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Invited review

Middle-Late Jurassic tectonostratigraphic evolution of Central Asia, implications for the collision of the Karakoram-Lhasa Block with Asia

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ABSTRACT

Mesozoic basins in different regions of Central Asia provide important records for investigating relationships between intraplate deformation in Central Asia and tectonic processes at Asian boundaries. The present study gives a review of the stratigraphic and structural evolution of basins in different regions of Central Asia during the Middle-Late Jurassic. It is shown that basins and mountain belts in northwest China experienced compressional deformation and were wholly or partially uplifted during the late Middle-Late Jurassic. Compared to extensively-distributed Middle Jurassic coal-bearing strata in northwest China, Upper Jurassic strata characterized by red mudstones and conglomerates have a much smaller distribution. In the mean time, the Tibet-Pamir plateau also underwent a folding and uplift event, and Upper Jurassic sedimentary rocks are generally missing in the Pamir and western Tibet. The intense compressional deformation and uplift event of the late Middle-Late Jurassic from the Tibet-Pamir plateau to northwest China requires a new tectonic model, as proposed here. We suggest that the Karakoram and Lhasa blocks were a single giant block, which was accreted to Asia in the late Middle Jurassic-earliest Cretaceous and cross-cut by the Karakoram Fault in the Cenozoic. During the Callovian, the western part of the Karakoram-Lhasa Block initially collided with the southern Asian margin. Collision and continued convergence during the late Middle-Late Jurassic caused sinistral strike-slip faulting along the Central Badakhshan Fault and South Tian Shan Suture, accommodating crustal shortening in areas to the southeast of the faults: the Pamir, western Tibet, Tarim Block, Qilian-Qaidam Block, and Bei Shan. Meanwhile, the northeastward transpressional motion of the Tarim Block produced strong compressional stresses to areas north of the Tarim Block: the Kyrgyz Tian Shan, Central Tian Shan, Junggar Basin, and Turfan Basin. With the northward movement of the Karakoram-Lhasa Block, the eastern part of the Karakoram-Lhasa Block began to collide with the southern Asian margin during the latest Jurassic-earliest Cretaceous, resulting in strong crustal deformation and thickening in East Asia and Central Asia.

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1. Introduction

Exploring mechanisms of Mesozoic intraplate deformation in Central Asia can help us to better understand the relationships between tectonic processes operating along Asian margins and the geological evolution in intraplate regions in Central Asia during the Mesozoic (Fig. 1). Traditionally, evolution of basins (Junggar, Turfan, and Tarim) in northwest China during the Late Triassic-Late Cretaceous was interpreted to have been driven by far-field effects of collisional events along the southern Asian margin (Watson et al., 1987; Hendrix et al., 1992) (Fig. 2). However, with the emergence of more detailed geological data in intraplate regions of Central Asia, the traditional tectonic interpretation has been questioned (e.g., Ritts and Biffi, 2001; Vincent and Allen, 2001; Lamb et al., 2008; Yang et al., 2015a), and, therefore, new problems have been raised. For example, what caused strong contractional deformation, rapid exhumation, and deposition of thick conglomerate beds in Central Asia during the late Middle-early Late Jurassic (Fig. 2)?

During the Late Jurassic, the Zhayier Shan and the western and central parts of the Junggar Basin were folded and uplifted (Yang et al., 2015a) (Fig. 2). Thrusting occurred in the Bei Shan during the late Middle Jurassic, and Lower-Middle Jurassic coal-bearing strata were truncated by thrust faults (Zheng et al., 1996). In the southwestern Tarim Basin, Middle Jurassic shales and sandstones are sharply overlain by Upper Jurassic boulder to cobble conglomerates (Sobel, 1999). During the late Middle Jurassic-earliest Cretaceous, a significant contractional deformation and metamorphism event occurred in the Pamir (Dronov and Leven, 1963; Burtman and Molnar, 1993; Hildebrand et al., 2001; Robinson, 2015). In most areas of the Pamir, Upper Jurassic and lowermost Cretaceous rocks are missing and Upper Cretaceous conglomerates or limestones unconformably overlie folded Middle Jurassic strata (Dronov and Leven, 1963; Gaetani et al., 1990; Burtman and Molnar, 1993; Leven, 1995; Gaetani, 1997; Zanchi and Gaetani, 2011). In addition, thermochronologic data record a cooling event during the late Middle Jurassic-early Late Jurassic in many mountain belts in Central Asia, including the Zhayier Shan, Choltagh Shan, Central Tian Shan, South Tian Shan, Kyrgyz Tian Shan, Northern Pamir, Central Pamir, West Kunlun Shan, East Kunlun Shan, and Altyn Tagh Shan (Fig. 2, references therein).

