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Reservoir Characteristic of Lacustrine Shale and Marine Shale

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1 Introduction

Shale oil deposits are ‘unconventional resources’ in which oil has been generated and retained in fine grained sedimentary rocks. According to lithology and the presence of fractures, shale oil deposits can be classified into three types: tight shale oil (e.g. Barnett and Tuscaloosa deposits), hybrid shale oil (e.g. Niobrara and Bakken depositis) and fractured shale (Monterey and Pierre deposits) (Jarvie, 2012). Large amounts of shale oil have been produced from marine shales of the USA, such the Bakken, Eagle Ford and Monterey deposits (Jarvie, 2012), but shale oil has also been extracted from lacustrine shales (Wang et al., 2015). Some ‘low maturity’ oils occur in shales deposited in saline to hypersaline lakes including the Wilkins Peak Member of the Green River Formation (Wyoming), the Jingjingzigou Formation (Junggar Basin, China), the Jianghan and Qaidam basins (China), and the Blanca Lila Formation (Argentina) (Carroll and Bohacs, 2001), but overall few publications exist on saline mudstone shale oil deposits.

A good understanding of the shale reservoir, especially the shale oil storage mechanism, is of great importance to shale oil exploration and development, which necessitates the determination of pore type, size, and PSD. However, it is difficult to characterize the PSD of shale using conventional experimental and analytical methods, probably due to influencing factors, such as the small size of shale pores (nanometer-scale), wide range of pore sizes, maturity, TOC, and mineral contents, etc.

Recently, many researchers studied pore types and sizes of gas producing shales, using FIB-SEM (focused ion beam-scanning electron microscope), FE-SEM (field emission scanning electron microscope), CT scanning (micron and nanometer scale), gas adsorption (low pressure CO2 and N2 adsorption), and high pressure mercury injection methods. Some progress has been made toward understanding the controlling factors of gas content, shale microstructure, and gas flow mechanisms in marine shale (Bustin et al., 2008; Chalmers et al., 2012). However, as the shale oil/tight oil exploration work started fairly recently, international papers on the reservoir features of marine shales in the oil generation stage are quite limited (Curtis et al., 2012), let alone the lacustrine shale. Two aspects of the difference between shale oil and shale gas are presented: (1) As molecular radius of oil is much larger than that of gas, which makes it quite difficult for oil to flow, the reservoir space in shale that is favorable to the accumulation of gas may not be necessarily effective for oil; (2) The microscopic pore structure of shale in the oil generation stage is different from gas shale, probably affected by the diagenesis and hydrocarbon generation processes.

2 Methods

In this article, lacustrine shale from Qingshankou Formatin member 1 of Songliao basin and Shahejie Formation of Bohai Bay basin, and marine shale from lower Cambrian Niutitang Formation of Qiannan depression were conducted by using rock pyrolysis, TOC, X-ray diffraction, SEM, FE-SEM, high pressure mercury intrusion, and low pressure N2, CO2 gas adsorption experiments, in aim to reveal their reservoir characteristics.

3 Results

The results show that, (1) the width of micro-pore mainly ranges from 0.45 to 0.7 nm indicated by CO_2 isotherms, and width of meso-pore less than 10 nm, with a type Ⅳ adsorption isotherms and type H_2 hysteresis loop, which indicating the “ink-bottle” pores. There are good correlations among pore volume, surface area and averaged pore diameter, also exists a good positive correlation between micro-pore volume and TOC content, however,

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there is no obvious correlation between meso-pore volume and TOC content; (2) Interparticle pore, pores among the edge of mineral grains and some organic matter pores were all identified in marine and lacustrine shale, among them, the interparticle pore maybe influence by dissolution effect, and not all bituminous develop organic matter pore, only high to over mature bituminous present organic matter pore. Pores between clay platelets and mineral interlayer fractures are developed in lacustrine shale, and pyrite intercrystalline pores are presented in lacustine shale of Shahejie Formation and marine shale of Niutitang Formation.

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