International Journal of Coal Geology 82 (2010) 175–183

Contents lists available at ScienceDirect

International Journal of Coal Geology

journal homepage: www.elsevier.com/locate/ijcoalgeo

Effects of structural deformation on formation of coalbed methane reservoirs in Huaibei coalfield, China

Bo Jiang [a,b,*], Zhenghui Qu [a,b], Geoff G.X. Wang [c], Ming Li [a,b]

[a] School of Resources and Earth Science, China University of Mining and Technology, Xuzhou 221116, China
[b] Key Laboratory of CBM Resource and Reservoir-generating Process, China Ministry of Education, Xuzhou 221116, China
[c] School of Chemical Engineering, The University of Queensland, QLD 4072, Australia

ARTICLE INFO

Article history:
Received 25 May 2009
Received in revised form 18 December 2009
Accepted 21 December 2009
Available online 6 January 2010

Keywords:
Xu–Su nappe structure
Coalbed methane reservoir
Coal seam
Tectonically deformed coal
Permeability

ABSTRACT

Tectonically deformed coal is defined as coal formed by superimposed reformations from tectonic stress. The Huaibei coalfield is typically composed of various tectonically deformed coals containing rich coalbed methane resources. However, the occurrence of coal seam in this area is complicated largely by the structural deformation, which has not yet been evaluated systematically for exploration and exploitation of coalbed methane. In this study, tectonism in Huaibei coalfield is discussed by combining systematic analyses on the occurrence of coal seams and the formation of coalbed methane reservoirs. The study shows that, with structural deformation in the study area, the coal seams in Huaibei coalfield are distributed in north–south tectonic blocks and east–west tectonic zones. North tectonic block of Huaibei coalfield is not favourable for exploitation of coalbed methane because of low gas content or disadvantageous structural conditions. Within the south tectonic block, the east Suzhou syncline contains high gas content but coal permeability is very low. This area is generally not suitable for exploitation of coalbed methane and is a dangerous mining area due to gas outburst because of the widely developed mylonitic coals. South Suzhou and Nanping synclines in the middle part of the south tectonic block are exposed to relatively weak structural deformations. These synclines contain coals with high gas content and moderate permeability, which are beneficial for exploration and exploitation of coalbed methane. Linhuan mining area in the south tectonic block is generally not suitable for exploitation of coalbed methane, mainly because of well developed normal faults and interlayer slip structure, and presence of mylonitic coal, resulting in low gas content and poor structural conditions for mining coalbed methane. In contrast, Guoyang mining area in the west part of the south tectonic block, where tectonically deformed coal was generally underdeveloped, is a potential area for exploration and exploitation of coalbed methane because of moderate gas content and possibly higher permeability of its coal.

1. Introduction

The geologic background of coalbed methane reservoirs in China is highly diversified and complicated. Their geologic conditions for formation and recovery of coalbed methane are obviously different from other countries where the development of coalbed methane has been commercialized more successfully (Ye et al., 1998). For example, due to superimposed reformations from tectonic stresses with different types and orientations (Jiang et al., 2005), the coal texture and formation of coalbed methane in the Paleozoic coal seams in the east of China have been changed intensively, leading to various types of tectonically deformed coals with unique reservoir physical properties. Tectonically deformed coal is also called deformed coal characterized by tectonically induced features, notably a granular or mylonitic texture due to the generation of small particle sizes (Frodsham and Gayer, 1999; Cao et al., 2003). As a result, the coalbed methane exploration prospect of each mining areas in this area is much different (Jiang and Ju, 2004). Therefore, tectonic deformation and its characteristics may be the main factors that affect the formation of coalbed methane in Huaibei coalfield.

