Palaeogeography, Palaeoclimatology, Palaeoecology 399 (2014) 21–30

Contents lists available at ScienceDirect

Palaeogeography, Palaeoclimatology, Palaeoecology

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

Palynological evidence for the latest Oligocene—early Miocene paleoelevation estimate in the Lunpola Basin, central Tibet

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ARTICLE INFO

Article history:
Received 3 June 2013
Received in revised form 16 January 2014
Accepted 5 February 2014
Available online 12 February 2014

Keywords:
Paleoaltitude
Lunpola Basin
Pollen
Central Tibet
Latest Oligocene–earliest Miocene

ABSTRACT

Uplift of the Tibetan Plateau is ultimately driven by the Cenozoic collision between the Indian and Eurasian plates and their continued convergence. One approach for studying the Tibetan Plateau uplift is to verify the paleoelevation changes from collision to present day. This is important for understanding both the tectonics and the climatic effects. The new high resolution palynological record of the uppermost Oligocene to the lowest Miocene strata from the Lunpola Basin indicates that the vegetation types during the latest Oligocene–earliest Miocene were dominated by mixed coniferous–broadleaved forests being different from the modern steppe vegetation. By using the Coexistence Approach to the fossil pollen records, after calibration the effects of temperature difference and the lapse rate, a maximum paleoelevation of 3190 ± 100 m asl was estimated in the Lunpola Basin in the latest Oligocene–earliest Miocene, being 1500 to 2000 m lower compared with the previous oxygen isotope paleoelevation in the same region.

1. Introduction

The uplift of the Tibetan Plateau is the result of the India and Eurasia collision at least since the early Cenozoic (e.g. Molnar and Tapponnier, 1975; Besse et al., 1984; Patrait and Achache, 1984; Harrison et al., 1992; Yin and Harrison, 2000). The Tibetan Plateau is characterized not only by the highest elevation but also by the largest area among orogenic belts on earth. By now, many important tectonic questions are still being debated: what mechanisms can account for the uplift of the highest plateau? Did the different blocks which constitute the Tibetan Plateau have initial elevations before collision? How about the question of diachronous uplift among different parts of the plateau? When did the plateau reach the present elevation?

Although there have been many different methods for understanding the above questions, one important approach is to study the paleoelevation of different blocks of Tibet before and after collision (e.g. Xu et al., 1973; Zhao and Morgan, 1985; Coleman and Hodges, 1995; Harrison et al., 1995; Fielding, 1996; Chung et al., 1998; Garzione et al., 2000a,b; Tapponnier et al., 2001; Williams et al., 2001; Wang et al., 2006; Deng et al., 2012; Wang et al., 2013).

In recent years, oxygen isotope paleoaltimetry has been widely used in estimating paleoelevation in Tibet (e.g., Garzione et al., 2000a; Cyr et al., 2005; Rowley and Currie, 2006; DeCelles et al., 2007; Rowley and Garzione, 2007; Xu et al., 2013). This technique relies on the systematic trends in the isotopic composition of modern precipitation of different topography. However, such studies have great uncertainties due to: (1) the commonly used authigenic mineral is carbonate, which is an unstable mineral under surface geochemical environment, both the diagenesis and the climate-induced chemical weathering can alter the isotopic compositions of carbonate; and (2) the Tertiary hydrological conditions, temperature and water vapor sources must be different compared with the present scenario, therefore the present stable isotopic altimeter cannot be directly used to the geological past.

Because the Tibetan Plateau elevation will have a direct effect on climate and flora, in this sense, paleobotany provides an alternative potential proxy for estimating paleoelevation. Xu et al. (1973) were the first to use the leaf fossils preserved in an elevation of 5700 m in the late Cenozoic deposits in the northern Himalaya to estimate the uplift history of Tibet. However, without considering the effect of Cenozoic climate cooling on plant distributions and elevations, their result underestimated the paleoelevation of the Himalaya Mountains. Recently, Spicer et al. (2003) estimated the paleoelevation of southern Tibet and concluded that the present elevation was reached 15 million years ago (Ma) by using a new technique on leaf physiognomy. Apart from the studies of leaf fossils, pollen assemblages have been also used to reconstruct

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http://dx.doi.org/10.1016/j.palaeo.2014.02.004
0031-0182/

paleoclimate in the Tibetan Plateau (e.g. Wang et al., 1975; Hoorn et al., 2000; Sun and Wang, 2005; Lu et al., 2007; Dupont-Nivet et al., 2008; Miao et al., 2013a,b).

The Co-existence Approach (CoA) is a method for quantitative terrestrial paleoclimate reconstructions in the tertiary (Mosbrugger and Utescher, 1997). The basic idea of CoA is very simple and follows the nearest living relative philosophy, with the assumption that the climatic requirements of a fossil taxon are similar to those of a very close living relative. As a whole, CoA has proven to be very useful in quantitative terrestrial paleoclimate reconstructions (e.g., Ivanov et al., 2002; Liang et al., 2003; Ivanov et al., 2007; Utescher et al., 2009; Jacques et al., 2011), although there are a few exceptions (e.g., Grimm and Denk, 2012; Hao et al., 2012). In this study, the maximum overlap of the environmental tolerances of all the nearest living relatives is regarded as being indicative of the most likely paleoaltitude following the method used by Song et al. (2010). In this study, the temperature difference between the geological past and the present, used for correcting paleoelevation, is not deduced by the CoA method but by GCM modeling results with considerations of the past boundary conditions (e.g., paleogeographic position, CO_2 concentrations and CH_4 values).

