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Climatic and tectonic controls on Cretaceous-Palaeogene sea-level changes recorded in the Tarim epicontinental sea

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ABSTRACT

During Late Cretaceous to Eocene times, a vast epicontinental sea existed in the western Tarim Basin of China, and its appearance, evolution, and demise played an important role in the paleogeographic and paleoclimatic history of central Asia. Sea-level changes in the Tarim Sea and its controlling factors have been poorly studied so far. Here we present a detailed stratigraphic and sedimentological analysis of six Upper Cretaceous to Eocene stratigraphic sections in the southwestern Tarim Basin. Seventeen lithofacies types were identified overall, based on which changes of paleowater-depth were reconstructed. Between the mid-Cretaceous (Cenomanian) and the late Eocene (Priabonian), the Tarim Sea experienced five transgressive-regressive cycles. Deposition took place in middle-ramp to inner-ramp settings during transgressions, and in coastal-plain, lacustrine, and braided-river environments during regressions. The sea retreated but did not withdraw completely during Late Cretaceous to early Paleocene regressive stages, whereas seaways disappeared completely from the studied area during late Paleocene to Eocene regressions. The Tarim Basin lay on a stable craton in the Late Cretaceous, when paleowater-depth was chiefly controlled by eustatic change. Tectonic subsidence started to increase at middle Paleocene time, simultaneously with the Selandian dry event in the Tarim Basin, when a thick gypsum unit was deposited during incipient development of a foreland basin. Such a middle Paleocene onset of tectonic activity, also indicated by discrepancies between the regional paleowater-depth curve and the global sea-level curve and by penecontemporaneous uplift of the West Kunlun range in northeastern Pamir, were most likely a far-field effect of the onset of the India-Asia continental collision to the south.

1. Introduction

During the Late Cretaceous to Paleogene, a shallow epicontinental sea extended across Eurasia from the Mediterranean Tethys to the Tarim Basin in western China, its eastern edge being referred to as the Tarim Sea (Yong and Shan, 1986; Tang et al., 1989, 1992; Burtman, 2000; Bosboom et al., 2011, 2014a, 2014b; Carrapa et al., 2015; Sun et al., 2016a, 2016b). The transgressive–regressive cycles documented in the stratigraphic succession of the Tarim Basin were controlled not only by the multistep uplift of the Tibetan plateau and by global climatic changes, but were closely linked as well to the aridification and monsoonal climate in Asia (Ramstein et al., 1997; Zhang et al., 2007; Licht et al., 2014). Previous studies have focused on the timing of final disappearance of the Tarim Sea and its paleoclimatic implications (Bosboom et al., 2011, 2014a, 2014b; Sun and Jiang, 2013; Carrapa et al., 2015; Sun et al., 2016a, 2016b), whereas the initial encroachment of the sea in the Cretaceous and the earlier stages of basin's evolution were not paid the same attention (Xi et al., 2015). Two competing models have been proposed to account for forced-regression stages, i.e. primary climatic-eustatic (Bosboom et al., 2011, 2014a, 2014b) versus tectonic control (Carrapa et al., 2015; Sun et al., 2016a, 2016b), but the controversy has remained unresolved. It is generally assumed that the Pamir-West Kunlun orogen has developed as a far-field consequence of the India-Asia continental collision since ~65–50 Ma (Hu et al., 2017). However, the timing of initiation of rapid uplift is hotly debated, and estimates, based on the study of the northwest margin of the Tibetan plateau with diverse approaches range widely from Late Eocene to Pliocene time (Sobel and Dumitru, 1997; Zheng et al., 2000; Yin et al., 2002; Wang et al., 2003; Li et al., 2011; Jiang and Li, 2014).

The Cretaceous and Palaeogene periods are generally considered as the warmest time interval in geological history, characterized by enhanced greenhouse conditions and high sea level (Miller et al., 2005; Hu et al., 2012b). However, the magnitude and time-steps of global sea-level rise during these periods are still unprecisely assessed, even though a series of global sea-level curves have been proposed (e.g. Haq