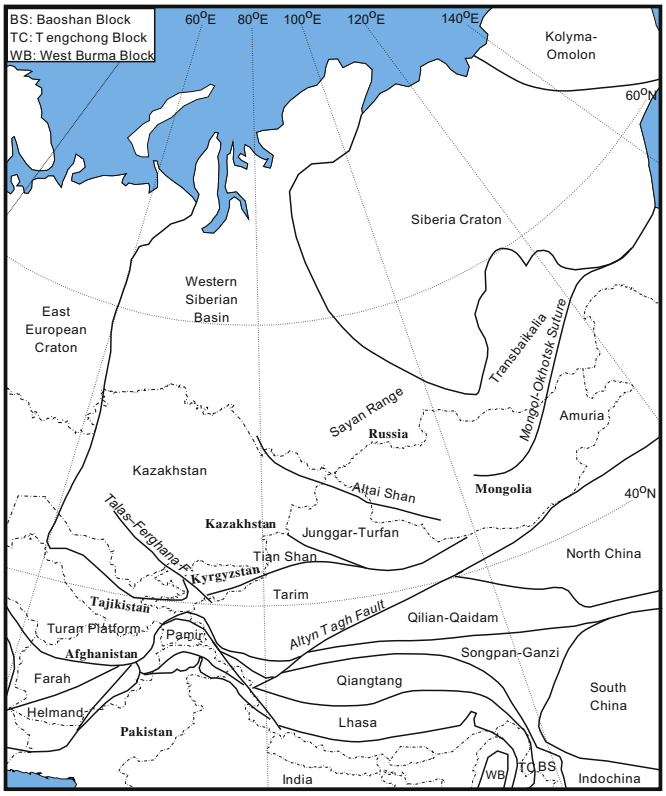

Fig. 1. Simplified tectonic map of Asia, modified from Ma (2002).

As bimodal volcanic rocks of 162–151 Ma formed in half-grabens in Transbaikalia (Donskaya et al., 2013) and extensional basins developed in central and eastern Mongolia during the Late Jurassic (Johnson, 2004; Johnson et al., 2014) (Fig. 1), it is implied that no strong compressional event occurred in the northern Asian Plate during the early Late Jurassic, such as closing of the Mongol-Okhotsk Ocean, to cause the abovementioned deformation event in Central Asia. Precise radiometric and paleontological dating of the Lhasa collisional event suggests that the main part of the Bangong-Nujiang Tethys Ocean closed during the Early Cretaceous (Kapp et al., 2007a; Baxter et al., 2009; Zhu et al., 2013, 2016; Fan et al., 2014) (Fig. 2), which could not be the cause of the deformation event in Central Asia too. Yang et al. (2015a) suggested that a continental collision of a microcontinent in the Pamir with the southern Asian margin possibly occurred during the late Middle Jurassic-early Late Jurassic, resulting in strong compressional deformation, deposition of thick conglomerates, and rapid exhumation in the Pamir, Junggar Basin, and other areas of Central Asia.

Yang et al. (2015a)'s hypothesis seems inconsistent with the common knowledge of accretionary history in the Pamir. It has been generally thought that Cimmerian orogenic events related to closing of the Paleo-Tethys had ended by the Early Jurassic and no continental collision occurred in the Pamir during the Middle Jurassic-Early Cretaceous (Gaetani et al., 1993, 2013; Gaetani, 1997; Zanchi et al., 2000; Zanchi and Gaetani, 2011; Angiolini et al., 2013, 2015; Faisal et al., 2014, 2016; Robinson, 2015). However, some researchers proposed that the Karakoram Block is the westward continuation of the Lhasa Block and that the Karakoram-Lhasa block was accreted with Asia during the Late Jurassic-Early Cretaceous (e.g., Sengör and Natal'in, 1996; Rolland, 2002; Lacassin et al., 2004; Rolland et al., 2002, 2009; Mahar et al., 2014, 2016). Moreover, no geological evidences have been provided to conclusively indicate that the Karakoram Block collided with the Asian margin during the latest Triassic-Early Jurassic as suggested by Zanchi and Gaetani (2011), e.g., *syn*-collisional magmatism, UHP-HP metamorphism, or strong structural deformation, etc.

In the present study, we first give a review of the stratigraphic and structural evolution of basins in different regions of Central Asia during the Middle-Late Jurassic, to summarize the significant effects of the late Middle-early Late Jurassic tectonic event. Secondly, a tectonic model is proposed to establish a causal relationship between the collisional event of the Karakoram-Lhasa Block with Asia and intraplate deformation in Central Asia during the late Middle-Late Jurassic. Finally, we compare the pre-Tertiary stratigraphic evolution histories of the northern Karakoram Block and the western Lhasa Block, to support the suggestion of a single Karakoram-Lhasa Block before the India-Asia collision. Not only does the new tectonic reconstruction of Central Asia provide a new interpretation for intraplate deformation of Central