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RESEARCH PAPER

Structure characteristics and major controlling factors of platform margin microbial reef reservoirs: A case study of Xiaoerbulak Formation, Lower Cambrian, Aksu area, Tarim Basin, NW China

BAI Ying[1, 2], LUO Ping[1, 2, *], WANG Shi[3], ZHOU Chuanmin[1], ZHAI Xiufen[1], WANG Shan[1], YANG Zongyu[1, 2]

1. PetroChina Research Institute of Petroleum Exploration & Development, Beijing 100083, China;
2. School of Earth and Space Sciences, Peking University, Beijing 100871, China;
3. Petroleum Exploration & Production Research Institute, SINOPEC, Beijing 100083, China

Abstract: The structure characteristics and major controlling factors of platform margin microbial reef reservoirs in the Lower Cambrian Xiaoerbulak Formation in the Aksu area, Tarim Basin were analyzed based on 5 outcrop sections, 162 thin sections, 12 SEM samples, 52 sets of porosity and permeability data. Macroscopically, small-scale microbial reefs form the platform margin. A single microbial reef has several microbial reef progradation complexes, including reef front, fore reef, reef crest, and back reef, but microscopically, they have different kinds of microstructures. The reservoir spaces in the reefs can be divided into microbial structure reservoir space, including fenestral, frame, moldic, and oversized dissolution pores, and non-microbial structure reservoir space, including microcracks and stylolites. The statistical results of porosity and permeability show that in the Yutixi Section, porosity and permeability of the microbial reef reservoirs are generally below 5% and 1.0×10^{-3} μm^2 respectively, characteristics of extremely low porosity and permeability reservoirs; while the reef reservoirs in the Sugaitebulake Section have a wide porosity range between 3% and 10%, and permeability range between 0.1×10^{-3} μm^2 and 50×10^{-3} μm^2, and strong heterogeneity, are low-medium porosity, low-medium permeability reservoirs. This demonstrates different microbial reefs have big differences in physical properties, and even the reservoir in the same reef has obvious heterogeneity. Paleotopography controls the formation of microbial reefs and sedimentation controls the facies distribution and the primary porosity development. Dissolution, controlled by the two former factors, finally decides evolution of reservoir pores.

Key words: microbial reef; thrombolites; laminites; reservoirs; rimmed platform; Tarim Basin; Lower Cambrian; Xiaoerblak Formation

Introduction

Microbial reefs are organic reefs, created by in place sessile microorganisms like Renalcis, Girvanella, Epiphyton and so on[1]. Microorganisms form in place microbialite by capturing and bonding debris, and their own calcification and stabilization, further to form microbial reefs with bonding or microstructures[2]. Major oil and gas discoveries have been made in microbial reefs, an important kind of reservoir, in Alabama, the United States, Santos Basin, Brazil, and East Siberia[3]. Microbial reefs oil and gas fields in China are mainly distributed in the upper Yangtze region and North China, for example, the large-scale gas field of the Middle Triassic Leikoupo Formation in the western Sichuan Basin and the Renqiu oil field in the Bohai Bay Basin[3]. With the deepening of academic research and exploration, the microbial reefs of the Lower Cambrian Xiaoerbulak Formation in the Tarim Basin have also become the focus of research. Song et al. analyzed the first-stage large-scale platform margin microbial reefs developed in the upper member of the Xiaoerbulak Formation in the Sugaitblak section and pointed out that they were mostly low-porosity and low permeability reservoirs, but they did not study the second-stage platform margin microbial reefs[4]. Through the field survey of the Aksu outcrop area in the Tarim Basin, we found that the first-stage reefs only occurred near the Sugaitblak section, and the second-stage reefs were mostly clustered and large in areal distribution. Based on outcrop measurement and thin section observation under microscope, the microbial reefs in the Yutixi section are analyzed, and their reservoir characteristics and controlling factors are

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*** Corresponding author.** E-mail: pluo@petrochina.com.cn
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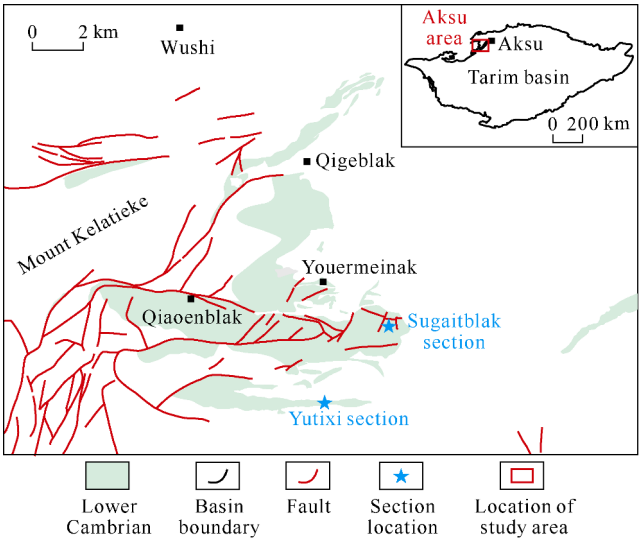

Fig. 1. Geological map and location of sections in Aksu area (according to reference [4]).

discussed by comparing with the Sugaitblak section.

