Journal of Asian Earth Sciences 151 (2018) 240–249

Contents lists available at ScienceDirect

Journal of Asian Earth Sciences

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

Full length article

Pollen record of the mid- to late-Holocene centennial climate change on the East coast of South Korea and its influential factors

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ARTICLE INFO

Keywords:
Climate change
East Asian summer monsoon
ENSO activity
Holocene
Pollen
Westerlies

ABSTRACT

To understand historical climate change in western Pacific coastal areas, a sediment core (SOJ-2) from the stable sedimentary environment of the Songjiho Lagoon on the east coast of South Korea was obtained for centennial-resolution palynological analysis. The ages of the SOJ-2 core is well controlled by carbon 14 dating with high-resolution accelerator mass spectrometry (AMS), and the results indicated a general warm to cold climate trend from the mid-Holocene to the present, which can be divided into two different stages: a warmer stage between 6842 and 1297 cal yr BP and a colder stage from 1297 cal yr BP to the present, with fluctuations during these stages. The climate was wetter from 6842 to 6227 cal yr BP and 4520 to 1297 cal yr BP and was drier from 6227 to 4520 cal yr BP. The climate changed to cold and dry during the period from 1297–425 cal yr BP. The impact of human activity on the climate began at approximately 1297 cal yr BP and became pronounced starting in 425 cal yr BP. The general cooling trend may represent a response to decreasing solar insolation; however, the relative dryness or wetness of the climate may have been co-determined by westerlies and the East Asian summer monsoon (EASM). The climate had a teleconnection with the North Atlantic region, resulting from changes in solar activity. Nevertheless, EI Niño–Southern Oscillation (ENSO) activity played an important role in impacting the EASM changes in western Pacific coastal areas.

1. Introduction

Climate change threatens sustainable development in the coastal areas of Asia (Wassmann et al., 2004; McGranahan et al., 2007; Syvitski et al., 2009; IPCC, 2014). Therefore, an understanding of paleoclimatic change in coastal areas is critical for predicting the future climate of the western Pacific.

The east coast margin of South Korea is located in the western Pacific coastal areas of northeastern (NE) Asia, where the climate is mainly controlled by the East Asian summer monsoon (EASM) (Yi, 2011) (Fig. 1). A large number of Holocene climate change records have been used to understand the mechanisms controlling the spatio-temporal variability of the EASM (e.g., Wang et al., 2005, 2010; Lim and Fujiki, 2011; Ran and Feng, 2013; Yang et al., 2014; Stebich et al., 2015; Park et al., 2016; Lei et al., 2017). However, due to different conditions among the regions, many reports primarily reflect local or regional climate characteristics. For example, Shi et al. (1994) determined that the Holocene Megathermal conditions occurred from 8.0–3.0 ka BP in the EASM region. An et al. (2000) found that the Holocene Optimum in the East Asian monsoon (EAM) region was time-transgressive from high to low latitudes. Ran and Feng (2013) reported that the Holocene Optimum in northern China lasted from 9.5 to 5 cal ka BP, whereas Zhou et al. (2016) suggested that it followed a time-transgressive onset from southern China to NE Asia. Even the classic concept of an early- to mid-Holocene precipitation maximum in the EASM has been challenged by long-term increases in rainfall to a maximum mean value of 4.0 cal ka BP in NE China (Stebich et al., 2015).

It has been recognized that in the EASM region, a wet climate follows a strong EASM and a dry climate follows a weak EASM (Hong

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http://dx.doi.org/10.1016/j.jseaes.2017.11.006
Received 14 April 2017; Received in revised form 29 October 2017; Accepted 1 November 2017
1367-9120/

