Review of Palaeobotany and Palynology 221 (2015) 22–31

Contents lists available at ScienceDirect

Review of Palaeobotany and Palynology

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

Holocene climate change on the northeastern Tibetan Plateau inferred from mountain-slope pollen and non-pollen palynomorphs

Yunfa Miao [a], Heling Jin [a,*], Bing Liu [a], Mark Herrmann [b], Zhong Sun [a], Yuanping Wang [a]

[a] The Key Laboratory of Desert and Desertification, Cold and Arid Regions Environmental and Engineering Research Institute, Chinese Academy of Sciences, Lanzhou 730000, China
[b] BFU—Buero für Umwelttechnologien GmbH, Gelnhausen, Germany

ARTICLE INFO

Article history:
Received 7 April 2013
Received in revised form 10 April 2015
Accepted 17 May 2015
Available online 25 May 2015

Keywords:
Pollen
Mountain slope
Tibetan Plateau
Holocene
Climate
Events

ABSTRACT

On the northeastern Tibetan Plateau, mountain slope sediments provide a uniquely sensitive perspective on past climate changes. Here, we report a Holocene record of pollen and non-pollen palynomorphs based on compiled data sampled from one continuous alpine slope sediment section (3780 m a.s.l.) near the Gonghe Basin. In the assemblages, higher-order plants are dominant by herbs and shrubs, mainly including Chenopodiaceae, Asteraceae and Poaceae; broadleaved and gymnosperms are very rare. The lower-order (non-pollen) palynomorphs are from fungi, pteridophytes and bryophytes. Both pollen percentages and concentrations show roughly gradual decreasing trends (from ~70% to ~30% and ~10,000 grains/g to ~2000 grains/g, respectively), indicating a deteriorating climatic trend characterized by colder and drier. Also, four phases at 8.2–7.4, 5.8–5.3, 3.4–2.9 and 1.8–1.3 ka correlate well with the coldest events that occurred at high latitudes and/or over the Tibetan Plateau. Therefore, we argue that analysis of pollen and non-pollen palynomorphs together can offer an efficient way to reconstruct palaeoclimate changes especially in sedimentary environments that have poor pollen enrichment, such as mountain slopes on the northeast Tibetan Plateau.

1. Introduction

The Tibetan Plateau, located in the middle latitudes of eastern Asia, is a huge upland which extends more than 3500 km in length and about 1500 km in width. Its average elevation is more than 4500 m (Fig. 1A). In its northeastern part, under the influences of the Asian summer monsoon, the Westerlies, and the winter monsoon, a triple junction of climate is formed (Bryson, 1986). Many of researches indicate that sedimentary records are sensitive to past variations in regional climate, including monsoonal precipitation (e.g., Zhao et al., 2007; An et al., 2012) and temperature (e.g., Herzschuh et al., 2006; MacDonald et al., 2006; Large et al., 2009; Mischke and Zhang, 2010; Zhao et al., 2011). However, these records are mainly from lake sediments and peatlands (and partly from alpine marshes) (e.g., Liu et al., 1998; Herzschuh et al., 2005; Shen et al., 2005; Zhao et al., 2007), all of which only occupy a small area in contrast to the whole area. In contrast to these two settings, the slope area of the high mountains that surround the northeast Tibetan Plateau are characterized by strong temperature fluctuations, low precipitation, and considerable soil depletion and bare rocks. Several higher- and lower-order plants have developed strategies to adapt to such hostile environments.

Palynological data extracted from these slopes can provide a unique perspective on regional vegetation and climate development. However, it is usually very difficult to obtain enough pollen from these slope deposits, in contrast to the pollen-enriched lakes and peatlands, unless non-pollen palynomorphs are incorporated into the total pollen and spores diagram. In fact, several studies have shown that using fossil non-pollen palynomorph records offers strong potential for the reconstruction of past lake levels (van Geel et al., 1983), vegetation patterns (Barthelmes et al., 2006; Chmura et al., 2006), human impacts (Mighall et al., 2006; van Geel et al., 2003), climate changes (Kramer et al., 2010) and so forth.

