

Upper Ordovician-Lower Silurian Shale Gas Reservoirs in Southern Sichuan Basin, China

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Extensive later Ordovician and initial early Silurian black marine shales are important Palaeozoic source rocks deposited in a partly restricted environment related to a worldwide transgression in Southern Sichuan Basin, Upper Yangzi platform, China. Upper Ordovician Wufeng Formation is dominated by grey-black carbonaceous siliceous shale. Lowermost Longmaxi Formation is organic-rich black graptolitic shale with subordinate limestone and siltstones overlain grey greenish shale and siltstone. Hirnantian Stage Kuanyinqiao Member between Longmaxi and Wufeng Formation preserves *Hirnantia-Dalmanitina* fauna in the marlstone and calcareous mudstone. Lower Silurian in Southwestern and Middle-Lower Silurian in Southeastern Sichuan Basin only remain for the erosion due to Caledonian movement.

The average organic content of the target interval for shale gas is about 3%± that is the consequence of hydrocarbon generation and expulsion during higher maturation (Ro 2.3-3.4%). Fieldworks in the Southern Sichuan provided some preliminary insight into the good potential for shale gas of lowermost Silurian ‘hot’ graptolitic shale as they contain sufficient organic material, thickness and fractures to hold significant recoverable gas reserves. Most of the wells analyzed and penetrated through the Longmaxi Formation in this study area were drilled during the late 1970s and 1980s. Widespread gas shows were recorded in all members of Silurian Formation in these wells. In some cases in these early wells, the elevated gamma-ray and resistivity values suggest the presence of the “hot” shale. The first shale gas exploration well further proves good gas content in the cored interval with a typical response on wireline logs. In addition, one of significant characteristics of Longmaxi target interval is that a great deal of micropores and nanopores are well developed in organic matter at much high levels of thermal maturation and decomposition of kerogen, although the remaining hydrocarbon potential is almost zero(Fig.1). Moreover, Silurian “hot” shale and Wufeng Formation in upper Ordovician are enveloped by lower tight Baota Limestone, primary frac barriers. This may impede some of the frac energy and aid in keeping the frac energy focused in the Longmaxi “hot” Shale. Grey greenish organically lean shale may be weak upper barrier.

Upper Ordovician-Lower Silurian shale analysis of logs, Pyrolysis, thin-sections, CL, XRD and XFD indicate the vertical lithological variations are notable, especially the clay, carbonate and pyrite content while kerogen (organic matter) is common throughout the interval. Integrated data sets can be used to characterize several lithofaces units rather than a whole homogeneous unit as the porosity, permeability, geomechanical properties of “hot” shales can be related to the lithologies. We conclude that there is a strong potential for substantial shale gas development in southern Sichuan basin, despite it poses different challenges for the development of high –over thermally mature black shale.

