Seismic Sedimentary Technology and Its Application in Deposition Analysis of SQ7 in Shannan Region

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Abstract. The thickness of SQ7 sand body in Shannan area is thin, the lateral variation is fast, the distribution of sedimentary sand body is not clear, and the conventional sedimentary analysis method and reservoir prediction technology can not meet the requirements of fine oil and gas exploration. On the basis of the principle and research method of seismic sedimentology, the lithologic reversion of seismic profile was carried out by using 90° phasorization, and seismic sedimentology was carried out to study the plane distribution characteristics of SQ7 sand body in this area by using the technique of stratum isochronous section. Based on the analysis of seismic attribute sections and lithologic time sections under the equivalent time frame, the temporal and spatial evolution law and sedimentary microfacies of braided river delta deposits in the southern source system of the SQ7 period in this area are revealed. The distribution of sand body is described in detail, which provides the basis of seismic deposition for oil and gas exploration and deployment.

1. Introduction

Seismic sedimentology is a geological discipline that determines the macroscopic characteristics of stratigraphic rocks [1-3], the genesis of sand bodies, the development and evolution of sedimentary systems and reservoir quality by studying sequence strata, stratigraphic sections, seismic attribute analysis, core lithology and sedimentary facies scale. Seismological sedimentology is the subject of Zeng Hongliu and so on. Founding, they defined "seismo-sedimentology" as the study of sedimentary facies, sedimentary rocks and sedimentary structures using the relationship between the spatial reflection morphology of sedimentary systems and sedimentary landforms. The practice and application of seismo-sedimentary science in oil and gas basins at home and abroad have achieved remarkable results in oil and gas exploration and development.

The S1 sand formation in Shannan area is one of the main oil and gas production strata in the tertiary cycle SQ7[4]. Braided river delta sedimentary system is mainly developed in the three-stage cycle SQ7 in this area. It is difficult to determine the distribution characteristics of sand body. On the basis of seismic sedimentology research, this paper analyzes the current seismic sedimentology technology and understanding, and then carries out seismic sedimentology research in this area. On the basis of high-precision sequence stratigraphic framework, the sedimentary plane distribution analysis is carried out, the sedimentary evolution characteristics of the tertiary cycle SQ7 in this area are clarified, and the
distribution law of sand body plane in S1 sand formation is determined, which effectively guides oil and gas exploration.

2. Seismic Sedimentary Principles and Geophysical Significance

Zhu Xiaomin and others proposed that the study of seismic sedimentology is based on two basic principles[5-8]: (1) the general sedimentary system has the characteristics that the width is much larger than the thickness; (2) the geological body which can not be recognized in the vertical direction with the vertical resolution of the earthquake may be identified by the lateral resolution of the earthquake in the plane. This principle takes into account the general characteristics of geological deposits and the resolution principle of geophysical seismic data.

There are two kinds of resolution of seismic data: lateral resolution and longitudinal resolution. With the present technical means and the inherent characteristics of the present seismic data, the longitudinal resolution and prediction of thin reservoirs are difficult from the longitudinal resolution. However, in terms of lateral resolution, the distribution of sediment distribution and sand layer is much larger than the minimum resolution \( \lambda/4 \) of seismic wave. Therefore, seismic sedimentology uses the concept that the actual sedimentary plane size is much larger than the lateral resolution to carry out the analysis of geological body distribution from the plane.

Among the key techniques of seismic sedimentology are: 1 phase adjustment, 90° phase adjustment of seismic data body wavelet, conversion of seismic reflection waveform to corresponding lithologic change; 2 formation slice analysis, extraction of seismic reflection attributes of sedimentary strata under the control of fine sequence lattice, analysis of isochronous seismic response reflecting lithology, identification and classification of palaeogeomorphological features, and then interpretation and imaging analysis of sedimentary system.

It is well known that most of the seismic data used in oil and gas exploration for a long time are not constant values, which may be zero phase, a certain value phase or mixed phase, the purpose of which is that the peaks or troughs in the same phase axis of the earthquake are consistent with the geological reflection interface, which is convenient for structural interpretation of horizon tracking. The characteristic of the traditional seismic data in oil and gas reservoir exploration is that the peaks and troughs of the same phase axis of the earthquake mostly reflect the boundary of the rock body, but lack a good one-to-one correspondence with the rock body. A 90° phase adjustment is carried out to correspond the peak trough of seismic data to the peak lithologic reflection sampling point for thin-layer reflection. Some scholars understand 90° phase adjustment of seismic data as 90°, which is not correct. There are also scholars who do 90° phase shift of existing seismic data, that is, the 90° phase profile obtained is also incorrect. Correct practice is to normalize the phase of seismic wave and adjust the phase to 90°, so as to achieve accurate matching of rock body and peak trough.

Stratigraphic slicing technology has been widely used in oil and gas exploration. It is generally believed that only by ensuring its isochronicity can the multi-solution of seismic lithologic interpretation be reduced. Many scholars have also put forward the technical method of extracting stratigraphic slices, but most of them pay too much attention to the extraction technology, and ignore the basic principles that stratigraphic slices should follow. The author thinks that the foundation of stratigraphic section research is the establishment of high-precision sequence stratigraphic framework in the study area. Only under the control of established sequence stratigraphic framework can the study of stratigraphic section really have seismic sedimentary isochronous significance, and it can have the basic attribute of plane sedimentary distribution analysis. The range of stratum section extraction should be in a complete set of sedimentary sequence lattice frame or relatively stable secondary sequence frame, that is, the top and bottom two control layers are respectively stable and isochronous, which can ensure that the layers generated during it are isochronous. If one of the top and bottom control layers does not have sedimentary stability and isochronicity, the extracted strata sections can not truly reflect the same geological body or sedimentary distribution in the same period.
3. Deposition Analysis in Shannan Region

