EDITORIAL
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Editorial: Advances in the Exploration and Development of Unconventional Oil and Gas: From the Integration of Geology and Engineering

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Editorial on the Research Topic

Advances in the Exploration and Development of Unconventional Oil and Gas: From the Integration of Geology and Engineering

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INTRODUCTION

Unconventional oil and gas resources are comprised of shale oil, shale gas, tight oil, tight gas, coalbed methane, etc (Zou, 2014). With the advancements of theory and technology, oil and gas exploration has transformed from conventional hydrocarbons outside of source rocks to unconventional hydrocarbon resources retained in source rocks. Unconventional oil and gas related to source rocks are sequence hydrocarbon resources. During the depositional period, the combination of high paleoproductivity and favorable preservation conditions result in the extensive distribution of organic-rich mudstones or shales (Bohacs et al., 2005; Tyson, 2005), deposited in marine or lacustrine sedimentary environments. At the stage of shallow burial, shales with high organic matter abundance are immature (Ro < 0.5%) and are commonly referred to as oil shale resources. When shales are buried deeper, once the thermal maturity of their organic matter reaches the oil generation threshold, liquid hydrocarbons are generated in shales. Oil maybe retained in these source rocks forming shale oil resources (Jin et al., 2021). At the early stage of shale oil, the organic matter has a low-maturity (R_o is between 0.5% and 1.0%). This kind of shale oil has a high density and viscosity, poor mobility, and low conversion efficiency of organic matter. Therefore, it is generally thought that these low-mature shale oil resources can be recovered through underground *in situ* transformation technology (Zhao et al., 2018). At the later stage of shale oil, the thermal maturity is relatively high (R_o is between 1.0% and 1.5%). This kind of highly mature shale oil has relatively low density and viscosity, and good mobility, and can be extracted through horizontal well drilling and hydraulic fracturing technologies. However, the effectiveness of hydraulic fracturing is highly dependent on the texture and mineral compositions of rocks. With increasing burial depth, kerogen and residual crude oil (shale oil) in organic-rich shales will further crack into natural gas (shale gas) (Bernard et al., 2012; Loucks and Reed, 2014). Simultaneously, abundant organic-matter hosted pores generate and act as important storage space for shale gas (Guo et al., 2017). If the burial depth is higher than 3,500 m, shale gas resources can be labeled as deep shale gas, and their formation pressures are usually overpressured. If shale formations have undergone intense tectonic uplift and their burial depths are lower than 3,500 m, natural gas in shale reservoirs is referred to as shallow shale gas. Due to the variation in preservation conditions and gas leakage during uplift, shallow shale gas resources are at various states of overpressure, weak overpressure, or geostatic pressure (Hao et al., 2013). Furthermore, oil and gas can migrate from their source rocks and accumulate in tight sandstone or carbonate beds (whether adjacent or interlayered beds) to form tight oil and gas resources. Certainly, there are significant differences in hydrocarbon generation, expulsion, storage, occurrence, and mobility in source rocks with different sedimentary environments, lithofacies, and organic matter (e.g., abundance, type, and maturity). Therefore, systematic theoretical and technical research are necessary for the effective exploration and development of different types of unconventional oil and gas resources.

SHALE GAS

In the last decade, China has achieved significant success in the exploration and development of shale gas, benefited from the advanced petroleum geology theories and innovational engineering techniques. Commercial production successes are achieved in marine shales from Sichuan Basin. Tang et al. analyzed the controlling factors on the lithofacies spatial variations of Silurian Longmaxi shales in this basin. Pang et al. used a combination of reflected light microscopy, focused ion beam SEM (FIB-SEM), and Raman spectrum to describe the organic pore structure of different macerals of Longmaxi shales from Sichuan Basin. Yu et al. characterized pore connectivity of Longmaxi shales using Wood's metal intrusion and high-resolution imaging. Guo et al. analyzed the gas composition and carbon isotopic characteristics of shale gas from the Cambrian Niutitang Formation. Lan et al. discussed the enrichment and accumulation of normal pressure shale gas in Anchang syncline outside of Sichuan Basin. In addition to the marine shales, there are also considerable amounts of lacustrine shale gas resources in China. Shale gas accumulation in lacustrine formations is likely to be significantly different from marine shales. Zhang et al. investigated the controls on the full-sized pore structure of the coal-bearing shales. Zhang et al. used petrographic observation and element geochemistry to analyze the origin of silica of lacustrine shales from the Ordos Basin. Chen et al. measured gas sorption capacities of lacustrine shales from the Lower Jurassic Ziliujing Formation from Sichuan Basin, and thought that temperature and water saturation significantly affected the gas capacity of shales.

