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Pre-stack Fidelity Denoising Technique in Loess Plateau Area

Menglin Wang[1], Zhidi Liu[1, 2], Shuaiyu Song[1]

[1]School of Earth Science and engineering, Xi'an University of petroleum, China
[2]Shaanxi Key Laboratory of petroleum accumulation geology, China

Abstract: Based on the data of P work area in Ordos Basin, this paper makes a comparative analysis and summarizes its difficulties: there are many kinds of interference sources in the work area, linear noise is developed, external interference, abnormal noise interference and other background noise are serious, and the signal-to-noise ratio of the original data is low due to the influence of the thickness of the low deceleration zone, the thickness of loess cover and the excitation and reception conditions. Therefore, aiming at this difficulty, a set of pre stack fidelity denoising technology is adopted according to different noise types. For surface wave, refraction wave, linear interference, abnormal energy interference and other noise, classification, zoning, step-by-step, domain, frequency and time-sharing fidelity processing are used to improve the data imaging effect. Frequency division abnormal amplitude suppression technology, prestack coherent noise suppression and ground roll wave simulated removal technology are used to solve the problem of noise interference. The results show that the signal-to-noise ratio and resolution of seismic data in this area have been significantly improved by using the above technologies.

Keywords: Prestack fidelity denoising, Surface wave, Abnormal amplitude suppression, Signal to noise ratio.

1. Introduction

The Ordos Basin has great potential for exploration resources and has typical loess landform characteristics [1]. The topography of the loess plateau area in the south-central part of Ordos Basin is undulating, and the surface layer is covered with a huge thick layer of gravelly loess, and the surface has been weathered, eroded and cut for a long time, forming unique landscapes of loess plateau, beam, mount, slope and ditch [2]. In recent years, with the development of seismic exploration to lithological exploration, the requirements for reservoir prediction have become higher, and conventional data processing can no longer meet the exploration needs. In order to meet the subsequent lithological interpretation requirements for different target reservoirs, it is crucial to realize the fidelity and amplitude of the data processing process [3]. Therefore, it is necessary to study the characteristics of seismic data in this region and the special characteristics of its noise in more depth and detail based on the previous work, and explore the suitable denoising method for this region. In view of this, this study improves the quality of data by developing a reasonable noise suppression process and applying effective denoising techniques to maximize the noise suppression and improve the signal-to-noise ratio under the premise of fidelity and amplitude [4].

The work area belongs to the Tianhuan Depression, a secondary tectonic unit of the Ordos Basin. The study area is located in the loess plateau area in the south of Ordos Basin, where the gullies and ravines are longitudinal and dendritic, and it is a typical loess plateau erosion landform. The surface geology is complex, and most of the surface layer is covered by the fourth series loess, and the thickness of loess varies drastically with the topography. The area is affected by several large fractures and underground volcanic intrusions, and the seismic wave field is complex and tectonically diverse, with many types of interference waves. The main interference waves of the original seismic data in the study area are strong energy surface waves, linear interference, various types of abnormal amplitude interference and various types of mechanical interference, etc. Strong energy interference exists near the gun point in the loess plateau, and random interference is also an important type of interference in the seismic data, especially on the imaging of weak reflections such as middle and deep layers. It is the key to fully and reasonably suppress the noise, improve the signal-to-noise ratio of pre-stack and post-stack seismic data, and adhere to the processing principle of amplitude and truth preservation in this study area.

2. Noise Classification

Noise is divided into coherent noise and random interference noise. The method of suppressing coherent noise is mainly to suppress the noise by using the difference between the effective signal and noise in frequency and apparent velocity, mainly including surface waves, acoustic waves, industrial electrical interference, multiple waves, etc. Such waves have certain regularity in the temporal and spatial distribution of seismic data. And random interference noise is divided into random noise, low frequency, high frequency background, wind noise, human motion, vehicle motion, etc., which does not have any regularity in time and space on the seismic data. The causes and types of noise are complex and diverse, so the method of suppressing noise also differs according to the characteristics of the effective reflected wave and noise to minimize the damage of the effective reflected signal in the process of suppressing noise [5].

3. The Characteristics of the Original Data

Interference waves are developed in the work area, mainly surface waves, shallow refraction waves, strong energy noise near the gun point, various types of abnormal amplitude interference, and external mechanical interference (Figure 1). Surface wave speed is generally V = 300 ~ 1100m / s, apparent main frequency 7 ~ 15Hz, dispersion phenomenon is obvious; shallow refraction and the first to multiple refraction interference apparent speed V = 2400 ~ 3100m / s, apparent main frequency 10 ~ 25Hz (Figure 2).