3.1. High-precision sequence stratigraphic framework
The construction of high-precision sequence frames is the basis of fine sedimentary system and reservoir prediction research. It is necessary to synthesize and unify seismic, logging, core or outcrop and paleontological data in datum level rotation identification. Based on the long-term datum rotation, the high-resolution sequence stratigraphic framework is constructed by using logging data, core and outcrop data, and wavelet transform of logging data, and the study strata belong to the tertiary sequence SQ7. is determined. the SQ7 can be subdivided into two quaternary sequences of SC14 and SC13, in which the main oil and gas reservoir sands in the developed area S1[9]. The braided river delta SQ7 mainly developed in Shannan area under the shallow water background of the southern gentle slope, among which SC14 mainly developed the braided river delta front. Longitudinal overlapping and lateral migration of the channel, the microphase changes rapidly. The S 1 sand body is thin and the phase transition is frequent, and the general thickness of single sand body reservoir is 6~10m, It is very difficult to determine the distribution characteristics of sand body plane.

3.2. Seismic data processing
The phase unification of seismic data requires special processing in processing stage, zero phase or fixed phase correction. For the seismic data specially processed by zero phase correction, the deconvolution method is usually used in the production of 90° phase profile. the peak trough in the homogeneous axis of the earthquake before deconvolution is the reflection characteristic of the lithologic interface, which can correspond one-to-one with the drilling stratification divided according to the lithologic change, but can not fully reflect the information such as lithologic thickness. after deconvolution, the seismic homogeneous axis can reflect the thickness of the lithologic body, the superposition and other characteristics (Figure 1).

By using 90° phase seismic section to extract time slice to predict lithology and deposition at a certain geological time, it must be carried out under the control of high precision sequence frame. The top of the S 1 section in the SC14 and the bottom of the S 2 section in the fourth sequence is the largest lake surface of the fourth sequence, which is a relatively stable marker layer in the whole area, and has strong contrast and traceability from the earthquake (Figure .2). Using these two layers of seismic tracking horizon as the control boundary to extract seismic sedimentary strata can ensure the isochronous of strata. By using isochronous stratigraphic slices, the seismic plane attributes, i. e. seismic attributes at a certain time, can be extracted from the calculated seismic attributes such as root mean square amplitude and instantaneous frequency.

![Figure 1](https://example.com/figure1.png)

**Figure 1.** Lithology demarcate of Conventional seismic profile and 90° phase seismic profile
3.3. Analysis of Plane Deposition Characteristics

The study of sediment distribution and sand distribution also needs to be carried out under the control of the established high-precision sequence frame, and the comprehensive analysis of sedimentary evolution is carried out by using traditional sedimentary analysis technology and combining all kinds of logging, drilling and logging information [10].

Using the conventional seismic attributes as the guidance of plane information, combined with the information of heavy ore, formation inclination and paleocurrent provided by drilling and logging data, it is considered that the material source in Zhengnan area is the source direction of southeast or south, and even more inclined to the southern material source system. However, there are differences in heavy minerals, light minerals, stratigraphic dip and conventional seismic attributes, and the sources and sedimentary directions indicated by various data are inconsistent. Among them, heavy minerals show that the source of the south and the source of the southeast exist at the same time, and the size of the source of the southeast is small. The difference of information on source direction increases the multi-solubility of sedimentary research in this area and can not provide effective guidance for oil and gas exploration.

Because the strata sections extracted from 90° of phasic seismic data are controlled by the fine sequence lattice, they basically reflect the isochronous interface of the sediments in the sequence. Combined with the information provided by drilling and logging, the sediment consistency analysis was carried out on the seismic attributes extracted by stratigraphic sections (Figure 3). The seismic attribute section of the S1 section indicates that the overall sedimentary direction of the study area is a delta sedimentary system distributed from southeast to northwest. This information confirms that the main body of the study indicated by the heavy mineral zoning is the source direction of the southeast and the west of the study area is the characteristics of the northwest trend distribution. The SNN1 well north developed a local north-north direction of the sedimentary distribution branch, which is consistent with the SNN1 well north-north formation dip, indicating the reasons for the difference in the direction of the main heavy minerals in the study area. Guided by the sections of many seismic attributes in S1 section, the differences of dip angle, heavy minerals and light minerals are unified, and the distribution of sedimentary plane in S1 section is clarified (Figure 4).
Figure 3. Isochronous Slice map (root mean square amplitude) of S1 in SQ7, Shannan Region

Figure 4. Sedimentary microfacies plan map of S1 in SQ7, Shannan Region
4. Conclusion

Seismic sedimentology provides different ideas and methods from traditional seismic-sedimentary analysis. It not only broadens the resolution ability of seismic data to sand body from the principle of seismic exploration, but also provides relevant techniques such as stratum section to analyze the evolution of sedimentary space directly from plane.

Stratigraphic section extraction should be carried out in a complete set of sedimentary sequence shelves or in a relatively stable secondary sequence shelves, that is, the top and bottom two control layers are respectively stable and isochronous, which can guarantee the isochronous generation of the slices.

Using the method of seismic sedimentology, 90° phase-shifted seismic data were used to extract seismic isochronous slice properties under the control of high-precision sequence framework, and the sedimentary evolution characteristics of S 1 section of Shannan area were clarified.

Acknowledgments

We gratefully acknowledge the financial support for this study from the National Natural Science Foundation of China [Grant nos 41472004] and the China Geological Survey [Grant nos DD20190092].

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