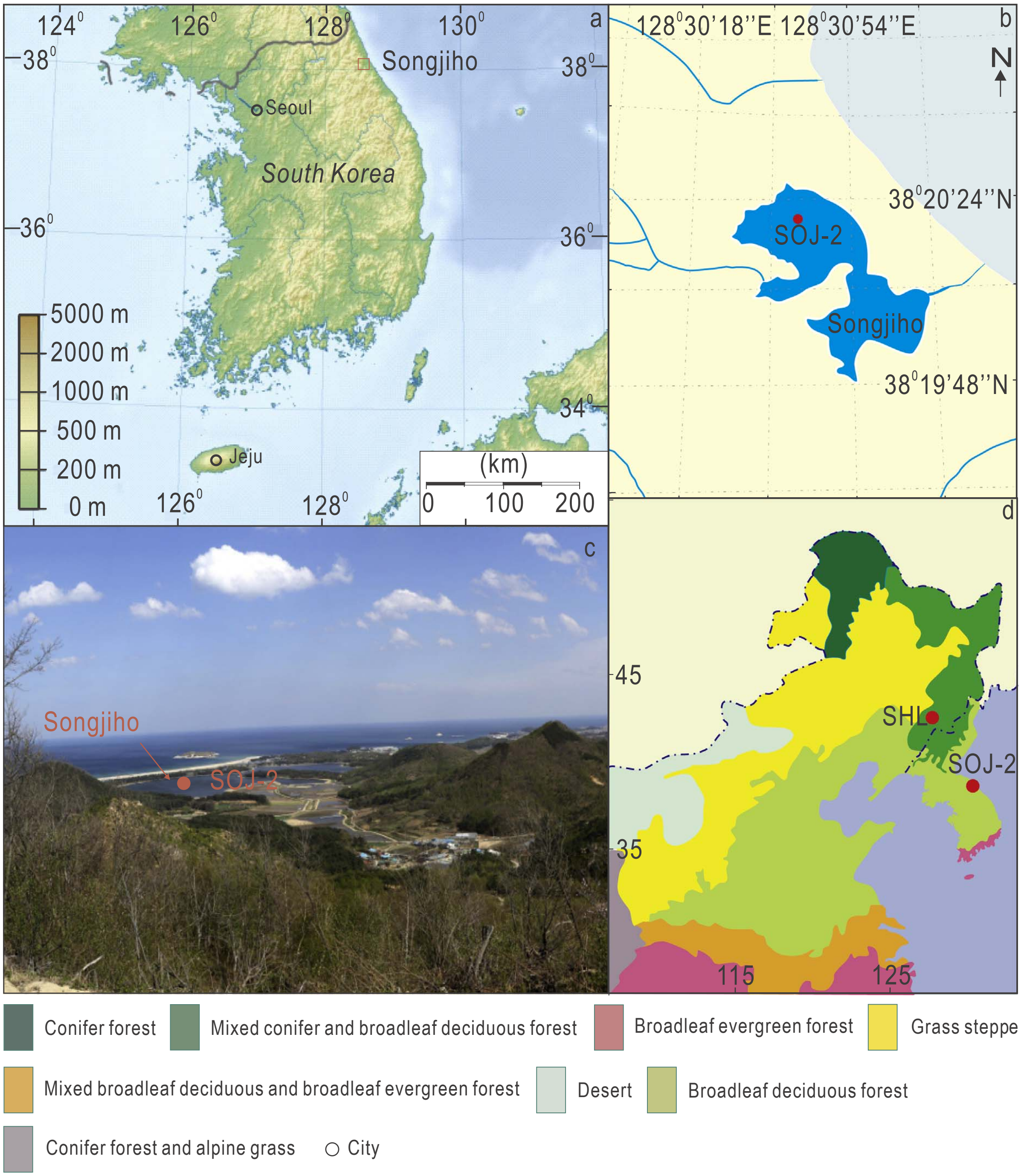

Fig. 1. The study area at the Songjiho Lagoon. (a) Geomorphology map of South Korea (modified from https://upload.wikimedia.org/wikipedia/commons/a/a8/Korea_topographic_map.png). (b) Specific location of the drill core (modified from Google Maps). (c) The natural environment in the Songjiho Lagoon region. (d) Northern East Asian vegetation (Yim, 1977; Yi, 2011; Stebich et al., 2015). SHL: Lake Sihailongwan (Stebich et al., 2015).

et al., 2005). Based on high-resolution Dongge Cave oxygen isotope records, Wang et al. (2005) determined that monsoon variability at these frequencies is the result of changes in solar output, which have a teleconnection with North Atlantic climate change. Recently, Stebich et al. (2015) suggested that monsoonal precipitation and solar insolation-driven temperature changes co-determine the environmental dynamics in NE Asia. However, the northward/southward movement of the monsoon rainfall belt may be restricted by strong and/or dry westerlies (An et al., 2012; Zhao and Yu, 2012; Stebich et al., 2015). Tropical ocean forcing is another important influence on climate change in the EASM coastal area (Lim and Fujiki, 2011; Lim et al., 2017; Park, 2017). Solar and tropical ocean forcing may have affected climate change in East Asian coastal areas during the late Holocene (Park, 2017). An understanding of the complex EASM and the spatial and temporal differences requires more study, particularly using more precisely dated high-resolution paleoenvironmental records (Zhang et al., 2011; Donges et al., 2015; Stebich et al., 2015).

The eastern coastal area of the Korean peninsula is a bridge between the NE Asian continent and the northwestern (NW) Pacific; its climate is very sensitive to interactions between the sea and land. Understanding regional climate changes and their controlling mechanisms will be helpful in forecasting future climate changes under impending global warming. Using pollen as a proxy, several climate studies have been conducted in different areas in South Korea. For example, in the