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Late Cretaceous biostratigraphy and sea-level change in the southwest Tarim Basin

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ABSTRACT

The Upper Cretaceous sediments of the southwest Tarim Basin include the remnants of a large epicontinental sea. In this study, based on the analyses of sedimentation, foraminifera, ostracods, bivalves, and other fossils from the Simuhana Section, as well as published biostratigraphy data, we present a field-based biostratigraphy and review of sea-level change for the Upper Cretaceous strata in the southwest Tarim Basin. The Upper Cretaceous marine strata include the Kukebai and Dongba formations. Relatively abundant foraminifera, ostracods, and bivalves were discovered and identified. Based on the biostratigraphy and correlation, the proposed age of the Lower and Middle Kukebai Formation is Cenomanian to earliest Turonian; the Upper Kukebai is of Turonian to early Coniacian age. The Lower Dongba Formation is late Coniacian to early Campanian, the Middle Dongba Formation is late Campanian to early Maastrichtian, and the Upper Dongba Formation is late Maastrichtian in age, possibly extending into the Danian. The relative sea level began to rise during sedimentation of the Lower Kukebai Formation (Cenomanian), and reached a maximum by the time of the middle to upper part of the Upper Kukebai Formation (Turonian to early Coniacian). After a subsequent sea level fall, another transgression began during sedimentation of the Middle Dongba Formation. Above the Upper Dongba Formation, the sea level fell dramatically. The sea level of the southwest Tarim Basin shows a close relationship with the global sea level curve, and with the sea level of south Tibet.

1. Introduction

During the Cretaceous Period, the existence of enhanced greenhouse conditions and high sea level are generally accepted (Huber et al., 2000; Skelton, 2003; Hu et al., 2012). The global Cretaceous sea level and the level of the western and eastern Tethys Sea have been widely studied (Haq et al., 1987; Haq, 2014; Wan, 1992; Zhang, 2000; Wang et al., 2005; Miller et al., 2005; Cloetingh and Haq, 2015). The Late Cretaceous to Paleogene sediments of the southwest (SW) Tarim Basin in western China include the remnants of a large epicontinental sea (Tang et al., 1992; Bosboom et al., 2011). During that period of global rise in sea level and tectonic forcing, the Neo-Tethys covered the SW Tarim Basin (Late Cretaceous to Paleogene). The Paleogene sediments of the SW Tarim Basin have been recently studied in detail (Bosboom et al., 2011; Sun and Jiang, 2013; Wang et al., 2014). Though the biostratigraphy and sedimentation of Cretaceous marine strata have been the subject of much work (Hao et al., 1982, 2001; Mao and Norris, 1988; Tang et al., 1989, 1992; Zhong, 1992; Lan and Wei, 1995; Yang et al., 1995; Jiang et al., 1995; Guo, 1990, 1995), the Late Cretaceous biostratigraphy and sea level are still not perfectly understood. The SW Tarim can help us to understand the level of the epicontinental sea, and the paleoenvironment of the northwest Tethys.

This paper presents a field-based biostratigraphy and sea-level of Upper Cretaceous strata in the SW Tarim Basin. The aim of the study was to provide a stratigraphic framework, by which to assess and discuss the relative evolution of the Late Cretaceous sea level, in the study area.

2. Geological setting

2.1. Tectonics and stratigraphy

The Tarim Basin is a large Mesozoic–Cenozoic composite inland basin, superimposed upon a Paleozoic platform (Zhou, 2001). It is situated south of the Tianshan Mountains (Tianshan Mts.) and north of the West Kunlun Moutain (Kunlun Mts.) and Altun Mountain (Fig. 1A). The areal extent of the basin is 560,000 km^2, and the basin is part of a relatively undeformed crustal block within the India–Asia collision system (Yin and Harrison, 2000). The Tarim is a poly history superimposed basin that has seven evolutionary stages: (1) Sinian–Cambrian–Ordovician aulacogen stage, (2) Silurian–Devonian intracratonic depression stage, (3) Carboniferous marginal sea stage, (4) Permian rift-basin stage, (5) Triassic–Jurassic foreland basin stage,

