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Injecting Large Volumes of Preformed Particle Gel for Water Conformance Control

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Introduction to special section: China shale gas and shale oil plays

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In the last 10 years, the success of shale gas and shale oil productions as a result of technological advances in horizontal drilling, hydraulic fracturing and nanoscale reservoir characterization have revolutionized the energy landscape in the United States. Resource assessment by the China Ministry of Land and Resources in 2010 and 2012 and by the U.S. Energy Information Administration in 2011 and 2013 indicates China's shale gas resource is the largest in the world and shale oil resource in China is also potentially significant. Inspired by the success in the United States, China looks forward to replicating the U.S. experience to produce shale gas to power its economy and reduce greenhouse gas emissions. By 2014, China had drilled 400 wells targeting marine, lacustrine, and coastal swamp transitional shales spanning in age from the Precambrian to Cenozoic in the last five years. So far, China is the leading country outside of North America in the viable production of shale gas, with very promising prospects for shale gas and shale oil development, from the Lower Silurian Longmaxi marine shale in Fuling in the southeastern Sichuan Basin. Geological investigations by government and academic institutions as well as exploration and production activities from industry indicate that the tectonic framework, depositional settings, and geomechanical properties of most of the Chinese shales are more complex than many of the producing marine shales in the United States. These differences limit the applicability of geologic analogues from North America for use in Chinese shale oil and gas resource assessments, exploration strategies, reservoir characterization, and determination of optimal hydraulic fracturing techniques. Understanding the unique features of the geology, shale oil and gas resource potential, and reservoir characteristics is crucial for sweet spot identification, hydraulic fracturing optimization, and reservoir performance prediction.

Even though China shale gas and shale oil exploration is still in an early stage, limited data are already available. We are pleased to have selected eight high-quality papers from fifteen submitted manuscripts for this timely section on the topic of China shale gas and shale oil plays. These selected papers discuss various subject areas including regional geology, resource potentials, integrated and multidisciplinary characterization of China shale reservoirs (geology, geophysics, geochemistry, and petrophysics) China shale property measurement using new techniques, case studies for marine, lacustrine, and transitional shale deposits in China, and hydraulic fracturing. One paper summarizes the regional geology and different tectonic and depositional settings of the major prospective shale oil and gas plays in China. Four papers concentrate on the geology, geochemistry, reservoir characterization, lithologic heterogeneity, and sweet spot identification in the Silurian Longmaxi marine shale in the Sichuan Basin in southwest China, which is currently the primary focus of shale gas exploration in China. One paper discusses the Ordovician Salgan Shale in the Tarim Basin in northwest China, and two papers focus on the reservoir characterization and hydraulic fracturing of Triassic lacustrine shale in the Ordos Basin in northern China. Each paper discusses a specific area.

S. Jiang et al. summarize the geology of organic-rich shales in China, their resource potential, and

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properties of emerging and potential China shale gas and shale oil plays. In particular, the key differences between marine, transitional, and lacustrine shale deposits in China and the influence of tectonics and sedimentology on shale gas accumulations are analyzed.

Guo presents a case study of the Fuling Shale Gas Field in the Southeast Sichuan Basin in China. The geologic, geochemical, mineralogical, and petrophysical characteristics of the organic-rich Lower Silurian Longmaxi and Upper Ordovician Wufeng marine shale are documented; the results indicate that the pay zone of the Silurian marine shale reservoir in the Sichuan Basin is characterized by complex structure, high thermal maturity, overpressure, and the presence of natural fractures.

Tang et al. analyze the molecular and carbon isotopic compositions of the retained gases in the organic-rich Longmaxi formation shale from the Changning outcrop, Sichuan Basin, by using an on-line vacuum, one-step crushing, mass spectrometry method to reveal the main controls on gas chemistry of retained gas in the Longmaxi shale. The findings show a strong similarity in chemical and carbon isotopic compositions between the gas released from rock crushing and gases produced from the Weiyuan shale gas field, which might provide important evidence of the origin and storage of gas in the Silurian Longmaxi Formation.

Y. Jiang et al. develop a set of criteria to quantify and rank marine shale reservoirs of the Lower Silurian Longmaxi formation in the Sichuan Basin, and they identify the most prospective area in the southern Sichuan Basin by examining the correlation of various parameters to form a regionally consistent set of criteria combining topographic factors and infrastructure. These reliable parameters in the model that help in model development include geologic factors (rock properties), engineering factors (rock brittleness, in-situ stress, and pressure gradient), availability of pipeline, and accessibility of land.

Z. Jiang et al. show that the heterogeneity of shale occurs at multiple scales as exemplified by the disorderly and unsystematic distribution of mineral grains, the variable lamination widths, and the significant lithologic changes. The proposed model of multiscale heterogeneity in shales can be of great significance to shale gas distribution prediction at multiple scales (from nanometer to kilometer).

Q. Wang et al. present the geochemistry and significant contributions of insoluble organic matter to late-shale gas generation for the mature Ordovician Salgan Shale in the Tarim Basin. Bulk rock, solvent-extracted bulk rock, isolated kerogen, and bitumen are used as reactants in pyrolysis experiments; the molecular and stable carbon isotopic compositions of the generated hydrocarbon gases demonstrate that kerogen cracking is important to late-stage gas generation at high thermal stress.

X. Wang et al. study the storage spaces and gas storage processes of a lacustrine shale reservoir of the seventh member of Triassic Yanchang Formation in the Ordos Basin using multitechnologies; the results show the storage spaces of Yanchang Shale include primary intergranular pores, secondary dissolved pores, and fractures. Adsorption and desorption experiments for this lacustrine shale indicate that primary migration processes in the Yanchang shale are very complex, and currently a large amount of shale gas exists in pores, fractures, and organic matter as stages free gas, dissolved gas, and adsorbed gas.

X. Wang investigates the practical applications of liquid-CO_2/slick-water hybrid fracturing technology in a lacustrine shale gas reservoir in the Ordos Basin of China. Compared to slick-water fracturing alone for lacustrine shale, a test of this hybrid fracturing technique proves that this technology is more effective for improving the stimulated reservoir volume, increasing cleanup rate, shortening the fracturing-fluid cleanup period, and increasing the production rate.