Due to the influence of the near-surface structure and poor excitation and reception conditions, the original single-shot signal-to-noise ratio is extremely low, and the overall quality of the data is poor, especially the strong energy noise at the near-shot point has a large impact on the data quality, which is a major difficulty in this data processing. The abnormal amplitude of the single gun excited by the controlled source is very serious, which seriously affects the signal-to-noise ratio of the data. On the single gun, the surface wave interference is prominent, the dispersion phenomenon is obvious, and the interference to the effective wave is large. Therefore, this study focuses on the processing of strong energy, anomalous amplitude and surface waves near the gun point, and forms a processing technology with the characteristics of this block.

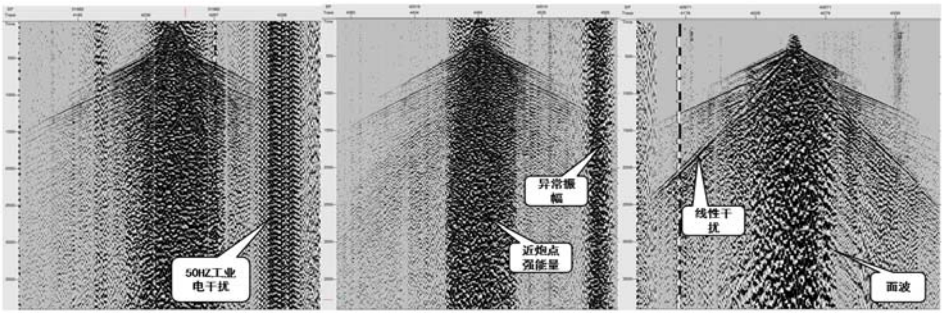

Figure 1. Typical single gun and interference

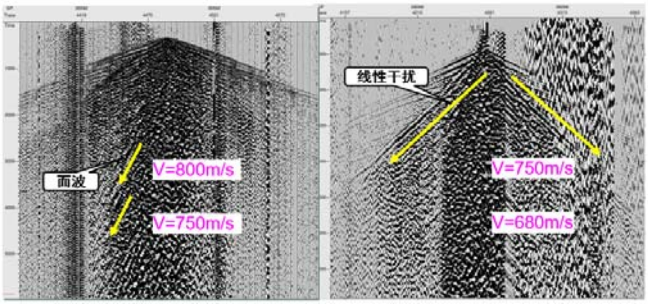

Figure 2. Noise speed analysis

4. Key Technology Applications

For the noise characteristics of the study area, the general principle of noise suppression of strong first and then weak, regular first and then random is to be adopted. According to the classification of noise, single-frequency interference suppression, abnormal amplitude suppression, surface wave suppression, coherent noise suppression, and adaptive near-gun-point strong energy noise suppression techniques are performed sequentially, and seismic data are analyzed in the common gun-point domain, common checkpoint domain, and common CMP domain, and single-frequency and large time-window energy statistics are performed with different time-window suppression coefficients and thresholds [6]. That is, the six-division denoising techniques of zoning, classification, domain, frequency, step, and time are used to suppress various types of interference (Figure 2), and finally a set of pre-stack amplitude preservation denoising process for this work area is formed (Figure 3).