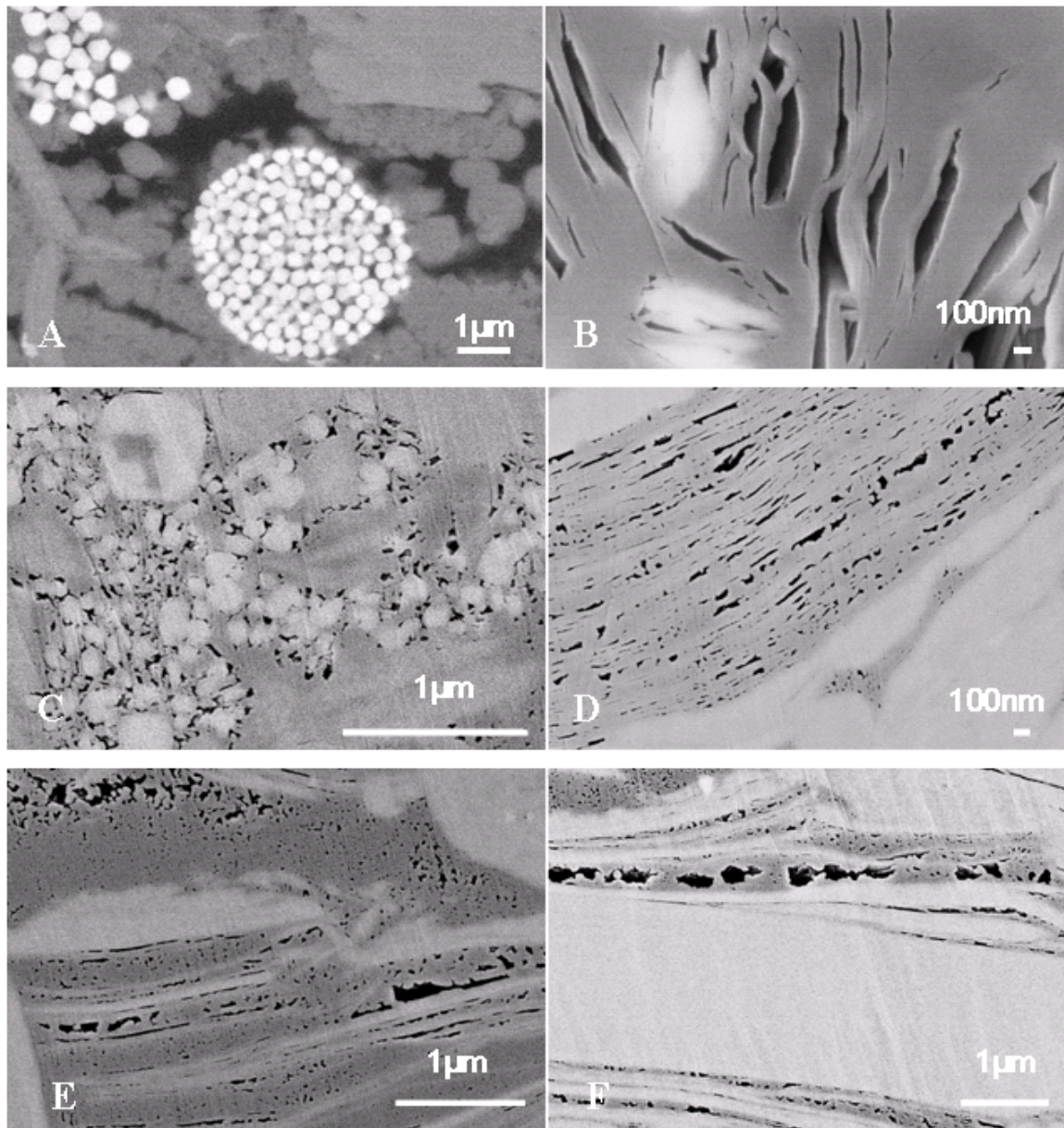


Fig.1 Nanopores in organic matter and nonorganic grains in Longmaxi black shale. A. Pyrite framboid containing intercrystalline micropores and nanopores; B. Angular micropores and nanopores in organic matter C. Nanopores around the nonorganic grains.D. Parallel and some interconnected nanopores in laminated organic matter. E. Interconnected micropores and disconnected highly developed nanopores. F. Thin micropore throats connecting elliptical pores in organic matter.

Acknowledgements

The authors would like to thank Chad Hartman, Yi Wang, Childers Jeremy M and Keith Lewis, etc. from Unconventional Reservoir Services, Weatherford Laboratories for their knowledge and support. Clif Cornelison from Well-Tech is gratefully acknowledged for his field support. The authors would like to thank Robert M. Reed from Bureau of Economic Geology, Jackson School of Geosciences, The University of Texas for his generous instruction. Wenhai Song and Xinan Yang from Exploration and Development Research Institute, Petrochina Southwest Oil and Gas Field Company, Zhong Luo and

Jingang Cui from RIPED, Petrochina are gratefully acknowledged for their rich knowledge and truehearted support.