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RESEARCH PAPER

Accumulation features and mechanisms of high saturation natural gas hydrate in Shenhu Area, northern South China Sea

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Abstract: Based on the comprehensive interpretation of cores, loggings and 2D/3D seismic data of Shenhu GMGS3 drilling area in the northern South China Sea, the distribution characteristics, differential accumulation mechanism and reservoir forming mechanism of diffusion type natural gas hydrate with high saturation discovered from clayey silt reservoirs were investigated. The following findings are reached through the research: (1) Gas hydrate with high saturation often displays high resistivity, low interval transit time, and strong bottom-simulating reflectors (BSRs), and accompanies with fluid seepage phenomena beneath BSRs, such as mud diapiric structure and gas chimney. (2) The gas hydrate reservoirs are dominated by fine grained clayey silt sediments, and the reservoirs have higher porosity and permeability in local parts. (3) The gas hydrate is largely type I, whereas type II gas hydrate may exist below the type I gas hydrate. (4) The gas sources are mixed microbial and thermogenic gases, and the thermogenic gas originated from the deep formation in the center of Baiyun Sag migrated into shallow strata through faults, mud diapirs and gas chimneys, then was mixed with microbial gas in situ and continued to migrate until they accumulated in the temperature and pressure stability zone and formed diffusion type gas hydrate with high saturation finally. (5) The fluid migration system influenced and controlled the differential distribution of gas hydrate with high saturation.

Key words: natural gas hydrate; high saturation; distribution characteristics; accumulation mechanism; Shenhu area; Pearl River Mouth Basin; northern South China Sea

Introduction

The reservoirs with the natural gas hydrate (gas hydrate) saturation of higher than 60% are the most favorable target strata for successfully experimental mining around the world under present development technology[1–3], so the formation, occurrence, reservoir forming mechanism and controlling factors, etc. of gas hydrate with high saturation have been investigated intensively[4–9]. In 2015, the Guangzhou Marine Geological Survey (GMGS) carried out the second drilling expedition in the Shenhu GMGS3 drilling area in the northern slope of South China Sea (SCS)[10], during this expedition, 19 sites were drilled and 23 boreholes in total were accomplished. The GMGS acquired gas hydrate shows in all of the wells, moreover, it conducted in-situ measurements and coring in four wells among them and obtained samples of gas hydrate (invisible). In the GMGS3 drilling area, diffusion type gas hydrate characterized by large thickness, high saturation, and large storage was discovered[11–12]. Preliminary analysis showed that the gas hydrate reservoirs are silty fine grained sediments with abundant foraminifers[13], which are different from the opinion that the gas hydrate with high saturation dominantly exist in coarse-grained sandy reservoirs[5–7], the reasons are still unknown. In addition, the identification and fine depiction of migration pathways of hydrocarbons and the coupling relationship between the migration conduction system and the formation and distribution of gas hydrate with high saturation in the GMGS3 drilling area need further investigation[14]. Although gas hydrate with high saturation has been discovered in this area, the saturation and thickness of reservoirs of gas hydrate show big variation in vertical and lateral directions, in other words, the distribution of gas hy-

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drate is obviously heterogeneous[12–13], so it is urgent to find out the mechanism of variation accumulation of gas hydrate and the controlling factors of reservoir forming, to provide theoretical support for the design optimization of borehole drilling programs[12].

Based on fine depiction of the reservoir forming characteristics of gas hydrate with high saturation in the clayey siltstone reservoirs of site W19 in the Shenhu GMGS3 drilling area in northern slope of SCS, the reasons of differential accumulation, reservoir forming mechanism and controlling factors of gas hydrate are examined to figure out the migration and accumulation model of diffusion type gas hydrate with high saturation, in the hope of providing references and guidance for the reservoir forming mechanism research, drilling target selection and resource evaluation of gas hydrate with high saturation in clayey siltstone reservoirs in northern SCS.

