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The Gas-Source Study of Gas Hydrates in Wuli and Muli Permafrost Region of Qinghai-Tibet Plateau

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1 Introduction

Muli permafrost region is located in the south Qilian Mountain of the northern Qinghai-Tibet Plateau, which belongs to Kunlun Mountain terrain in geo-tectonics (Fig.1). The average elevation of the region is 4100m and the thickness of the permafrost is about 60 to 100m (ZHOU Youwu, etc, 2000; PAN Yulu, etc, 2008). The average surface temperature in the permafrost regions is -1.95℃. Gas hydrates samples of this region have been obtained by China Geological Survey in 2008. Studies have shown that Muli permafrost region has good gas hydrates accumulation conditions (LV Zhenquan, etc, 2010; ZHU Youhai, etc, 2010).

Wuli permafrost region is located in the north Tanggula Mountains of the southwestern Qinghai-Tibet Plateau, which belongs to Qiangtang terrain in geo-tectonics (Fig.1). The average elevation of the region is 4700m and the thickness of the permafrost is about 100m. The average surface temperature in permafrost regions is -3.6℃ (WU Qingbai, etc., 2006). The average geothermal gradient is 2.06℃per hundred meters. The first test hole named ZK1 for gas hydrates was drilled by Qinghai Institute of Coal Geological Exploration in the region. No any physical samples of gas hydrates have been acquired, whereas a lot of gas escaping from the core has been collected, the main ingredients of which are carbon dioxide.

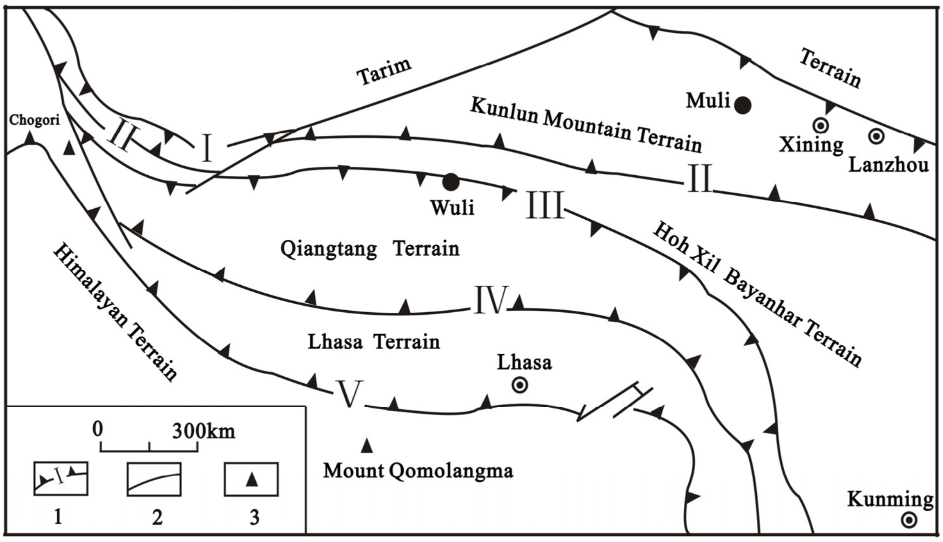

Fig.1 Tectonic locations of Wuli and Muli permafrost regions of Qinghai-Tibet Plateau (after WU Junhu, 2011)
1.Terrain suture lines and its number,2.Faults,3.Mountains, Ⅰ Western Kunlun Mountains-Altun Mountains-Northern Qilian Mountains suture zone, Ⅱ Southern margin suture zone of Kunlun Mountain, Ⅲ Jinsha River suture zone, Ⅳ Pangong Lake-Nujiang River suture zone, Ⅴ Yarlung Zangbo River suture zone

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Both Muli and Wuli permafrost regions belong to the Qinghai-Tibet plateau permafrost regions, why did gas hydrates accumulate in the former region rather than the latter? Did this caused by different genetic types of gas hydrates? To solve these problems, the natural gas components, stable carbon isotope and noble gas isotope in head-space gas of the core between Wuli and Muli permafrost region have been compared and analyzed. In addition, by studying hydrocarbon generation potential and tectonic backgrounds, the accumulation regularity and favorable exploration areas of gas hydrates have been explored.

2 Geochemical Characteristics of the Natural Gas

Based on the analysis of the test results of the two permafrost regions, we found that there are great differences between them on geochemical characteristics such as natural gas composition, stable carbon isotope and noble gas isotope. These indicate that Muli and Wuli permafrost regions have different gas sources.

2.1 Natural gas composition

Test result of natural gas composition of the samples from gas hydrates test hole in Wuli permafrost region shows that the average content of CO_2 is 98%, and hydrocarbon gases such as methane accounts for only 2 percent. Besides, gases escaped from the bottom of the lake near the test hole show that CO_2 accounts for 100 percent. According to the genetic classification of carbon dioxide (HE Jianxiong, etc., 2009), if CO_2 is more than 10% in the gas, it is considered to be inorganic origin. So the CO_2 from the test hole in Wuli permafrost region is regarded as inorganic CO_2.

