Diagenesis and Origin of Porosity Formation of Upper Ordovician Carbonate Reservoir in Tazhong No.1 Slope Break, Tarim Basin*

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Abstract

A spectrum of condensate gas fields had been exploited from the reef carbonate reservoirs in Lianglitage Formation of Upper Ordovician in Tazhong No.1 Slope Break since 2005. Additionally, the early paradigm for porosity formation in this Fm. stressed subaerial exposure and attendant shallow meteoric diagenesis in syngenetic period. However, this theory above had been proved to be invalid during the exploration of oil and gas when it was applied to the northwestern No.1 Slope Break. Subsequently, numerous authors have interpreted deep-burial dissolution in carbonate reservoirs, and some have proposed that primary volumes of porosity were created in this manner. As many have argued, carbonate pore types are formed by depositional, diagenetic, or fracture processes such that the spatial distribution of porosity may or may not conform to depositional facies boundaries and pores may be formed or altered by diagenesis and brittle fracture. Therefore, a comprehensive origin of reservoir should be taken into consideration. Cores, thin sections, cathodoluminescence and geochemical analysis technique are utilized to understand the categories of porosity and cementation and analyze the origin of porosity formation from broader perspective. The result of this study demonstrates that pore network in northwestern Tazhong is mainly controlled by intracrystal microporosity, enlarged corrosion pores and fissures. Furthermore, five phases' differential cementation and five phases' dissolution of aragonitic skeletal allochems are identified in the diagenetic process. In contrast to the porosity mechanism of Lianglitage Fm. in central or southeastern Tazhong, tectonic movement and meteoric dissolution processes in second phase of Middle Caledonian are the origin of porosity formation.
Abstract
A spectrum of condensate gas fields had been exploited from the reef-shoals carbonate reservoirs in Lianglitage Formation of Upper Ordovician in Tazhong No.1 Slope Break since 2005 (Fig.1). Additionally, the early paradigm for porosity formation in this region stressed subaerial exposure and attendant shallow meteoric diagenesis in eogenetic diagenesis period (Xinyuan Zhou et al., 2006; Zhenyu Wang et al., 2007; Zhaoming Wang et al., 2007). However, this theory above had been proved to be invalid during the exploration of oil and gas when it was applied to the northwestern No.1 Slope Break. Subsequently, numerous authors (Yixiong Qian et al., 2007; Honggang Xu et al., 2010; Bo Zhou et al., 2013) have interpreted deep-burial dissolution in carbonate reservoirs, and some have proposed that primary volumes of porosity were created in this manner.

As Wayne M. Ahr (2008) and other argued, carbonate pore types are formed by depositional, diagenetic, or fracture processes such that the spatial distribution of porosity may or may not conform to depositional facies boundaries and pores may be formed or altered by diagenesis and tectonic fracturing (Fig.2). Therefore, a comprehensive origin of reservoirs should be taken into consideration.

Intergranular pores, intracrystal microporosity, enlarged corrosion pores and fissures. Furthermore, 5 phases' cementation and dissolution were identified (Fig.6) have interpreted deep-burial dissolution in carbonate reservoirs, and some have proposed that primary volumes of porosity were created in this manner.

In contrast to the porosity mechanism of Lianglitage Fm. in central or southeastern Tazhong, tectonic movement and meteoric diagenesis processes in second phase of Middle Caledonian are the origin of porosity formation in northwestern Tazhong.

Introduction
Diagenesis refers to any physical or chemical changes in sediments or sedimentary rocks that occur after deposition. And it is highly essential to make clear the origin of porosity formation.

Chocquet and Pray (1970) illustrated three diagenetic stages in the evolution of a limestone (Fig.3), that is early stage, mesogenetic (burial period) and telogenetic (uplift period) stage respectively.

Since then, meteoric dissolution during telogenetic stage was firstly put much attention due to oil and gas exploration breakthroughs of carbonate reservoirs. 5 phases' cementation and dissolution were identified (Fig.6) in the diagenetic process in northwestern Tazhong, and tectonic movement and meteoric dissolution produced the existing porosity.

Methodology
About 62 core samples of oil limestone were collected from more than 20 wells along the No.1 slope break and were then made into doubly polished thin sections. Then, around 40 calcite samples filled in vugs or fractures were crushed into very fine powder in an agate mortar for carbon and oxygen isotope analyses.

Results
1) 5 phases’ cementation and dissolution were identified (Fig.6) in the diagenetic process in northwestern Tazhong, and tectonic movement and meteoric dissolution produced the existing porosity.
2) Integrating the previous study in Tazhong No.1 slope break, we hold that there are three categories of porosity genesis, that is, mixing water karst, meteoric water karst and hypogenic karst.
3) Preserved porosity categories, porosity formation mechanism varied along Tazhong No.1 slope break.

Porosity genesis
According to the existing porosity types and their genesis identification along Tazhong No.1 slope break, three different porosity genesis were illustrated. While meteoric water karst acted as a main process for porosity shaping in northwestern area, mixing water karst generated primary porosity space in southeast part. And hypogenic karst distributed almost the whole slope break, but performed to be destructive for porosity in northwestern and central part, while constructive in southeastern part.

Discussion

Conclusion
(a) Diagenesis sequence in Lianglitage Fm. displayed that porosity preservation varied a lot along No.1 slope break. (b) The difference of porosity origin between northwestern and southeastern areas is closely related to the deposition environment and tectonic differentiation.