Song et al. (2010) used this technique and estimated the Eocene–Miocene elevation of central Tibet. However, their chronology is from earlier reported microfossil age assignments with great uncertainties (e.g. Wang et al., 1975; Xu, 1980; Xia, 1982; Xia, 1983; Bureau of Geology and Mineral Resources Xizang Autonomous Region, 1993; Rowley and Currie, 2006), and the used pollen data are from previous palynological records covering a variety of outcrops and lake cores.

The aim of this paper is to reconstruct paleo-vegetation and estimate the latest Oligocene to early Miocene paleoelevation in central Tibet, based on the new age control and the high resolution pollen record of the Cenozoic sediments in the Lunpola Basin.

2. Geological settings, materials and methods

The studied Lunpola Basin is a Tertiary rift basin situated along the central part of the Bangong–Nujiang Suture Zone, which extends east–west for a distance of approximately 220 km and a width of 15–20 km (Fig. 1a). The present elevations of this basin vary between 4600 m and 5040 m above sea level (asl). The Cenozoic deposits in the basin can be up to 4000 m thick (Xu, 1980). Such deposits are deformed associated with the Cenozoic thrusting and folding within the basin. The Cenozoic sediments mainly consist of two stratigraphic units: the Niubao Formation in the lower part, and the Dingqing Formation in the upper part. The Niubao Formation, with a thickness of about 3000 m, is marked by reddish clastic deposits, dominated by mudstone, sandstone and gravel, mostly representing fluvial to marginal lake environment. It

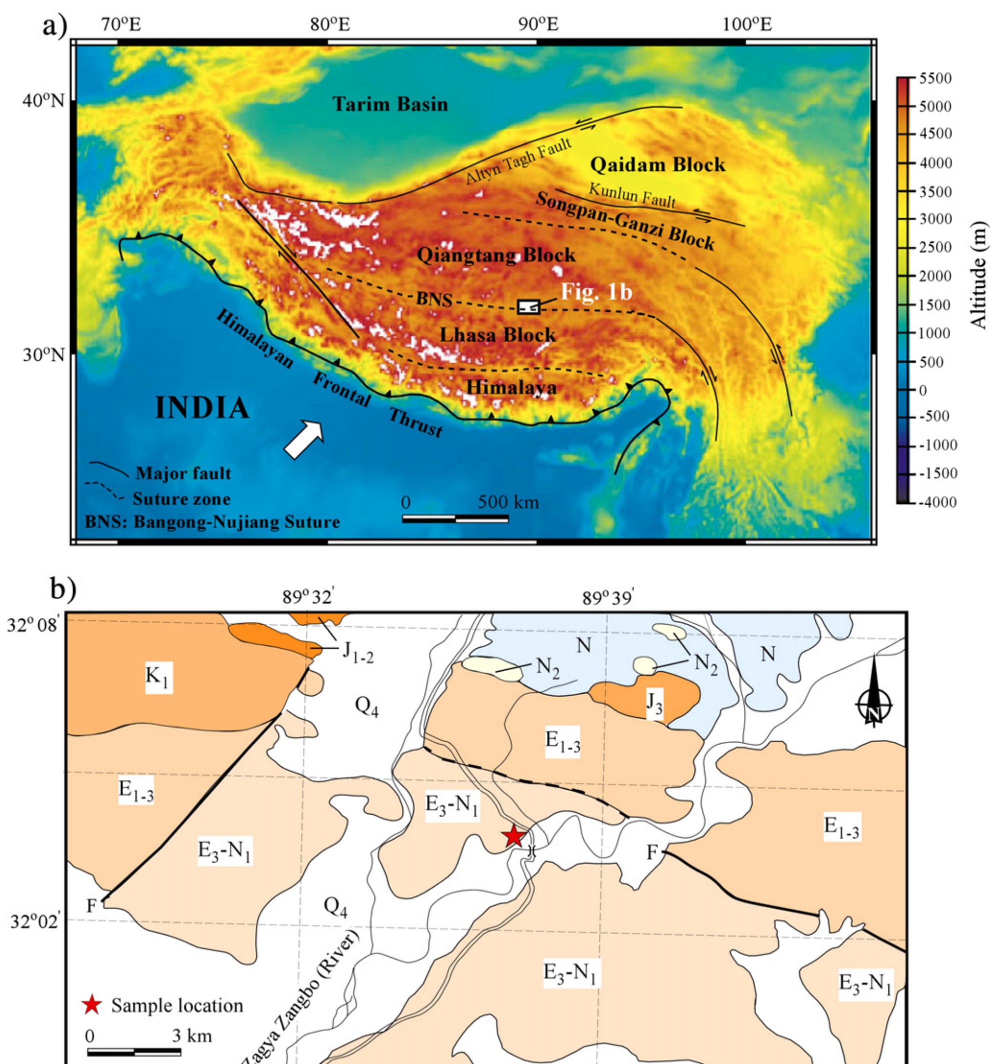

Fig. 1. (a) Digital elevation map of the Tibetan Plateau and its neighboring region showing the main tectonic terranes of Tibet and location of the Lunpola Basin. (b) Schematic geological map of the study area (revised Wang, 2012); red star indicates the location of the section.