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Full Length Article

# Characteristics of dolomite karstic reservoir in the Sinian Dengying Formation, Sichuan Basin

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ABSTRACT

The Sinian dolomite reservoir in Dengying Formation was developed extensively in the Sichuan Basin, and typically was the facies-controlled dolomite karstic reservoir. The development of this kind of the reservoir was related with the special deposits, diagenetic environment as well as the multi-phase and multi-type dissolution and fracturing actions. The arid-hot/dry paleo-climate was favourable to develop the large-scale microbial reef-shoal bodies and mound–shoal bodies, which was characterized by the organic framework and the sea floor hardening, thus forming primary matrix pore-type reservoir. In the background of the arid-hot/dry paleo-climate, the water-rock interaction was weak, the mineral stabilization process was slowly, and the vadose pisoliths, aragonite and high-magnesium calcite were well preserved, therefore, this diagenetic environment especially was beneficial for pore preservation. Moreover, the syngenetic and penecontemporaneous dissolution, especially three phases of weathered crust karstification due to three episodes of the Tongwan movement, led to further dissolution of spaces and form numerous non-fabric selective dissolution fractures and dissolution caves along faults and fractures. Multi-phase fractures, especially the late Yanshanian-Himalayan tectonic fractures, resulted in connection among pores, vugs and dissolution caves, and improved quality of the reservoir tremendously.



## 1. Introduction

The Sinian was extensively developed in the southern China with the age from 635 to 541 Ma and maximum residual thickness of more than 1 km, in which Doushantuo Formation and Dengying Formation in the Upper Yangtze region had an area of $0.78 \times 10^6$ km$^2$ and $0.75 \times 10^6$ km$^2$ respectively (Tang et al., 1981; Guan et al., 1984; Yin, 1984). The area of the Sichuan Basin was about $19 \times 10^4$ km$^2$. In 1964, the Weiyuan Gasfield was discovered in the Dengying Formation, and was the first discovery in the ancient microbial mound in the world. Through research and exploration in recent years, another large gasfield was discovered in the Moxi-Gaoshiti area in the basin (Xie et al., 2013; Zou et al., 2014; Wei et al., 2015). The Dengying Formation was divided into four members from bottom to top, i.e., Member 1, Member 2, Member 3 and Member 4. For rock type, the Member 3 of Dengying Formation was dominated by the fine clastic rock, and the other Members were dominated by dolomite. Due to episodes I, II and III of Tongwan movement, three phases of the regional palaeo-karst unconformities were formed at the top of Member 2 of Dengying Formation, the top of Member 4 of Dengying Formation, and the top of the Maidiping Formation respectively (Fig. 1), therefore, two sets of high-quality large-area karst reservoirs were developed in Members 2 and 4 of Dengying Formation. The residual thickness of carbonate in the Maidiping Formation in the central Sichuan area was 0–20 m, leading to limited hydrocarbon exploration potential. Member 2 of Dengying Formation was characterized by the superimposition between the multicycle interlayer karst and the weathered crust karst reservoir of Tongwan Episode I, while Member 4 of Dengying Formation was characterized by the weathered crust karstification of Tongwan episodes I and II as well as wide distribution of large dissolution caves with deep burial (Zou et al., 2014).

Since the Sinian standard section in the Yangtze Gorge was initially set up by Lee and Chao (1924), many scholars carried out multidisciplinary researches in different areas and made