The stratigraphy and geologic structure determine the shape, continuity, and permeability of coal beds (Pashin, 1998; Frodsham and Gayer, 1999). A better understanding of the stratigraphy and geologic structure of coal beds is therefore critical to design exploration and production strategies for development of coalbed methane. Considerable work has been done in this aspect, resulting in an improved understanding of these phenomena. Study of Harris et al. (1996) shows that, a further consequence of increased brittle deformation is the enhancement of permeability which has been investigated in connection with coalbed methane extraction from anthracite. According to the research of structural controls on fractured coal reservoirs in the southern Appalachian Black Warrior foreland basin (Groshong et al., 2008), reservoir behaviour of

* Corresponding author. School of Resources and Earth Science, China University of Mining and Technology, Xuzhou 221116, China. Tel.: +86 516 83591002; fax: +86 516 83590998.
E-mail address: jiangbo@cumt.edu.cn (B. Jiang).

0166-5162/$ – see front matter © 2009 Elsevier B.V. All rights reserved.
doi:10.1016/j.coal.2009.12.011

deformation largely depends on distance from the thrust front. Far from the thrust front, normal faults are barriers to fluid migration and compartmentalize the reservoirs, while close to the thrust front, productive rates of the reservoirs are enhanced along some normal faults. Wei and Han (2003) investigated the structure controlled coalbed methane reservoirs in Qinshui basin of China and found that open cleats in coal seams play a more significant role in controlling the formation of coalbed methane reservoir, compared with the coal structure of gentle fold. Generally different types of tectonic stress fields show different effects on formation of coalbed methane reservoir. Under compression tectonic stress field, mylonitic coal is developed limitedly along strong deformation belt in coal seam, most tectonically deformed coal exhibit brittle deformation, which is beneficial for coalbed methane exploration. Under extension tectonic stress field, the permeability of coalbed methane reservoir and cover rock is enhanced, which causes the coalbed gas to escape from coal seams easily, leading to bad conditions for gas preservation (Jiang et al., 2005). Tectonic stress field determines the permeability of coal reservoir through forming joints acted under ancient and recent tectonic stress fields in coal seam. This interdependent evolution strictly controls the permeability of coalbed methane in strata (Yun, 2004).

Huaibei coalfield, located in the north of Anhui province of China, is one of the major coalfields in China with 23 active underground coal mines (Zheng et al., 2008). It contains rich coal and coalbed methane resources, featured by thick coal seams with moderate depth and relatively high gas content. The estimated coalbed methane resources in the coal seams within the depth of less than 2000 m is about 315.9 billion m^3 (Yao and Wang, 2002). It has been a hot spot for development of coalbed methane, attracting many coalbed methane developers both nationally and internationally (Fan, 2004). However, development of coalbed methane in this coalfield is still immature because of a limited geological knowledge about this particular coalfield. This is largely attributed to the complexity of the coal structure, featured by different types of tectonically deformed coals formed by multiple tectonic deformations (Jiang et al., 2004). Furthermore, different types of

Erathem	System	Main lithology
Cainozoic	Quaternary	Widely distributed, mainly are alluvial, secondarily are lake, marsh and eluvium talus deposit.
	Neogene	Mainly are lake deposit.
	Paleogene	Widely distributed, mainly are river and lake deposit, composed of red clastic rock.
Mesozoic	Cretaceous	Widely developed lake deposit on early Cretaceous , lake and alluvial fan deopsit on later Cretaceous .
	Jurassic	Partially developed river and lake deposit on early Jurassic, and volcanic rock series on later Jurassic.
	Triassic	Only red fragmental deposit of lake facies developed.
upper Palaeozoic	Permian	Mainly are a series of coal-bearing clastic rock of marine-terrigenous facies
	Carboniferous	
lower Palaeozoic	Ordovician	A series of sea deposit, mainly composed of carbonatite.
	Cambrian	
upper Proterozoic	Sinian	A series of clastic and carbonatite rocks of beach and shelf facies.
	Qingbaikou system	
Archean		Composed of rocks with different metamorphism extents.

Fig. 1. Generalized stratigraphic sequence of Huaibei coalfield.