Journal of Asian Earth Sciences 37 (2010) 350–360

Contents lists available at ScienceDirect

Journal of Asian Earth Sciences

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

Commencing uplift of the Liupan Shan since 9.5 Ma: Evidences from the Sikouzi section at its east side

Xiubin Lin [a,b,c,*], Hanlin Chen [a,b], Karl-Heinz Wyrwoll [c], Xiaogan Cheng [a,b]

[a] Department of Earth Sciences, Zhejiang University, Hangzhou 310027, China
[b] Research Center for Structures in Oil and Gas Bearing Basin, Ministry of Education, Hangzhou 310027, China
[c] School of Earth and Environment, The University of Western Australia, Stirling Highway, Crawley, WA 6009, Australia

ARTICLE INFO

Article history:
Received 17 February 2009
Received in revised form 17 July 2009
Accepted 30 September 2009

Keywords:
Sikouzi section
Liupan Shan
Northeast Tibetan Plateau
Miocene

ABSTRACT

The Cenozoic evolution of the Liupan Shan, situated at the northeast of the Tibetan Plateau, will provide constraints to test the models and mechanisms of the evolution of the plateau. In this contribution, the Sikouzi section, at the east of the Liupan Shan, has been selected to study Liupan Shan's uplift history. At around 9.5 Ma, constrained by the magnetostratigraphy, the sediment and depositing architecture characteristics obviously changed. Synchronously, flow direction changed from E → W to W → E, and accumulation rate increased to more than double. All these evidences suggest that the Liupan Shan initiated uplifting at around 9.5 Ma. Subsequently, a stage of intense uplift happened during 8.2–7.3 Ma, indicated by the apatite fission-track (AFT) data across the Liupan Shan. Regional comparison indicates that this stage of uplift is not only with local but also regional significance. The Miocene uplift of the Tibetan Plateau triggered the intensification of the East Asian Monsoon and Asian intercontinental aridity, which has been implied by the pollen results of the Sikouzi section.

1. Introduction

The formation of the Tibetan Plateau, with average elevation more than 5000 m, is one of the most dramatic geological events during Cenozoic around the world, which has exerted impacts to wide aspects, including tectonics, magmatism, crustal deformation, sedimentology, atmospheric circle variation and climate changes. Numerous models have been suggested to explain the formation, growth, evolution and mechanism of the Tibetan Plateau, e.g. episodic uplift (Li, 1995; Shi et al., 1998; Li and Fang, 1998; Zhong and Ding, 1996; Wang and Ding, 1998), convective removal around 8 Ma (Platt and England, 1993; Molnar et al., 1993; Molnar, 2005), oblique stepwise rise and growth (Tapponnier et al., 2001), entire intact Indian lithosphere thrusting beneath the Tibetan Plateau (Seeber and Ambruster, 1981), north–south shortening of southern Eurasian crust (England and Houseman, 1986), mid-lower crustal channel flow (Royden et al., 1997; Clark and Royden, 2000), growth from the central to southward and northward (Wang et al., 2008), etc.

Among the large-scaled mountain and fault ranges, triggered by the Indian–Asian collision, Haiyuan–Liupan Shan bounds the northeast margin of the present Tibetan Plateau. The study of the uplift timing of the Haiyuan–Liupan Shan range will provide constraints to test the models, which have been proposed to explain the formation, evolution and mechanism of the plateau.

Regarding to the uplift timing of the Haiyuan–Liupan Shan area, so far, it has been being a controversial issue. Zhang et al. (1991) and Burchfiel et al. (1991) proposed that the uplift and crustal deformation happened during late Pliocene and early Quaternary. However, as lack of reliable technique to constrain the timing, this timing has uncertainty to some extent. More recent studies, based on the structural geology, magnetostratigraphy, apatite fission-track thermochronology, implied that the uplift probably occurred during late Miocene (Song et al., 2001; Ding et al., 2004; Zhang et al., 2006; Zheng et al., 2006a). However, Zhang et al. (2005), based on the sedimentology of this area, proposed an even older uplift timing, around 30–40 Ma. This controversy is partly because that different sites or sections and methods have been selected in their studies. Another reason probably is that the uplift and existing relief occurred since late Cretaceous through early Cenozoic has not been taken into consideration.

In this contribution, a well-exposed section, the Sikouzi section at the east side of the Liupan Shan, has been selected to study the sedimentology and palaeo-flow direction. Combined with the previous magnetostratigraphy and apatite fission-track results, the authors determine the timing of the commencing uplift of the Liupan Shan to be around 9.5 Ma. After then, the Liupan Shan underwent a stage of intense uplift since 8.2–7.3 Ma.

* Corresponding author. Address: Department of Earth Sciences, Zhejiang University, Hangzhou 310027, China. Tel.: +86 571 87952791; fax: +86 571 87951336.
E-mail address: linxiubin1984@163.com (X. Lin).

1367-9120/$ - see front matter © 2009 Elsevier Ltd. All rights reserved.
doi:10.1016/j.jseaes.2009.09.005

2. Geologic setting

The studied Haiyuan–Liupan Shan area is situated at the northeast of the Tibetan Plateau. It consists of four ranges of mountains and related intermont basins (Fig. 1). Haiyuan–Liupan Shan fault belt connects the Qinling and Qilian orogen in the south and west, respectively, while stable Ordos and Ala Shan blocks stand at the east and north.

