Gondwana Research 31 (2016) 241–252

Contents lists available at ScienceDirect

Gondwana Research

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

A Late-Eocene palynological record from the Hoh Xil Basin, northern Tibetan Plateau, and its implications for stratigraphic age, paleoclimate and paleoelevation

Yunfa Miao [a], Fuli Wu [b,c,*], Hong Chang [d], Xiaomin Fang [b,c], Tao Deng [e], Jimin Sun [f], Chunsheng Jin [f]

[a] *Key Laboratory of Desert and Desertification, Cold and Arid Regions Environmental and Engineering Institute, Chinese Academy of Sciences, Lanzhou 730000, China*
[b] *Key Laboratory of Continental Collision and Plateau Uplift, Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Beijing 100010, China*
[c] *CAS Center for Excellence in Tibetan Plateau Earth Sciences, Beijing 100101, China*
[d] *State Key Laboratory of Loess and Quaternary Geology, Institute of Earth Environment, Chinese Academy of Sciences, Xi'an 710075, China*
[e] *Key Laboratory of Evolutionary Systematics of Vertebrates, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing 100044, China*
[f] *Key Laboratory of Cenozoic Geology and Environment, Institute of Geology and Geophysics, Chinese Academy of Sciences, P.O. Box 9825, Beijing 100029, China*

ARTICLE INFO

Article history:
Received 18 July 2014
Received in revised form 3 January 2015
Accepted 13 January 2015
Available online 18 February 2015

Handling Editor: Z.M. Zhang

Keywords:
Tibetan Plateau
Palynology
Late Eocene
Paleoclimate
Paleoelevation

ABSTRACT

The Hoh Xil Basin, lying in the central Tibetan Plateau, is key to understanding the Cenozoic tectonics, paleoelevation and paleoclimate changes that have occurred in the Tibetan Plateau since the collision of the Indian and Asian tectonic plates. However, the stratigraphic age and paleoelevation indicated by the sediments of the Hoh Xil Basin remain hotly debated. Here we report on one palynological record from the TTH-C section, extracted from the Yaxicuo Group (the stratigraphic unit between the Fenghuoshan and Wudaoliang groups), and analyze its implications for stratigraphic age, paleoclimate and paleoelevation in the Hoh Xil Basin. The record shows that palynological taxa are mainly dominated by xerophytic *Ephedripites*, *Nitrariadites* (*Nitrariapollis*) and *Chenopodipollis*, with few ferns and conifers. Rich morphologies correspond well with those in the Xia Ganchaigou Formation (Fm) of the Qaidam Basin to the north. Palynological percentages are well correlated with the middle member of the Xia Ganchaigou Fm in the Qaidam Basin as well as the lower member of the Mahalagou Fm in the Xining Basin to the northeast. The ages of the middle member of the Xia Ganchaigou and lower member of the Mahalagou Fms from these two basins are both identical to the Bartonian Stage (~40–37 Ma) of the Late Eocene, according to their respective high-resolution magnetostratigraphic dating. This means that the age of the Yaxicuo Group at least covers the Bartonian Stage. Besides the Qaidam and Xining basins, the palynological assemblages of the TTH-C section are also similar to those of three other sites (the Jiuquan, Tu-ha and Hetao basins), indicating similarly arid climates dominated by a northwestern Chinese subtropical high, and a relatively low paleoelevation in the Hoh Xil Basin (mostly <2000 m a.s.l.) in the Late Eocene.

1. Introduction

The Tibetan Plateau, characterized by its immense size (ca. 2.5 million km^2) and highest average elevation (>4000 m a.s.l.) of all of the orogenic belts on Earth, was formed by the collision of the Indian and Eurasian tectonic plates which began in the early Cenozoic (e.g. Molnar and Tapponnier, 1975; Patrait and Achache, 1984; Harrison et al., 1992; Yin and Harrison, 2000; Aitchison and Davis, 2001; Wang et al., 2008; Xia et al., 2010; Aitchison et al., 2011; Zhang et al., 2012). Such major topographic uplift has not only altered the tectonics and distortion history of the lithosphere, but has also strongly influenced the global, and especially the Asian, climate, such as the inner Asian aridification and the development of the Asian monsoonal systems (e.g., Kutzbach et al., 1989; Molnar and England, 1990; Raymo and Ruddiman, 1992; Ramstein et al., 1997; Rea et al., 1998; Murakami, 2000; An et al., 2001; Molnar, 2005; Li et al., 2014). These topographic and paleoclimatic changes have been accompanied by the retreat of Paratethys (Ramstein et al., 1997; Fluteau et al., 1999), the opening and closing of straits (Haug and Tiedemann, 1998; Lawver and Gahagan, 1998; Potter and Szatmari, 2009), and even global cooling (Zachos et al., 2001; Miao et al., 2012). Study of the uplift history, paleoelevation and expansion of Tibetan Plateau is therefore critical to an understanding of paleoclimatic change in Eurasia. However, there is continued debate about the uplift time, paleoelevation and range. One opinion is that by the late Cenozoic the Tibetan Plateau had been strongly uplifted and had reached its modern height (Xu, 1978; Harrison et al., 1992; Molnar et al., 1993; Coleman and Hodges, 1995; Li and Fang, 1999; Garzione et al., 2000; Williams et al., 2001; Spicer

