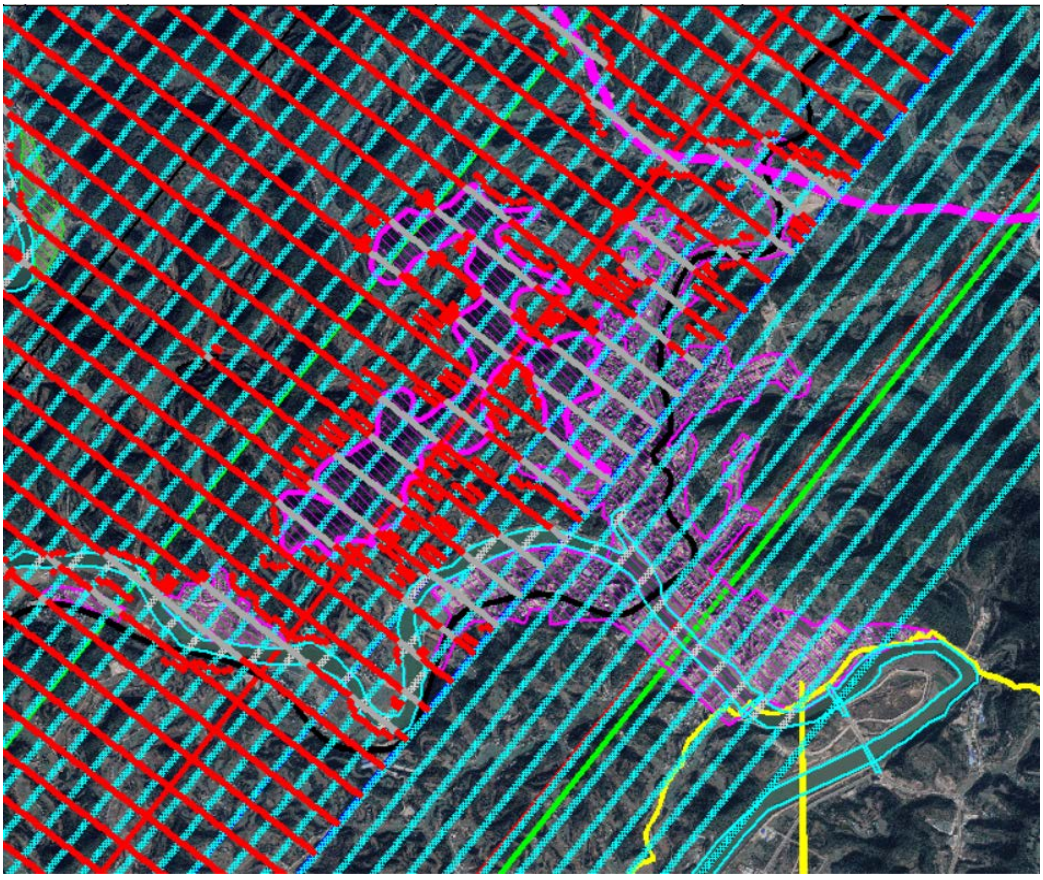

Figure 4. Diagram of recovered shots location in the county and park.

4. Analysis of Acquisition Practice Effect

Combined with the characteristics of the project, the acquisition of YBT block in Sichuan Basin has ensured the safety, high quality and efficiency of the acquisition process by reasonably designing the construction scheme, optimizing the excitation and reception parameters, reducing external interference and improving the uniformity of physical points (Wu et al., 2021b). The seismic data with high signal-to-noise ratio and high resolution have been obtained, which has been highly praised and recognized by the leaders and experts of Party A.

Figure 6 demonstrates two PSTM profiles, the left is the former data and the right is the new one this time. Compare to the former data, the new section has