1. Geological background

The Aksu outcrop area, belonging to the eastern part of the Kalpin faulted uplift, is located in the northwest of the Tarim Basin about 76 km from the Aksu City, and the Yutixi section and the Sugaitblak section are located in the southern part of the outcrop area (Fig. 1). In this paper, the Lower Cambrian Xiaoerbulak Formation deposited about 515–521 Ma, is the mainly study object, which is held in between Yuertusi Formation below, and Wusonggeer Formation above[5].

Taking the Yutixi section for example, during the deposition of the Xiaoerbulak Formation, the Aksu outcrop area was located in the northwest margin of the Taxi Platform. At the end of the Late Sinian period, the Kalpin Movement led to the parallel unconformity of the Cambrian and Sinian, and the early large-scale transgression of the early Cambrian resulted in the deposition of extensive black shale and siliceous rock and phosphate rock, and on this base, the gentle slope of the carbonate platform in a deeper water body formed[6]. After the transgression, with the drop of the sea level, the microbiological reefs developed on the ancient gentle slope gradually formed the slightly rimmed margin edge, which marked the gradual transformation of the Taxi Platform to a slightly rimmed carbonate platform[7–8] (Fig. 2).

2. Geological characteristics of microbial reefs

2.1. Macro geological features

At the Yutixi section, the small microbial reefs forming slightly rimmed platform margin, are located in the middle of the upper Xiaoerblak Formation (Fig. 2). Longitudinally, the reefs prograde along the gentle slope to the basin (Fig. 3a); laterally, they are distributed in a parallel manner along the gentle slope, with the layered microbial rock distributed around or between the reefs (Fig. 3b). We analyzed a large-scale SSW to NNE microbial reef, with a maximum

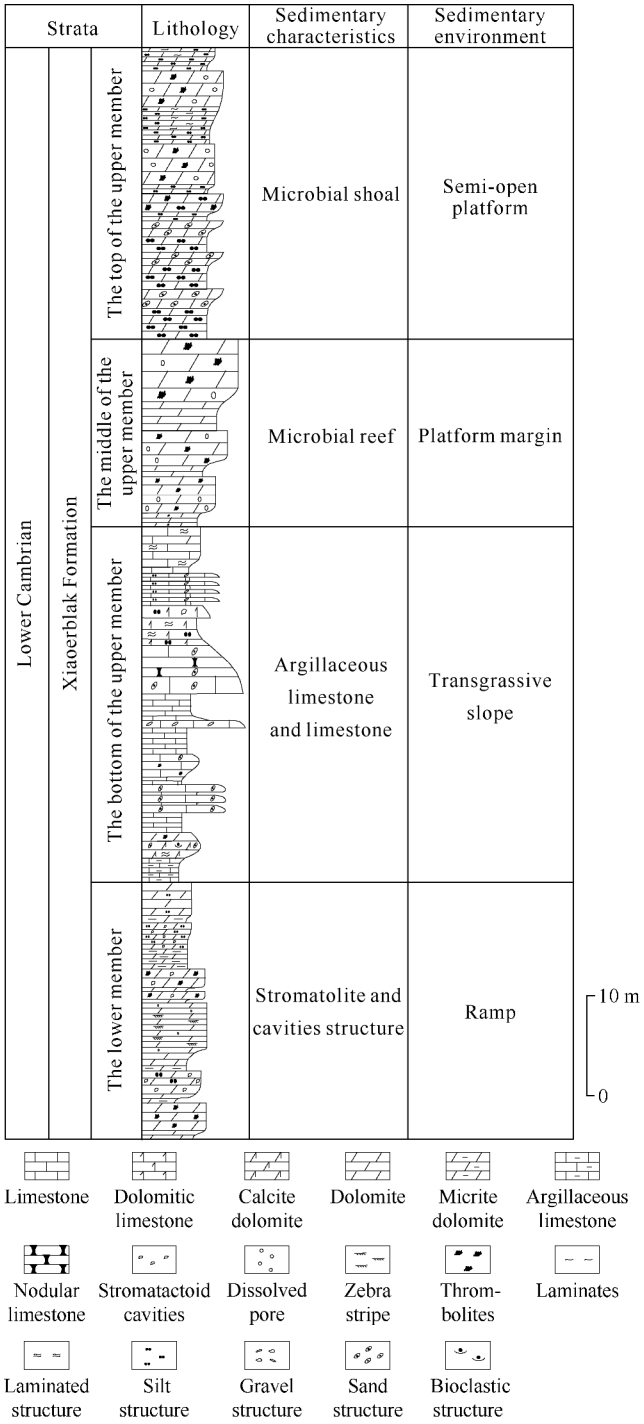

Fig. 2. Composite columnar section of Yutixi section, Aksu area.

observed thickness of 15 m, and the lateral extension of 20 m only due to fault segmentation. The arched asymmetry reef is in natural transition with the surrounding normal sediments; contain not much beddings in the main body, and higher in sand content, indicating that it grew in turbulent environment, in contrast to the deep lime mound formed in quiet deep water environment[9]. According to James's reef facies division model[10], it is believed that four microfacies including reef front, fore reef, reef crest, and back reef can be identified in each reef complex (Fig. 4a, 4b).

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