Front. Earth Sci. 2023, 17(1): 1−3
https://doi.org/10.1007/s11707-022-1066-2

EDITORIAL

Frontiers in Coal-related Resources——introduction to the special issue

Dameng LIU (✉)[1], Shen JIAN[2], Hongfei CHENG[3], Yidong CAI[1], Guangyao SI[4]

1 School of Energy Resource, China University of Geosciences, Beijing 100083, China
2 Key Laboratory of Coalbed Methane Resources and Reservoir Formation Process (Ministry of Education), China University of Mining and Technology, Xuzhou 221008, China
3 School of Earth Science and Resources, Chang'an University, Xi'an 710054, China
4 School of Minerals and Energy Resources Engineering, University of New South Wales, Sydney, NSW 2052, Australia

1 Introduction

Coal-related resources, as a popular development in recent years, is the focus of research in the field of coalbed methane (CBM), coal measure gases, coal-associated rare earth resources and nonmetallic minerals (Moore, 2012; Dai and Finkelman, 2018; Qin et al., 2018). Due to its complexity in concentration, occurrence and exploitation, many key issues need to be addressed (Sayed et al., 2017; Bera et al., 2022; Liu et al., 2022). This special issue showcases new developments related to the assessment and analysis of coal-related resources, illustrating basic theory, practical application, and new discoveries. A collection of 26 papers is compiled in this issue, mainly focusing on new advances in coalbed methane, shale gas, coal associated minerals and related to geological evaluation and their performance.

A total of eighteen papers are related to CBM, five of which are in the direction of CBM engineering and development. Three papers focused on the effect of geological stress on CBM preservation. The remaining papers include eight studies on the microstructural mechanisms of CBM and two studies on microbiology. Techniques and methods including sonic detection, adsorption and permeation experiments, gas diffusion, and multifactorial integrated analysis were used in these studies. Two papers on coal associated minerals. One is on lithium adsorption in coal-bearing strata kaolinite, with the effect on the lithium adsorption capacity was studied under the same adsorption conditions with controlled variables. One is on examining the transitions from anthracite to semi-graphite to CDNG by bulk characterization and powder Raman spectroscopy, along with optical microscopy, scanning electron microscope (SEM) and micro-Raman spectroscopy.

Five papers are related to shale gas. Two articles focused on the shales, including the evolution of nanopores, pore characteristics of organic matter, and porosity studies. One paper performed 3D computed tomography and stratigraphic microscanner image data acquisition to characterize microfracture morphology. One paper developed a multi-factor evaluation model. One paper investigated the mineralogy, enrichment, distribution pattern, occurrence pattern and sediment source of REY. One paper is about new discovery and indicative significance of Amblystegiaceae.

2 Overview of special issue papers

This grouping of papers addresses the topical areas of hydrocarbon accumulation and production for coalbed methane and shale gas, and coal associated minerals and their paleoenvironments

Received November 30, 2022

E-mail: dmliu@cugb.edu.cn

2.1 Coalbed methane accumulation and production advances

Jia et al. (P4–17) used the overburden pressure porosity and permeability experiment to study the permeability variation law of samples in the southern Qinshui Basin under different effective stresses and explore its stress sensitivity characteristics and its influence on coalbed methane productivity. The transformation interval of stress to permeability is divided, and the CBM production model of *in-situ* stress sensitive strata is established. By analyzing low-rank coal samples under different ash contents and comparing the strength characteristics of coal ash and other components, Dong et al. (P18–29) revealed the pore structure characteristics under ash content and establishes the ash-pore control model. Yu et al. (P30–44) analyzed fault characteristics in the central and northern part of the basin, dividing regional strain intensity, and dynamically analyze the evolution of coal structure and tectonics under stress and heat. Based on the evolution characteristics of physical properties in the process of coalification, Huang et al. (P45–57) adopted the method of combining experiment and numerical value from the mechanical properties of coal. Li et al. (P58–70) made a comprehensive analysis of thin coal seam basin geological control mechanism, using experimental analysis and comprehensive evaluation methods, from the deposition, structure, thickness and other multi-angle analysis. Fang et al. (P71–86) analyzes micro-nano diffusion behavior and controls influencing factors to evaluate and compare seepage effects. Zhang et al. (P87–99) conducted the elemental analysis, FTIR spectrum, XPS electron energy spectrum, 13C NMR, and isothermal adsorption tests on the semi-anthracite of Changping mine and the anthracite of Sihe Mine in Shanxi Province, China. The relationship between pore morphology, methane aggregation morphology, and coal molecular structure was revealed. Liu et al. (P100–108) performed acoustic tests on dry and different gas-water saturated coal samples with different degrees of metamorphism and deformation, collected from several coal mining areas in China. They also analyzed the influence of coal type and gas-water saturation on the acoustic response of CBM formations. From the viewpoint of basin gas filling, Wang et al. (P109–120) establish a gas diffusion evaluation model from the viewpoint of hydrocarbon generation and migration with multi-stage gas injection and diffusion. Zhang et al. (P121–134) carried out CH_4 isothermal adsorption measurements on 64 coal samples collected from western Guizhou Province of China, and the coalbed methane (CBM) desorption processes are quantitatively analyzed. The result shows that the higher-rank coals have the higher initial, turning and sensitive pressures, with larger difference between pressure nodes. Most CBM wells only undergo partial desorption stages due to the differences in Pcd caused by the present-gas content. Under the same gas content conditions, the higher the coal rank, the less desorption stages that CBM needs to go through. During coalbed methane co-production from multiple coal seams within vertically superposed pressure systems, the reservoir pressure, the Pcd, the initial working liquid level (WLL) height, and coal depth are key factors for evaluating whether coal seams can produce CBM simultaneously. To analyze the response characteristics of the pore-fracture system by the changing stress, Han et al. (P135–144) simulated reservoir and fluid pressures during the exploitation by adjusting confining pressure and displacement pressure. Stress sensitivity experiments under different effective stresses are conducted to systematically study the stage variation characteristics of porosity and permeability of coal. Guo et al. (P145–157) tested coal samples from Zhangjiamao (ZJM) coal mine, Ordos Basin, and Sihe (SH) coal mine, Qinshui Basin, by isothermal adsorption—desorption experiment, natural imbibition experiment, nuclear magnetic resonance, mercury injection porosimetry, contact angle test, and permeability test. Bao et al. (P158–169) comprehensively analyzed the accumulation model by geochemical methods based on geology. The oil accumulation model of Jurassic coal measures in Huangling mining area was established. Zhang et al. (P170–179) analyzed the response mechanism of different coals using the change in the propagation rate of sound waves in different media and reveals the evolution in geological time in combination with the different sensitivities of structural evolution under temperature and pressure.