* Corresponding author at: Key Laboratory of Continental Collision and Plateau Uplift, Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Beijing 100010, China. Tel.: +86 10 8409 7056; fax: +86 10 8409 7079.
E-mail address: wufuli@itpcas.ac.cn (F. Wu).

http://dx.doi.org/10.1016/j.gr.2015.01.007
1342-937X/

et al., 2003; An et al., 2006; Sun et al., 2014). The second opinion, mainly based on stable isotope methods, argues that the Tibetan Plateau formed at the beginning of the Indian–Eurasian collision and reached its modern height in the early Cenozoic (Cyr et al., 2005; Rowley and Currie, 2006; DeCelles et al., 2007; Mulch and Chamberlain, 2007; Polissar et al., 2009; Quade et al., 2011; Xu et al., 2013; Ding et al., 2014). The reasons for such divergent conclusions are possibly related to the different methods or proxies used, such as geomorphological analysis (Li, 1995), vs. fossilized plant analysis (Xu, 1978; Spicer et al., 2003) or stable isotope analysis (Quade et al., 2011 and references therein; Xu et al., 2013; Ding et al., 2014). Another possibility is that different age estimations for the same strata may vary widely dependent upon the parameter used. For example, in Hoh Xil, basin catchment's paleoelevation yield results closer to 4000 m (Quade et al., 2011), in contrast to the 2000 m (Cyr et al., 2005) indicated by isotope data, or the 1400/2600 m suggested by D/H ratios of lipid biomarkers (Polissar et al., 2009). However, these ages remain fiercely debated (Liu et al., 2003; Duan et al., 2008; Staisch et al., 2014). Such uncertainties impede further interpretation of the scientific studies mentioned above.

The Hoh Xil Basin, located in the central Tibetan Plateau, is the largest continental Cenozoic basin in the plateau's interior (Fig. 1; Liu and Wang, 2001). The Cenozoic strata include, from the bottom up, the Fenghuoshan, Yaxicuo and Wudaoliang groups as well as the younger Quguo Formation. Previous studies have revealed the thickness of the sediments to be constrained by the south-to-north extension dynamics mechanism of the Tanggula thrust (Liu and Wang, 2001; Wang et al., 2002; Liu et al., 2003; Zhu et al., 2006; Wang et al., 2011; Li et al., 2012). In a study of the Fenghuoshan Group, the lowest strata underlying the Yaxicuo Group in the east of Hoh Xil Basin, Wang et al. (2008) proposed a 'Proto-Tibetan Plateau' uplift model. However, thus far, magnetostratigraphic dating and fossil interpretation (e.g. palynology, and analyses of charophyte, ostracod, characeae and fossilized plants, etc.) have yielded different depositional ages for the Fenghuoshan Group. For example, in the 'Proto-Tibetan Plateau' uplift model, the Fenghuoshan Group has a magnetostratigraphic age of 52.0–31.3 Ma (Liu et al., 2003), or 52–42 Ma (Yi et al., 2004), which is younger than the fossil estimates of mainly Cretaceous or Cretaceous to early Cenozoic age (Gou and Xing, 1989; Li and Yuan, 1990; Ji, 1994; An et al., 2004). Recently, Staisch et al. (2014) inferred a depositional age of ca. 85–51 Ma for the Fenghuoshan Group using new radiometric dating and a compilation of published biostratigraphic data to reinterpret existing magnetostratigraphic data from research into the Fenghuoshan Group by Liu et al. (2003). Such complex results only complicate our understanding of the tectonics, paleoelevation changes and paleoclimate history of the Tibetan Plateau. In this study, using our new palynological results from the Hoh Xil Basin, we discuss: (i) the ages of the Yaxicuo and Fenghuoshan groups; and (ii) the paleoclimate and paleoelevation at that time.

