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Relationship between depositional textures and seismic velocities of the Yijianfang Ordovician reef complexes in the Bachu area, west Tarim Basin, China

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ABSTRACT

The Yijianfang Ordovician reef complexes in the Bachu area, western Tarim Basin contain eight facies elements: reef cores, fore-reef breccias, reef bases, tidal channels, fore-reef inner shoals, fore-reef outer shoals, back-reef inner shoals, and back-reef outer shoals. The reef cores and fore-reef breccias are characterized by *Calathium* bafflestones and rudstones, respectively. The reef bases are composed of skeletal packstones with moderately sorted grains of 0.1–2.5 mm diameter, whereas the tidal channels are dominated by cross-bedded packstones in which the grains are moderately to poorly sorted with a diameter of 0.3–6 mm. The fore-reef and back-reef inner shoals are composed of grainstones, while the fore-reef and back-reef outer shoals are dominated by packstones. From inner to outer part of the shoals, the grain content becomes gradually less, the size of grains becomes gradually finer, and the grains become worse sorted. The fore-reef and back-reef inner shoals tend to be potential reservoirs for hydrocarbon. Studies on predictive relationship between depositional textures and seismic velocities show that the seismic velocities decrease with an increase of grain content or median grain diameter, and a decrease of standard deviation. With these correlations, acoustic data could provide useful information about recognizing the depositional textures of reef complexes, which is crucial to predict facies of the reef complexes based on seismic data. Seismic simulated experiment reveals that the mound seismic reflection configurations of the reef cores are pronounced, surrounding which the potential reservoirs can be recognized in the synthetic seismic profiles.

1. Introduction

Reef complexes have been always considered as typically effective hydrocarbon reservoirs (Madi et al., 2000; Westphal et al., 2004; Ma et al., 2007). Well documented studies have been focused on the depositional elements, diagenesis, and reservoir properties of reef complexes (Doherty et al., 2002; Coniglio et al., 2003; Westphal et al., 2004; Adams et al., 2005; Shen et al., 2008; Jiao et al., 2011; Wang et al., 2012). However, studies on quantitative descriptions of their depositional textures remain rarely reported. The reef-shoal reservoirs generally have strong heterogeneity that significantly changes seismic velocities and complicates the interpretations of seismic reflection data (Brigaud et al., 2010; Casteleyn et al., 2011). Several studies have been conducted to make quantitative evaluation of the potential controlling parameters on seismic velocities in carbonate strata (Anselmetti and Eberli, 1993; Kenter et al., 2007; Fabricius et al., 2008; Verwer et al., 2008; Ameen et al., 2009; Weger et al., 2009; Rajabi et al., 2010), but little attention has been paid to relationship between the depositional textures and seismic velocities in the carbonate strata with low porosity (i.e., less than 15%) (Zampetti et al., 2005; Saberi et al., 2009; Brigaud et al., 2010; Rong et al., 2012). Well-exposed reef complexes at Yijianfang of Bachu area provide excellent opportunity for quantitatively correlating the depositional textures to seismic velocities of the carbonate strata with low porosity. Result of this study can provide guidance for understanding reservoir heterogeneity and improving predictions for the reef complexes.

The purpose of this study is to quantitatively characterize depositional textures, mineral composition and reservoir properties

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of the reef complexes at Yijianfang. According to these data, predictive relationship between depositional textures and seismic velocities of the reef complexes will be established, and two-dimensional synthetic seismic profiles will be simulated.

2. Geological background

The Tarim Basin is the largest hydrocarbon-bearing basin in western China. In recent years, commercially significant amounts of petroleum have been found in Ordovician reef complexes with a burial depth in excess of 5000 m in the Tazhong and Tabei uplift of the Tarim Basin (Kang, 2005; Jin et al., 2009; Fig. 1). Cumulative reserves of oil and gas equivalent to was up to 4×10^8 t known at the end of 2008 (Wang et al., 2010). The Ordovician reef complexes exposed at Yijianfang of Bachu area have been considered as analogs to these subsurface reservoirs (Shen et al., 2008; Zhao et al., 2009; Jiao et al., 2011; Wang et al., 2012).

The Yijianfang outcrop includes the Ordovician Yingshan Formation, Yijianfang Formation, Qiaerbake Formation, and Lianglitage Formation (Fig. 2). The Yingshan Formation is composed of bioclastic wackestones (Li et al., 2007; Zhao et al., 2009). The Yijianfang Formation consists of *Calathium* bafflestones, bioclastic packstones and grainstones in its lower part and thick-bedded bioclastic wackestones and mudstones in its upper part (Fig. 2). The Qiaerbake Formation generally referred to as the “lower red limestone” is characterized by iron-stained argillaceous mudstones (Li et al., 2007; Fig. 2). The Lianglitage Formation comprises thick-bedded nodular mudstones with packstones and rudstones interbeds in its lower part and algal bafflestones, grainstones, and oolitic grainstones in its upper (Rong et al., 2013; Fig. 2).

