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Human settlement and its influencing factors during the historical period in an oasis-desert transition zone of Dunhuang, Hexi Corridor, northwest China

Haiming Li [a], Fengwen Liu [a], Yifu Cui [a], Lele Ren [a], Michael J. Storozum [b], Zhen Qin [b], Jian Wang [a], Guanghui Dong [a, *]

[a] MOE Key Laboratory of Western China's Environmental System, College of Earth & Environmental Sciences, Lanzhou University, Lanzhou, Gansu Province, 730000, China
[b] Department of Anthropology, Washington University in St. Louis, St. Louis, MO, 63130, USA

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ABSTRACT

Many ancient cities and settlement sites have been found in Lucaogou, an ancient oasis near Dunhuang city in northwest China. These settlements indicate that humans inhabited this area during the historical period. However, the chronology and subsistence practices of this area remain unclear. Based on new data from radiocarbon dating, macrobotanical analysis, and the synthesis of historical documents and high-resolution paleoclimatic records, we discuss the inter-relationship between human settlements and plant resource utilization strategies at Lucaogou ancient oasis during historical period. Our results indicate that these ancient sites in Lucaogou area were built between the Han dynasty (202 BC-AD 220) and the Ming dynasty (AD 1368-AD 1644). People mainly used foxtail millet, broomcorn millet, barley and three types of wood (*Tamarix*, *Salix*, *Populus*), probably as fuel for cooking. Human settlement intensity in the area during the historical period was primarily influenced by political situations, which might also have been affected by fluctuations in precipitation.

1. Introduction

In recent decades, climatologists and archaeologists have started to disentangle the complex relationship between environmental change, climatic shifts, and human settlement patterns (e.g., An et al., 2014; Jousse, 2006; Kuper and Kröpelin, 2006; Carrión et al., 2007; Kuzmin and Rakov, 2011; Mercuri et al., 2011; Dong et al., 2012b; Zhang et al., 2013; Albert, 2015; Bonsall et al., 2015; Chen et al., 2015; Yang et al., 2015; Kawahata et al., 2016; Jia et al., 2016). Recent studies have shown that human settlement patterns in ecological transition zones are acutely sensitive to climate change. Some areas that were once habitable hundreds or thousands of years ago are now hyper-arid and uninhabitable, whereas some currently temperate areas were once deserts (Kuper and Kröpelin, 2006; Yang et al., 2015). These shifting ecological zones can have significant influences on shaping both the distribution of archaeological sites and human history. As archaeologists and climatologists continue to debate the role climate change has on desertification, case studies documenting the multifarious causes driving desertification and the resulting adaptive responses seen in human settlement patterns will become increasing important in exploring the social implications of environmental changes in these sensitive oasis-desert transition zones.

Northwestern China, an area currently experiencing rapid rates of desertification, contains many arid climatic zones and fragile ecologies that are vulnerable to climate change (e.g., An et al., 2004, 2005, 2006; Huang et al., 2004; Li et al., 2007a, 2007b; Barton et al., 2009; Yang et al., 2004, 2010, 2011; Dong et al., 2012a, 2012b, 2013, 2016a,b; Jia et al., 2013; Halik et al., 2013; Miao et al., 2016; Zhou et al., 2016). The locations of many way stations along the ancient route of the Silk Road and other ancient sites such as Xiaohe and Loulan are mute testimony to different ecological zones hundreds to thousands of years ago (Hedin, 1905; CRAIXAR, 2004, 2007; Lu et al., 2010). These changing ecological patterns are often temporally correlated with increases or declines in density of occupation. However, a purely environmental interpretation obscures the ability of human agents to adapt and mitigate the consequences of changing climatic conditions. We suggest that the geo-political

* Corresponding author.
E-mail address: ghdong@lzu.edu.cn (G. Dong).

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circumstances resulted in changing settlement patterns during China's historical period in Northwest China by presenting a case study of the Lucaogou ancient oasis, Gansu province.

The Lucaogou ancient oasis, located on the western margin of the Hexi Corridor, contains many archaeological sites that can clarify some of the complexities of the relationship between climate change, human settlement patterns, and local ecological transitions during China's historic period (Luo et al., 2014, Fig. 1). The large number of archaeological sites distributed along Silk Road routes has great potential for archaeological prospection, particularly in the Hexi Corridor. In addition, the Lucaogou region also is a key segment of the ancient Silk Road promoting cultural exchange between western and eastern Eurasia during historical period. In this article, we present the dates and macrobotanical evidence of archaeological sites in the Lucaogou region to discuss the relationship between human settlement patterns, historical events, and climatic changes in the Lucaogou ancient oasis during historical periods.

