ISSN: 2664-9640

Application of nodal system in the investigation of interference wave in Sichuan and Chongqing area

Jiuchun Yuan, Qiang Yue, Huai Zhang, Yong Zhu, Wei Kuang, Wei Kong, Wei Wu

Southwest Geophysical Exploration Branch, PetroChina Oriental Geophysical Exploration Co., Ltd., Chengdu 610213, China

Abstract

With the development of geophysical exploration technology towards the direction of "two wide and one high" high-precision and high-density seismic exploration, nodal system has become an important part of geophysical exploration equipment. The terrain of Sichuan and Chongqing area is complex. There are many factories and mines, and the road and railway network is dense. How to complete the interference wave survey in Sichuan and Chongqing area with high quality, high efficiency and low cost has become an important problem to be solved. This paper first introduces the existing methods of interference wave investigation, and explains the reasons of the interference source investigation method used in Sichuan and Chongqing area; Then, the characteristics of interference wave survey in Sichuan and Chongqing area and the limitations of existing cable equipment to complete interference wave survey are described; It also introduces the methods and characteristics of interference wave investigation by node equipment; Then, the practical application of nodal instrument in the interference wave investigation project and the comparison with the construction at the same position of wired equipment are explained in detail; Finally, the conclusion is drawn. These contents help researchers to understand the situation of interference wave investigation in Sichuan and Chongqing area, and facilitate further research.

Keywords

Interference wave investigation; nodal system; Wired equipment;background noise.

1. Preface

At present, geophysical exploration technology is developing towards "two widths and one height" high-precision and high-density seismic exploration. The exploration construction mode has changed from the traditional all wired instrument acquisition mode to the wired wireless instrument combined construction mode or even the pure wireless instrument independent construction mode. The field exploration area has also changed from some areas with good terrain and easy wired construction to all terrain.

With the expansion of the construction area, more complex areas are included in the survey scope of interference wave. There are many cities and towns in Sichuan and Chongqing, and the traffic is complex. The existing methods of interference wave investigation through wired equipment can not meet the requirements of high-density and high-precision seismic exploration. How to complete the interference wave survey with high quality, high efficiency, low cost and more environmental protection and ensure the authenticity and effectiveness of seismic data has become a difficult problem for seismic exploration projects.

2. Methods and selection of interference wave investigation

The interference wave investigation in the field of seismic exploration is the construction of targeted investigation before the exploration project in order to obtain more real seismic data and avoid the spatial aliasing of important wave fields affecting the later seismic data processing. At present, there are usually three kinds of interference wave investigation: ① "cross arrangement" or "l arrangement" shot point pursuit investigation method [1]. This method is an active investigation method. By designing multiple equally spaced shot points in the direction of the detection point and the vertical direction, and continuously tracking the interference wave, the characteristic parameters such as the wavelength, frequency, energy intensity and apparent velocity of the interference wave in the two directions are obtained. In the later stage, based on this method, a variety of geophone string embedding methods can be designed, and the best geophone array form can be selected through the pressure noise comparison test; ② Square array survey method. This method is an active investigation method. A large number of excitation points are designed in the vertical direction, and the characteristic parameters such as wavelength, frequency, energy intensity and apparent velocity in different directions are obtained through intensive monitoring through square arrangement. In the later stage, it can not only carry out combined noise suppression and spatial false frequency analysis based on this method, but also analyze effective waves to provide effective data for exploration and acquisition design; ③ Interference source investigation method. This method is a passive survey method, also known as environmental noise recording method. By arranging and monitoring the background noise and uncontrollable interference sources in real time, the characteristic parameters such as wavelength, frequency energy intensity and apparent velocity in different directions are obtained. This method can analyze the occurrence law of interference waves by recording data, and design relevant preventive measures of interference waves.