The Sikouzi section, around 35 km northwest to the Guyuan City, with a GPS of 36.299°N and 106.034°E, at the east of the Liupan Shan northeast Tibetan Plateau, has been exposed by the incision of the river sourced from the Liupan Shan. The entire Cenozoic sequences have been well-exposed in this section, with a thickness of 3263 m. The Cenozoic sequences cover the lower Cretaceous in an unconformity, with the upper Cretaceous sequences absent. All the lower Cretaceous and Cenozoic sequences have been deformed to form a syncline and an anticline. The Quaternary loess covers the Cretaceous and Cenozoic sequences in an angular unconformity.

The stratigraphical division of the Cenozoic sequences is still a controversial issue. In the past, Cenozoic sequences have been divided into several formations, each of which means not only a lithological assemble, but also a timing signification (Zhang et al., 1991, 2005; Shen et al., 2001; Fu and Li, 2002). More recent studies took an advisable methodology, dividing the sequences into different successions to avoid using the formation names and being driven into the stratigraphical argument (Jiang et al., 2007; Jiang and Ding, 2008). In this paper, the authors will follow this methodology, dividing the Cenozoic sequences of the Sikouzi section into four successions based on the lithological variation (Fig. 2).

The first succession is predominated by red sands. Poorly cemented medium-graded sand and occasional fine-graded sand form mega cross beds and complex tabular cross bedding. The top of this succession is dominated by carbonate paleosol, with

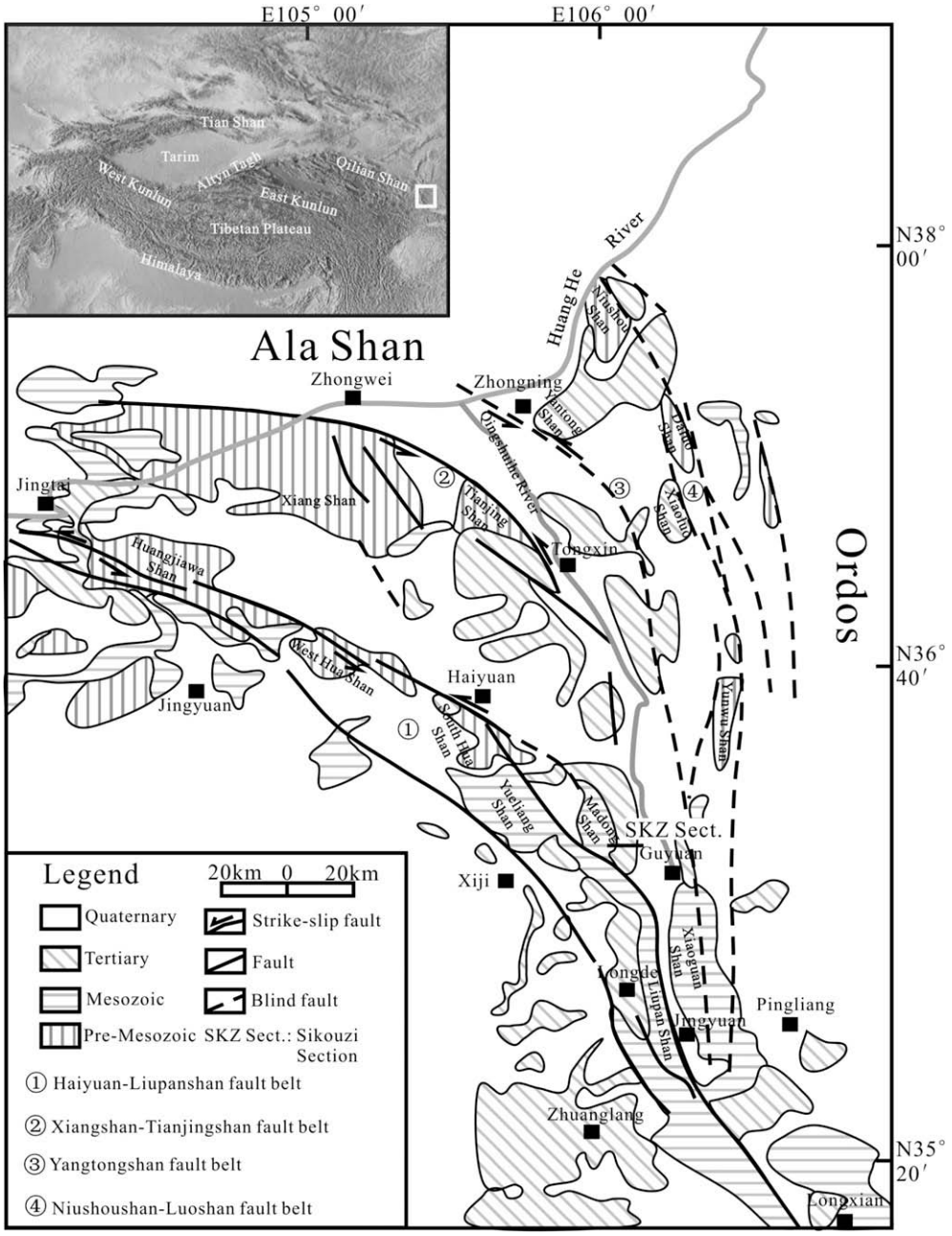

Fig. 1. Simplified geological map of the Haiyuan–Liupan Shan area and the situation of the studied Sikouzi section.