Geochemical Characteristics of the soil above Muli Gas Hydrate Reservoir

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ABSTRACT

The Muli gas hydrate reservoir in Qilian Mountains was chosen as the test area for the geochemical exploration of gas hydrate in the middle-latitude region. Soil headspace gas, acid-extracted hydrocarbon, and carbon isotope of methane were tested. Results reveal that geochemical anomalies were consistent with the underlying gas hydrate reservoir. The carbon isotope of methane and the hydrocarbon composition of the surface geochemical anomaly indicated a thermogenic origin, which suggests that the gas source of the potential gas hydrate reservoir in this area may be contributed by oil gases. The proposed accumulation model was also studied for the gas hydrate reservoir.

KEY WORDS: Gas hydrate; middle latitude permafrost; Qilian mountain; Geochemical characteristics; soil; Gas hydrate accumulation model; thermogenic origin.

INTRODUCTION

Gas hydrate reservoirs are mainly distributed in marine sediments and permafrost regions. The first discovery of a gas hydrate reservoir occurred in the polar permafrost in 1967 by a Russian scientist (Sloan, 1990). Later, eight documented discoveries occurred in high latitude areas, including USA, Russia, Canada, and Norway (Collett, 1993; Collett and Dallimore, 1999, 2000; Dallimore and Collett, 1999; 2005; Sloan and Koh, 2008). On 5 November 2008, the first discovery of gas hydrate in the middle-latitude region occurred in the drilling hole DK-1 in the Qilian Mountain permafrost in China (Zhang et al., 2007). The gas hydrate in this area mainly comprises methane, with a small amount of ethane, propane, and butane, and appears to be type II gas hydrate (Zhu et al., 2010).

Most methods applied to gas hydrate exploration in the polar permafrost regions include the seismic reflection method and integrated well logging. These methods appear to be effective in both Alaska and Mackenzie Delta (Schmitt et al, 2005; Michael et al., 2009). However, gas hydrate in Qilian Mountain mainly occurs in fine-grained clastics, siltite, mud stone, and dunnet shale of middle Jurassic Jiangchang formation and in the form of “fracture filling” and “pore filling” (Wang et al., 2011). These geophysical premises made the generation of the BSR (bottom simulating reflections) phenomenon difficult.

Therefore, the seismic reflection method seems to be difficulty for gas hydrate exploration in this area. Although scientists have conducted several route geochemical surveys on gas hydrate exploration in Qinghai–Tibet Plateau (Wu et al., 2006; Lu et al., 2010; Zhang et al., 2008), exploration in the middle-latitude permafrost region remains at its early stage. Yet, an effective geochemical method for gas hydrate exploration in this region is to be developed.

A pilot geochemical exploration project in Qilian Mountain was conducted to examine the effectiveness of geochemical methods for gas hydrate exploration in middle-latitude regions. Soil headspace gas, acid-extracted hydrocarbon, and carbon isotope of methane were tested. The geochemical characteristics of the gas hydrate discovery area were interpreted, and an effective combination of geochemical indicators was developed. The accumulation model of gas hydrate in Muli area was also developed for the geochemical exploration of gas hydrate in middle-latitude areas.

GEOLOGICAL CHARACTERISTICS OF THE STUDY AREA

Qilian Mountains lie north of Tibetan Plateau. The tectonic units of these mountains are the North Qilian tectonic belt, Middle Qilian land block, and the South Qilian tectonic belt. These three tectonic units are divided by four fractures, including the northern edges of the North Qilian and Middle Qilian fractures, southern edge of the Middle Qilian fracture, and Tuergendaban Mountains–Zongwunong Mountains–Qinghai Lake fracture. The study area is located in the Juhugeng mining area of the Muli coalfield in Qilian Mountains. The mining area is generally an anticline structure. Sanjingtian, Erjingtian, and Yilutian are distributed in the southern syncline. The gas hydrate reservoir is located in the Sanlutian (Fig. 1) (Fu and Zhou, 1998; Wen et al., 2006; Wang and Zhu, 2011).

The outcropped strata in the mining area are Upper Triassic (T3), Middle Jurassic (J2), Upper Jurassic (J3), and Quaternary (Q) (Fig. 1). The outcropped Upper Triassic layer widely occurs in the northern and southern parts of the mining area and anticlinal axis. The lithology of the Upper Triassic mainly consists of black siltstone, mudstone, and thin coal seams. Middle Jurassic contains Muli (J2m) and Jiangchang groups (J1J2). The lower Muli group (J1m1) is a braided river alluvial plain deposit and is middle-coarse clastic, occasionally with a thin layer