The third interference source investigation method is usually used in the interference wave investigation in Sichuan and Chongqing, and the main reasons are as follows: ① high signal-to-noise ratio. The signal-to-noise ratio in this area is high. At present, high-sensitivity single detector is mainly used for exploration, and there is no need to explore in combination mode; ② There are many times of exploration. This area is a national key exploration area for natural gas and shale gas resources. Repeated exploration has effectively analyzed the naturally formed spatial aliasing, and the relevant data can be reused; ③ External interference is complex. With the economic development, transportation, industry, mining, etc. are developing rapidly, and external interference sources are also increasing rapidly, expanding the scope of influence; ④ Environmental factors. With the development of green exploration projects, the passive method of interference source investigation has gradually become the mainstream method of interference wave investigation in mature areas.

3. Difficulties of interference source investigation in Sichuan and Chongqing

3.1. Characteristics of work areas in Sichuan and Chongqin

Sichuan Chongqing area, located in Sichuan Basin, is rich in natural gas resources and is also a national key exploration area for shale gas. This area has the following characteristics: ① the terrain is complex. This area is located in Sichuan Basin, mostly in hilly areas, with undulating mountains and numerous gullies; ② Abundant vegetation. Affected by climate, regional location and other factors, this area is rich in vegetation all year round; ③ The water system is developed. This area is located in the middle and upper reaches of the Yangtze River, with many river systems such as Jialing River and Fujiang River; ④ There are many towns. Due to the large population of Sichuan and Chongqing, there are many regional cities and towns; ⑤ There are many factories and mines. Due to the rapid economic development, there are many factories and mines in this area, especially in some areas where there are rich mineral resources and many mining factories and mines; ⑥ The transportation is developed. Due to the national

ISSN: 2664-9640

western development policy and the rapid development of Railways and highways, many airports have been built and are under construction.

The purpose of interference source investigation is to find out the occurrence law of interference wave in the work area and avoid the interference of interference wave on exploration and construction to the greatest extent. The main investigation areas of interference sources in Sichuan and Chongqing are as follows: ① urban areas. Investigate the interference of roads, markets and other factors on Construction in cities and towns; ② Factory and mine areas. Investigate the interference of factory and mine construction to construction; ③ Traffic area. Investigate the interference of high-speed rail, expressway and other factors to the construction in the work area; ④ Construction in progress. Investigate the interference of railway, tunnel, highway and other engineering factors in the work area to the construction.

3.2. limitations of existing interference source investigation methods in Sichuan and Chongqing

Wired equipment has been dominant in the investigation of interference sources in Sichuan and Chongqing for a long time. The investigation process of interference sources for wired equipment is as follows: first, the construction design of interference sources. Select the interference source area and investigation sequence that need to be investigated, and carry out relevant scheme design; Secondly, measure the position of construction points according to the construction scheme; Then, arrange wired equipment according to the construction scheme; Thirdly, use the instrument car to collect the background noise; After completing the background noise collection of all survey points in turn, submit the collected data for investigation and analysis of interference sources; Finally, complete the analysis, draw a conclusion and find out the countermeasures.

With the expansion of the exploration area, the wired equipment has the following problems in the investigation of interference sources: ① poor monitoring accuracy. The survey of interference wave of wired equipment is carried out in full accordance with the construction design, and the generation characteristics of interference sources cannot be foreseen and found in the non design period. In some design periods, due to insufficient prediction, it is impossible to temporarily encrypt the interference source test period; ② Poor deployment flexibility. Affected by the limitations of wired equipment deployment, many discrete locations have to deal with Lane loss due to the need for more detours, battery power supply and other factors; ③ Low construction efficiency. The investigation of interference sources is not only affected by the small number of wired acquisition instruments and other factors, which makes it impossible for multiple survey points to collect at the same time, but also affected by factors such as the need for centralized power supply of wired instruments and the connection of large lines, it takes more time for wired instruments to arrange and check; ④ The construction cost is high. The interference wave investigation by wired instruments requires on-site main instruments and supporting instrument vehicles, more cables and batteries, more detours, and more construction personnel, which lead to higher construction costs; ⑤ Poor reliability. The influence of electric leakage and other factors on the large line will cause single channel acquisition to be affected not only by external noise, but also by electrical factors, resulting in poor reliability of collected data. In particular, when the monitoring area is a factory or mine, the authenticity of wired equipment is more likely to be reduced due to factors such as cable aging. Therefore, the existing wired equipment for interference source investigation can not meet the needs of interference wave investigation in Sichuan and Chongqing.

