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## Review and Significance of Microbial Carbonate Reservoirs in China

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### 1 Introduction

Numerous studies on the Meso-Neoproterozoic life evolution show that the cyanobacteria which thrived and dominated the biological world in the Proterozoic Era is closely related to the genesis of microbial carbonate rocks. Considerable oil and gas resources can be found in microbial carbonate rocks and many related oil and gas fields have been discovered on the earth up to now.

The microbial carbonate rocks are widespread in China which are mainly found in Meso-Neoproterozoic, Cambrian and Ordovician System. Some of these rocks are proved to have great potential in hydrocarbon exploration and can be important hydrocarbon reservoirs. Oil and gas bearing marine carbonate rocks in China are primarily distributed in the Upper Yang Zi area in south China(Sichuan Basin), North China block(Bohai Bay Basin and Ordos Basin) and the Tarim Basin where the microbial carbonate rocks constitute considerable part of the deeply buried and ancient marine carbonate reservoirs. Among the strata related to the microbial carbonate rocks, there is great hydrocarbon discoveries in the Sinian and Triassic System in the Sichuan Basin, the Wumishan Formation of Meso-Neoproterozoic Jixianian System in the Bohai Bay Basin and the Majiagou Formation of Ordovician System in the Ordos Basin, as well as significant oil and gas show in the Sinian and Cambrian System in the Tarim Basin.

### 2 Review of Microbial Carbonate Reservoirs in China

The microbial carbonate reservoirs in China mainly take on the forms of microbial layers and microbial reefs with stromatolites and thrombolites being the most common types which are mostly dolomitized. The

reservoirs generally feature low porosity and low permeability with various pore spaces.

The microbial carbonate rocks in the Sichuan and Tarim Basin include primarily stromatolite dolomite, thrombolite dolomite, foam-like dolomite, laminar algal dolomite and chondrite dolomite, among which the former three possess comparatively better reservoir property. Specifically, the microbial carbonate reservoirs in the Sichuan Basin develop mainly in the 2nd and 4th Members of Dengying Formation of Sinian System all over the basin and the 4th Member of Leikoupo Formation in Triassic System in the western part of the basin. The pore spaces in Dengying Formation include mainly grape-like cavities, window-pane-like pores, frame pores and dissolved pores among the clots with the porosity of 1%~6% and general permeability of less than  $1 \times 10^{-3} \mu\text{m}^2$ . Weiyuan and Gaoshiti gas fields have been proved to be closely related to such kind of reservoirs. The pore spaces in Leikoupo Formation are mainly window-pane-like pores and frame pores with the porosity of 0.2%~13% and a wide range of permeability of  $(0.00073-710) \times 10^{-3} \mu\text{m}^2$ . The microbial carbonate reservoirs in the Tarim Basin develop chiefly in Sinian to Lower Ordovician System. The pore spaces include mainly window-pane-like pores, chondrite-related dissolved pores, foam-like pores and cavities, dissolved pores among the clots and inter-crystalline (dissolved) pores with the porosity of 2%~9% and permeability of  $(0.001-1.5) \times 10^{-3} \mu\text{m}^2$ .

On the north margin of North China block, the microbial carbonate rocks are widespread in Gaoyuzhuang, Wumishan and Tieling Formations in Mesoproterozoic Erathem with the thickness of up to 500~1000m. Renqiu oilfield in the Bohai Bay Basin is the most ancient oilfield in China whose reservoir is carbonate rocks of Wumishan Formation of Mesoproterozoic Jixianian System composed mainly of stromatolite and thrombolite dolomite with matrix micropores (1~10  $\mu\text{m}$ ). On the west margin of North

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China block, certain kinds of microbial carbonate reservoirs have also been found recently in the 5th Member of Majiagou Formation of Ordovician System in the Ordos Basin including mainly stromatolite dolomite, laminar algal dolomite, algal bound dolomite and thrombolite dolomite in which frame pores and inter-granular pores among algal bound grains are well-developed with the porosity of 0.99%~7.58% and permeability of  $(0.01-0.37) \times 10^{-3} \mu\text{m}^2$ . These microbial carbonate reservoirs may constitute another type of important matrix porosity reservoirs besides gypsum moldic-pore porosity reservoirs in Jingbian gas field in the Ordos Basin.

### 3 Significance of Microbial Carbonate rocks exploration

Similar to all the other kinds of carbonate reservoirs, the formation of the microbial carbonate reservoirs also reflects a comprehensive effect of sedimentation, diagenesis and tectonism among which the rock texture and the sedimentary structure of the microbial carbonate rocks are key to the genesis and evolution of the pore spaces. Therefore, the microbial carbonate rocks provide the fundamental material bases to the formation of such kind of reservoirs.

With the improvement in the level of hydrocarbon exploration and development in middle to shallow strata, seeking deeply buried oil and gas resources becomes the inexorable trend which makes the deep strata in the basins the important exploration targets. Recent hydrocarbon exploration in China takes on a trend of several diversions from structural traps to lithological ones, from continental strata to marine ones and from shallow strata to deep ones, which all put emphasis on the deeply buried strata in the basins. The exploration of deep and ancient oil and gas resources will become the most important and practical energy strategy in China in the near future. The microbial carbonate rocks primarily develop in ancient and mostly deep strata with relatively low exploration degree which makes them significant potential targets in future hydrocarbon exploration. Moreover, with great breakthrough made in the practice and research on the clastic unconventional tight oil and gas reservoirs and shale gas in recent years, more and more attention has been paid to the micropores in the carbonate rocks. There are not only conventional pore spaces, but also micropores in the microbial carbonate rocks mainly found in the micro-biogenetic microcrystalline carbonate rocks 965-972.

and microcrystalline clot carbonate rocks including inter-crystalline pores, micro dissolved pores and micro fractures and so on which are effective to the storage of natural gas and clean oil.

In summary, with the development and urgent need for deep, ultra-deep and unconventional hydrocarbon exploration under the circumstance of energy pinch, the microbial carbonate rocks will become significant targets in Lower Paleozoic to Precambrian System and deep strata in China with considerable potential and broad exploration prospect.

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