Palaeogeography, Palaeoclimatology, Palaeoecology 393 (2014) 102–110

Contents lists available at ScienceDirect

Palaeogeography, Palaeoclimatology, Palaeoecology

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

Reconstructing late Holocene vegetation and fire histories in monsoonal region of southeastern China

Kangyou Huang [a,g,*], Zhuo Zheng [a], Wenbo Liao [b], Linglong Cao [a,c], Yanwei Zheng [d], Hua Zhang [a], Guangqi Zhu [a], Zhong Zhang [e], Rachid Cheddadi [f]

[a] Department of Earth Sciences, Sun Yet-san University, Guangzhou 510275, China
[b] School of Life Sciences, Sun Yet-san University, Guangzhou 510275, China
[c] South China Sea Marine Engineering and Environment Institute, SOA, Guangzhou 510300, China
[d] Institute of Geography, Guangzhou 510070, China
[e] Administration Bureau of Jinggangshan National Nature Reserve, Jinggangshan 343600, China
[f] Institut des Sciences de l'Evolution de Montpellier, UMR 5554, CNRS-UM2, 34095 Montpellier cedex 5, France
[g] Guangdong Provincial Key Laboratory of Mineral Resources & Geological Processes, Guangzhou 510275, China

ARTICLE INFO

Article history:
Received 8 January 2013
Received in revised form 8 October 2013
Accepted 4 November 2013
Available online 16 November 2013

Keywords:
Late Holocene
Pollen analysis
Charcoal
East Asian Summer Monsoon
Subtropical China

ABSTRACT

Eastern subtropical China is a key region for understanding the variability of the East Asian Summer Monsoon (EASM). Multidisciplinary studies in southeastern China have shown that the summer monsoon intensity declined in the mid-late Holocene. We present a high-resolution pollen record of the last 4000 cal yr BP in Jinggang Mts of Jiangxi Province, southeastern China. The identified pollen taxa from the core can be statistically divided into three groups corresponding to evergreen, deciduous and wetland communities. The transitions between evergreen and deciduous-coniferous pollen associations is likely caused by temperature fluctuations, indicating that climate was relatively cool at 3800–3200 cal yr BP and 2200–1300 cal yr BP and warmer at 3200–2800 cal yr BP and 1300–800 cal yr BP. The vegetation study suggests that an *Alnus*-dominant association represents a secondary forest that usually takes place and expand after repeated forest fires. The charcoal concentration from the core depicts at least six major forest fire events since 4000 cal yr BP, most of which were followed by the development of an *Alnus* forest community. This result suggests that the EASM weakened toward the late Holocene and that its related decrease in moisture led to large forest wildfires. Furthermore, the rapid formation of a swamp and the subsequent development of the *Alnus* wetland community at ~550 cal yr BP suggest a gradual drying up of the lake, which was likely related to "the Little Ice Age". As a result of a substantial burning related to an intensification of the human cultivation practices, *Alnus* reached its highest values in the last 200 years along with abundant wetland herbs, pioneer ferns (mainly *Dicranopteris*) and high charcoal concentrations. The present evidence of several sharp floristic and climate changes coincides with either the collapse or the beginning of some Chinese dynasties, which will need further research on the relationship between natural and human cultural changes.

1. Introduction

The variations of the East Asian Summer Monsoon (EASM) have prominent impacts on the vegetation in southeastern China, where the zonal forests are composed of tropical rainforest, subtropical evergreen broadleaved forest and mixed broadleaved forest. EASM precipitation is a key issue for regional agricultural production and for maintaining natural biodiversity and ecological balance (Zhang et al., 2011). Thus, the aim of the present study is to contribute to a better understanding of the relationship between ecosystem changes and the monsoon system. Reduced precipitation during late Holocene often induces forest fires over the mountain regions in subtropical China (Sun et al., 2000; Zong et al., 2007; Wu et al., 2008). There are continuous records of the Asian monsoon over the Holocene from $\delta^{18}O$ measurements of stalagmite calcite (Dykoski et al., 2005; Wang et al., 2005). However, the response of forests to the EASM remains poorly understood (Yue et al., 2012; Li et al., 2013) due to the paucity of high-resolution subtropical pollen records.