ISSN: 2664-9640

4. Process and characteristics of nodal instrument in interference source investigation

4.1. Flow analysis of interference source investigation by node instrument

With the development of seismic instrument technology, node equipment has entered the field of seismic exploration in China. The adaptability of nodal instrument to complex terrain is gradually being widely recognized in Sichuan and Chongqing. The process of interference source investigation by node instrument is as follows: first, select the investigation points according to the investigation area, and carry out the construction design of interference source investigation; Then, carry out construction point measurement; Secondly, according to the construction scheme, the node instrument is arranged, and multiple measurement points can be constructed at the same time; Thirdly, after the measurement points are deployed, it automatically enters the background noise acquisition stage; Then, recycle the node instrument to download and synthesize data; Then, investigate and analyze the interference sources. If the noise area is not obvious and encryption is required, recombine and analyze the downloaded data until the requirements are met; Finally, draw conclusions and find solutions.

4.2. Characteristics of node instrument relative to wired equipment

The comparison between node instrument and wired equipment in the process of interference source investigation is shown in Table 1. ① The construction results are better. Compared with wired equipment that completely depends on construction design, node construction can obtain more reliable background information. The node station continuously collects data during the investigation, so it can synthesize data at any time in the construction time area to enhance the reliability of the investigation. The wired equipment can only obtain the information of the construction design time, and cannot reflect the background data of more times; ② Less construction equipment. Node equipment does not need cable connection and battery power supply, nor does it need the server to control; ③ There are many construction steps. Compared with wired devices, node devices need to download and synthesize data; ④ The construction efficiency is higher. Node devices can investigate multiple interference sources in parallel, while wired devices can only complete the investigation in different areas in sequence due to the influence of server control; ⑤ High construction safety. Node equipment does not need cable connection, and there is no need for wired detours in urban areas, highways, railways, factories and mines. In addition to reducing the safety risks caused by detours by construction personnel, it also reduces the safety risks caused by detours to motor vehicles and urban personnel. Therefore, node devices are more suitable for interference source investigation than wired devices.

Table 1 Comparison of interference source investigation equipment

	inode	Wired equipment
Construction results	OK, you can obtain data at any time during the collection period	Poor, completely dependent on construction design
construction equipmen	Less, wireless cable connection, no battery power supply, no server control	Many, need cables, batteries, servers
Construction steps	Many, need data download, synthesis to obtain information	Less, get data immediately after collection
Construction efficiency	High, multi region parallel investigation	Low, multi area survey needs to be completed in sequence
Construction safety	High, wireless cable connection	Low, need large line bypass

5. Application of nodal instrument in the investigation of interference sources in Sichuan and Chongqing Areas

5.1. Scheme formulation and Implementation

This node instrument is applied to the investigation of interference sources of a three-dimensional project, which is similar to the investigation of interference sources of wired equipment three years ago. A total of four monitoring points, including urban area, industrial park, power station and Bridge under construction, were set up in the survey. The arrangement according to the monitoring line is shown in Table 2. A total of 816 stations are arranged, including 81 monitoring stations, 365 bridges under construction, 190 industrial parks, and 180 urban noise surveys. The arrangement is based on the production arrangement, and the track spacing is 80m. The recording time of the survey starts from the time point when the node meter is embedded on the same day, and the length of time is 24 hours.

Table 2 interference source monitoring arrangement setting table

interference source	Line	Point		Point number
The power station	1309	1245	1405	81
The bridge under construction	1358	1001	1729	365
the industrial park	1393	1160	1538	190
Urban	1449	1144	1502	180
Total number				816

5.2. Data analysis

This node station is placed according to the construction design, as shown in Figure 1. After 24-hour collection according to the construction scheme, data download and synthesis shall be carried out, and data analysis shall be carried out for interference sources.