Test results of natural gas composition of the samples from DK2 hole in Muli permafrost region show that CH_4 accounts for 96.6 percent, C_2H_6 for 3.3 and C_3H_8 for 0.1. Besides, the R (C_1/C_2+C_3) is generally less than 100. The comprehensive analysis shows that hydrocarbon gases of DK2 hole have thermogenic origin (LV Zhenquan, etc., 2010).

2.2 Stable carbon isotope

The CO_2 carbon isotope of the samples from the test hole in Wuli permafrost region ranges from -13.9‰ to -1.18‰, mainly distributing between -4‰ and -6‰, which indicates inorganic origin of CO_2(HE Jianxiong, etc., 2005). The methane content of the core samples in the region is very low and only part of them could be used to test the methane carbon isotope, which ranges from -32.38‰ to -27.82‰ and have characteristics of heavy carbon isotope. So it is considered that the origin of the methane is inorganic.

The methane carbon isotopes of the samples from the DK2 hole in Muli permafrost region range from -24.5‰ to -47.2‰, with an average of -40‰. Ethane carbon isotopes of the samples range from -25.2‰ to -38.4‰, with an average of -32.5‰. Propane gas carbon isotope ranges from -27.6‰ to -34.5‰, with an average of -32‰ (HUANG Xia, etc., 2011). According to the methane carbon isotopes and the characteristics of $\delta^{13}C_1<\delta^{13}C_2<\delta^{13}C_3$ of methane homologous carbon isotopes, it was considered that DK2 hole have the obvious characteristics of thermogenic gas.

2.3 Noble gas isotope

The test result of rare gas composition in Wuli permafrost region show that the $^3He/^4He$ ranges from 0.15×10^{-6} to 0.73×10^{-6} and R/Ra ranges from 0.11 to 0.52 (Table 1). It was considered by HE Jiaxiong(2005) that different values of R/Ra represent the different gas source. If R/Ra is less than 1, the gas is derived from the earth's crust; if it's lager than 2, the gas is derived from the earth's mantle; if R/Ra ranges from 1 to 2, it indicates the crust-mantle mixing origin of the gas. So the non-hydrocarbon gases in the samples could be derived from the earth's crust.

3 Discussion

It was generally considered that inorganic gases formed in the deep mantle and crust. It migrates towards the surface through the plate suture zones, stylolite, fault, magma and so on (HOU Dujie, etc., 2011). The pure inorganic gas only accumulates under special geological background. The gas hydrates test hole in Wuli permafrost region located next to Jinshajiang suture belt in the most north of the Qiangtang terrain of Qinghai-Tibet plateau. There exist lots of deep faults and magma intrusion in the region. Besides, recent fault activities are frequent (WU Junhu, 2011), which provide good paths for the migration of CO_2 from the crust. For a long time the tectonic movements in the research area have strongly destroyed the preservation conditions of gas and gas hydrates. This may be one of the reasons why gas hydrates cannot be discovered in this area.

Unlike Wuli permafrost region, the Muli permafrost region has different tectonic settings. The Muli permafrost region is located in the Muli depression, where tectonic activity is relatively weak. There are 4 sets of hydrocarbon source rocks from bottom to top in Muli depression (GONG Jianming, etc, 2015): dark mudstones of Carboniferous, dark limestone of the lower Permian, dark

Table1 Rare gas test data of gas hydrate test hole in Wuli permafrost region

Sample-No	1	2	3	4	5	6	7	8
3He/4He	0.42	0.17	0.25	0.20	0.52	0.32	0.15	0.73
R/Ra	0.30	0.12	0.18	0.14	0.37	0.23	0.11	0.52

Note: The name of the laboratory :Key Laboratory of Petroleum Resources Research，Institute of Geology and Geophysics，Chinese Academy of Sciences

mudstones of the upper Triassic and dark mudstones of Jurassic. The quality of the source rocks are overall good, especially the Jurassic source rock. 3 sets of the source rocks are between mature and high mature stage, except the source rock of Carboniferous is in over-mature stage, which is favorable for hydrocarbon generation. Therefore, the gas source of Muli permafrost region is thermogenic gas.

4 Conclusion

(1) Test result of natural gas composition of the samples from gas hydrates test hole in Wuli permafrost region show that the average content of CO_2 is 98%, while hydrocarbon gases such as methane account for only 2 percent. However, 96.6 percent of the gases from the samples of DK2 hole in Muli permafrost region are methane, the average carbon isotopes of which are -40‰. They also have the characteristics of $\delta^{13}C_1<\delta^{13}C_2<\delta^{13}C_3$, and containing a small amount of carbon dioxide

(2)The test result of rare gas composition in Wuli permafrost region shows that the $^3He/^4He$ range from 0.15×10^{-6} to 0.73×10^{-6} and R/Ra range from 0.11 to 0.52.

(3) The CO_2 from the test hole in Wuli permafrost region comes from the earth's crust. However, the gas source of the gas hydrates of Muli permafrost region is thermogenic gas.

(4) The strong and continuous tectonic movement may be the major reasons that affect the gas source of Wuli and Muli permafrost region. The gas hydrate samples in the test hole of Wuli permafrost region are not discovered, because it’s close to the Jinshajiang suture belt. So it can be speculated that the middle of Qiangtang terrain may have a good gas hydrate accumulation conditions because tectonic activity are relatively weak there.

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