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Study on coalbed methane accumulation characteristics and favorable areas in the Binchang area, southwestern Ordos Basin, China

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ABSTRACT

The Binchang area of southwestern Ordos Basin is one of the most promising areas for low-rank coalbed methane (CBM) in China. This work investigates the Jurassic Yanan Formation coal and CBM geology and accumulation characteristics of CBM in the southwestern Ordos Basin based on data from 46 wells and laboratory measurements of 14 coal samples from 7 mines. The results show that coal rank in the Binchang area is mainly sub-bituminous A and high-volatile C bituminous (0.46%–0.73%R_o). Coals are dominated by inertinite (14.7–85.6%); less abundant are vitrinite (8.5–77.7%) and liptinite (1.5–15.2%). Minerals are found only in small amounts (0.4–8.3%). Permeability is between 0.04 and 25.3 mD, and porosity ranges from 2.4% to 20.1%. Most coal pores are less than 100 nm in diameter, making them favorable for gas adsorption but unfavorable for gas permeability. Pore morphology is represented mainly by micro- and mesopores with a well-connected and ink-bottle shaped (narrow throat and wide body) morphology. These coals are characterized by a high adsorption volume of more than 3.0×10^{-3} ml/g. Methane isothermal adsorption measurements of 12 coal samples revealed that their maximum adsorption capacity (on a dry and ash-free basis) varies from 5.06 to 13.37 m^3/t, depending on moisture content. However, under the influence of gas preservation conditions, the in-place gas content is generally 0.11–6.26 m^3/t. Finally, based on a comprehensive analysis of coal thickness, gas content, hydrogeology conditions, roof, floor, and depth properties, this study indicated that the best prospective target areas for CBM production are forecasted to be the Tingnan and Dafosi areas, which are located in the syncline, central south part of the study area.

1. Introduction

Early coalbed methane (CBM) exploration and development in the 1990s targeted middle and high-rank coals distributed throughout the southern Qinshui Basin and the eastern Ordos Basin, China (Cai et al., 2011; Li et al., 2011; Wei et al., 2010). However, in recent years, with the successful development of CBM in the Powder River Basin, Uinta Basin, and Raton Basin in the United States (Ayers, 2002; Flores, 1998) and in the Surat Basin of Australia (Scott et al., 2007), low-rank deposits have also been shown to be economically significant. China has a large amount of low-rank CBM resources (Wang, et al., 2009), which are becoming a focus of much research and offering a new field of CBM exploration and development.

The Binchang area in the southwestern Ordos Basin is one of the most potential areas for low-rank CBM in China. Previous investigations of the CBM in this area have focused on the geological background and coal geology (Lin et al., 2009; Wang et al., 2004) or on the assessment of CBM potential (Long and Wang, 2005; Xu et al., 2010). Until now, however, the Binchang area has not had any commercially producing CBM wells, although there have been a number of companies exploring the area, conducting research and assessing the size and nature of potential resources. Multidisciplinary and systematic studies on CBM are still needed. This paper presents a comprehensive study of coal geology, CBM reservoir properties, and accumulation characteristics in the Binchang area to evaluate the potential for CBM production.

2. Geological setting

2.1. Tectonic setting

The Ordos Basin is situated in central China with an area of 250,000 km^2 (Fig. 1). It is a stable polycyclic sedimentary basin, which was formed on the North China Craton (Tang et al., 2012; Xu et al., 2011). The Ordos Basin contains the second largest coal resources in China, next only to the North China Coal Basin. The coal-bearing deposits of the basin consist of Pennsylvanian, Permian, Triassic, and Jurassic strata (Dai et al., 2002, 2006; Wang, 1996).