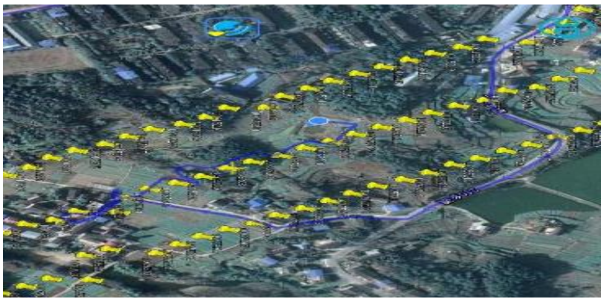

Fig.1 layout diagram of interference source node stations

The interference of the power station is shown in Figure 2, affecting a total of 9 node stations, and the estimated interference radius is 360 meters. The acquisition time is from 21:00 to 06:00, and the interference is small. The frequency division scanning of the background record is shown in Figure 3. The interference frequency of the power station is mainly concentrated in the area of 20-60hz, which provides a basis for the processing and filtering of this position.

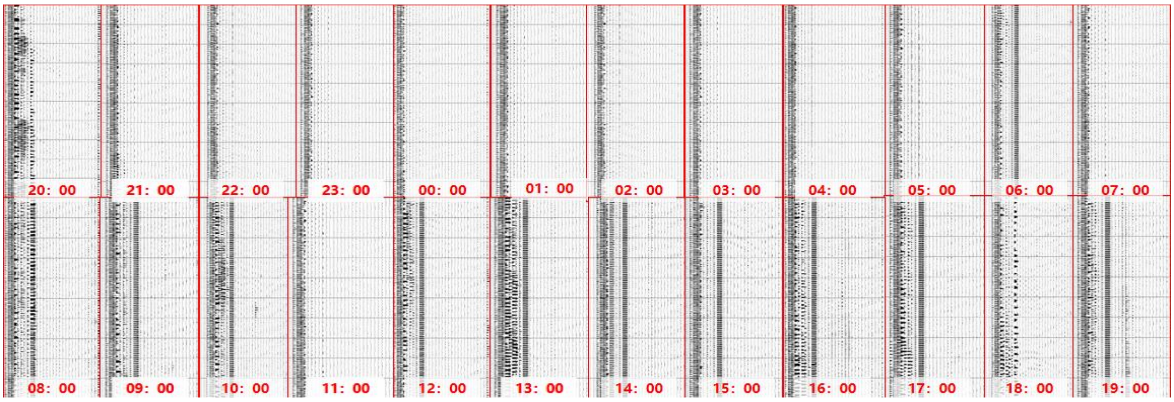

Fig.2 full time record of power station interference

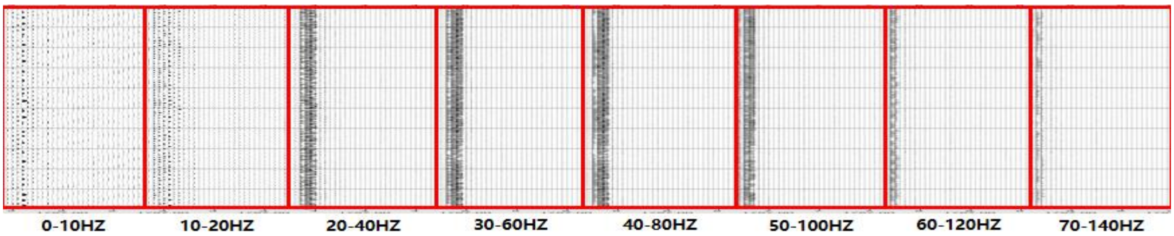

Fig. 3 interference frequency division scanning diagram of power station

The interference of the bridge under construction is shown in Figure 4, affecting 128 node stations in total, and the estimated interference radius is 2.56 km. The acquisition time is from 22:00 to 07:00, and the interference is small. The frequency division scanning of the background record is shown in Figure 5. The interference frequency of the bridge under construction is mainly concentrated in the low-frequency region of 0-50Hz, which provides a basis for the processing and filtering of this position.