In this study we present a Holocene record of pollen and non-pollen palynomorphs sampled from continuous alpine slope sediments at the southern margin of the Gonghe Basin, northeast Tibetan Plateau (Fig. 1). The objectives of this study were to (1) reconstruct the local vegetation history using pollen and non-pollen palynomorph collection results; and (2) evaluate the pollen and non-pollen palynomorph relationships to climate change.

2. Study area

The KE section (35°38.713′ N, 101°06.005′ E; 3780 m a.s.l.) is located at the southeastern edge of the Gonghe Basin on the northeast Tibetan Plateau, near the influence of the Asian summer monsoon (Winkler and Wang, 1993) (Fig. 1A). The Gonghe Basin, spanning an area of 13,800 km^2, is surrounded by Xiqing Mountain to the east, Heka Mountain and Wahong Mountain to the south and southwest, the Qinghai South Mountains to the north (and the adjacent Qinghai Lake),

* Corresponding author.
E-mail address: jinhl@lzb.ac.cn (H. Jin).

http://dx.doi.org/10.1016/j.revpalbo.2015.05.006
0034-6667/

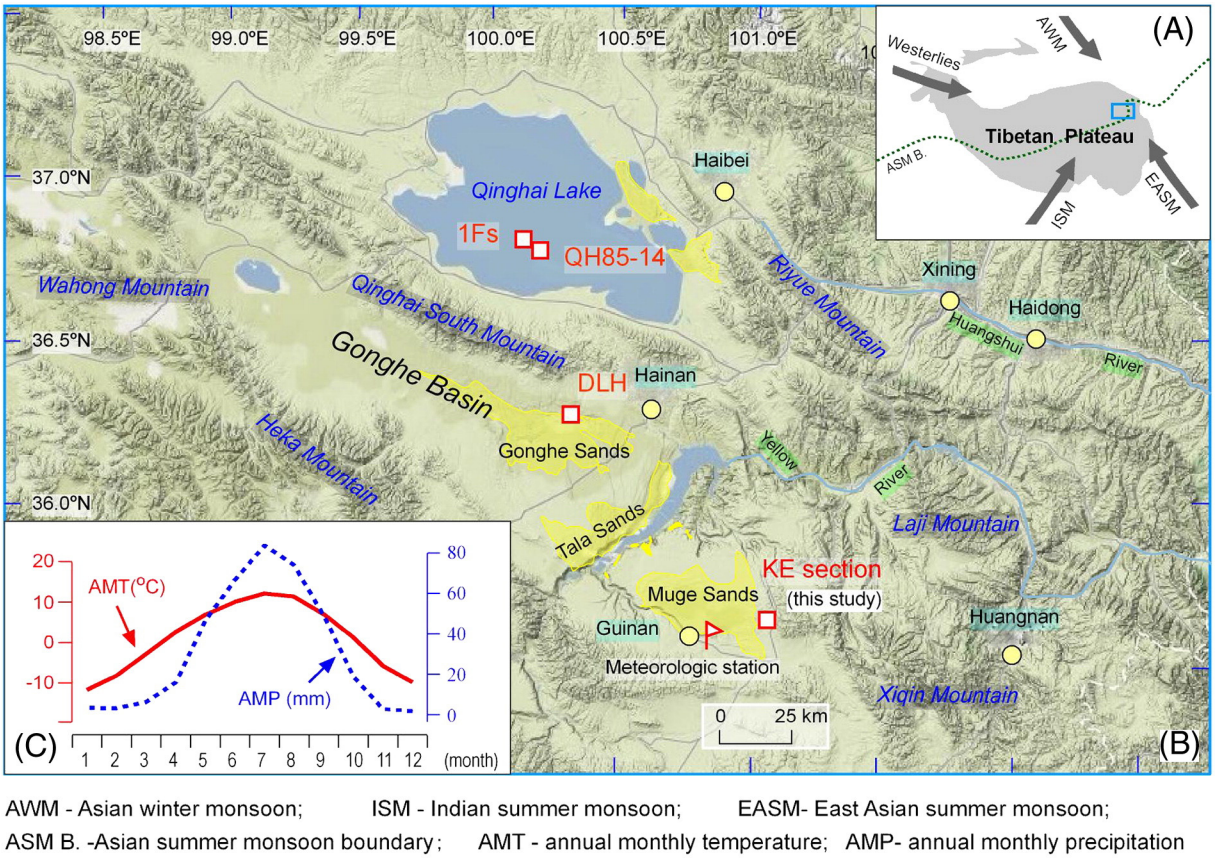

Fig. 1. Location map and climate settings at the KE section, northeast Tibetan Plateau: (A) Tibetan Plateau and the main climate-driving systems; (B) Gonghe Basin and its surrounding regions marking the locations of study sites discussed in text: KE section, southeastern margin of Gonghe Basin (this study); DLH core, Gonghe Basin (Cheng et al., 2010); DH85-14 core (Shen et al., 2005) and 1Fs composite cores 1A and 1F (An et al., 2012), Qinghai Lake; (C) temperature and precipitation recorded by the meteorological station of Guinan County.