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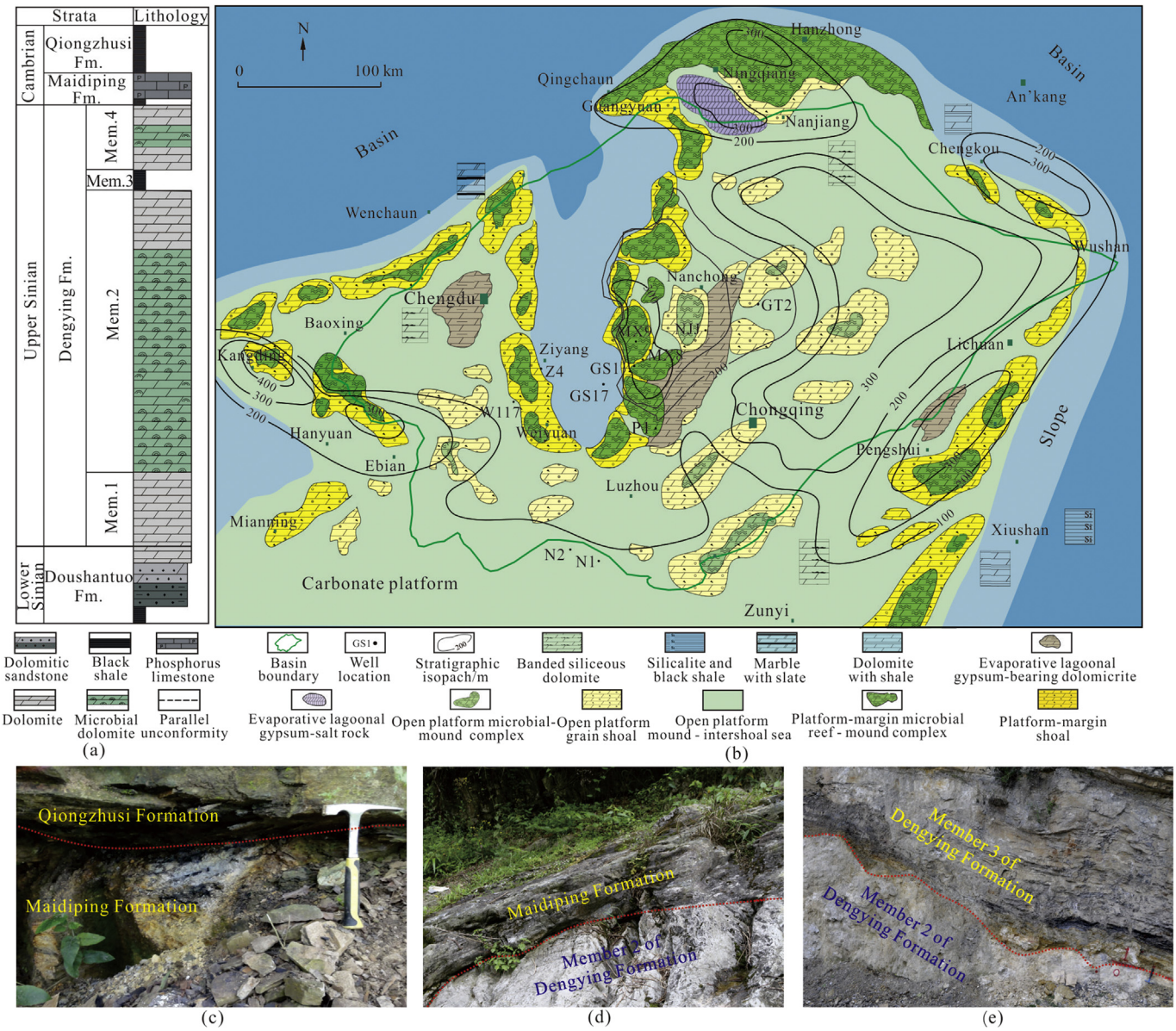


**Fig. 1.** Characteristics of Sinian stratigraphic system and lithofacies palaeogeography in the Sichuan Basin and its periphery. (a) Sinian stratigraphic column. (b) Lithofacies palaeogeography of Member 4 of the Dengying Formation, modified from Zou et al. (2014). (c) Unconformity between the Lower Cambrian sandy mudstone of the Qiongzhusi Formation and underlying siliceous dolomite of the Maidiping Formation, Xianfeng outcrop of Ebian. (d) Unconformity between siliceous dolomite of the Maidiping Formation and underlying dolomite of the Dengying Formation, Gaoqiao outcrop of Pengshui. (e) Unconformity between mudstone of Member 3 of the Dengying Formation and underlying dolomite of Member 2 of the Dengying Formation, Xianfeng outcrop of Ebian.

remarkable achievements. Researches on reservoirs in Dengying Formation involved discussions on vadose pisoliths (Cao and Xue, 1983), botryoidal and snowflake structures (Xiang et al., 1998a; Chen et al., 2002; Zhang et al., 2014a), identification of syn-sedimentary exposure (Liu et al., 1991), evaluation and prediction of reservoir genesis and pore evolution (Hou et al., 1999; Wang et al., 2000; Huang et al., 2009). But discussion on the combined effect of special deposits and diagenetic environment on reservoir formation was insufficient. For fluid inclusions, the diagenetic and accumulation phases were mostly determined from homogenization temperature, whereas reservoir genesis was rarely investigated on the basis of salinity data combined with micropetrological evidence of dissolution; therefore, the authors made some preliminary discussions in this respect to further understand formation, preserving mechanism and evaluation prediction of reservoir.

## 2. Characteristics of reservoir petrology and sedimentology

### 2.1. Petrology

Members 1, 2 and 4 of the Dengying Formation in the Sichuan Basin were characterized by various types of dolomite containing or rich in benthic microorganisms (Burne and Moore, 1987), including microbial framework dolomite, thrombolite dolomite, spherulitic thrombolite dolomite, foam layer dolomite, stromatolite dolomite, laminated dolomite, as well as oncolite dolomite, ooids dolomite, sand- and gravel-sized dolomite, dolarenite, dolomicrite, argillaceous dolomicrite and so on (Fig. 2). Diagenetic structures were also very special, including (vadose) pisolitic, botryoidal, lacy and ctenoid textures. Except dolomicrite and argillaceous dolomicrite, all the rest dolomites were favorable reservoir rocks.

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