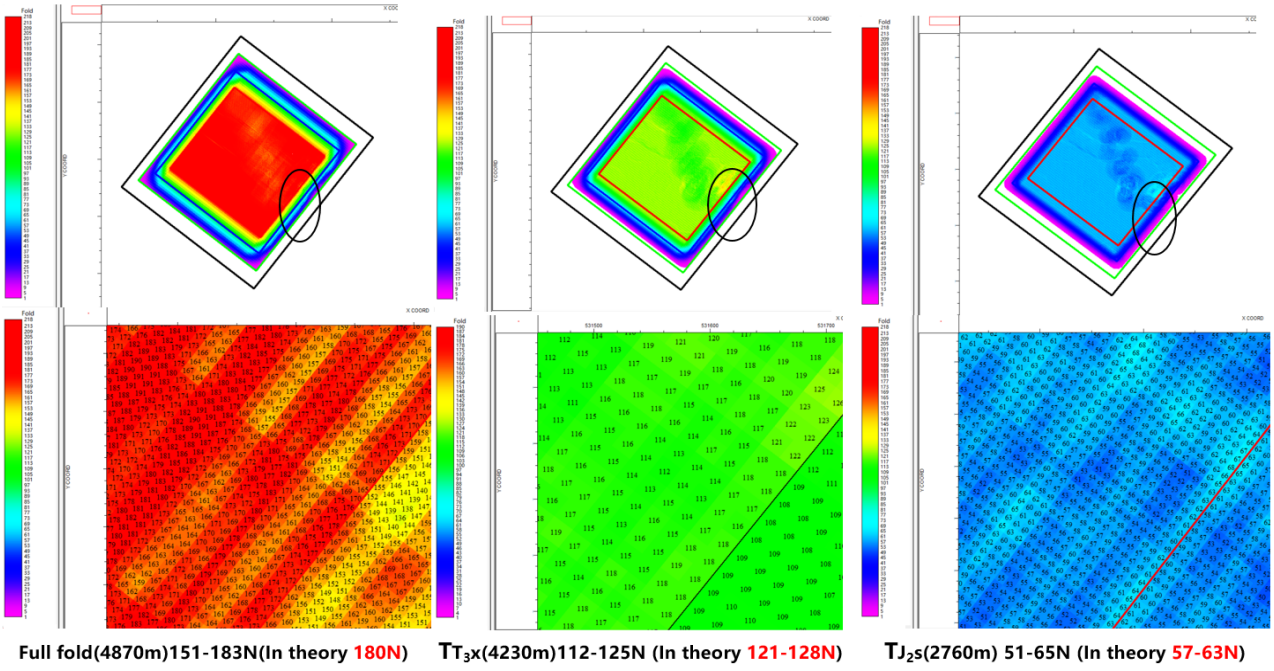

Figure 5. The simulation of the recovered observation system.

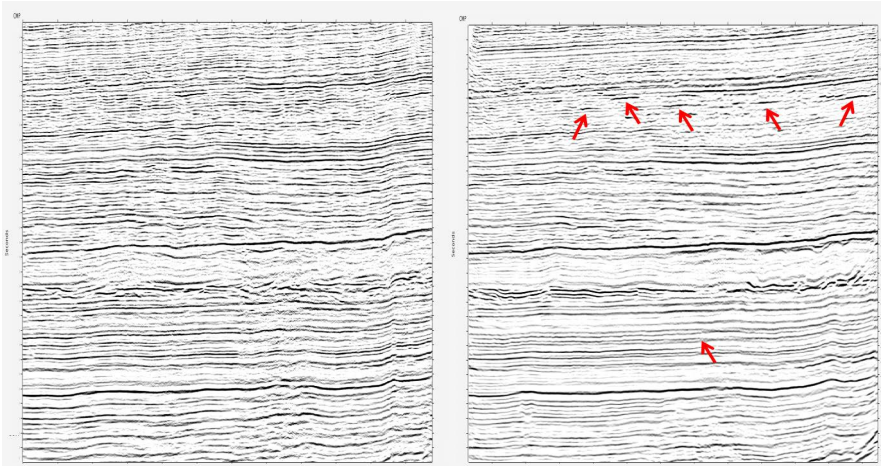

Figure 6. Comparison of new (right) and old (left) PSTM profiles.

higher signal-to-noise ratio and higher resolution. The seismic reflection is more continuing and the wavepacket characteristic is more clear and typical. Shallow reflection signal-to-noise ratio was improved obviously. The profile enhances J_2s channel formation. As for deep zone, new data include more low frequency and more information to show geologic body. Volcanic is described clearly. **Figure 7** is comparison of the new 3D PSTM profile and one adjacent 3D PSTM profile. Both data in target zones have similar characteristic. The same reflection can be tracked together. Channel sands are described clearly. **Figure 8** is a PSTM profile which demonstrates a volcanic clearly.

