Journal of Asian Earth Sciences 118 (2016) 111–124

Contents lists available at ScienceDirect

Journal of Asian Earth Sciences

journal homepage: www.elsevier.com/locate/jseaes

Magnetostratigraphy of syntectonic growth strata and implications for the late Cenozoic deformation in the Baicheng Depression, Southern Tian Shan

Zhiliang Zhang [a,b,*], Jimin Sun [a,c], Zhonghua Tian [a], Zhijun Gong [a]

[a] Key Laboratory of Cenozoic Geology and Environment, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China
[b] University of Chinese Academy of Sciences, Beijing 100049, China
[c] CAS Center for Excellence in Tibetan Plateau Earth Sciences, China

ARTICLE INFO

Article history:
Received 23 July 2015
Received in revised form 18 December 2015
Accepted 30 December 2015
Available online 12 January 2016

Keywords:
Magnetostratigraphy
Growth strata
Cenozoic deformation
Southern Tian Shan

ABSTRACT

The collision between India and Eurasia in the Cenozoic has caused a series of intracontinental deformation in the foreland basins of Tian Shan, but there are debates about the timing of tectonic deformation and the relationship between tectonic uplift and sediment accumulation in the foreland basins. Based on the magnetostratigraphy of growth strata in the Baicheng Depression, Southern Tian Shan, we suggest that an episode of crustal shortening in the late Cenozoic evidenced by syntectonic growth strata in the Kelasu-Yiqikelike structural belt (KYSB) initiated at ~5.3 Ma, since then the sedimentation rate accelerated abruptly and coarse molasse deposits accumulated. Combined with the results of growth strata on both flanks of Tian Shan and the fact that the Xiyu Formation on the southern limb of the Kasangtuokai Anticline was involved into the growth strata, we conclude that the period from ~7–5 Ma to the early Pleistocene was one of the important episodes of intracontinental deformation in the foreland basins of Tian Shan, as a response to the Cenozoic collision between India and Eurasia.

1. Introduction

The Tian Shan Range, stretching east–west for at least 2500 km (Fig. 1a), is a late-Paleozoic orogen (Burtman, 1975; Windley et al., 1990; Allen et al., 1991, 1993; Xiao and Kusky, 2009) but was denuded into peneplain in the Mesozoic (e.g., Zhang and Wu, 1985; Shu et al., 2004; Du and Wang, 2007; Gao et al., 2014), the present high relief of Tian Shan is attributed to the tectonic reactivation as a response to the intracontinental deformation of the Cenozoic India–Eurasia collision (Molnar and Tapponnier, 1975; Patriat and Achache, 1984; Avouac et al., 1993).

The collision between India and Eurasia has caused intense deformations within Asia (Avouac et al., 1993). The crustal movement measured from GPS observations indicated that the convergence is still ongoing (Abdrakhmatov et al., 1996; Wang et al., 2001). In Tian Shan and its adjacent areas, 80–90% of the total convergence was absorbed by the N–S shortening along the southern and northern edges (Yang et al., 2008). As one of the most famous intracontinental belts in the world, the Tian Shan Range, lying in the north of the Tarim Basin, provides significant potentials for studying intracontinental deformation and mountain building.

To the north and south, Tian Shan is flanked by sedimentary foreland basins. In the Southern Tian Shan, the Baicheng and Kuqa depressions are examples of Cenozoic forelands (Fig. 1). The fold-and-thrust belts at Baicheng and Kuqa, roughly parallel to the Southern Tian Shan, indicating that the Cenozoic intracontinental deformation and crustal shortening is caused by N–S contraction (Tapponnier and Molnar, 1979; Avouac et al., 1993; Burchfiel et al., 1999; Sun et al., 2004, 2009).

