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# Characteristics of hydrothermal-structure-controlled fracture–vug dolomite reservoir and its influence on oil–water distribution: Lower Cretaceous, Baiyinchagan sag, Erlian Basin, North China

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**Abstract**

Fractures and vugs were used as the primary dolomite reservoir space in the study area, which improved the reservoir's physical properties and influenced the distribution pattern of oil and water that were developed in the Upper Tenger Formation, Lower Cretaceous, Baiyinchagan sag, Erlian Basin. Based on the core observation data, thin slice analysis, and image logging, the cave-fractured reservoir was primarily developed in the actic region near the side of a depositional fault. Tectonic and diagenetic fractures were the primary types of fractures. High-angle tectonic fractures in the closure and open status were developed well in dolomitic mudstone, while a low-angle fracture and reticulate fractures were developed in the tectonic-hydrothermal hybrid process and were filled with hydrothermal minerals. The reservoir was located in low-lying land; therefore, detrital grain pressolution fractures were formed by burial diagenesis. Intergranular and intrangranular dissolved pores, which were formed by hydrothermal activity, were developed primarily in the highly dolomite lithology. According to the diagenesis temperature of dolomite from a carbon–oxygen isotope analysis, multiple hydrothermal fluid injection events occurred, and dolomitization ensued before massive hydrocarbon migration. The dissolution of organic acids formed by hydrocarbon charges after dolomitization and inorganic acid produced by burial diagenesis for soluble minerals effectively promoted the reservoir properties. Strong heterogeneity due to lithology and fracture–vug systems led to intricate oil–water relationships. Four statuses occurred, including cave-fracture oil, isolated oil, stored oil, isolated water, and stored water. The oil–water distribution patterns were established based on the core observation.


*Keywords:* hydrothermal dolomite; fracture–vug reservoir; oil–water distribution; North China; Erlian Basin

## 1. Introduction

Hydrothermal dolomite has recently been found in the Tarim Basin (Guo et al., 2016; Li et al., 2016; Zhu et al., 2015), the Jiuquan Basin (Fan et al., 2003; Wen et al., 2013), the Erlian Basin (Guo et al., 2013), the Sichun Basin (Feng et al., 2017; Liu et al., 2014; Liu et al., 2016) in China, the Northeast Basin (Diehl et al., 2010; Hendry et al., 2015; Slater and Smith, 2012) in the USA, and the West Basin (Conliffe et al., 2010; Morrow, 2014; Qing and Mountjoy, 1994; Schrijver et al., 1996) in Canada. There are many ways to study the genesis and recognition of structure-controlled hydrothermal dolomite (Al-Aasm, 2003; Dai et al., 2004; Debruyne et al., 2016; Fan et al., 2003; Graham et al., 2006; Hendry et al., 2015). Authors primarily focused on petrology characteristics, which were related to hydrothermal fluid, such as saddle shaped dolomite crystals, hydrothermal fluid mineral combinations of analcite-gioberite-siderite and the characteristics of carbon-oxygen isotopes. However, few studies examine the influence of cave-fractured reservoirs formed by hydrothermal on oil–water contact.

Evidence of oil in the dolomitic mudstone cave-fractured at well X26 was found in 2009, producing more evidence regarding fractured mudstone oil, and this finding was further confirmed by a mudstone cave-fractured hydrocarbon reservoir in Xilinhaolai area, Baiyinchagan sag with the successful drillings of wells X3-69 and X31. This area is now a significant oil exploration area. The latest research indicated

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that fractures and solution vugs could provide favorable reservoir space and flow pathway for petrology, solution promoted reservoir space and fracture linked up of different types that improved the connectivity and permeability. At the same time, fractures were the key factors for hydrocarbon accumulation and high levels of production. Therefore, understanding the distribution characteristic of fracture and dissolution vugs and their impact on oil–water distribution was very important for the hydrocarbon exploration and development of the Xilinhaolai area, Baiyinchagan sag.

Guo et al. (2012) and Hu et al. (2013) discussed the genesis, petrology characteristic, seismites, the origin of $Mg^{2+}$ and the distribution of Lower Cretaceous structure hydrothermal dolomite in Baiyinchagan sag. Results suggested that dolomite formed under the condition of xerothermal and depositional fault connected supracrustal hydrothermal fluid upwelling fluid dolomized marlstone on the hanging wall. Yue et al. (2009) studied the two special geological phenomena of deformation and chink and deemed that seismic and tectonic forces were formed microfaults, crack networks, and sandstone veins. However, this research did not include fracture characteristics.

This paper used well logs imaging of 3 wells, nuclear magnetic resonance logs of 2 wells, cores observation data of 3 cores, 24 casting sheet slices and the common slice of one cored well, well testing data, and cores petrophysical analysis data to discuss the fracture–vug characteristics and their influence on oil and water distribution.