SHALE OIL

The study of shale lithofacies assemblages and pore systems is of great significance to reveal the enrichment mechanism of shale oil resources. Shu et al. discussed the significance of the lithofacies assemblages for shale oil and gas exploration. Guo et al. designed a series of high-temperature thermal simulation experiments to study the thermal evolution degree and hydrocarbon yield of kerogen under open and closed systems. Taking the Cangdong Sag of Bohai Bay Basin as an example, Zhao et al. investigated the geochemical, mineralogical, and lithofacies characterizations of lacustrine shale oil resources. Xu et al. discussed the geological controls on oil content of lacustrine shales with laminated, layered, and massive lithofacies. Pan et al. calculated the fractal dimensions of multi-scaled pores in lacustrine shales from the Cangdong Sag, Bohai Bay Basin. Liu et al. divided the lithofacies combinations of shale strata in the Shahejie Formation in Dongying depression according to the sedimentary environment, internal structure and the superposition relationship of vertical lithofacies. Yin et al. examined the wettability of lacustrine shales from Dongying depression, Bohai Bay Basin. Yin et al. studied the lithofacies architecture and distribution of Permian shales from Lucaogou Formation in Jimsar Sag, Junggar Basin. Wei et al. investigated the sedimentary subfacies, mineral compositions, geochemical characteristics of shale oil formations from the Dongyuemiao Formation, Sichuan Basin. Jiang et al. used thermal simulation experiments to investigate the pore structure evolution of Cretaceous shales from the Nenjiang Formation of Songliao Basin. Ma et al. discussed the effects of sedimentary environment on the deposition of lacustrine shales from the Gaoyou depression, Subei Basin. Qi et al. evaluated the organic geochemistry and hydrocarbon potential of shales from the Qamdo Basin, eastern Tibet.

TIGHT SANDSTONE AND CARBONATE

Zhao et al. examined the characteristics of the Upper Paleozoic sandstone reservoir from the Dongpu Depression, Bohai Bay Basin. Wu et al. used the nuclear magnetic resonance (NMR) technology to measure the movable fluid of tight sandstone reservoirs in Yanchang Formation, Ordos Basin. She et al. evaluated the hydrocarbons generation and expulsion capability of microbial carbonate rocks from the western Qaidam Basin. Zhang et al. summarized the accumulation model of a Silurian tight sandstone gas reservoir in the Shajingzi Belt, northwest Tarim Basin. Song et al. combined 2D and 3D fractal analysis for the pore structure characterization of tight sandstone in the Xujiahe Formation, and found that micro-fractures and clay cementation were the two main controlling factors on fractal dimensions. Zhang et al. measured the mechanical properties of ultra-deep tight carbonate rocks.

HYDRAULIC FRACTURING ENGINEERING

Wang et al. optimized hydraulic horizontal wells in Longmaxi shales based on Gaussian Process Regression (GPR) and Convolution Neural Network (CNN methods). Yang et al. proposed a hydraulic fracturing fluid-mechanical coupling numerical model based on a global cohesive zone model (GCZM) to study the effects of geological factors on hydraulic fracture networks. Ma et al. proposed an efficient and straightforward approach to predict the early-age elastic properties of cement pastes. Chen et al. reviewed the studies of incorporation of magnesia (magnesium oxide) into Portland cement material from the geotechnical well construction perspective. Cheng et al. used a combination of logging, seismic, fracturing and production data from 301 shale gas wells in Longmaxi Formation in Changning shale gas field of southern Sichuan Basin to analyze the main controlling factors of the stimulated reservoir potential.

AUTHOR CONTRIBUTIONS

All authors wrote the primary paper, SX and FY revised the paper, all authors had reviewed the paper.

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.