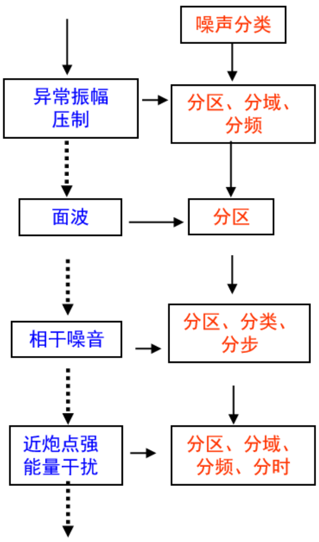

Figure 2. The main technique of denoising before stacking fidelity processing

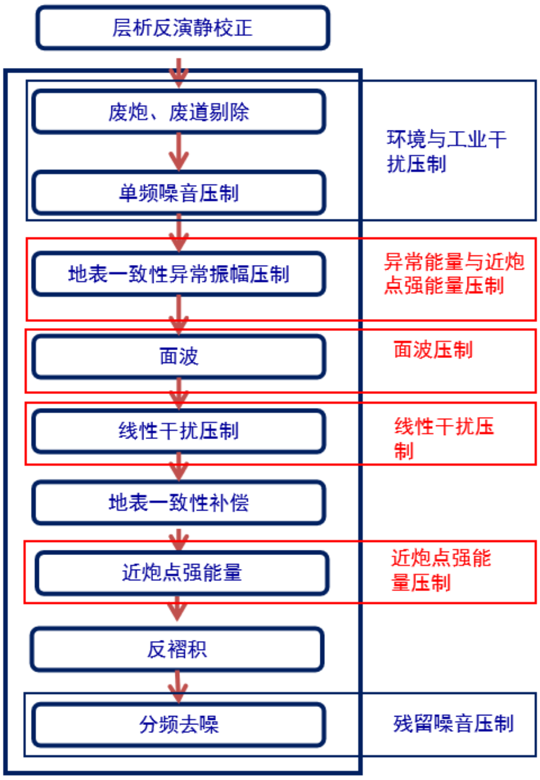

Figure 3. The flow of combined denoising technique before stacking with amplitude fidelity preservation

4.1. Cross-frequency abnormal amplitude suppression

This technique mainly uses partitioning, domain separation and frequency separation to suppress the abnormal amplitude. The abnormal amplitude is partitioned, and then the abnormal amplitude is suppressed according to the difference between the abnormal amplitude and the normal seismic channel in different domains. Then the idea of sub-frequency multi-channel statistics and identification and single-channel suppression is used to automatically identify the strong energy disturbance existing in the seismic record by multi-channel statistics in different frequency bands and determine the spatial location of noise appearance. It is worth noting that the threshold value and attenuation coefficient need to be tested several times, and then suppressed according to the time and space variation, and the fidelity of denoising is improved. The split-frequency anomalous amplitude suppression technique can be applied to the common gun point channel set, common offset distance channel set or common center point channel set data, in order to suppress the noise as much as possible without affecting the effective signal.

Figure 4 shows the comparison before and after the anomalous amplitude suppression and the noise removed. It can be seen from the figure that there is no significant effective signal in the removed noise, indicating that the method is relatively fidelity [7].

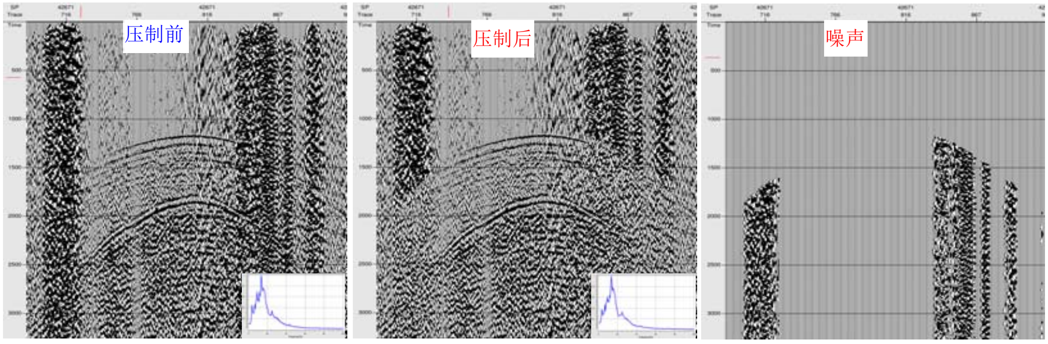

Figure 4. Comparison of single gun before and after abnormal amplitude suppression and noise

4.2. Random domain near gun point strong energy noise suppression technique

For the problem of suppression of strong energy noise near the gun point, through the research in recent years, we have formed the random domain near the gun point strong energy noise suppression technology to effectively solve the problem of suppression of strong energy noise at the gun point.

The random domain near gunpoint strong energy noise suppression technology is mainly based on the characteristics of strong noise energy, wide frequency band and poor linearity regularity, and combined with the characteristics of small dip angle of subsurface reflection homogeneous axis in Ordos Basin and limited energy difference level of effective signal at the same time level, the near gunpoint strong energy noise is transformed into random anomaly noise by rearranging the channel sequence of pre-stack seismic data. The original channel order is restored to achieve the strong energy noise suppression at the near gun point by using the frequency division anomaly amplitude suppression technique.

Figure 5 shows the comparison of the noise removed before and after the strong energy suppression at the near gun point. Looking at the noise removed. The fidelity fidelity is better in the data processing.