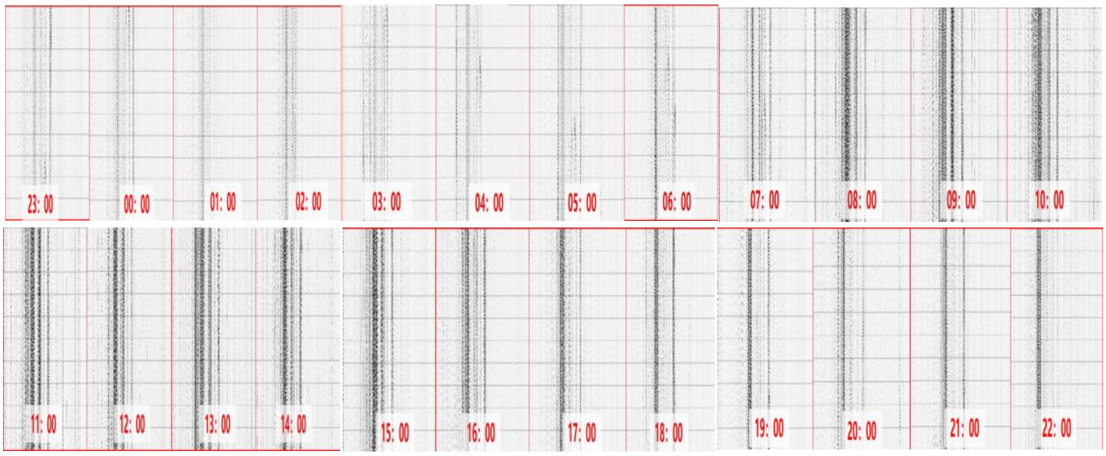

Fig.4 full time record of interference of bridges under construction

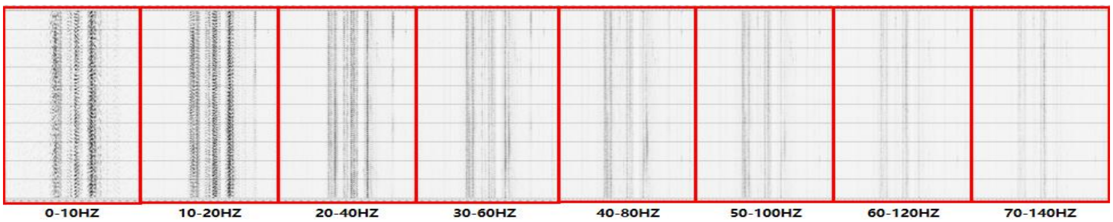

Fig.5 interference frequency division scanning diagram of bridge under construction

The interference in the industrial park is shown in Figure 6, affecting 33 node stations in total, and the estimated interference radius is 640 meters. The acquisition time is from 21:00 to 06:00, and the interference is small. The frequency division scanning of the background record is shown in Figure 7. The interference frequency of the industrial park is mainly concentrated in the low-frequency region of 0-20hz, which provides a basis for the processing and filtering of this position.