However, due to the absence of paleonotological fossils and volcanic rocks appropriate for accurately dating, the age of the Cenozoic deposits within the foreland basins are still controversial. Although some magnetostratigrahpic studies have been carried out in recent years (e.g., Teng et al., 1997; Charreau et al., 2005, 2006, 2009a; Huang et al., 2006, 2010; Zheng and Meng, 2006; Sun et al., 2004, 2009; Zhang et al., 2014), the ages of Cenozoic deposits, especially the Paleogene deposits, have not been well constrained. Moreover, the exact timing of tectonic uplift of Tian Shan is still in debate. There have been several different opinions about the timing of the major tectonic deformation and uplift ranging from Eocene (Du and Wang, 2007; Du et al., 2007) to Oligocene

* Corresponding author at: Key Laboratory of Cenozoic Geology and Environment, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China.
E-mail address: zhangzhiliang.1987@163.com (Z. Zhang).

http://dx.doi.org/10.1016/j.jseaes.2015.12.024
1367-9120/

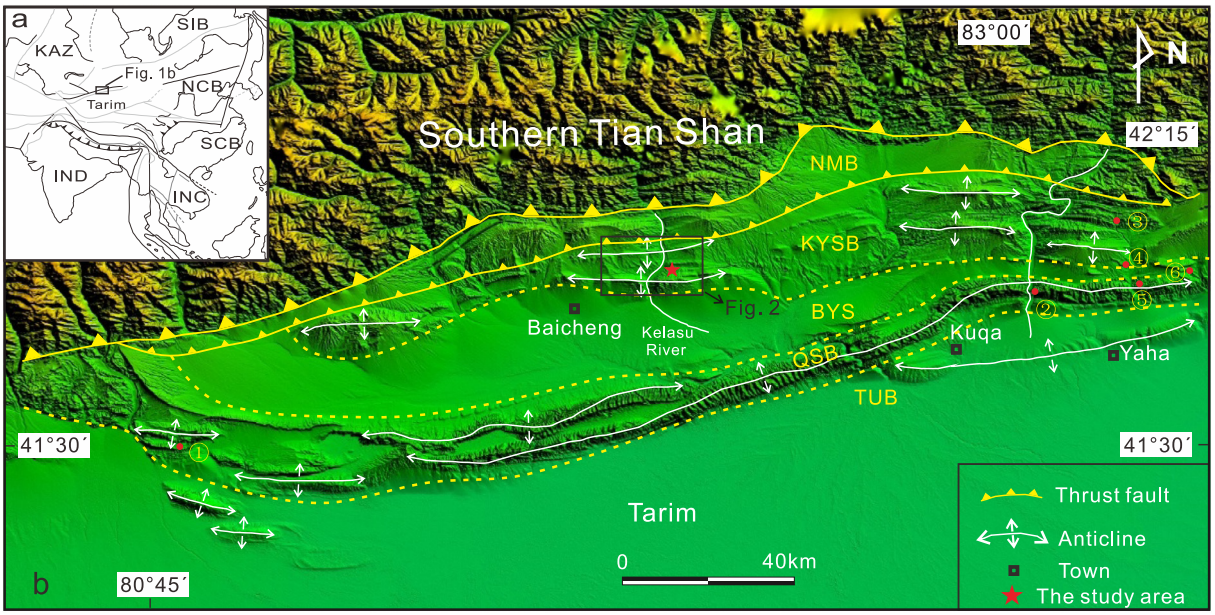

Fig. 1. (a) Simplified structural map of Asia showing the location of the Baicheng Depression. KAZ: Kazakhstan, IND: India, SIB: Siberia, NCB: North China Block, SCB: South China Block, INC: Indochina. (b) Topographic map showing tectonic framework of the Baicheng Depression and the location of the Kelasu section. NMB, KYSB, BYS QSB and TUB are the abbreviation for the northern monocline belt, Kelasu-Yiqikelike structural belt, Baicheng-Yangxia sags, Qiulitag structural belt and Tabei uplift belt, respectively. (1) Jing et al. (2011); (2) Sun et al. (2009); (3) Huang et al. (2006); (4) Huang et al. (2010); (5) Charreau et al. (2006); (6) Zhang et al. (2014).

(Windley et al., 1990; Hendrix et al., 1994; Yin et al., 1998; Sobel et al., 2006), late Miocene (Abdrakhmatov et al., 1996; Bullen et al., 2003; Sun et al., 2004, 2009; Charreau et al., 2005, 2006, 2009a; Huang et al., 2006; Ji et al., 2008; Sun and Zhang, 2009), Pliocene (Fu et al., 2003), or even early Pleistocene (Burchfiel et al., 1999). These differences are mostly due to the different methods used to constrain the initial time of intracontinental deformation or probably regional diachronous uplifts.

