

Fault Control of Gas Hydrate Accumulation in Qilian Mountain Permafrost

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Gas hydrate was successfully sampled again in the DK-9 hole in Qilian Mountain permafrost since it was first discovered in 2008. However, gas hydrate occurrences are heterogeneous both in horizon and in profile, which are restricted just within a limited area. The geological controlling factors that affect gas hydrate occurrences are not yet known in Qilian Mountain permafrost. Since the features of gas hydrate and other related geological information were well recorded in DK-9, on the basis of analyses of geochemical and geological data in this hole, a possible geological pattern is put forward for a gas hydrate reservoir in this area. In this paper, the features of hydrocarbon in headspace gases from cores at various depths are compared with the occurrences of gas hydrate, faults, or fractures in DK-9 in Qilian Mountain permafrost. The results show that gas hydrate and its related anomalies fall into intervals with higher hydrocarbon contents in headspace gases. In the meantime, faults or fracture zones serve as migration paths for gases in the deep and provide accumulation space for gas hydrate in the shallow in Qilian Mountain permafrost. Specifically, the F_1 and F_2 faults mainly control gas hydrate accumulation in Qilian Mountain permafrost.

INTRODUCTION

Gas hydrate is a crystalline material formed from water and gases, such as methane, under low-temperature and high-pressure conditions (Sloan and Koh, 2008). In nature, gas hydrate is distributed at a water depth of more than 300 m in submarine sediment (Kvenvolden et al., 1993) or at a depth greater than 130 m below ground (about 3.5 MPa) in permafrost (Shi and Zheng, 1999). Its total amount is generally believed to include about $0.1\sim 2.1 \times 10^{16}$ m³ methane, which is twice as much as that of fossil fuels, such as coal, oil, and natural gas, in the world (Kvenvolden et al., 1993; Milkov, 2004). At present, gas hydrate was found or indicated by geophysical clues in 132 places, including 123 in marine subsurface sediment and nine in permafrost (Makogon, 2010).

Apart from discoveries in the Messoyakha gas field in West Siberia in Russia (Makogon, 2010), in the Mackenzie delta in Canada (Dallimore and Collett, 2005), and in Mount Elbert in Alaska in America (Collett et al., 2011) in permafrost, gas hydrate was first discovered in Qilian Mountain permafrost in 2008 in China (Lu et al., 2011; Zhu et al., 2010). At present, nine gas

hydrate scientific drilling wells, DK-1, DK-2, DK-3, DK-4, DK-5, DK-6, DK-7, DK-8, and DK-9, have been completed in this area. However, gas hydrate was just encountered in the wells of DK-1, DK-2, DK-3, DK-7, DK-8, and DK-9, and the distance is no more than 30 meters between each well except DK-9, which is about 500 meters from these other wells (see Fig. 1). In the wells of DK-4, DK-5, and DK-6, gas hydrate was not observed; these wells are several hundred meters to 1000 meters away from known gas hydrate locations. In fact, gas hydrate occurrences are discontinuous and uncorrelated in the profile of wells in Qilian Mountain permafrost. What geological factors control gas hydrate accumulation or occurrences? In this paper, headspace gases from cores were systematically sampled above, within, and below faults or fracture zones in DK-9. Their geochemistry and geological constraints were then analyzed. The aim of this paper is to indicate the constraint of faults or fracture zones on gas hydrate accumulation in Qilian Mountain permafrost.

GEOLOGICAL SETTING

The study area is located in Muli in Qilian mountain permafrost. It is tectonically situated in the Middle Qilian block formed in the Caledonian Movement (513~386 Ma) adjacent to the South Qilian structural zone (Feng, 1997; Zhang and Yang, 2007); it also belongs to the Muli Depression of the South Qilian basin (Fu and Zhou, 1998, 2000). A coal field in Muli is the largest in Qilian mountain permafrost in Qinghai province. The

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KEY WORDS: Gas hydrate accumulation, geological control factor, Qilian Mountain, permafrost.