Quaternary International 344 (2014) 4–10

Contents lists available at ScienceDirect

Quaternary International

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

Late Holocene climate change and human impact inferred from the pollen record, Haman area, southern Korea

Chull-Hwan Chung [a,*], Choon Kil Ryu [b], Kang-Ho Oh [c]

[a] Korea Landscape and Geology Institute, Sunchon National University, 255 Jungang-ro, Sunchon, Chonnam 540-742, Republic of Korea
[b] Korea Institute of Geological Environments, Busan 617-731, Republic of Korea
[c] Department of Earth Science Education, Chonnam National University, 500-757, Republic of Korea

ARTICLE INFO

Article history:
Available online 27 April 2014

Keywords:
Late Holocene
Human impact
Climate change
Pollen
Haman in Korea

ABSTRACT

A pollen record (ca. 200 cal. BC–1210 cal. AD) from swamp deposits exhibits climate change and human-induced vegetation change in the Haman area, southern Korea. The predominance of deciduous *Quercus*, *Alnus* and *Pinus* from ca. 200 cal. BC to 80 cal. AD indicates a cool temperate mixed coniferous and deciduous broadleaved forest, cooler than today. The rise of warm temperate evergreen broadleaved trees in combination with the retreat of boreal taxa (*Picea*, *Abies* and *Betula*) from ca. 80 to 360 cal. AD indicates climatic amelioration similar to the modern temperate condition of the study area. The increase of *Pinus* and cultivated Gramineae pollen (>40 μm) during this period also suggests human impact. The high representation of *Pinus* and cultivated Gramineae pollen, and regular occurrence of farmland weed from ca. 360 to 1010 cal. AD indicate intensive cultivation, related to the growth of an ancient small kingdom (Aragaya). A climatic cooling from ca. 1010 to 1210 cal. AD is indicated by the retreat of warm temperate evergreen broadleaved trees and the rise of boreal coniferous and deciduous broadleaved trees, while intensive cultivation was persistent.

1. Introduction

Holocene vegetation change is important in understanding the modern vegetation and climate, because the late Quaternary vegetation is the direct ancestor of the modern flora, and modern phytogeographical distributions are the result of the historical development of past vegetation and climate. Especially, in approach to the late Holocene environments, human impact must be taken into consideration (Birks et al., 1988; Vitousek et al., 1997; Williams, 2003; Tarasov et al., 2006; Innes et al., 2009). Because of the interaction between human activity and nature, both human impact and environmental change must be considered simultaneously for reliable investigation of the late Holocene vegetation dynamics.

Among various terrestrial paleoclimate proxies, pollen is one of the most useful tools (Birks and Birks, 1980; Traverse, 1988). Pollen is well suited to examine the impact of rapid climate fluctuations on terrestrial ecosystems since the response of vegetation to climate change is pronounced and can occur on a decadal time scale (Tinner and Lotter, 2001). Pollen analysis is also effective method to detect human impact.

Korea has been an agricultural country from the Bronze Age to the first half of the twentieth century. In particular, the southern part of the Korean Peninsula, which is characterized by warm climate and development of fertile alluvial plains, is believed to have been an area of early agriculture. Many archaeological remains (Palaeolithic ∼ Chosun Dynasty) found in the region support this hypothesis. Despite many archaeological finds in this region, relationships between cultural evolution and environmental history remain poorly understood. In this paper we present a pollen record spanning the late Holocene from the Gayari archaeological site in the Haman area, southern Korea, and discuss vegetation dynamics resulted from climate change and human impact. The result is expected to contribute to understanding of interactions between humans and nature in this region during the late Holocene.

2. Location and setting

Korea is located in the eastern end of the Asian continent adjacent to the West Pacific and belongs to the temperate zone with four distinct seasons. During the winter, from December to February, it is cold and dry under the dominant influence of the

* Corresponding author.
E-mail address: chungch93@hanmail.net (C.-H. Chung).

http://dx.doi.org/10.1016/j.quaint.2014.04.012
1040-6182/

northwesterly Siberian air mass. The summer, from June to August, is hot and humid with frequent heavy rainfalls associated with the East Asian monsoon (Lim et al., 2007).

The Haman area is situated in the southern part of Korea, about 280 km southeast of Seoul (Fig. 1), and is close to the south coast of the Korean Peninsula. This area is surrounded by mountains with elevations of 500–800 m a.s.l., and is bordered on the north by the Nam River. There is a fertile alluvial plain deposited by the Nam River and its tributary streams.

Modern climatic condition of the Haman area is characterized by hot, humid summer and cold, dry winter under influences of the East Asian monsoon. The mean annual temperature is 13.1 °C, and the mean temperatures in August and in January are 25.7 °C and −0.1 °C, respectively (Korea Meteorological Administration, 2011). The mean annual precipitation is 1512.8 mm with peaks during the summer (June–August).

The modern vegetation of the study area belongs to the southern temperate deciduous broadleaved forest (Uyeki, 1933; Yim and Kira, 1975). This forest includes diverse deciduous broadleaved trees such as *Quercus acutissima*, *Q. variabilis*, *Q. serrata*, *Q. mongolica*, *Carpinus tschonoskii*, *C. coreana*, *Corylus heterophylla*, *Zelkova serrata*, *Castanea crenata*, etc. and coniferous taxa such as *Pinus densiflora* and *Juniperus chinensis* (Kim, 1988; Lee and Yim, 2002). In the lowlands some broadleaved evergreen taxa such as *Quercus acuta*, *Castanopsis cuspidate*, *Cinnamomum camphora* and *Camellia japonica* also are present.