Stalagmites from caves in southeastern China have provided many high-resolution $\delta^{18}O$ records that primarily reconstruct the amount of precipitation associated with the strength and character of the EASM circulation (Cosford et al., 2008). Correlations among the $\delta^{18}O$ records of stalagmites from the Lianhua, Heshang and Dongge caves show that

* Corresponding author at: Department of Earth Sciences, Sun Yet-san University, Guangzhou 510275, China. Tel.: +86 20 84111068; fax: +86 20 84112390.
E-mail address: hkangy@mail.sysu.edu.cn (K. Huang).

0031-0182/$ – see front matter. Crown Copyright © 2013 Published by Elsevier B.V. All rights reserved.
http://dx.doi.org/10.1016/j.palaeo.2013.11.005

monsoonal circulation weakened throughout the mid- to late-Holocene as the ITCZ shifted southward in response to the decreasing summer insolation at the northern latitudes (Dykoski et al., 2005; Wang et al., 2005; Cosford et al., 2008; Hu et al., 2008). It is generally accepted that both temperature and precipitation continuously rose during the early Holocene and reached their highest levels at the mid-Holocene, followed by a gradual lowering during the late Holocene (An et al., 2000; Chen et al., 2001; Wang et al., 2005). Accordingly, some pollen records in the region reveal that the mixed forest in Chinese subtropical mountains was gradually replaced by the expansion of evergreen broadleaved forest (Xiao et al., 2007) and that evergreen monsoonal forest was the dominant vegetation in subtropical mountains around 8500 yr BP (Yue et al., 2012). Unfortunately, such records remain too scarce in the Chinese subtropical/tropical domain that is largely affected by the EASM, and many vegetation changes in the late Holocene are usually interpreted as related only to human disturbances (Xu et al., 2013). The modern plant distribution is a result of interactions between the environment (abiotic and biotic) and the plants species. Fire, land usage and human activities have a strong impact on natural plant communities (Lubchenco et al., 1991; Hannah et al., 1995; Xu et al., 2013). Understanding the role of plant species in a community or in an ecosystem is a basis for predicting plant responses to climatic changes (Austin, 2002).

The present work is based on a ~4000 year record from a wetland in the Jinggang Mts, located in the middle subtropical zone of southern China. Pollen and charcoal analyses were performed to evaluate the vegetation changes and their possible relationship with monsoon variability and to better understand human-nature interactions in southern China during the late Holocene.

1.1. Study area

The coring site is a wetland located in the valley of the Jinggang Mts, in southeastern Jiangxi Province (Fig. 1). The site is an oval-shaped swamp with a size of approximately 300 m × 200 m. The bedrock of the sediment basin is composed mostly of Mesozoic granite. The area belongs to the southern limit of the middle subtropical zone. The regional mean annual temperature is approximately 14.2 °C, and the mean annual precipitation is approximately 1800 mm (Lin, 1990).

The present-day vegetation in the Jinggang Mts is dominated by a subtropical evergreen broadleaved forest (Fig. 1). The vegetation composition in altitude is as follows: below 1000 m, the evergreen broadleaved forest is dominated by *Castanopsis sclerophylla*, *Castanopsis concinna*, *Castanopsis fabric*, *Castanopsis tibetana*, *Machilus thunbergii*, *Phoebe hunanensis* and *Elacocarpus japonicus*. *Pinus massonia* occurs in a few areas. From 1000 m to 1400 m, some deciduous elements are often mixed with the evergreen broadleaved forest. The deciduous elements are *Castanopsis eyrei*, *Schima superva* and *Fagus lucida*. Above 1400 m, the mountain summits are covered by shrub vegetation dominated by *Rhododendron simiarum*, *Pieris formosa* and *Enkianthus quinqueflorus* (Wu, 1980). The present-day vegetation around the coring area is a secondary subtropical evergreen broadleaved forest that is composed of *Alnus trabeculosa*, *Phyllostachys heterocycla*, *Camellia cuspidata*, *Litsea elongata*, *Cleyera pachyphylla*, *Photinia schneideriana*, *Malus hupehensis*, *Rhododendron latoucheae*, *Daphniphyllum macropodum*, *Ilex serrata*, *Indocalamus latifolius*, *Liriope muscari* and *Peucedanum praeruptorum*. The surrounding mountainside is covered by planted bamboo and pine forest (*Pinus massoniana*), reflecting a strong human impact on the local vegetation.