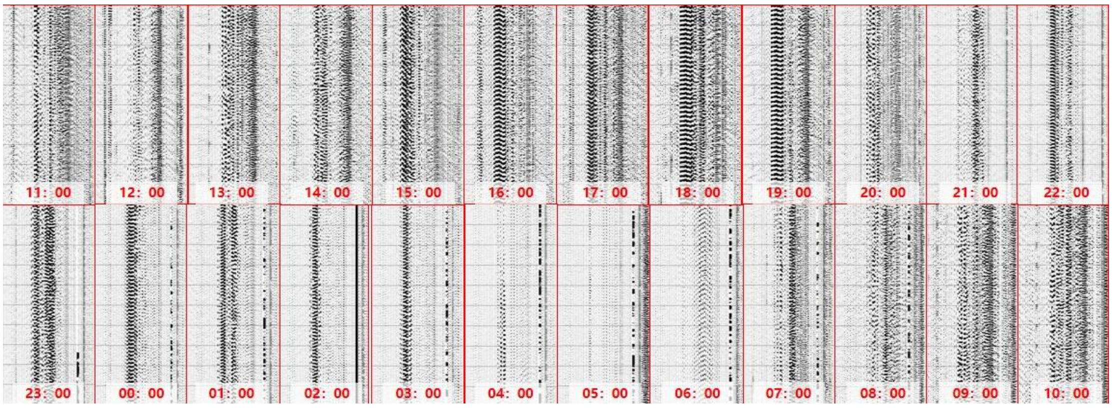

Fig.6 full time record of interference of the industrial park

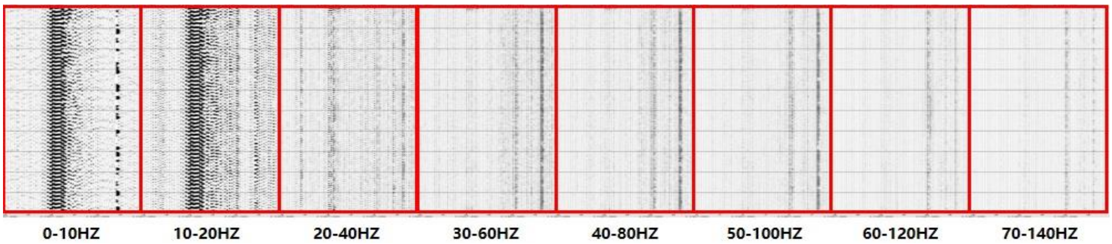

Fig.7 interference frequency division scanning diagram of the industrial park

Urban interference is shown in Figure 8, affecting 312 node stations in total, and the estimated interference radius is 4.26km. The acquisition time is from 00 o'clock to 07 o'clock, and the interference is small. The frequency division scanning of the background record is shown in Figure 9. The interference frequency of the bridge under construction is mainly concentrated in the low-frequency region of 0-40hz, which provides a basis for the processing and filtering of this position.

