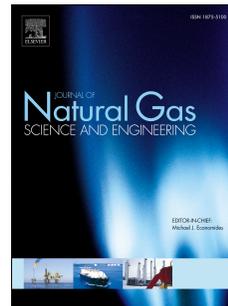


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Characterization of unconventional reservoirs and continuous accumulations of natural gas in the Carboniferous-Permian strata, mid-eastern Qinshui basin, China

Jun Li^a, Shuheng Tang^{b,*}, Songhang Zhang^b, Lei Li^b, Jianguang Wei^b, Zhaodong Xi^b, Ke Sun^b

^a College of Geoscience and Surveying Engineering, China University of Mining and Technology (Beijing), Beijing, 100083, China

^b School of Energy Resources, China University of Geoscience (Beijing), Beijing, 100083, China

* Corresponding author.

E-mail addresses: tangsh@cugb.edu.cn (Shuheng.Tang).

Abstract

Deep coalbed methane, with its associated shale gas and tight sandstone gas resources in coal-bearing strata has been an area of research focus in China. Identifying gas accumulation potential and reservoir characteristics is therefore of great importance in understanding the co-exploration potential of unconventional gases. Accordingly, comprehensive experimental results, and incorporation with drilling and well-testing data in the mid-eastern Qinshui basin were used and analysed in this paper for the reservoir study. Tests on organic geochemistry, gas storage capacities, petrology and petrophysics, and gas inclusions were performed on massive core samples in the Carboniferous-Permian (C₃t-P₁s) strata.

It is found that coal seams in this area are buried deeply, with the depth (mainly over 1000 m) increasing from east to west, and the gas contents of the coal generally increasing to depths of 400-1600 m, as a result of low-level temperature increment and high reservoir pressure. Dark shales and sandstones are widely distributed, with thicknesses of 12.2-65.9 m and 5-35 m in the Shanxi Formation and 40.5-131.7 m and 5-50 m in the Taiyuan Formation, respectively. Shales are rich in over-mature type II and type III organic matter and are mainly composed of clays (47%) and quartz (36%). Sandstones are mostly tight with low porosity (lower than 5% on average) and permeability (<1 mD) in the C₃t-P₁s strata, among which the Xiashihezi Formation shows relatively higher porosity and permeability than the underlying Shanxi and Taiyuan Formations. After the sedimentation of C₃t-P₁s coal-bearing strata, two main gas generation episodes and one continuous gas expulsion process occurred during the Late Triassic to Early Cretaceous. High mature source rocks (i.e., coals and shales) and widely distributed reservoirs (i.e., coals, shales, and sandstones) offer good associations for continuous gas accumulation, in which two types of gas accumulation patterns existed in the coal-bearing strata. The whole coal-bearing system in this area is favourable for co-exploration of unconventional natural gases in different gas reservoirs.

Keywords: unconventional gas, Carboniferous-Permian, coal-bearing strata, Qinshui basin

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