1. Geological setting

The Shenhu gas hydrate enrichment region is located in the northern slope of SCS, and tectonically belongs to the Baiyun sag of the Zhuer depression in the Pearl River Mouth Basin (PRMB) (Fig. 1a). The seafloor in this region, relatively flat (with an average slope gradient of 3°), has knolls, submarine valleys, scour channels, gullies, and so on[15–16]. With a water depth range of 1 000–1 700 m, the area can be divided into two parts with 1350 m water depth as a cutoff. The north part

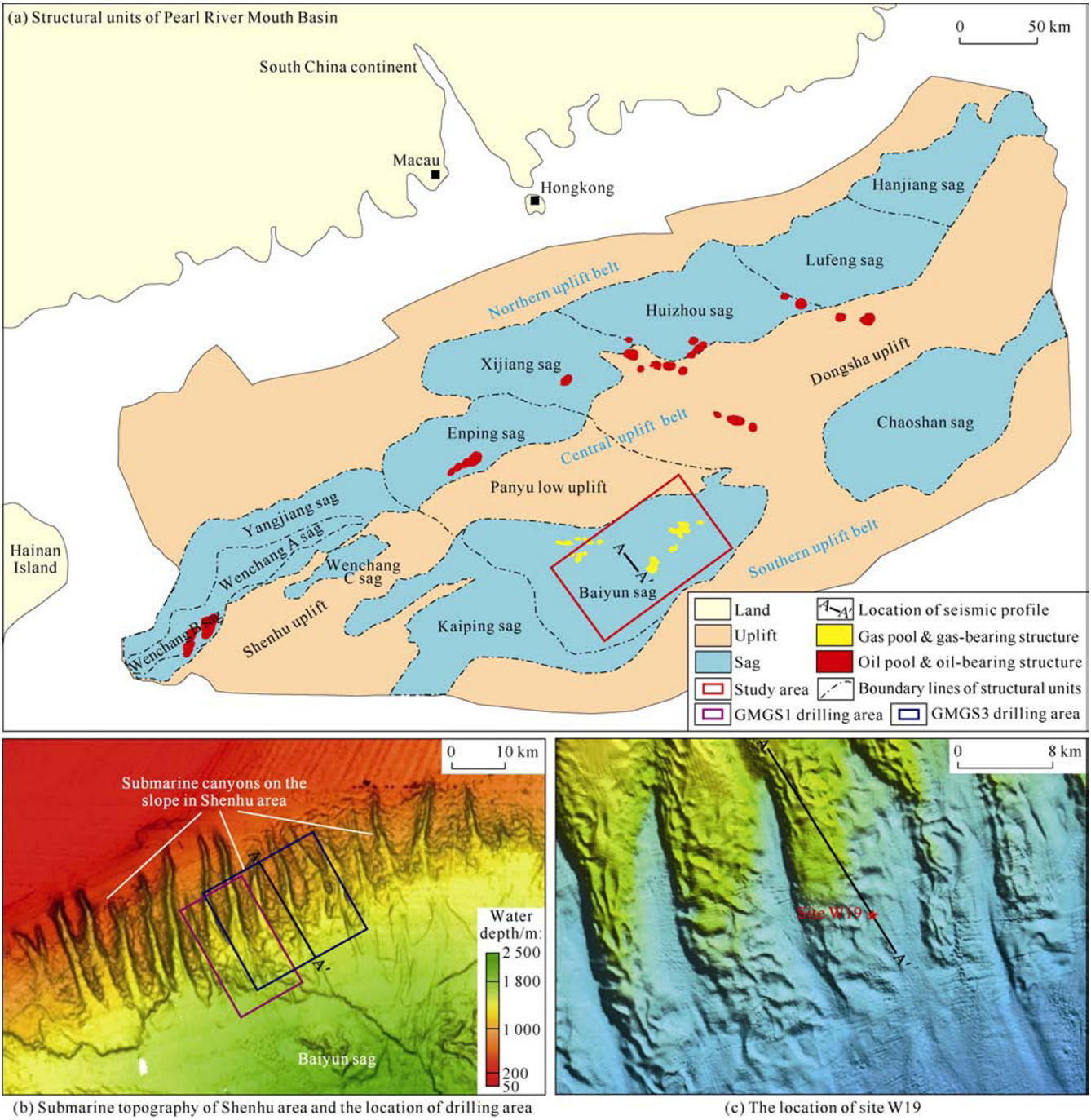

Fig. 1. Geological settings of Shenhu area in northern South China Sea, the locations of GMGS3 drilling area and site W19.