Research of Using Geophysical method to detect Natural Gas Hydrate-Application in Hala Lake area of Qinghai Province

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Abstract. Hara Lake is located in the south of Qilian Mountains. According to the previous geological survey in this area, the study area has a good prospect of gas hydrate prospecting. As a new type of clean energy, natural gas hydrate is seldom explored in our country. In order to find gas hydrate, two-dimensional reflection seismic exploration is carried out in this area, and the props are selected. Multiple coverage observation system and low frequency vibroseis. High quality 2-D seismic data are obtained by reflection seismic exploration, and the characteristics of velocity inversion anomaly and low frequency amplitude of gas hydrate are obtained, which provides a theoretical basis for gas hydrate acquisition.

1. Introduction

Natural gas hydrate is an ice-like crystalline compound formed by hydrocarbon gas (mainly methane) and water at low temperature and high pressure. It is distributed in solid form in rock crevices, fractures and shallow surface sediments on land tundra. Open fire can burn, so it is called flammable ice [1]. Natural gas hydrate is a new type of fuel energy because of its wide distribution, large amount of heat and no pollution after combustion [2]. In the study area of Hala Lake, the plateau desert steppe is the main area, the temperature difference between day and night is large, the temperature is lower, the climate condition is poor, the ecological environment is bad, and it is one of the main distribution areas in the frozen soil area on land in China. The Siberian Mesoaha gas field where gas hydrate has been discovered, the Mackenzie Delta in northwest Canada, and the Pradho Bay-Kupalek River region in northern Alaska, in the United States, are all alpine frozen regions. It is a favorable area for the formation of natural gas hydrate. The study area is located in the south Qilian basin on the northeast margin of the Qinghai-Tibet Plateau. It is one of the research areas of natural gas hydrate in the frozen earth area of our land because of the difficult traffic [3]. At present, a total of 301km CEMP6 bars have been completed in the South Qilian Basin, 8012km2 gravity and magnetic field, Muli depression, Shule depression and Hara Lake depression have been acquired by two-dimensional seismic data[4, 5]. 2D
seismic exploration using geophysical method has shown geophysical anomalies in the region where gas hydrate exists, which shows a good prospect of gas hydrate formation in this area.

2. Regional metallogeny and geological tectonic setting

Qilian Mountain is located in the northeast of Qinghai-Xizang Plateau. The tectonic unit is divided into Qilian uplift fold zone, Middle Qilian uplift fold belt and South Qilian uplift fold belt. The study area is located in the south of Qilian Mountains. The northern side is connected with the Precambrian Middle Qilian Mountains and the Lower Paleozoic Northern Qilian Mountains, and the southern end is adjacent to the Zongwu-Nanshan Mountains. The study area is located in the northern part of the Hara Lake depression and is structurally in the South Qilian geosyncline fold zone (Fig. 1) [6]. The Hala Lake depression is an intermountain basin in the western Qilian Mountains. It is located in the center of the South Qilian Basin and belongs to a high mountain inland lake. Lake elevation of 4077 meters, the maximum depth of 65 meters, an average of 27.4 meters. The lake is 32 km long and 13 km wide and covers an area of 580 square kilometers. In the north of the Hala Lake basin, there are Shulenan Mountains, which are above 5000 meters above sea level, and the south is the South Hala Lake, with an average elevation of less than 5000 meters. The watershed on the east and west sides of the basin is a low-level hilly area. The Upper Devonian, Carboniferous and Triassic strata are composed of the Upper Devonian, Carboniferous and Triassic strata in the North-South Ershan Mountains. In addition to the sporadic Tertiary strata, most of the basins are covered by Quaternary alluvium and ice-water alluvial matter [7,8]. Based on the previous field basic geological mapping and oil and gas exploration results, and according to the paleotectonic framework, structural deformation characteristics, basement and sedimentary characteristics and stratigraphic contact relations, etc. The Carboniferous-Jurassic in the South Qilian Basin, Qinghai Province, is divided into three stratigraphic zones, namely the Hara Lake, the Lower Japan-Hami and the Shule and Muli strata in the north. The main target layers in the Hara Lake area are Carboniferous, Permian and Triassic [9].

![Fig. 1 tectonic location map of Hara Lake](image)

3. Seismic methods and techniques

3.1. Layout of survey lines

Because the surface of the study area is complex, the surface conditions change greatly, and according to the previous exploration results, there are many hidden faults. In order to find out the deep fault structure, extension and stratigraphic distribution, four survey lines are arranged, among which ogs15-
ew1 and ogs15-ew2 are in the east-west direction, and ogs15-sn1 and ogs15-sn2 are in the north-south direction [6]. The location of the survey lines is shown in figure 2.