Reef complexes formed in the lower part of the Yijianfang Formation are 2–70 m wide and 0.8–29 m thick at Yijianfang. They show remarkably lateral migrations (Fig. 3), which have been interpreted to be related to their growth rate and ascending rate of sea level (Hanford and Loucks, 1993). Based on the facies stacking patterns and migrations of reef complexes, five transgressive-regressive cycles (i.e., Cycle A–Cycle E) are identified in the Yijianfang Formation. Each is composed of a basal bioclastic mudstone shallowing up to a packstone, grainstone or bafflestone, or retrograding reef complexes in the lower part followed by prograding ones in the upper part (Figs. 3 and 4).

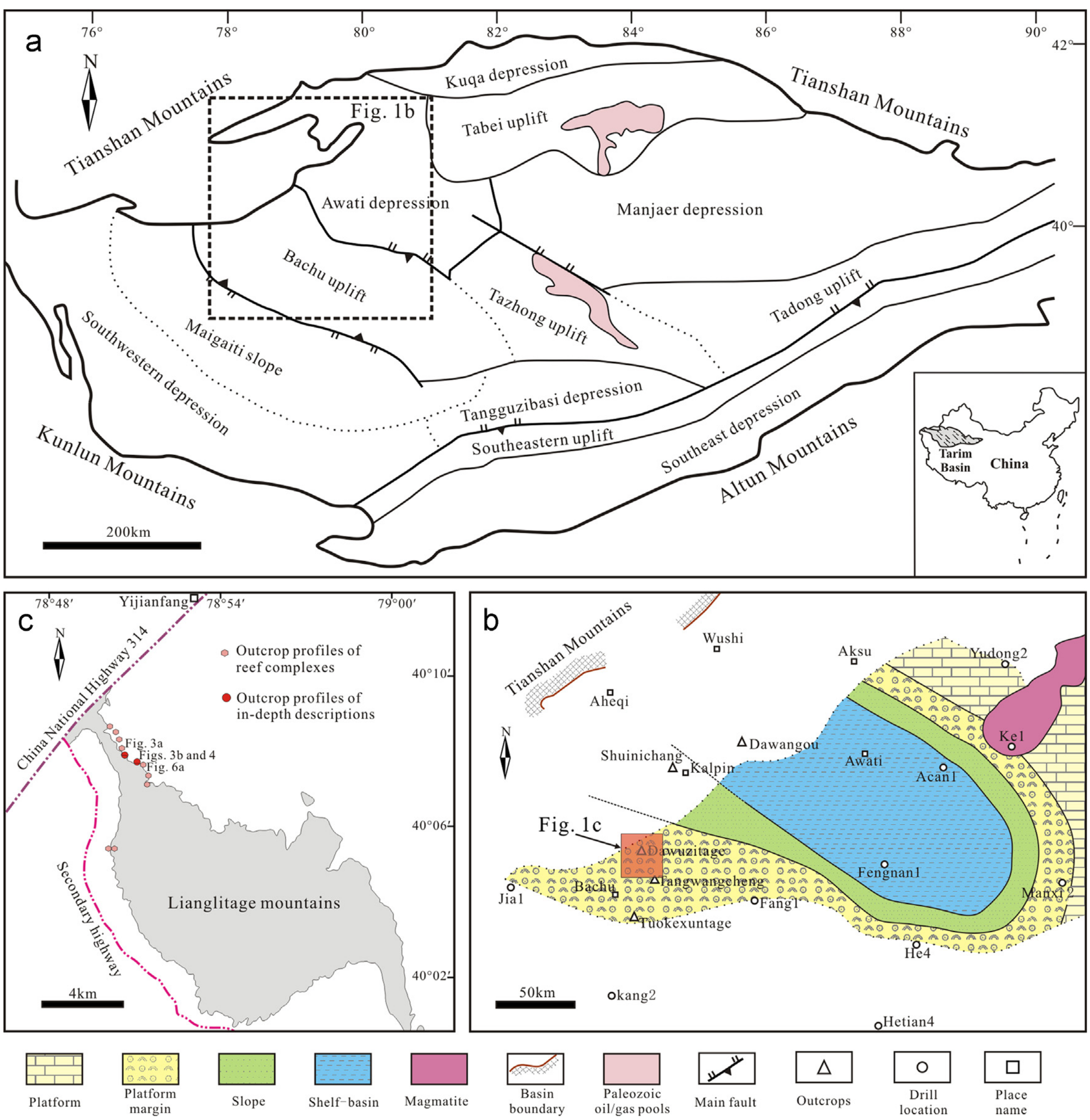

Fig. 1. (a) Tectonic units of the Tarim Basin; the Yijianfang outcrop area is located at the Bachu uplift. (b) Paleogeography of the Yijianfang Formation in the western Tarim Basin. (c) Traffic map of the Yijianfang outcrop area.