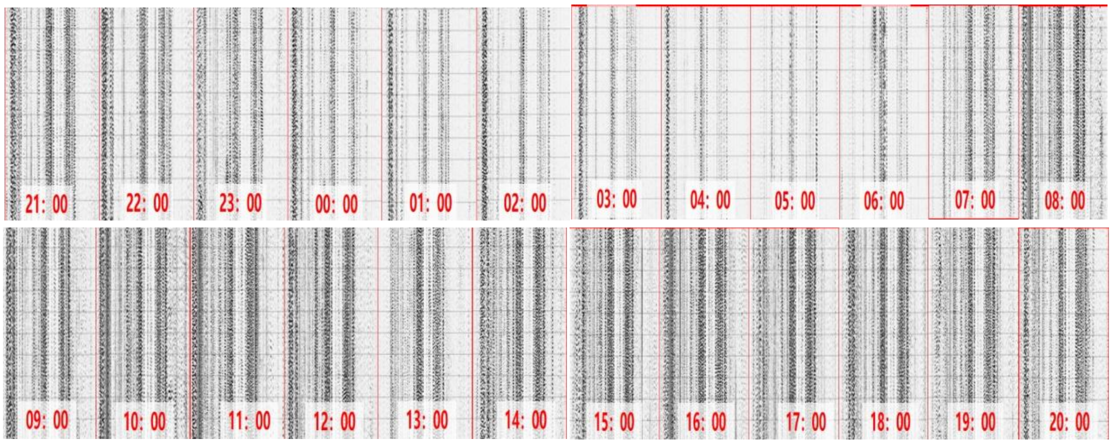

Fig.8 full time record of urban interference

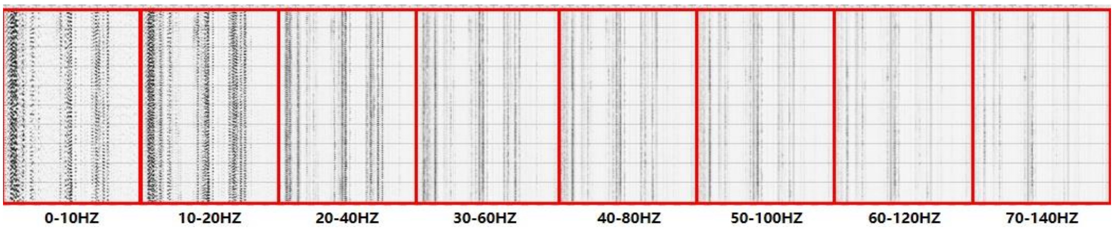

Fig.9 interference frequency division scanning diagram in urban area

After the analysis of different interference sources through the node collected data, the background energy of the 24-hour interference area is obtained, as shown in FIG. 10 24-hour energy comparison diagram of interference wave investigation. In the area from 23 o'clock to 5 o'clock, the background noise energy is within 50 microvolts; At 20:00 to 22:00 and 6:00 to 7:00, the background noise is less than 100 microvolts; From 8 o'clock to 19 o'clock, the background noise is greater than 100 microvolts. As shown in Figure 11 of the background noise curve, the number of strong interference channels above 19:50 microvolts began to decline, and the quiet channels with energy less than 20 microvolts began to increase; At 7 o'clock, the number of strong interference channels began to increase and the number of calm channels began to decrease. From 21 o'clock to 7 o'clock, the quiet lane accounts for more than 80% of the total number of lanes.

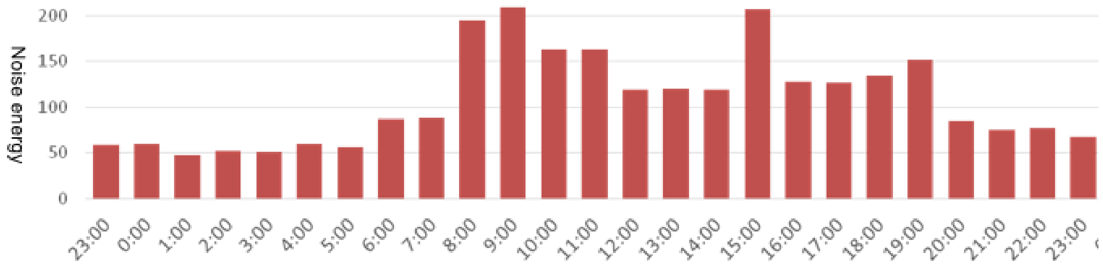

Fig.10 24-hour energy comparison diagram of interference wave investigation

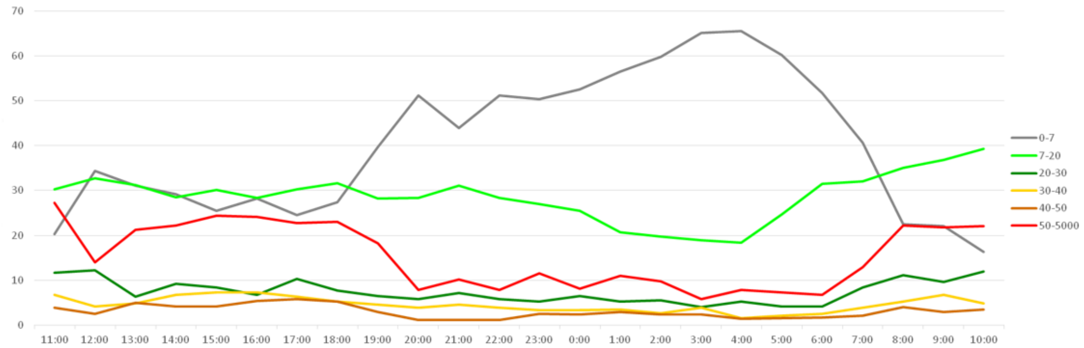

Fig.11 background noise curve

Therefore, through the investigation of interference sources by node equipment and the comparison and analysis of relevant data, the following conclusions are obtained: ① in this area, 21 to 7 points with quiet channels accounting for 80% of the total number of channels are selected for seismic exploration and acquisition; ② In the stage of exploration and acquisition, the local government and enterprises were asked to assist in stopping the pile driver interference of the bridge under construction; ③ Aiming at the interference sources in different areas, we find the factual basis for using different band-pass filtering methods.