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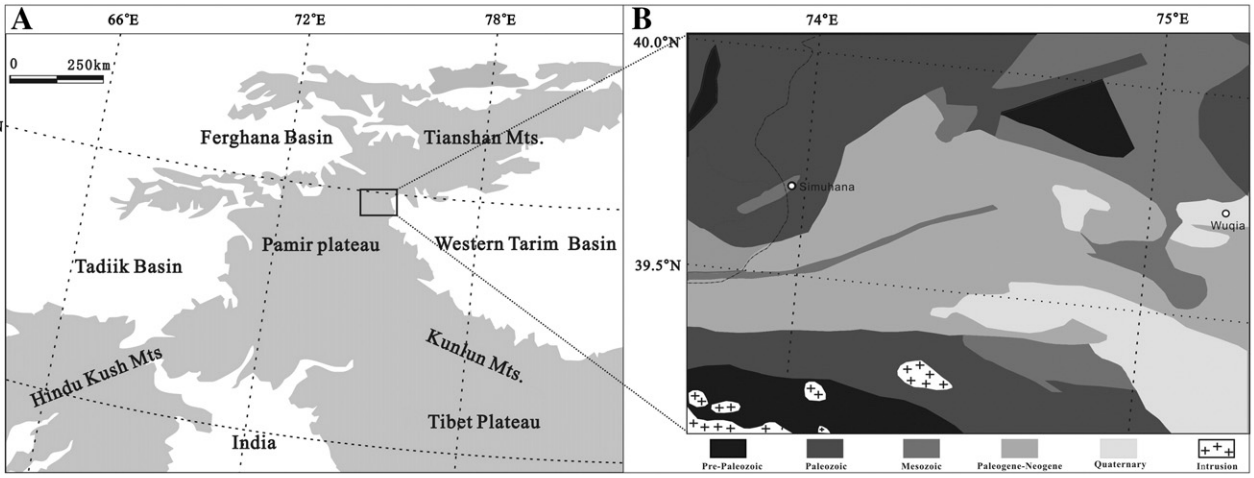

Fig. 1. Topography of the Western Tarim Basin (A, modified from Sun and Jiang, 2013) and geological map of the study area (B, modified from He et al., 2004).

(6) Cretaceous–Paleogene Neo-Tethys bay stage, and (7) Neogene–Pleistocene foreland and inland basin stage (Li et al., 2004).

The SW Tarim Basin is located between the West Kunlun Mts. (Pamir Mountains) and the Tianshan Mts. (Fig. 1). It sits on the southwest part of the basin with an area of 121 300 km^2 (Jia, 1997). The SW Tarim Basin presents a continuous stratigraphic sequence deposited since the Jurassic to the present (Tang et al., 1989; Hao et al., 2001; Jia et al., 2004). The paleogeography of the SW Tarim can be divided into the Tianshan Mts. and Kunlun Mts. (Tang et al., 1992). The Mesozoic SW Tarim Basin is composed of a non-marine sequence below (Jurassic Shalitashen, Kangsu, Yangye, Taerga, Kuzigongsu formations, Lower Cretaceous Kezilesu Group) and marine sequence above (Upper Cretaceous Kukebai, Dongba (Wuyitake, Yigeziya, Tuyiluoke) formations), while the Cenozoic SW Tarim Basin consists of a marine sequence below (Aertashi, Qimugen, Kalatar, Wulagen, and Bashibulake formations) and a continental sequence above (Keziluoyi, Anjuan, Pakabulake and Artushi formations) (Fig. 2; Hao et al., 1982; Zhou, 2001; Yin et al., 2002).

