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Occurrence features and gas content analysis of marine and continental shales: A comparative study of Longmaxi Formation and Yanchang Formation

Qianwen Li[a,b,*], Xiongqi Pang[b,**], Ling Tang[c], Gang Chen[a], Xinhe Shao[b], Nan Jia[d]

[a] Sinopec Petroleum Exploration and Production Research Institute, Beijing, 100083, China
[b] College of Geosciences, China University of Petroleum, Beijing, 102249, China
[c] The Unconventional Natural Gas Institute, China University of Petroleum, Beijing, 102249, China
[d] Bohai Oilfield Institute, Tianjin Branch of CNOOC Ltd., Tianjin, 300452, China

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ABSTRACT

To study the occurrence state and content of shale gas in different depositional environments, 15 marine shale samples from Longmaxi Formation in the Sichuan Basin and 15 continental shale samples from Yanchang Formation in the Ordos Basin were sampled. Then a series of experiments, including X-ray diffraction analysis, TOC content analysis, R_o measurement, NMR measurements, FE-ESEM observation, low-pressure N_2 adsorption, and CH_4 isothermal adsorption were conducted. In general, shale gas in Yanchang formation has the characteristics of primary adsorbed gas, moderate free gas, and non-ignorable dissolved gas, whereas shale gas in Longmaxi formation has the characteristics of joint dominated free gas and adsorbed gas, as well as negligible dissolved gas. Both macroscopic accumulation pattern and microscopic occurrence model show four stages in the whole thermal evolution, that is, adsorption, pore filling, fracture filling and accumulation. By analyzing the affecting factors of shale gas adsorption, conclusions can be drawn that geological characteristics, mineral compositions, pore structure features and formation conditions have influence on adsorbed gas content to various degrees. Cause analyses reveal that differences in occurrence state and gas content between marine and continental shales are immediately affected by the differences of organic matter type, thermal maturity, brittle minerals content, carbonate content, SSA, PD, porosity, gas saturation, residual oil quantity, as well as T&P, indirectly controlled by sedimentary environment and tectonic movement.

1. Introduction

Shale gas is a typical “self-generating and self-preserving” unconventional natural gas (Curtis, 2002), serving as both source rock generating gas and reservoir rock storing gas. In the light of occurrence states, shale gas can exist in a free form in fractures and pores, in an adsorbed form on the surface of kerogen and clay particles, or in a dissolved form in kerogen and asphaltene, in which free and adsorbed gas take up the most space (Montgomery et al., 2005; Bowker, 2007; Jarvie et al., 2007; Ross and Bustin, 2007, 2008; 2009; Zhang et al., 2012; Vidic et al., 2013; Tian et al., 2016). Controlled by various depositional environments, characteristics of shale are also diverse, so as the gas potential (Khalifa, 2005; Zou et al., 2010; Guo et al., 2014; Jiang et al., 2016). Thus, studying the occurrence forms and gas content ability is of great significance to analyze the accumulation mechanism, shale gas resources calculation as well as exploration and development potential evaluation, which is also of great value in theory and practicality.

Studies on the geological conditions, occurrence states and gas content of shale gas are increasing and some progress has been made (Curtis, 2002; Ross and Bustin, 2007; Chen and Zhang, 2016; Borjigin et al., 2017). Researches showed that the gas bearing capacity of shale was controlled by a variety of factors, which could largely affect the geological evaluation and gas production of shale (Harris et al., 1970; Pollastro et al., 2003; Ross and Bustin, 2008; Jiang et al., 2016; Shao et al., 2017). According to statistics on the five shale gas basins in the United States by Curtis (2002), the amount of shale gas in adsorbed state was about 20%–85% of the total gas content. Further study of Barnett Shale by Mavor (2003) revealed that the adsorbed gas content has reached 61% of the original shale gas geological reserves. Studies

* Corresponding author. Sinopec Petroleum Exploration and Production Research Institute, Beijing, 100083, China.
** Corresponding author. College of Geosciences, China University of Petroleum, Beijing, 102249, China.
E-mail addresses: liqw2018.syky@sinopec.com (Q. Li), Pangxq1020@163.com (X. Pang).