and Laji Mountain to the northeast (Dong et al., 1993) (Fig. 1B). These surrounding mountains rise to an elevation of >4000 m a.s.l., while the average elevation of the basin is above 2900 m a.s.l. Small lakes and rivers are distributed in the central and southeast part of the basin, interrupted by some mobile, semi-fixed, and fixed sand dunes. One of these lakes, Dalianhai Lake, dried out during the last century, and one core named DLH from this lake was used for pollen analysis (Cheng et al., 2010) (Fig. 1B). A typical cold arid and semi-arid continental climate dominates the basin. The mean annual temperature is between ~1.0 and 5.2 °C and the mean annual precipitation ranges from 311 mm in the southeast to 402 mm in the northwest, of which approximately 70% comes from monsoonal rainfall during the summer (Fig. 1C) (Xun and Li, 1987). The region is characterized by typical steppe, desert steppe, and cold steppe vegetation, dominated by *Stipa krylovill*, *Sarracenia purpurea*, and *Caragana tibetica.* In addition, *Artemisia arenaria*, *Agriophyllum squarrosum*, and *Iris lacteal* var. *chinensis* are

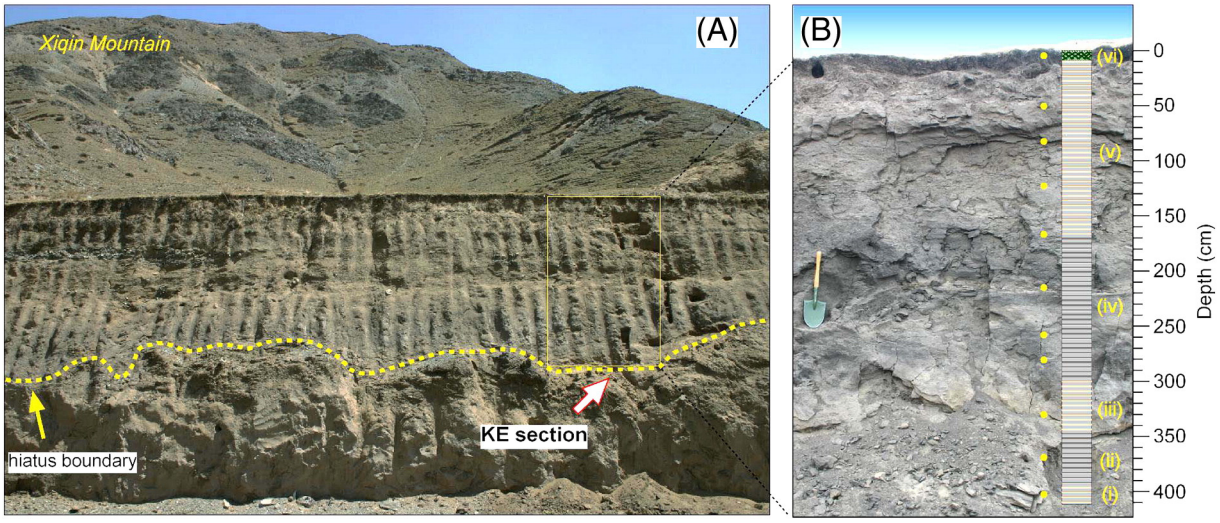

Fig. 2. Photos of KE section: (A) panoramic picture; (B) detailed stratigraphic characteristics (direction to the south, taken on May 10, 2010 by H.L. Jin; yellow dots showing the dating positions and Greek letters showing the stratigraphic unit numbers).