Quaterary Science Reviews 153 (2016) 40–50

Contents lists available at ScienceDirect

Quaternary Science Reviews

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

Late-Holocene vegetation and climate change in Jeju Island, Korea and its implications for ENSO influences

Jungjae Park [a,*], Young Ho Shin [a], Roger Byrne [b]

[a] Department of Geography and Institute for Korean Regional Studies, Seoul National University, Sillim-dong, Gwanak-gu, Seoul, 151-742, Republic of Korea
[b] Department of Geography, University of California at Berkeley, CA 94720, USA

A R T I C L E I N F O

Article history:
Received 20 June 2016
Received in revised form
17 October 2016
Accepted 21 October 2016
Available online 28 October 2016

Keywords:
El Niño Southern-Oscillation
East Asian Monsoon
Climate change
Kuroshio Current
Western Tropical Pacific
Late Holocene
Pollen
Jeju Island
Korea

A B S T R A C T

Several recent studies suggest the hypothesis that the El Niño-Southern Oscillation (ENSO) is an important factor controlling the Holocene East Asian Monsoon (EAM). However, the mechanism underlying this influence remains unclear due to the lack of high-resolution paleoclimate records from the coast of East Asia. Here, we provide a new record of late Holocene climate change in coastal East Asia based on multi-proxy evidence (pollen, organic content, magnetic susceptibility, grain size) obtained from a sediment core from Jeju Island, South Korea. As Jeju Island is strongly influenced by the Kuroshio flow, our sediment proxy records contain ENSO signals from the tropical Pacific. The study area was affected by dry/cool conditions in the western tropical Pacific (WTP) between 4350 and 1920 cal yr BP when El Niños were frequent, and by rapid warming/wetting and forestation since 1920 cal yr BP when La Niñas were more common. Jeju Island was relatively dry/cool between 2100 and 1600, 1300–1200, 1100–1000, 800–650, and 300–50 cal yr BP, as opposed to the Galápagos Islands, which were relatively wet/warm, reflecting the ENSO-related negative correlation between eastern and western margins of Pacific. Wet conditions may have prevailed during the early Little Ice Age (LIA) (620–280 cal yr BP) despite consistent cooling. This period of high precipitation may have been associated with the increased landfall of typhoons and with warmer Kuroshio currents under La Niña-like conditions. According to our results, EAM on the East Asian coastal margin was predominantly driven by ENSO activity, rather than by the precession effect. Paleoclimatic data from Jeju Island, with its insular position and closeness to warm Kuroshio currents, provide clear evidence of these ENSO influences.

1. Introduction

Changes in Holocene East Asian Monsoon (EAM) are attributed to various factors. High-resolution records of the Holocene reconstructed from Chinese cave stalagmites demonstrate the influence of variations in precession-induced insolation, solar activity, and Atlantic meridional overturning circulation (AMOC) on Asian summer monsoon (Wang et al., 2005; Dykoski et al., 2005; Hu et al., 2008). However, another important climatic factor, the El Niño-Southern Oscillation (ENSO), has never been clearly identified in East Asian proxy records and precession-induced climate change overwhelmed millennial-scale ENSO influences in most of East Asian during the Holocene.

Some researchers have suggested that the coastal climate of East Asia was influenced by the variability of ENSO during the Holocene epoch (Selvaraj et al., 2007; Lim and Fujiki, 2011; Wu et al., 2012; Yang et al., 2014; Jia et al., 2015). Nevertheless, the mechanisms of these influences have not been elucidated due to the paucity of paleoclimate records from coastal areas of East Asia. Moreover, the reported ENSO signals vary significantly in strength, despite being reported from the same general area. This has obscured the mechanisms underlying the ENSO influence on Holocene climate in East Asia. For example, high-resolution pollen records from two maar lakes of the Longgang Volcanic field (42°17′N, 126°21′; 42°17′N, 126°36′ E) show no obvious oceanic influence (Xu et al., 2014; Stebich et al., 2015), whereas carbon isotope data from Hani peat bog (42°13′N, 126°31′E), which is located near these pollen sites, do show ENSO signals, such as increased precipitation after 2000 cal yr BP and relative dryness between 4000 and 2000 cal yr BP (Hong et al., 2005) (Fig. 1).

Conversely, climate proxy records from Taiwan and Jeju Island including pollen, $\delta^{13}C$, and sediment geochemistry, with few

* Corresponding author.
E-mail address: jungjaep@snu.ac.kr (J. Park).