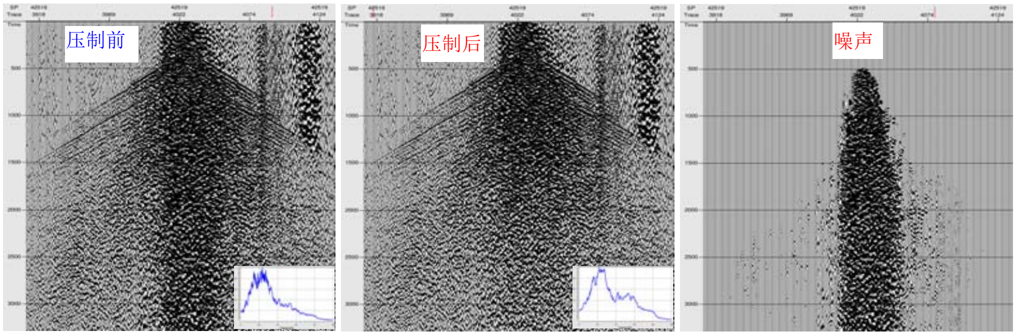

Figure 5. Comparison of before and after strong energy suppression at the near gun point and noise

4.3. Coherent noise suppression before stacking

In general, the shallow refraction interference has strong energy and large apparent velocity range, which may overlap with the apparent velocity and apparent rate of the effective waves in high and steep structure parts. Using the pre-stack coherent noise suppression technique, frequency division processing, control the frequency range of coherent noise, but also according to the distribution range in time and space, limit the denoising area, and multi-channel identification and channel-by-channel suppression, the advantage of this method is that it can better adapt to the changes in linear noise with the phase axis, but also to overcome the F-K method and τ-p domain suppression of noise brought about by the earthworming phenomenon (Figure6).

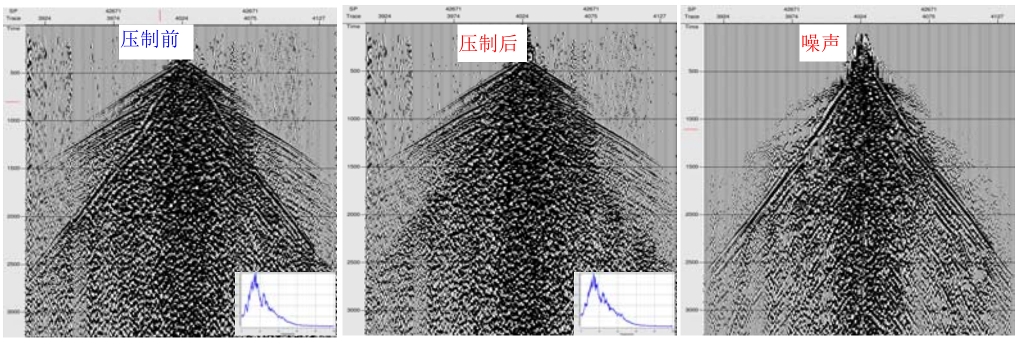

Figure 6. Comparison of before and after linear interference suppression and noise

4.4. Variable speed ground roll wave simulation excision

Through the analysis, the low frequency surface wave interference on the original single gun record is more prominent, and the surface wave frequency has the characteristics of low range, low apparent velocity, and strong energy. velocity filtering; and two-dimensional filtering F-k filtering and τ-p filtering, etc., but the disadvantage of these methods are only considered the frequency of the surface wave and the characteristics of the apparent velocity, but did not consider the characteristics of the surface wave energy strong, the results produce some artificial artifacts or elimination is not clean, and lead to the loss of near-channel effective signal. In this study, the KLLinRemv module of Geoeast is mainly used to suppress the surface waves, and three techniques, namely band decomposition, K-L transform eigenfiltering and adaptive attenuation, are used to achieve adaptive suppression of the ground roll wave and retain the effective signal of the near channel with ideal denoising effect.

Figure 7 shows the comparison of the single gun and the noise removed before and after the surface wave suppression, and the effective signal is well protected from the noise removed.