2. Material and method

A 165-cm core was collected using a Russian Corer at 26°34′51.63″N, 114°04′37.55″E and 1269 m a.s.l. The core lithology may be described as follows: 0–31 cm: dark brown peat with rich plant roots and fragments; 31–72 cm: gray-green silt with little sand; 72–81 cm: gray–yellow medium sand; 81–117 cm: dark gray clay; 117–143 cm: brown silt-clay with plant remains; 143–155 cm: gray–brown clay; 155–165 cm: clay with sandy gravel (Fig. 2).

The time frame of the core is based on three AMS ^{14}C dates (Table 1). All radiocarbon ages were measured at the laboratory of Beta Analytic Inc., Miami, USA. The ^{14}C dates were calibrated using the IntCal09 dataset (Reimer et al., 2009). The age model for the core was plotted using the Clam 1.0.2 software package (Blaauw, 2010) (Fig. 3).

We used a visible light spectrophotometer (722 s) for peat humification evaluation. A total of 48 samples (3-cm interval) were collected from the core segments, which were mashed and dried in an oven. After filtering through a 240-μm sieve, each sample weighing 0.1 g was put into 100 ml of 8% NaOH and boiled for one hour, then diluted into 100 ml liquid. Five milliliters of liquid was taken out and diluted into 50 ml in a volumetric bottle. In the final step, the absorbency was

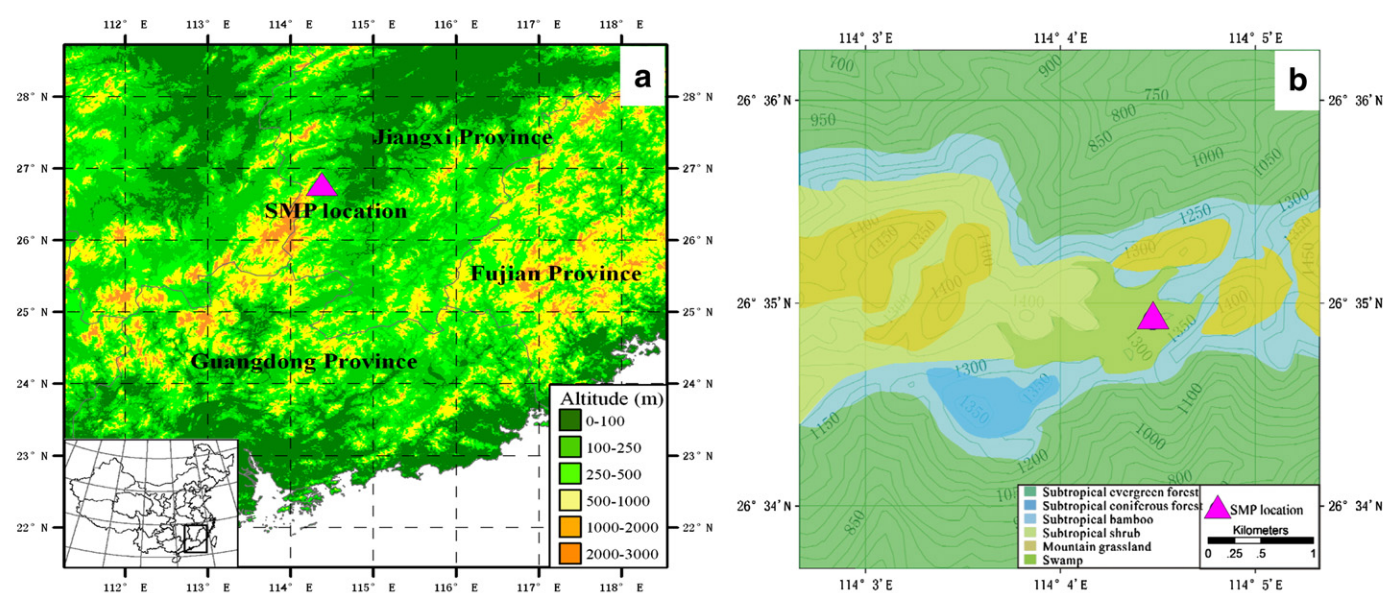

Fig. 1. Geographical location of the study core (a) and local vegetation map (b).