Tian et al. (P180–196) evaluated the microbial community characteristics and gas production potential in the produced water of coal-bed methane wells in Qianxi, east Yunnan. Yan et al. (P197–217) discussed the geological samples from the Daning-Jixian block in the eastern part of the Ordos Basin and retrace the key tectonic events. The analysis is carried out for the key periods of reservoir formation. Combined with the tectonic and other conditions, the geological control role is evaluated comprehensively, which is a guide for the development of the subsequent blocks. Li et al. (P218–229) reviewed the progress of research on microbial metabolism to enhance CBM production and coal pretreatment to improve its bioavailability, and presents the outlook for subsequent research.

2.2 Coal associated minerals accumulation and production advances

Lu et al. (P230–250) reported the geochemical characteristics of REY in the Late Permian coals from an underground K1a seam section of the Zhongliangshan coalfield in Chongqing, southwestern China. The mineralogy, degree of enrichment, distribution patterns, modes of occurrence, and sediment origin of REY were investigated. Compared with

the average of world coals, the concentration of REY in the K1a coals were normal, dominated by light REY (LREY), with less medium and heavy REY (MREY, HREY). Chen et al. (P251–261) studied lithium adsorption in coal-bearing strata kaolinite (CSK). The effects of pre-activation acid leaching and dimethyl sulfoxide intercalation on the lithium adsorption capacity were studied under the same adsorption conditions. The adsorption capacity of CSK and its modified products to Li were explored, providing a new option for the reuse of CSK and the extraction of Li et al. (P262–272) obtained ten metamorphic coals from anthracite to CDNG from Lutang and Xinhua in the Hunan Province and Panshi in the Jilin Province. Bulk characterization (proximate and ultimate analyses, X-Ray powder diffraction (XRD), and powder Raman spectroscopy), along with optical microscopy, scanning electron microscope (SEM) and micro-Raman spectroscopy were utilized to examine the transitions from anthracite to semi-graphite to CDNG.

2.3 Shale gas accumulation advances

Cheng et al. (P273–292) examined the samples in Wuxiang area of Qinshui Basin due to the influence of water in rock strata on the gas content of over-mature coal measure shale. By observing and analyzing the evolution of nanopores in shale, a water-controlled over-mature coal shale model was established. It provides a theoretical basis for regional shale gas development. Lu et al. (P293–309) comprehensive analyzed the Upper Paleozoic coal-bearing shale accumulation mechanism from multiple angles to establish a multi-factor evaluation model. Ning et al. (P310–321) analyzed the over-mature marine black shale and established a pore model under different density organic components by analyzing the pore characteristics of organic matter. Gao et al. (P322–336) carried out an integrated investigation of deep gas shale (3740–3820 m depth) of the Lower Paleozoic Wufeng—Longmaxi Formations in the Dingshan area, Sichuan Basin. Sun et al. (P337–350) made a detailed description of full-diameter shale drill core, together with 3D Computed Tomography scans and Formation MicroScanner Image data acquisition to characterize microfracture morphology. The fracture type, orientation, and their macroscopic and microscopic distribution features are evaluated. The results show that the difference in tortuosity between horizontally and vertically oriented fractures reveals their morphological complexity.

2.4 New species and paleoenvironmental research advances

Xiao (P351–360) reported the Amblystegiaceae from the lower Miocene for the first time in Asia, indicating the signs of life of lower Miocene, which may have important implications for the sedimentation and paleogeography, and the subsequent evolutionary studies.

References

Bera A, Kumar S, Foroozesh J, Gharavi A (2022). Multiphysics gas transport in nanoporous unconventional reservoirs: challenges of mathematical modelling. J Nat Gas Sci Eng, 103: 104649

Dai S, Finkelman R B (2018). Coal as a promising source of critical elements: Progress and future prospects. Int J Coal Geol, 186: 155–164

Liu D, Yao Y, Chang Y (2022). Measurement of adsorption phase densities with respect to different pressure: potential application for determination of free and adsorbed methane in coalbed methane reservoir. Chem Eng J, 446: 137103

Moore T A (2012). Coalbed methane: a review. Int J Coal Geol, 101: 36–81

Qin Y, Moore T A, Shen J, Yang Z, Shen Y, Wang G (2018). Resources and geology of coalbed methane in China: a review. Int Geol Rev, 60(5–6): 777–812

Sayed M A, Al-Muntasheri G A, Liang F (2017). Development of shale reservoirs: Knowledge gained from developments in North America. J Petrol Sci Eng, 157: 164–186