3.2. Working method

In 2010, the study area was mainly aimed at deep data exploration, with large array, large track distance observation and combined well stimulation. The refraction wave and surface wave interference developed on the original single gun record. The middle and deep data had a certain signal-to-noise ratio, but the shallow data had a low main frequency and narrow frequency band. In the adjacent area (multi work area) in 2013, small permutation length, path distance observation and single well excitation are adopted. The shallow data have a high resolution, but the signal-to-noise ratio of the middle and deep data is low [10]. The principle of this exploration is to give prominence to the shallow strata and give consideration to the middle and deep strata. On the basis of careful analysis and reference to the previous two-dimensional seismic acquisition methods, combined with the geological tasks in this area, to ensure the data imaging effect. The observation system USES the reflection seismic data acquisition method with path distance and high coverage times. In order to improve the ability of receiving signal, digital detector is adopted. The reflection seismic measurement in the research area adopts 600 channels, with the channel spacing of 10m, the offset of 5m, the gun spacing of 10m, the coverage times of 300 times, and the most artillery spacing of 3000m. The permutation observation system with intermediate excitation is adopted. 428XL seismic data acquisition equipment is adopted, recording format is seg-d, recording length is 5s, sampling interval is 1ms, front gain is 12 dB, prefiltering is 0.8N_LIN. The source model is bv-620lf low-frequency vibroseis, with one vibration stage for each time. The linear up-frequency scanning mode is adopted. The scanning length is 14 seconds, the scanning frequency is 1.5-96hz, and the driving amplitude is 65%.

4. Analysis of geophysical characteristics

Seismic exploration is a geophysical exploration method that utilizes the difference of elasticity and density of underground medium to observe and analyze the response of the ground to seismic waves generated by artificial excitation, so as to infer the nature and morphology of underground rock strata [11]. Compared with surrounding rock, the density of NGH is lower and close to that of ice, which is the basis of seismic exploration. The compressional wave velocity of NGH is higher than that of semi-cured sediments. The gas hydrate reservoir has the characteristics of low density and high total wave velocity, which has been verified in the gas hydrate exploration in different areas. Therefore, NGH must
have regular seismic attributes, and the study of seismic attributes such as amplitude and frequency has certain guiding significance for NGH exploration [12].

In the process of seismic data analysis and processing in the study area, it is found that velocity is a very important parameter in the whole data processing. Affects the effect of horizontal stacking; Migration velocity affects the accuracy of migration imaging. In this area, a velocity control point is set every 250 meters, fine velocity is picked up, and quality control is carried out by means of dynamic correction gather and stacking section. Shallow velocity has obvious velocity inversion. In addition, it can be seen from the velocity spectrum that there is an obvious velocity inversion in the shallow layer. The statistics of the position of shallow velocity inversion are as follows: ogs15-sn2 survey line, the shallow velocity inversion range is around cmp1800-3000, the time is 460-580ms (the time is the time from correction to the unified datum (4600m)), and the dotted line in the velocity spectrum represents the layer velocity. The velocity inversion anomaly is not found in other areas including muli area. Figure 3 shows the CMP2950 and CMP3000 velocity spectra with obvious velocity inversion anomalies on SN2 line and their corresponding seismic section positions (the red line in the seismic section indicates the position of the velocity spectra), indicating that the velocity inversion is caused by the occurrence of high-speed anomalies in the local area of the working area in the shallow layer [13, 14].

![Fig.3 OGS15-SN2 line CMP2950, CMP3000 velocity spectrum and its corresponding seismic section (speed reversal)](image)

It can be seen from the low-frequency scanning signal that the low-frequency signal in this area is rich and the shallow-layer imaging effect is good. the low-frequency amplitude analysis is carried out from the result of pre-stack time shift, taking the OGS15-SN2 line as an example, in the low-frequency analysis below 6 Hz, the phenomenon that the amplitude of the shallow velocity inversion region is abnormal and the low-frequency amplitude is white is found, that is, the weak amplitude phenomenon is shown in FIGS.4, 5 and 6, And the speed non-inversion region does not have an amplitude phenomenon.
As shown in figure 5, pink in the left is marked as a shallow velocity reversal plane map, and the right picture shows a low-frequency amplitude plane below 6Hz. The velocity reversal region is basically the same as the low-frequency weak-amplitude region. It can be seen from the chart that the anomaly in the southeast of the study area is more obvious, and the possibility of gas hydrate is greater.

5. Conclusion
High quality geophysical data are obtained by using low frequency vibroseis, track distance, high coverage number, middle excitation arrangement observation system. Through the processing and analysis of seismic data, it is found that near CMP1800-3000 and within the range of time of 460~580ms, the velocity inversion anomaly in the Hara Lake depression area, including Muli area, has not been found in the OGS15-SN2 line. According to its distribution range, it is found that there is a certain correlation between the velocity reversal region and the low frequency amplitude, which provides an important reference for the study of natural gas hydrate.
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