The Gayari archaeological site is situated in the central part of the Haman County (Fig. 1). The site lies on the floodplain of the Shineumcheon Stream which is a tributary to the Nam River, and is adjacent to hills with low elevations. About 3 m-thick swamp deposits were exposed during the archaeological excavation in 2010. The deposits consist of a modern cultivation layer, sandy clay, clay, and peaty clay, and appear to have been formed in a back swamp of the Shineumcheon Stream.

3. Materials and methods

For this study, a 300 cm-deep trench was excavated. The deposits exposed on the vertical section of the trench consist mainly of peaty and/or clayey sediments with a modern cultivation layer on the uppermost part (Fig. 2). The lowermost 50 cm consists of dark grey to brown peaty sediments with abundant plant rootlets, which appear to have been deposited in a swamp. The overlying layer is 95 cm thick, brown sandy clay containing thin sand layers and a dark grey peaty clay layer. The overlying 45 cm is peaty clay with abundant plant rootlets. The overlying layer is 10 cm thick, pebbly sand. The overlying 50 cm is a homogeneous yellowish brown clay layer with abundant plant rootlets. The uppermost layer is 50 cm thick, brown silty clay, disturbed by modern cultivation.

For pollen analysis, 25 samples were taken at 10 cm intervals from 50 to 290 cm depth in the swamp deposits, excluding the uppermost, 50 cm-thick, disturbed layer. Two grams of each sample was processed for extraction of pollen and spore using standard pollen preparation techniques, which included treatments with 10% KOH and 45% HF, mineral separation with a $ZnCl_2$ solution (sp. gr., 2.0), acetolysis, and mounting in glycerin jelly. Lycopodium spore tablets (batch #483216, mean = 18,583 ± 764 spores per tablet) were added to each sample prior to preparation to estimate pollen concentration (Stockmarr, 1972; Maher, 1981). Pollen and spores were identified and counted with a light microscope at 400× magnification, but a magnification of 1000× was used for some critical determinations. Taxonomic identification was based upon Chang and Rim (1979), Nakamura (1980a,b) and Wang et al. (1995). Over 300 pollen grains of trees and herbs were counted for each sample. The percentages of arboreal pollen (AP) and non-arboreal pollen (NAP) were calculated from total sum of pollen and spores. Pollen diagram was constructed using the TILIA program (Grimm, 1993). Only the principal pollen and spores were included in the percentage pollen diagram. Gramineae pollen were divided

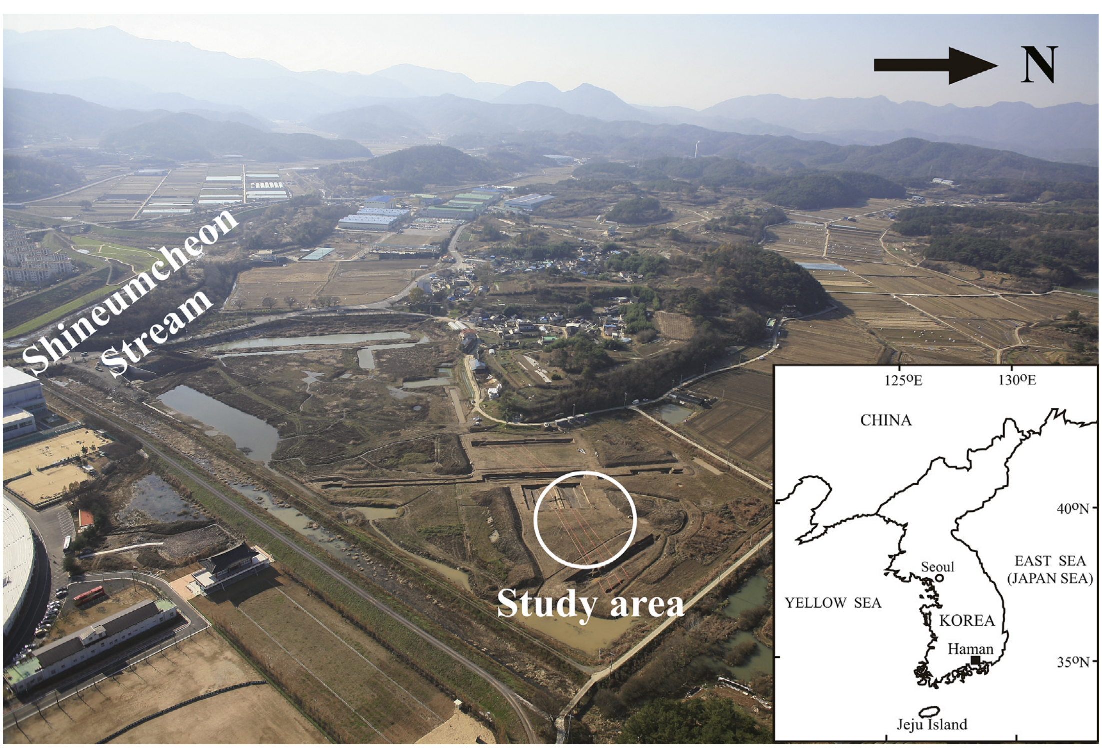

Fig. 1. Location of the Haman area and the Gayari site.