Growth strata are direct evidence of deformation in foreland basins because the formation of growth strata is synchronous with fault-related folding. In this context, constraining the initial time of syntectonic sediments is essential for understanding the deforming history and the relationship between tectonics and deposition (Suppe et al., 1992; Burbank et al., 1996). Although syntectonic growth strata of the second Cenozoic fold belts both in the northern and southern foreland basins of Tian Shan have been studied (Hubert-Ferrari et al., 2007; Sun and Zhang, 2009; Sun et al., 2009; Lu et al., 2010; Wang et al., 2011), the chronology of syntectonic deposits in other structural belts and their links with the Cenozoic deformation are still not clear.

The aims of this paper are to address: (1) the chronology of the syntectonic growth strata in the Baicheng foreland basin of the Southern Tian Shan; (2) constrain the timing of the late Cenozoic deformation evidenced by growth strata at Baicheng; and (3) understand the relationship between sedimentation and mountain building.

2. Geological setting and stratigraphy

The Baicheng Depression, located in the piedmont of the Southern Tian Shan, is the north edge of the Tarim Basin (Fig. 1b). As a consequence of Cenozoic N–S compressive stress, five structural belts can be divided in the Baicheng and Kuqa depressions (Fig. 1b). From north to south, they are: the northern monocline belt (NMB), Kelasu-Yiqikelike structural belt (KYSB), Baicheng-Yangxia sags (BYS), Qiulitag structural belt (QSB) and Tabei/Frontal uplift belt (TUB) (Lu et al., 1999; Zhang et al., 2013; Yu et al., 2014). The strata exposed in the Baicheng and Kuqa depressions, in the foothills of the Southern Tian Shan, show classic sedimentary and structural features of foreland basins (Lu et al., 1994; He and Chen, 2004). The Mesozoic to Cenozoic strata were deformed in the Baicheng and Kuqa depressions, forming three roughly parallel rows of fold-and-thrust belts (Fig. 1b), which are visible in the satellite images. The first row contains two anticlines (the Kumugeliemu Anticline to the north and the Kasangtuokai Anticline to the south) and one syncline between them, cut by the south-flowing Kelasu River (Figs. 1 and 2). The Kumugeliemu and Kasangtuokai anticlines are composed of Cretaceous to Pliocene and Eocene to Pleistocene strata, respectively. The Qiulitag Anticline (the second row) consists of Miocene to Pleistocene strata, while the Yaken Anticline (the third row) consists of deposits since the Pliocene.

The strata in the Baicheng Depression range from Mesozoic to Quaternary in age. The Eocene Kumugeliemu formation with basal age of ~54 Ma (Zhang et al., 2015) are characterized by green-gray conglomerates in the lower part and reddish mudstones interbedded with gravels in the upper part. The sedimentary environments were alluvial-lacustrine (GMRMXUAR, 1993; Sun et al., 1999; Li et al., 2012). The existence of thin (usually less than 10 cm, mostly 1–2 cm) layers of gypsum occasionally intercalated in the reddish mudstone indicating very short episodes of enhanced evaporation of paleolakes. The overlying Suweiyi Formation consists of reddish mudstones/siltstones occasionally with thin gravel intercalations in the upper part. The thin horizontal lamina, rhythmical bedding and the dominant fine particle size imply lacustrine environment. The Oligocene–Miocene Jidike Formation is dominated by reddish mudstones/siltstones as well as commonly interbedded with greenish siltstones and conglomerates representing fluvial-lacustrine condition. The late Miocene Kangcun Formation is mainly composed of brownish siltstones interbedded with conglomerates while the Pliocene Kuqa Formation is dominated by brownish siltstones interbedded with thick conglomerates. The coarsening trend from the Jidike to the Kuqa formations indicates proximal and higher energy transportation. The Xiyu Formation which is widespread around the Tian Shan forelands consists of gray pebble to conglomerates. Its basal age is still in controversial from the latest Pliocene to the early Pleistocene (e.g., Sun et al.,