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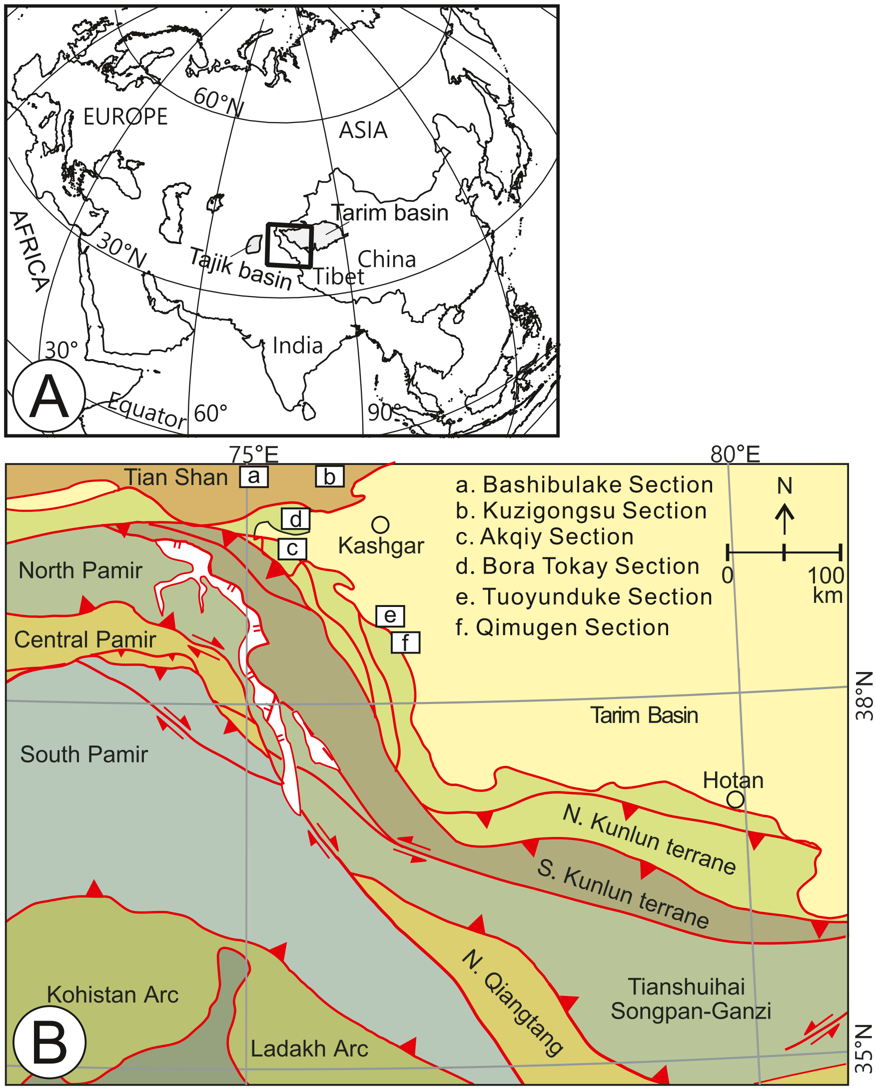

Fig. 1. Location of the Tarim Basin (A) and simplified tectonic map of the Pamir collision zone (B; modified from Cowgill, 2009) showing locations of the six measured sections.

et al., 1987; Miller et al., 2005; Haq, 2014; Cloetingh and Haq, 2015). Sedimentation in the Tarim Sea took place in a relatively stable epicontinental environment, and was thus very sensitive to sea-level change. The variations in paleowater-depth documented in the stratigraphic record, therefore, offer a key to evaluate the local response to both eustatic fluctuations and regional tectonic activity, and to unravel tectonic evolution and changes in paleoclimate along the northern margin of the Tibet Plateau, in the Pamir, and along the southern margin of the Tianshan range (Yong and Shan, 1986; Tang et al., 1992; Sun and Jiang, 2013; Bosboom et al., 2014a, 2014b; Carrapa et al., 2015; Sun et al., 2016a, 2016b).

In this study, six stratigraphic sections were measured in the West Kunlun and southern Tianshan areas of the western Tarim Basin (Fig. 1). Sedimentary structures and carbonate lithofacies were described, and the distribution of sedimentary environments, changes of paleowater-depth, and the formation and subsidence history of the Tarim Sea were reconstructed. The factors that controlled the appearance, evolution, and disappearance of the Tarim Sea could thus be clarified.

2. Geological setting

The study area is located in the western Tarim Basin (Xinjiang Uygur Autonomous Region, China), and is bounded to the north by the Tianshan range, to the west-southwest by the Pamir, and to the south by the West Kunlun range, with the vast Taklimakan Desert to the east (Fig. 1). This area presents continuously exposed stratigraphic successions documenting the entire age spectrum since the Jurassic. The sequence includes Jurassic-Lower Cretaceous non-marine strata, an Upper Cretaceous-Eocene transitional (marine-continental) interval, and continental deposits from the Oligocene upward (Compiling Group for Xinjiang Regional Stratigraphic Chart, 1981; Zhou, 2001). This study focuses on the Upper Cretaceous to Eocene marine-transitional successions.

2.1. Lithostratigraphy

The Upper Cretaceous-Lower Paleocene marine-transitional sequence, defined as Yingjisha Group, is composed of the Kukebai, Wuyitake, Yigeziya, and Tuyiluoke formations from bottom to top. (Tang et al., 1989, 1992; Hao et al., 2001). Among them, Wuyitake, Yigeziya, and Tuyiluoke are collectively known as Dongba Formation on the southern Tianshan areas (Tang et al., 1989). The Kukebai Formation is dominated by gray-green argillite, muddy siltstone and limestone, interbedded with gypsum and dolostone. The Wuyitake Formation consists of orange-red argillite, gypsiferous argillite, and siltstone. The Yigeziya Formation is dominated by white and purple-red