The Upper Jurassic Kuzigongsu Formation is characterized by laminated gray–white sandstone and mudstone with coal beds and abundant non-marine plant fossils (Zhou, 2001). It is overlain by the Lower Cretaceous Kezilesu Group, which contains reddish and white sandstone. The Upper Cretaceous assemblages include the Kukebai and Dongba formations in the Tianshan Mts. area, and the Kukebai, Wuyitake, Yigeziya, and Tuyiluoke formations in the Kunlun Mts. area (Fig. 2). The Kukebai Formation is subdivided into three members. The lower one is dominated by purple–red mudstone with intercalated thin gypsum layers, while the middle and upper parts are made up of gray–green mudstone with abundant marine fossils (Tang et al., 1989; Hao et al., 2001). The Dongba Formation, conformably overlying the Kukebai Formation, is subdivided into three members. The lower and upper ones consist of red mudstone with intercalated thin gypsum rock, and the middle part is made up of carbonate and gray–green mudstone with abundant marine fossils (Tang et al., 1989).

2.2. The study section

The study area is located in the Tianshan Mts. area of the SW Tarim Basin. Cretaceous sediments are well exposed along the Kezilesu River (Fig. 1B). The Simuhana Section is situated in Simuhana Village of Wuqia County, and crops out along the Kezilesu River (Fig. 3). The measured section contains Cretaceous to Cenozoic strata. The Simuhana section includes two separated sections: Simuhana Section 1 located along the south bank of the Kezilsu River (39°43′36.92″ N; 73°59′38.03″ E), and Simuhana Section 2 along the north bank of the Kezilesu River (39°43′44.92″ N; 73°59′39.29″ E). Section 1 includes the Kezilesu Group, Lower and middle Kukebai Formation, and Section 2 includes the Upper Kukebai Formation and Dongba Formation. This work was carried out in the Upper Cretaceous Kukebai Formation and Dongba Formation (Wuyitage, Yigeziya and Keziluoyi formations).

3. Material and methods

About 100 microfossil and bivalve fossil samples were collected from 193.2 m thickness of the Simuhana section. Samples of 100 g dry weight were dispersed in water for several weeks prior to sieving through a 200 microns sieve. Ostracods and foraminifera were picked from the samples under a low-power binocular microscope. Microfossil and bivalve studies were carried out at the micropaleontological laboratory of the China University of Geosciences (Beijing).

4. Lithostratigraphy

4.1. Kukebai Formation

The lower Kukebai Formation (51.9 m) is divided into eight beds (Fig. 4A). The first bed (1.1 m) is composed of gray coarse to medium sandstone with parallel bedding and cross bedding (Fig. 4C). The second bed (7.8 m) is composed of brown red silty mudstone, with intercalated gray green mudstone and gypsum layers (0.5–1 cm for each layer). The horizontal bedding appears at the top of this bed. The third bed (1.8 m) is mainly composed of gray green mudstone, with horizontal bedding and intercalated thin gypsum layers upwards. The fourth bed (15.1 m) is composed of brown red mudstone and silty mudstone, with intercalated gray–green mudstone and a great many thin gypsum layers. The fifth bed (8.6 m) is composed of gray–green mudstone and, silty mudstone, with intercalated purple red mudstone and gypsum layers. Brown yellow siltstone and silty mudstone appeared at the top of this bed (Figs. 4D, 5A). The sixth bed (7 m) is composed of bioclastic limestone (Fig. 4D). Abundant bivalves, gastropods, and other biological debris were found in this unit (Figs. 4C, 5B). The seventh bed (3 m) is composed of intercalated calcareous shale, with relatively abundant ostracod fossils (Fig. 5C). The eighth bed (7.5 m) is composed of bioclastic limestone and calcirudite. Besides relatively abundant bivalves and gastropods, some gravel stone (0.2–1 cm) appeared at the top of the limestone.

The Middle Kukebai Formation (29.9 m) can be divided into three beds (Fig. 4B). The first unit (9.3 m) is made up of dark gray–green mudstone with intercalated silty mudstone (Fig. 5C). Two thin shelly layers have been found in this bed. The second bed (0.2 m) is made up of shelly layer, which is mainly composed of bivalve. The third bed (18 m) is made up of dark gray–green mudstone, with more thin shelly layers.