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Block scale investigation on gas content of coalbed methane reservoirs in southern Qinshui basin with statistical model and visual map

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A B S T R A C T

This study performs a block scale investigation on gas content of a coal reservoir in Zhengzhuang Block of the southern Qinshui basin in China. The gas content of Coal Seam No. 3 in this coal reservoir was measured in field and laboratory in conjunction with tests on coal properties such as adsorption isotherm, maximum vitrinite reflectance, coal composition and maceral component etc. Total 36 coal cores collected from 3 adjacent coalmines in the southern Qinshui basin were investigated, including analysis of logging data from the drilling wells. The investigations provided experimental data for block scale modeling and visualization analyses on the correlation between gas content and the key factors such as coal properties and geological conditions of the coal reservoir. Data obtained by field and lab tests were analyzed by statistical models in order to correlate gas content and individual type of coal properties and geological variables. The statistical model was then used to map the gas content of the target coal seam in the studied area, resulting in a flood map of gas content at a 1:50000 scale. The flood map was further visualized with other variables in terms of the properties of coal and coal reservoir and its geological conditions. These visualized maps provide useful geological interpretation for block scale investigation of the comprehensive relationships between the gas content and the coal properties and regional structure in the given coal reservoir. The results show that gas content has little correlation with coal rank, maceral composition, coal thickness, cap and bottom lithology, while it is highly related to the structural properties such as burial depth and effective cover thickness. A stagnant hydrodynamic condition is favorable to the higher gas content on the whole but does not contribute to gas lateral and local variation. Canonical correlation and principal component analysis on the statistical model reveal the key factors that control the gas content are burial depth, effective thickness of overlying strata, groundwater level and moisture content in coal seam.

1. Introduction

Gas content of coalbed methane (CBM) reservoirs is one of most important indices for exploration and exploitation of CBM resource deposited in coal seams. The methane adsorption isotherm has been widely used to measure the gas content of coals (AQSIO and SAC, 2004a, 2008a). However measurement of the adsorption isotherm on coals cannot accurately represent the gas content of CBM reservoirs since the ideal laboratory conditions are different from the in-situ circumstance of the CBM reservoirs. To determine the gas content of CBM reservoirs, standardized field tests have to be carried out, consisting of estimating the lost gas content during sampling and measuring desorbed and residual gas contents based on the adsorption isotherm method (AQSIO and SAC, 2004b,2008b; Wang et al., 2011). The field experiments are integrated with other measurements of coal and reservoir properties, such as measurements of adsorption isotherm and gas component, the maceral composition, proximate and ultimate analyses, and tests for vitrinite reflectance and porosity. These measurements provide the experimental data for block scale investigation on the gas content of CBM reservoirs.

Qinshui basin is the largest basin for CBM bearing resource as well as the most active area for exploration and development of coalbed methane in China. It is located in Shanxi province of

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northwest China, characterized by one of the deposited most abundant anthracite coal reservoirs in the world. Currently, there are about 3000 CBM wells completed in China and most of them are located in the southern Qinshui basin, making up over 95% of the total CBM wells in the country. It can be predictable that there will be increasing research activities and investments on projects for CBM recovery in this basin. However, the studies on block scale evaluation of gas content in the whole Qinshui basin are still limited (Qin et al., 2005; Song et al., 2005; Zhao et al., 2005; Cai et al., 2011; Song et al., 2012), in particular for the southern part of Qinshui basin (Zhao et al., 2005, Cai et al., 2011; Song et al., 2012). Among these studies, only a few attempted to investigate the effect of various geological factors on gas content (Cai et al., 2011). These studies investigated the control mechanism on gas content from different perspectives, mainly based on large-scale CBM basins. The distribution of gas content in the field, which is essential for optimizing well pattern and minimizing investment risk for CBM recovery, has not been fully understood and needs to be investigated further.

As well known, gas content of CBM reservoirs is generally controlled by comprehensive geological conditions, including tectonic setting, depositional environments (Ayers, 2002; Song et al., 2005; Song et al., 2012), hydrological features (Kaiser et al., 1994; Scott, 2002; Pashin, 2007), reservoir pressure (Liu et al., 2005), burial depth (Su et al., 2005; Liu et al., 2012; Song et al., 2012), coal quality and rank (Langenberg, et al., 2006), and coal petrology (John et al., 1989; Levine, 1992; Scott, 2002). Despite many attempts which have been made to measure gas content of various coals, and to discuss a general relationship between the gas content of coal and the coal geological conditions in basin scale, the quantitative relationship between gas content and the geological factors has not been clear particularly in the developing CBM field. This uncertainty makes it difficult to evaluate the CBM potential capacity of CBM reservoirs in a block scale, and hence increases the risk of investments for the exploitation of a CBM field.

This paper presents a block scale investigation on gas content of the CBM reservoir in Zhengzhuang Block of the southern Qinshui basin by systematic sampling of coal samples and comprehensive analyses of gas content data measured in field and laboratory.