2. Stratigraphy and palynological samples

The Hoh Xil Basin, with an area of 101,000 km^2 and an average elevation >4700 m, is situated in the northern Qiangtang Terrane, bounded by the Tanggula Shan (shan means mountains in Chinese) to the south and the Kunlun Shan to the north. The highway from Lhasa to Golmud crosses the basin (Fig. 2). The pre-Cenozoic sedimentary basement of the Hoh Xil Basin includes slate, phyllite and metasandstone of Carboniferous, Permian and Triassic origins (Zhang and Zheng, 1994). As mentioned above, from the bottom up, the Cenozoic strata include the Fenghuoshan, Yaxicuo and Wudaoliang groups as well as the Quguo Fm which unconformably overlies the Wudaoliang Group. The Fenghuoshan Group consists mainly of gray-violet sandstone, mudstone and conglomerate, intercalated gray-green Cu bearing sandstone, dark-gray bioclastic limestone, and gray-layered and tubercular gypsum. In the Yaxicuo Group, the strata are dominated by alternating sandstone and mudstone, with intercalated gray-layered gypsum. The Wudaoliang Group consists mainly of lacustrine carbonate rock, with minor amounts of black oil shale (Liu and Wang, 1999).

In this study, the TTH-C section (92°29′48.36″ E, 34°05′15.48″ N; 4623 m a.s.l.), ~20 km southeast of Tanggulashan Town, was selected for the palynological analysis. The TTH-C section is ca. 130 m thick, and was measured along a north/south limb projecting from the core of the anticline. The sediments are mainly fluvial facies comprising magenta calcareous sandstone, with intercalated thin siltstone and pebbly

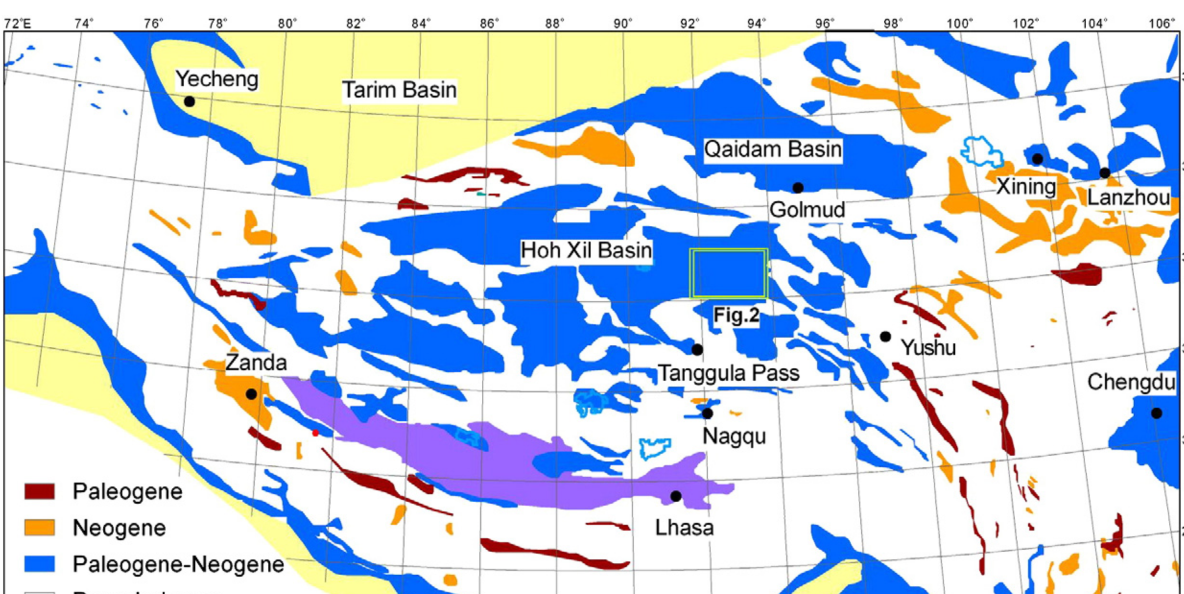

Fig. 1. Distribution of remnant basins and stratigraphic zones on the Tibetan Plateau (after Zhang et al., 2010).