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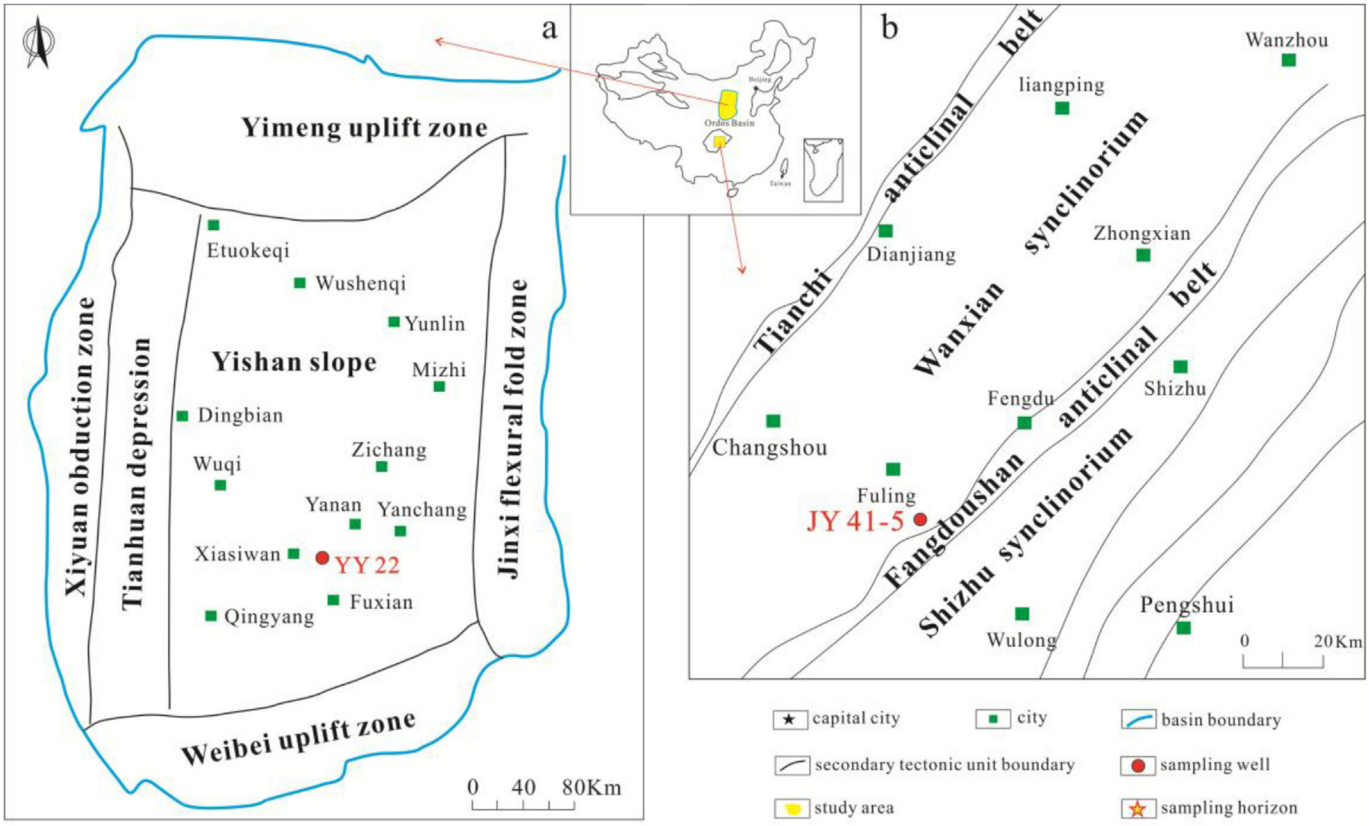

c Comprehensive histogram of the studied area in Ordos basin

Epoch	Formation	Member	Lithology Column	Thickness (m)	Sedimentary facies
Lower Jurassic	Yanan	Yan-1 to Yan-10		250-300	Fluvial-Lacustine-Swamp
Upper Triassic	Yanchang	Chang-1		0-245	
		Chang-2		120-160	Fluvial-Lacustine
		Chang-3		100-170	
		Chang-4+5		90-130	
		Chang-6		180-200	
		Chang-7			Deep-Lacustine
		Chang-8		100-190	Lacustine
		Chang-9			
		Chang-10		200-320	Fluvial

Conglomerate Sandstone Sandy mudstone
Mudstone Shale Coal

d Comprehensive histogram of the studied area in Sichuan basin

Epoch	Formation	Member	Lithology Column	Thickness (m)	Sedimentary facies
Lower Silurian	Longmaxi	Long-3		130-140	Shallow shelf
		Long-2		10-34	
		Long-1		83-115	Deep shelf
Ordovician	Wufeng	Upper			
		Lower			
	Jiancaogou				Open platform
	Baota				

Siliceous shale Siltstone Muddy siltstone
Shale Mudstone Carbonate

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