2. Geological setting

Fig. 1 shows the studied area with the primary geological information such as faults and well locations for sampling. Coal-bearing strata of the studied area consists of Benxi, Taiyuan, Shangshihezi and Shiqianfeng formations of the Permo-Carboniferous from bottom to top, and Coal Seam No. 3 in the studied area is developed in Shanxi formation, as indicated in Fig. 2. Shanxi formation comprises mudstone, sandstone, sandy mudstone and coal deposited in deltaic environments, such as mouth bar, interdistributary estuary and delta plain, of Paleozoic North China Epicontinental Sea. Its thickness is 50 m in average, ranging from 39 to 79 m.

The coal-bearing strata in the area mainly experienced four periods of tectonic movement: Hercynian period, Indosinian period, Yanshanian period and Himalyan orogenic period. During the Hercynian–Indosinian period, the area experienced a long

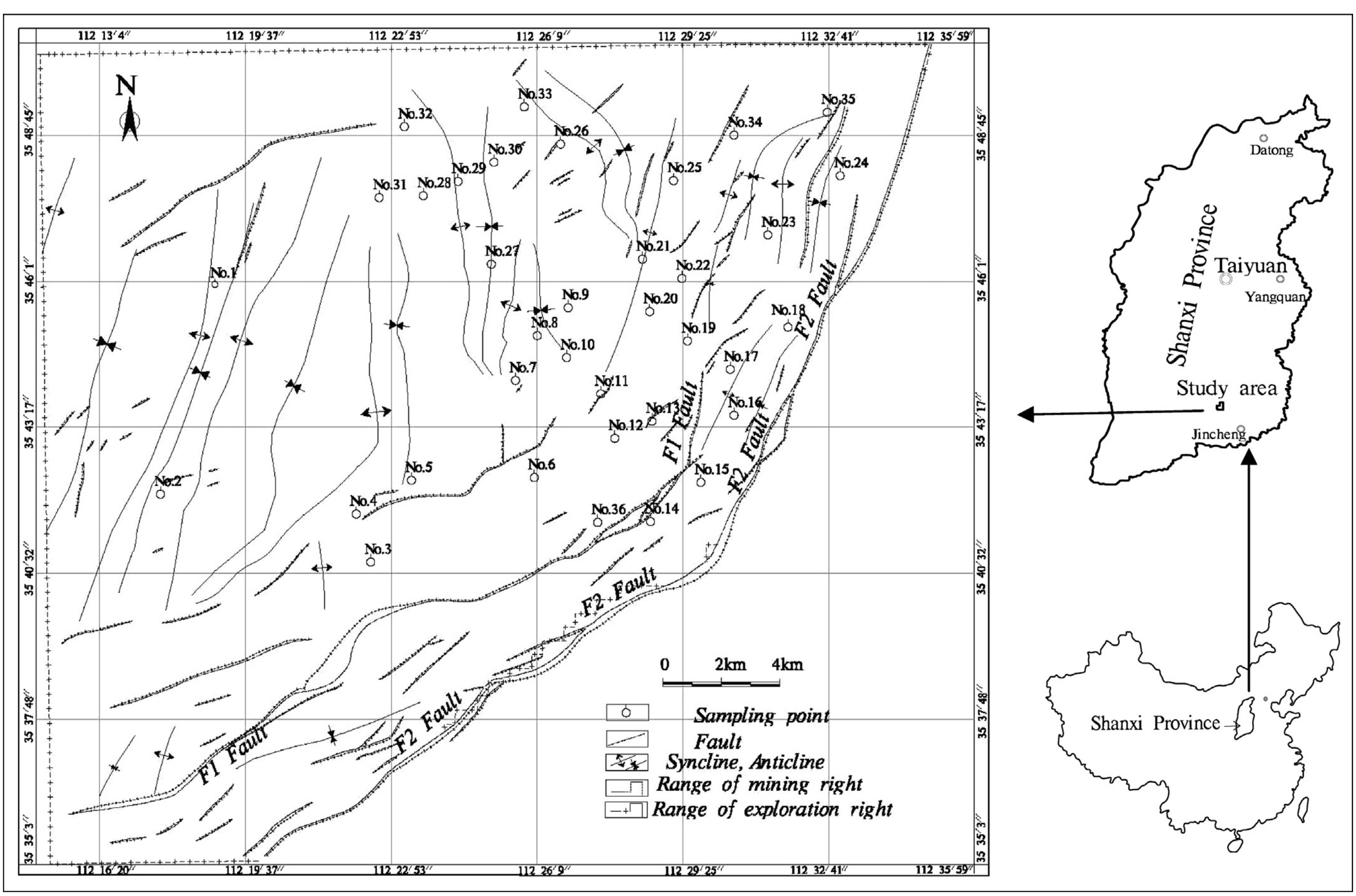

Fig. 1. Tectonic setting of Zhengzhuang Block in southern Qinshui basin.