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Validation of Seismic Methods to Detect Natural Gas Hydrates in Permafrost

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ABSTRACT

The physical samples of natural gas hydrate were obtained first by drilling in permafrost region of Qilian Mountain of China in 2008. Permafrost area in Qilian Mt. is located in lower latitudes at high altitude, and the samples form in the Jurassic stratum under hard rock environment, rather than in unconsolidated soil layer. The environment of the Gas hydrate discovered is different from in the Arctic region.
The validity experimental study of seismic reflection method at Muli region in Qinghai province was carried out for detecting natural gas hydrate in 2010. High-precision seismic reflection method is used in the experimental study. Under the environment of high altitude and permafrost, the seismic survey is very difficult. The seismic data to be able to interpret is obtained through the hard work of field staff.
It is considered preliminary that reflections formed from natural gas hydrate media on seismic profile possess low velocity and low amplitude, high frequency characteristics, through comprehensive analyzing and interpreting the seismic and well logging and geological data. According to the dynamic features of the reflections and logging results, anomaly segments of natural gas hydrate found in the DK-4 and crystal segments of gas hydrate revealed by the DK-3 borehole are analyzed. The analysis results do not support natural gas hydrate drilled in the DK-4. Combined with borehole data, the enrichment zones of the natural gas hydrate are inferred.

KEY WORDS: Natural Gas Hydrate; Seismic Reflection; P-wave Velocity; Fault Structure; Permafrost.

INTRODUCTION

Natural gas hydrate, commonly known as "combustible ice", with characteristics of high energy density and shallow buried depth, has once been found to attract the attention of scientists in the world, became one of the hot spots in the study of today.
The gas hydrates mainly distribute in terrestrial permafrost and the edge of the continental shelf as well as continental slope sediments of the sea. There are more examples of detecting and studying natural gas hydrate on the sea, but in the land, the gas hydrates are only found at Siberia in Russia, Mackenzie De1ta in Canada and Alaska North Slope in United States. The physical samples of natural gas hydrate were obtained first by drilling in permafrost region of Qilian Mt. of China in 2008 (Xu Shuishi et al., 2009; Zhu Youhai et al., 2011). Because Siberia and Mackenzie Delta as well as Alaska North Slope are located near the Arctic Circle, so called polar permafrost area, but plateau permafrost in Qilian Mt. distributes in lower latitude areas, and its state is different from state in the Arctic permafrost, there are the differences of gas hydrate occurrence conditions and characteristics.
In marine hydrate exploration, the seismic reflection is one of the most effective methods. The method applied to natural gas hydrate exploration in the land is currently limited to Mackenzie Delta region in Canada (B.Milkereit et al. 2005; D.R.Schmitt et al. 2005; R.D.Miller et al. 2005; Michacel Riedel et al. 2009). In the Mackenzie Delta region, due to the Gas hydrate-bearing strata are unconsolidated layers and hydrate content is relatively high, so velocity of reflections formed from hydrate-bearing strata is relatively high. The amplitude of reflection formed from the hydrate-bearing stratum is proportional to the hydrate content, hydrate content the higher the reflection amplitude the stronger. Seismic results also show that hydrate distribution associated with the deep fault zone.
To investigate the effectiveness of detecting the gas hydrate using seismic methods, seismic reflection method were carried out in Muli region of China in 2010 (Xu Ming-cai et al. 2011) (Fig. 1), and before that, the seismic exploration has not been carried out for natural gas hydrate in the permafrost regions of China. According to the results of seismic and geophysical logging, the gas hydrate anomaly drilled in DK-4 borehole is interpreted.

1 GEOLOGICAL SUMMARY

Qilian Mt. is located at north of the Tibetan plateau, generally divided into three tectonic units: tectonic belt of North Qilian Mt., landmass of Middle Qilan Mt. and tectonic belt of South Qilan Mt. Ever since the Sinian, Qilian Mt. has experienced more than a continental rift valley phase, sea-floor spreading and the trench-arc basin system phase as well as orogenic evolution stages, formed a geological tectonic framework nowadays (Wen Huai-jun et al. 2011). Muli region is located in depression between the Middle Qilian Mt. and South Qilian Mt. tectonic units. Local geological structure of test area is a monocline structure cut by faults. Main faults are a series of the NWW and NEE trend thrust faults. Strata attitude is overall tendency to the South.
The strata outcropped from old to new in test zone are Upper Triassic (T3), Lower Jurassic (J1), Middle Jurassic (J2), Upper Jurassic (J3),