http://dx.doi.org/10.1016/j.quascirev.2016.10.011

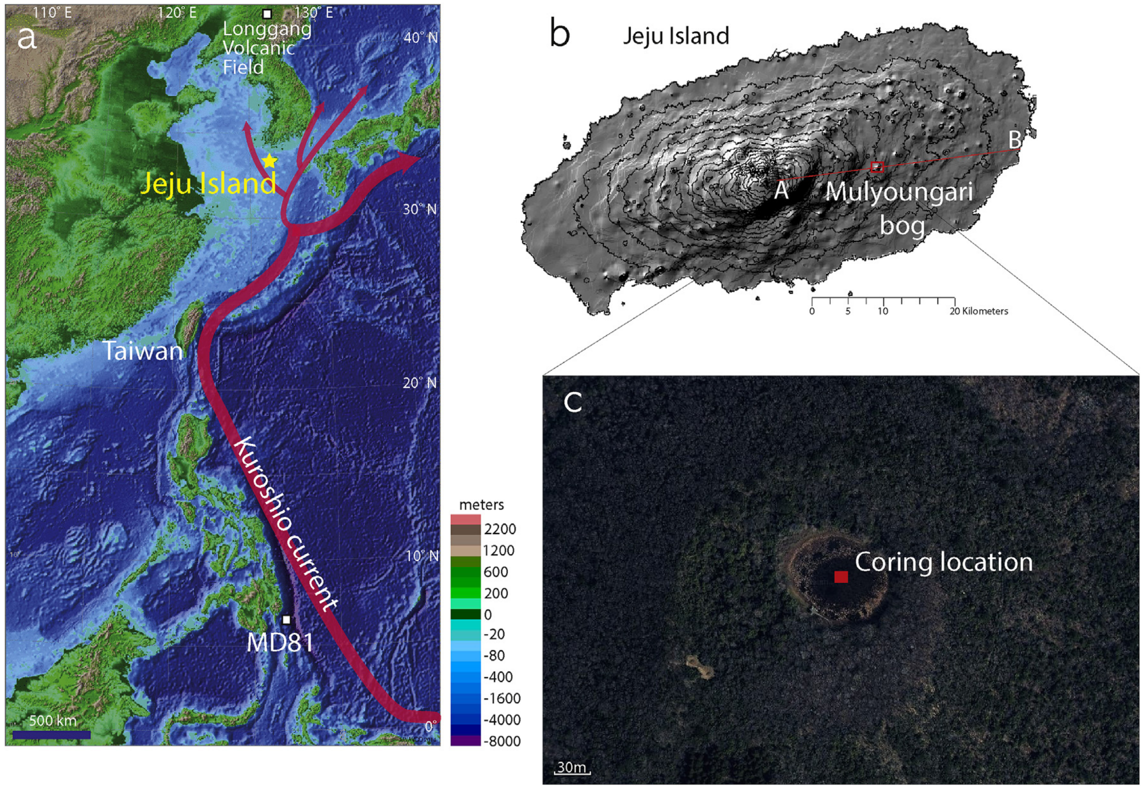

Fig. 1. (a) Location of paleoclimate sites mentioned in the text: MD81 in western tropical Pacific (Stott et al., 2004) and Longgang Volcanic Field in northeastern China (Stebich et al., 2015; Xu et al., 2014). This map was modified from the UNAVCO map tool (UNAVCO Inc., jules.unavco.org). (b) Location of the Mulyoungari bog in Jeju Island. The line AB indicates the position of the vegetation profile shown in Fig. 2a. (c) Aerial photo showing the sampling site in the crater.

exceptions, do show ENSO influences on local climates, probably due to the influence of the Kuroshio Current (Selvaraj et al., 2007, 2011; Lim and Fujiki, 2011). However, these studies do not have the temporal resolution needed to convincingly establish the details of an ENSO connection. To address this research gap, we herein present high-resolution multi-proxy records (pollen, organic content, magnetic susceptibility (MS), sediment grain size) of the late Holocene climate change from a small volcanic crater named Mulyoungari on Jeju Island. A previous pollen study of a 300-cm long core from Mulyoungari has been reported by Lee et al. (2011a,b), but no discussion of the paleoclimatic implications was presented. In this paper, we reconstruct vegetation and climate change in Jeju Island since 4800 cal yr BP and evaluate the possible influence of ENSO.

We assumed that human disturbance was scarcely present in the study site until the early 1900s AD when people started to plant pines and Japanese cedars on the outer slope of the crater. Rice agriculture is believed to have reached Jeju Island around 2300 cal yr BP from the southern part of the Korean peninsula (M. Kim, personal communication, September 4, 2016). However, there was a significant decline in rice agriculture after its arrival because the high permeability of the basalt bedrock prevented people from cultivating rice. As indicated in stone-tool assemblages between ~2300 and 1700 cal yr BP, they mostly lived by shore fishing and collecting shells and nuts. Their subsistence activities minimized the disturbance to inland forests (Kim and Kwon, 2010). Moreover, the crater environment has been well protected from human activities until very recently since its steep slopes hindered access (Yang, 2013). Human impact is thus not considered an environmental factor in the study area.

2. The study area

Mulyoungari crater (33°22′09″N, 126°41′36″E) is located at an altitude of 508 m in the eastern part of Jeju Island, South Korea (Fig. 1). Jeju Island is a shield volcano formed on the continental shelf of the Yellow Sea. It consists of massive sheets of basaltic lava and minor pyroclastic deposits and contains over 450 Quaternary satellite cones such as cinder (scoria) cones, lava cones/domes, and hydromagmatic tuff rings/cones. Mt. Halla rises to 1950 m above sea level at the center of the island. Mulyoungari crater is located in a parasitic cone on the eastern side of the main volcano. The basalt that makes up most of the Jeju volcano is permeable and surface water is therefore relatively scarce. However, in several parasitic craters such as that of our study site, water is confined due to impermeable sediments formed by fine clastics. Pollen and macrofossil evidence shows that continuous sedimentation in the Mulyoungari crater over the last 5000 years has resulted in a slow succession from lake to meadow. The Mulyoungari bog is currently protected under the Ramsar Convention and the Korean Wetland Conservation Act. The crater rim is almost circular with a maximum diameter of approximately 224 m. The crater has a surface area of about 56,000 m^2. The altitudinal difference between the bottom of the crater and the surrounding rim is 13–40 m (Yang, 2013).

The Korean climate is characterized by a large difference in mean monthly temperatures between summer and winter and relatively high rainfall concentrated mostly in the summer. The southeast summer monsoon brings hot and humid weather to the whole peninsula, whereas the northwest winter monsoon brings cold and dry weather. The monsoonal climate over coastal East Asia is strongly influenced by the heat capacity differences between the