Gas Hydrate Features in the Qilian Mountain Permafrost, Qinghai Province, China

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Permafrost Associated Gas Hydrate Projects in China

In 1999, a marine gas hydrate investigation was officially carried out offshore China under the sponsorship of China Geological Survey. Gas hydrate was discovered in the spring of 2007 in the northern slope of South China Sea (Zhang et al., 2007). In 2002 and 2003 a precursory geological and geochemical investigation along the Qinghai-Tibet railway permafrost zone on gas hydrate potentials (Lu et al., 2007) was financed by our organization, the Institute of Mineral Resources, Chinese Academy of Geological Sciences. Since the preliminary results were possibly indicative of gas hydrate potentials in the Qinghai-Tibet railway permafrost (Lu et al., 2009), China Geological Survey formally initiated a project for “investigation on gas hydrate prospects within permafrost areas around China from 2004 to 2006”. As a continuum, another project for “investigation and evaluation on gas hydrate potentials in the Qinghai-Tibet permafrost from 2008 to 2010” was subsequently launched by China Geological Survey.

Geological Settings in the Qilian Mountain Permafrost

The study area is situated in the Qilian Mountain permafrost and geographically located in the Muli town of Tianjun county, Qinghai province in the northeast of the Qinghai-Tibet plateau (Figure 1). Tectonics there are composed of the North Qilian structural zone, the middle Qilian block and the South Qilian structural zone. The alpine Qilian Mountain permafrost is about 10×104 km² in area and about 60~95 m in thickness (Zhou et al., 2000). In the Qilian Mountain area there are many well-developed, small-scale coalfields, of which the Middle Jurassic Muli coalfield (with the Jiangcang) and the Muli formations) is biggest in

Figure 1: Topographic map of Qilian Mountain area, China. Yellow star indicates area of interest.
Qinghai province. The drilling sites lie in the southern flank of a complex syncline of the Juhugeng mining district of the Muli coalfield. Due to thrust faulting, the complex syncline is actually composed of two monoclines with all levels of fault.

**Scientific Results from the Drilling**

In the winter of 2008 and the summer of 2009, four scientific experimental wells were drilled in the Qilian Mountain permafrost in Qinghai province, China. White to grayish white ice-like gas hydrate (Figure 2) was encountered in three holes and its related anomalous phenomena were observed in all the four holes in the field, including flammable phenomenon (Figure 3), strongly bubbling and water seeping on the fresh surface of cores, a chain of bubbles coming from under water when cores were submerged, extraordinary gases coming from the hole when gas hydrate bearing layers were drilled through, a large amount of gases when gas hydrate bearing cores were extracted under airtight conditions, heavy hydrocarbon traces and residual cellular textures over the surface of gas hydrate bearing cores, concomitant rhombic autogenic calcite crystals, relatively low temperature signals indicated by infrared camera, etc. Furthermore, peaks of large and small cages of gas hydrate were explicitly detected by Raman spectrometry. Additionally high electric resistivities and sonic velocities were recorded in the well log, corresponding to gas hydrate bearing layers.

In the Qilian Mountain permafrost, gas hydrate and its associated anomalies are vertically and horizontally discontinuous and occur mainly in fissures of mudstone, oily shale, siltstone, fine sandstone, secondly in the pore space of fine to middle grained sandstone at an interval of 133 to 396 mbs, which are not necessarily related to lithography but strongly controlled by fissures. Gas geochemical characteristics reveal that gas hydrate is mainly composed of CH₄, secondly of C₂H₆, C₃H₈, and CO₂. Their Raman spectra are indicative of a kind of Structure II gas hydrate. Gas composition and carbon and hydrogen isotope geochemistry of gas hydrate show that gases from gas hydrate mainly originate from thermo-genetic gases partially mixed with microbial gases.
It is speculated that in the study area, gas hydrate and its related anomalous phenomena are generally confined to the gas hydrate stability zone under appropriate P and T conditions; individual gas hydrate occurrences are jointly controlled by fissures and gas sources; after hydrocarbon gases are generated by organic matter, they are driven by all levels of fracture to migrate upwards; while they arrive in the gas hydrate stability zone, they are coupled by cryogenic permafrost, leading to their preferable occurrences in fissures.

**Further Tasks to Be Done**
The discovery of gas hydrate in the Qilian Mountain permafrost is a good start. The amount of hydrate is not clear yet. How gas hydrate forms is also a subject of interest. What methods other than drilling are applicable to other permafrost areas around China for gas hydrate exploration is still complex. Whether it is possible to find gas hydrate in other permafrost areas is a determination to be made. What will be done in relation to a test production is another issue such as environmental effect. All of these tasks need to be completed in the future.

**References**