## 2. Geological setting

Erlian Basin was located in the center of the Inner Mongolia autonomous region in North China and was a primary Mesozoic strata continental rifted basin developed on the Hercynian folding basemen (Fig. 1*A*). Baiyinchagan sag was located in the west margin of the Erlian Basin and is a secondary tectonic unit of the north Chuanjing depression. This location was a dustpan-shaped faulted sag that faulted to the west and overlapped to the east (Fig. 1*B*) (Huang et al., 2003; Zuo et al., 2016). The Xilinhaolai area included the sub-tectonic units in the Baiyinchagan sag and was located in the southern slope of the western areas, whose structure was a monocline striking NE, and dipping to the NW (Fig. 1*C*).

The Cretaceous sequence can be divided into the following five formations: Aershan, Tenger, Duhongmu, Saihantala, and Erliandabu Formations, proceeding from bottom to top (Fig. 2). The overall depositional stage of the Lower Cretaceous of Baiyinchagan sag was lacustrine transgression to

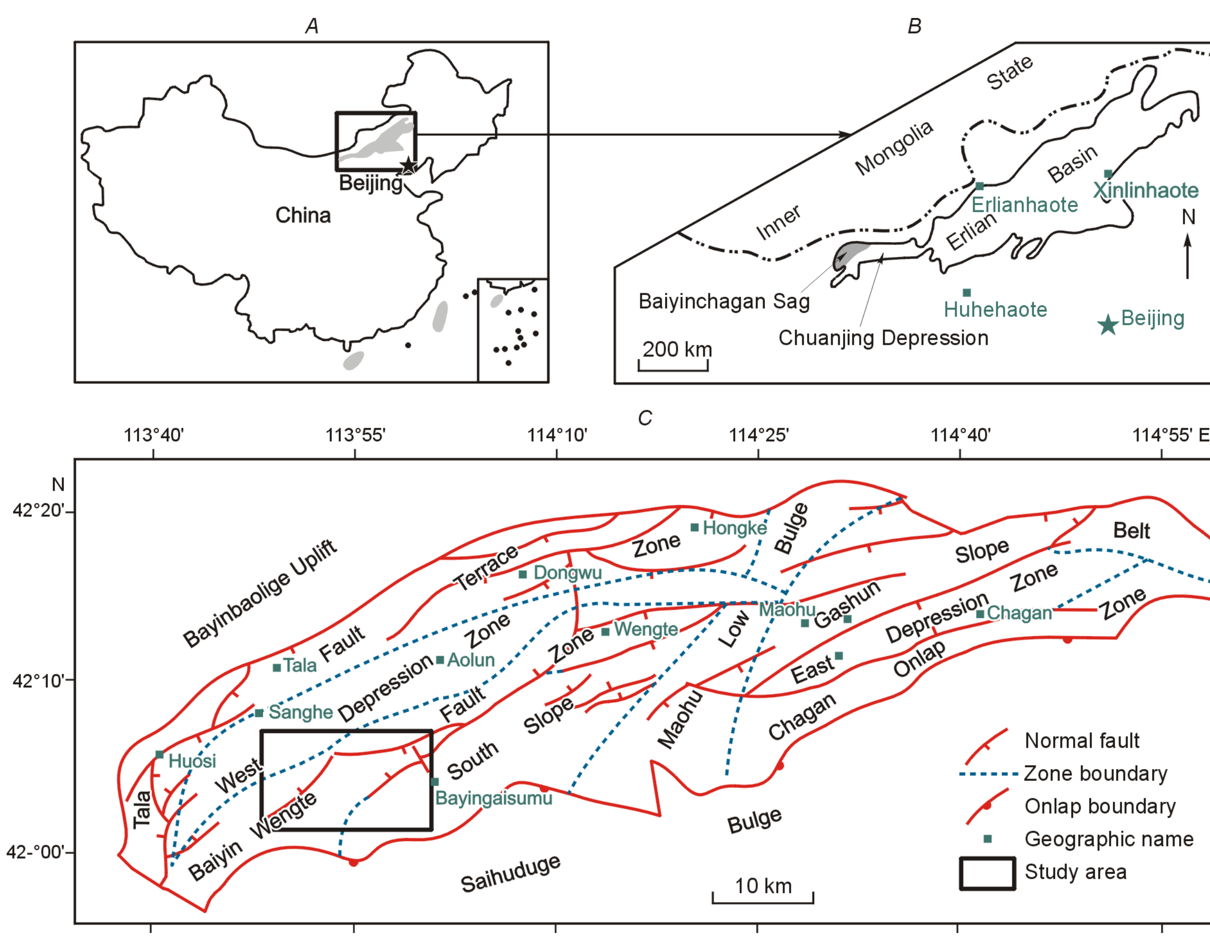


Fig. 1. *A*, *B*, *C* are the structural locations of the Erlian Basin, the Baiyinchagan sag and the Xilinhaolai area, respectively (modified from Deng et al., 2013).