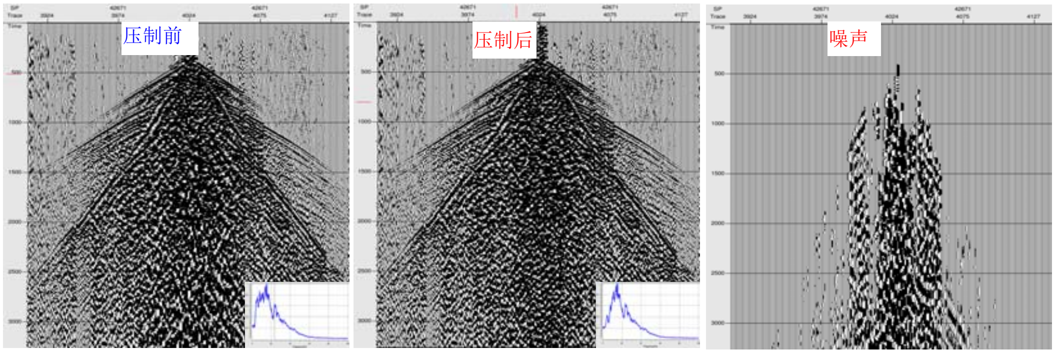

Figure 7. Comparison of **b**efore and after surface wave compression and noise

4.5. Integrated denoising

The above is the noise suppression situation existing in the data, from the profile (Figure 8), the imaging of weak reflections such as middle and deep layers is enhanced, and the signal-to-noise ratio of the superimposed profile is obviously enhanced after comprehensive denoising, and the effective signal is reflected, and from the noise superimposed profile, there is no effective signal and the data is fidelity. From the comparison graph of signal-to-noise ratio before and after denoising (Fig. 9), the signal-to-noise ratio is from 0.5 to 1.5, and the fidelity and amplitude of the data processing process is achieved.

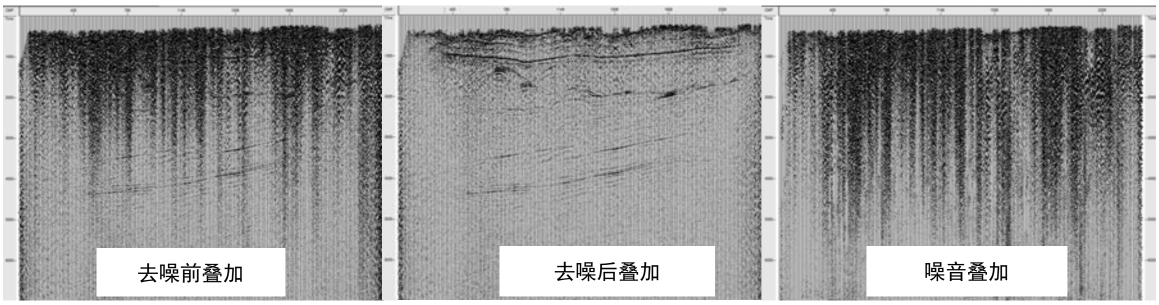

Figure 8. Superimposed profiles before and after integrated denoising

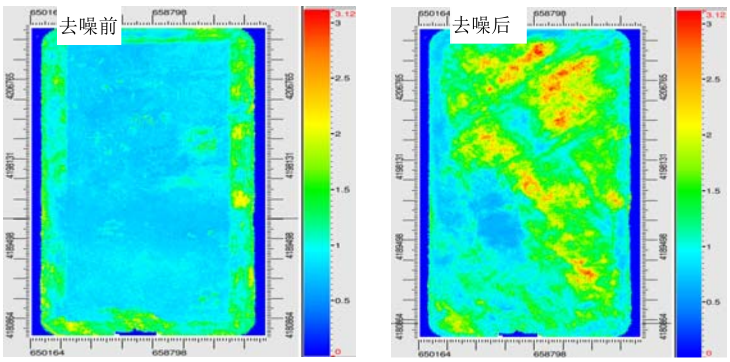

Figure 9. Comparison of signal-to-noise ratio before and after comprehensive denoising

5. Conclusion

In order to meet the subsequent demand of lithological interpretation for different target reservoirs, this paper has preferred the pre-stack amplitude de-noising technique, and finally proposed a combined amplitude and fidelity pre-stack de-noising technique according to the type of noise, using the "sextant method" and targeted de-noising techniques for the data in this work area [8-10]. The results show that the application effect is satisfactory, and the results of the application are very good. The results show that the application effect is satisfactory, which is mainly reflected in the following aspects.

(1) The use of sextant pre-stack multi-domain amplitude fidelity denoising technique effectively improves the quality

of seismic data and increases the imaging accuracy of the target layer segment for the identification of target lithology in later seismic data.

(2) The adopted variable-speed ground roll wave simulation excision technique has better adaptivity compared with the previously used two-dimensional filtering method, which can achieve accurate positioning and effective suppression of the face wave.

(3) The study conducts a lot of experiments in parameter selection, especially in the selection of threshold value and suppression coefficient, and selects suitable methods and parameters according to the characteristics of noise speed and frequency. The parameters are suitable, and the signal-to-noise ratio and resolution of this work area are greatly improved.

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