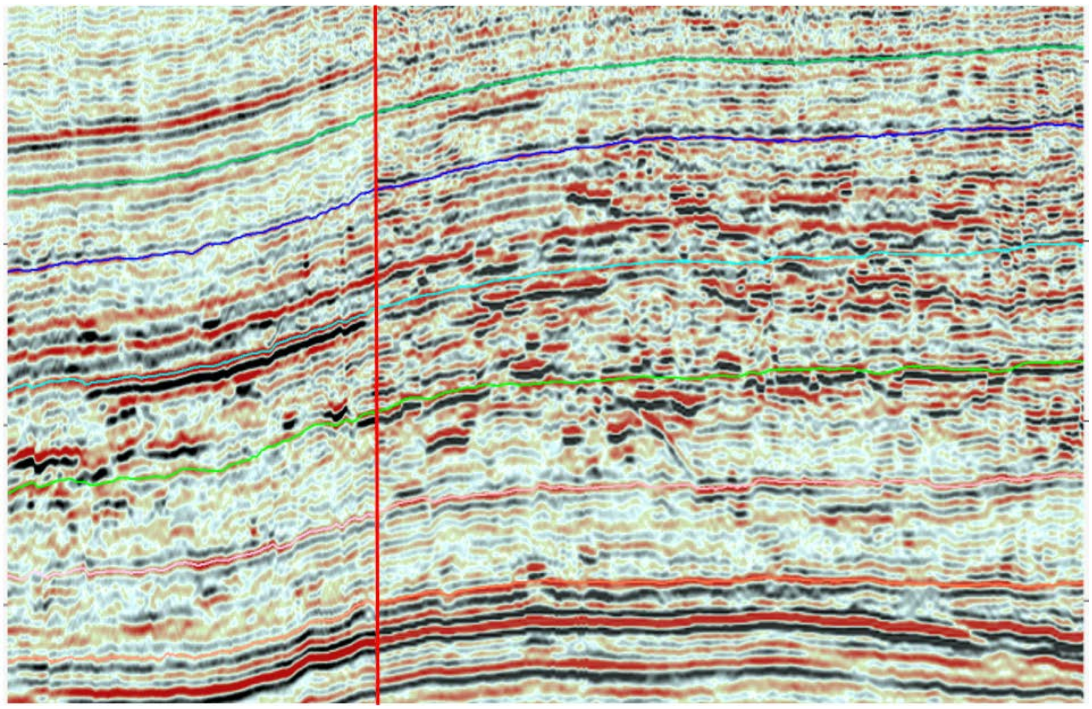

Figure 7. Comparison of new (right) and old (left) PSTM profiles.

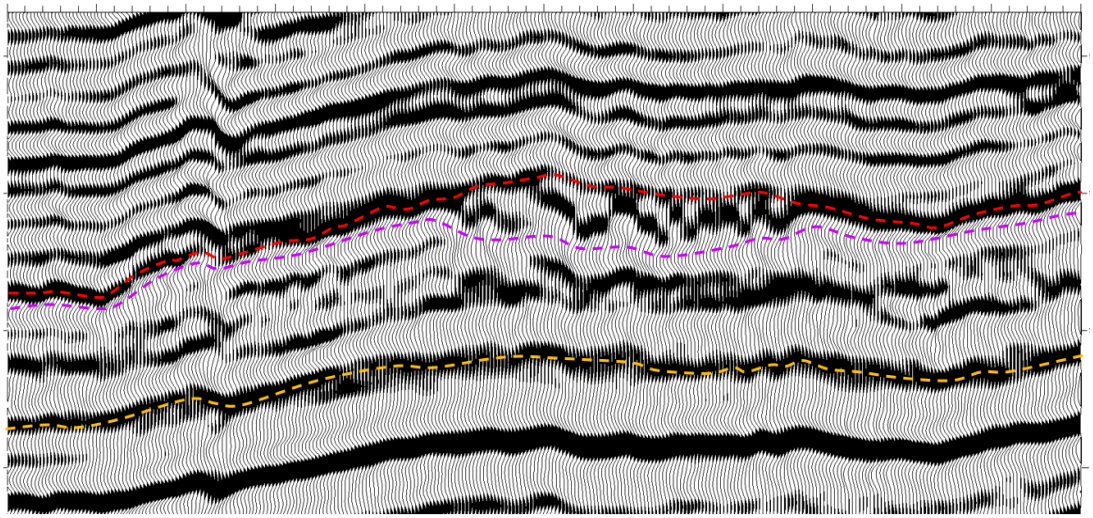

Figure 8. A PSTM profile which demonstrates a volcanic clearly.

5. Conclusion

This paper adopts a dynamical mode that is designing indoor in advance, measuring in field, redesigning indoor to obtain a reasonable design. Based on the principle of nearby recovery in a grid, shot points were recovered and geometry attributes were improved. In practice, the project obtain the high quality data that can describe Permian volcanic distribution and highlight J_2s and T_3x reservoirs.

Acknowledgements

This paper is a demonstration of some achievements of 3D seismic exploration project of YTB block in Sichuan Basin. Thanks to all colleagues who participated in the project!

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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