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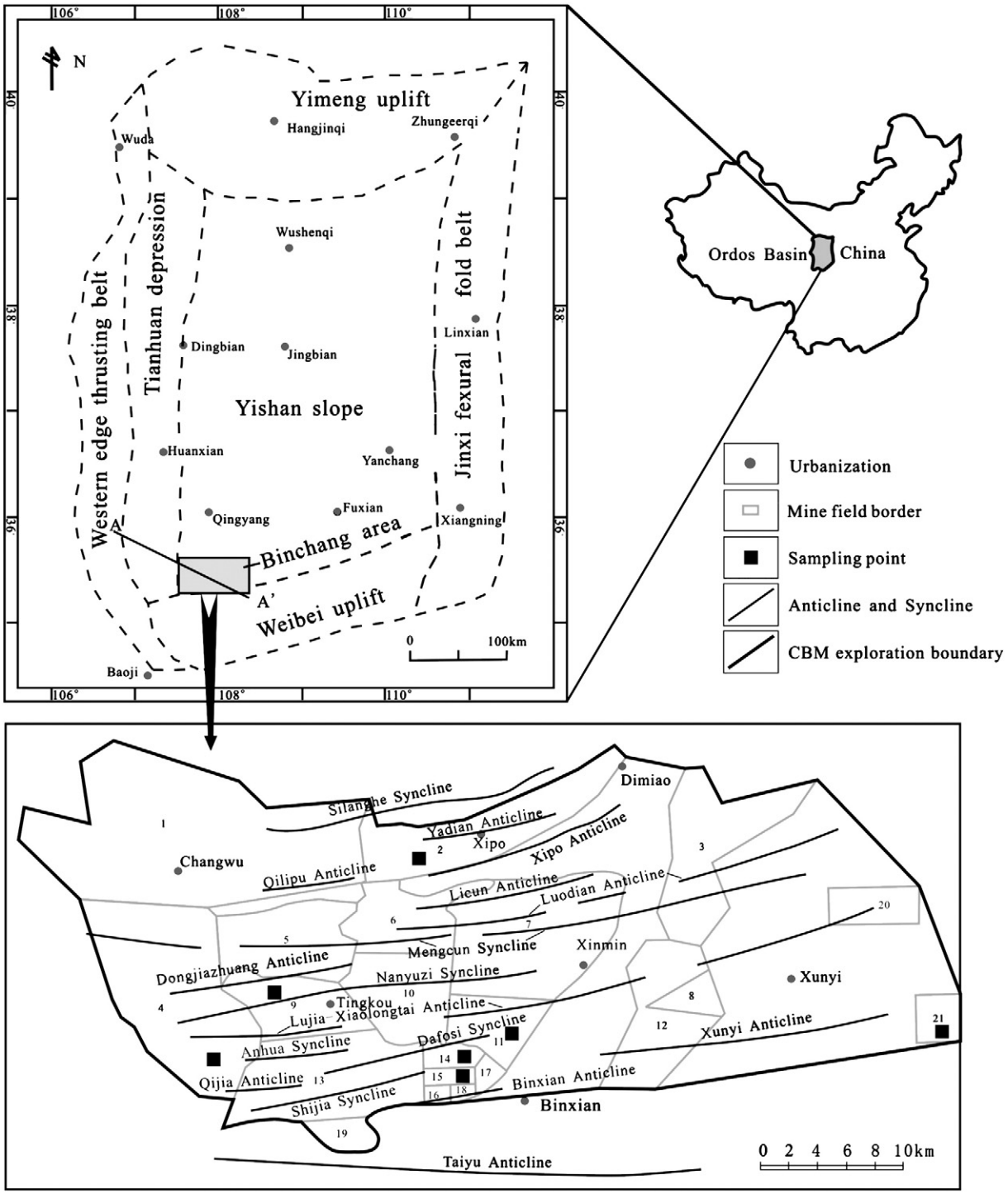

Fig. 1. Location of the Binchang area in China (1—Gaojiapu exploration area, 2—Yadian exploration area, 3—Bindong exploration area, 4—Yangjiaping exploration area, 5—Mengcun mine field, 6—Hujiahe mine field, 7—Wenjiapo exploration area, 8—Yanjiahe mine area, 9—Tingnan mine area, 10—Xiaozhuang mine field, 11—Huoshizui mine, 12—Baizigou mine area, 13—Dafosi mine, 14—Xiagou mine, 15—Shuilian mine, 16—Hushengou mine, 17—Shizui mine, 18—Yangshan mine, 19—Jiangjiahe exploration area, 20—Liushicun mine, 21—Heigou mine; A-A' is the location of the hydrogeological profile in Fig. 13).

Abundant coal resources (shallower than 2000 m) occur in the Permo-Pennsylvanian (421 Gt), Triassic (0.67 Gt), and Jurassic (119 Gt) sequences (Wang, 1996).

The basin is divided into six structural units (Fig. 1): the Yimeng uplift, Weibei uplift, Western edge thrusting belt, Jinxi flexural fold belt, Tianhuan depression, and Yishan slope (Zhang et al., 2009). Tectonically, the Binchang area is located in the northern margin of the Weibei uplift belt (Fig. 1), which is a monoclinal structure where faults cover only a small area. The Jurassic coal-bearing strata in this area dip gently towards the northwest at an angle of less than 10°. The area was structurally altered, with numerous broad and gently dipping anticlines and synclines with a W–E strike.

2.2. Coal-bearing strata and depositional environments

In the Binchang area, the main coal-bearing sequences occur in the Middle Jurassic Yanan Formation (Nos. 1–4 coal seams), which contain 3 members (Lin et al., 2009). The upper member is composed