5.3. Conclusion of use

A total of 816 nodal stations were used in this interference source investigation, which took 48 hours. Compared with the survey of interference sources conducted in the same area using wired equipment three years ago, the comparison is as follows: ① less equipment is used. A total of 816 nodal stations were used in this survey. Three years ago, a total of 1012 wired devices were used in wired devices, including 823 acquisition channels and 189 for detours. In addition, there are 26 batteries, 3 cross stations, 26 power stations, and a set of instrument cars and wired servers; ② High construction efficiency. After the embedding of different interference sources in this investigation, the time of interference source investigation will be started immediately, and the embedding and collection will take 48 hours in total. Using wired equipment to collect, due to a set of wired servers, the four interference sources were investigated separately, and the total time of embedding and collection was 142 hours. ③ There are few construction personnel. A total of 33 people were used in this survey, including

ISSN: 2664-9640

32 arrangement personnel and 1 field arrangement manager. A total of 36 people were used in the wired equipment survey, including 33 arrangement personnel, 1 instrument operator, 1 field arrangement administrator and 1 instrument vehicle driver. ④ The investigation results are good. After 24 rounds of 24-hour jamming source data acquisition and synthesis, 30 minute encryption synthesis was carried out for some periods of time, which more truly reflected the noise status of the background jamming source at the time change node. After 24 rounds of whole point data acquisition as required for wired equipment investigation, it is impossible to conduct relevant encryption synthesis after the completion of field construction in the later stage. ⑤ Construction is safer. This survey crosses 18 roads. Compared with wired equipment, there is no need to detour from the street, which not only reduces the risk of construction workers being hit by vehicles, but also avoids traffic accidents caused by large lines.

6. Concluding remarks

The use of node equipment for interference source investigation has been recognized and praised by Party A and the construction party. In the project, the node instrument can truly and effectively collect the background noise of the interference source at each time point in the interference wave investigation, which provides a factual basis for the later response of the construction party. In the construction process, the high efficiency, low cost and low risk of node construction are also favored by both parties.

With the increase of large-scale and high-density seismic exploration projects, node instrument will be widely used in interference wave investigation projects because of its low cost and high flexibility. But its use also brings two new risks: ① it is easy to lose. Compared with the real-time monitoring of field acquisition stations by wired equipment, the node stations are in the "blind acquisition" state in the field, and can only be monitored irregularly by patrol personnel. Loss cannot be avoided. The loss of node stations not only represents the loss of equipment, but also brings the loss of collected data; ② The damage cannot be found in time. Compared with the real-time monitoring of full array by wired devices, node stations cannot be found in time under fault conditions. This leads to the failure of the station to collect enough effective construction data. Therefore, how to effectively avoid these two construction risks will become a new topic of the node interference source investigation project.

References

[1]Han Wengong, Yu Jing, Zhang huaibang, et al Application of interference wave survey method in high-density seismic acquisition [j] Petroleum geophysical exploration, 2011, 50 (5): 499-507.

[2]Song Ben. Analysis and understanding of fixed interference sources in block 6-7 of Tahe Oilfield in Tarim Basin [j]. Inner Mongolia Petrochemical Industry: 2010 (09): 56-58.

[3]Shi Zile, Huang Yanlin, Li Jing, et al Current situation and development of onshore seismic data acquisition node equipment [j] Petroleum pipes and instruments, 2019, 1 (3): 14-18.

[4] Ling Yun, Zhang Rujie, Gao Jun Research on the investigation method of square array interference wave [j] Petroleum geophysical exploration, 2000,35 (2): 175-184.