2. Study area and setting

Lucaogou ancient oasis is located 80 km northeast of the modern city of Dunhuang, in the Hexi Corridor, northwestern China. It has an extremely arid climate with annual mean precipitation of 45.3 mm and annual mean temperature of 8.8 °C (maximum 24.9 °C and minimum −10.4 °C). Altitude gradually declines from the south to the north. The highest elevation in the area is 5808 m above sea level (a.s.l) in the Qilian Mountains and the lowest elevation is 1100 m a.s.l in Guazhou County. The Shule River and Dang River flow through this region (Fig. 1).

According to the results of the Second National Archaeological Survey, less than ten Bronze Age and more than a hundred historical period sites have been found in this area (Bureau of National Cultural Relics, 2011). These Bronze Age sites are associated with Siba culture (3900-3400 cal BP), Shajing culture (2800-2400 cal BP) and Shanma culture (3000-2400 cal BP) (Li, 2009, 2010a,b; Pu and Pang, 1990; Wang, 2012). The historical sites include 28 Han Dynasty (202 BC- AD 220) sites, 17 Wei Jin Southern and Northern Dynasties (AD 220-AD 589) sites, 26 Sui (AD 581-AD 618) and Tang (AD 618-AD 907) Dynasties sites, 20 Five Dynasties and Ten Kingdoms (AD 897-AD 979) sites and Song Dynasty (AD 960-AD 1279) sites, 14 Yuan Dynasty (AD 1271-AD 1368) sites, 8 Ming Dynasty (AD 1368-AD 1644) sites.

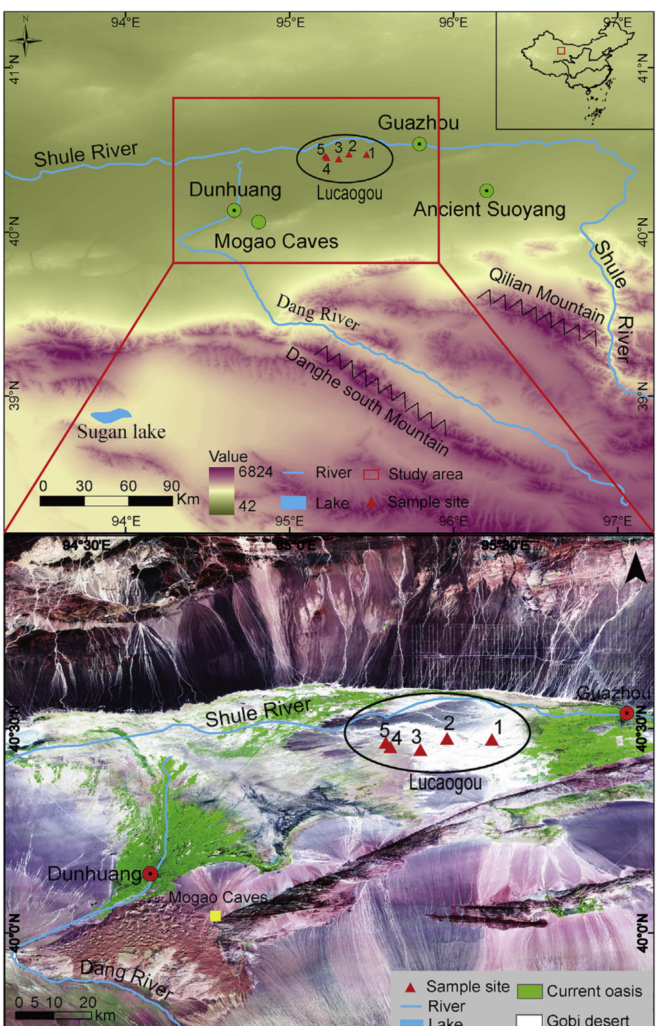

Fig. 1. Location of the study area. Sampled sites: 1. Site 1 of Lucaogou, 2. Payaoshu site, 3. Site 2 of Lucaogou, 4. Site 3 of Lucaogou, 5. Xishawo site.

3. Materials and methods

In 2013, we investigated five locations within the study region shown in Fig. 1. At each sites (Site 1 of Lucaogou, Site 2 of Lucaogou, Site 3 of Lucaogou, the Payaoshu site and the Xishawo site), we profiled several archaeological deposits to expose ash pits or cultural layers (Fig. 2). We recorded and photographed each profile (Fig. 2).

At each site we exposed several cultural layers and ash pits. At Site 1 of Lucaogou, we identified three ash pits in the northwest, northeast, southwest corner of the site (Fig. 2a). All three ash pits are approximately 30 cm high by 50 cm wide (Fig. 2b). At Site 2 of Lucaogou, we found an ash pit in the northwest corner, approximately 30 cm high by 30 cm wide (Fig. 2d and e). At Site 3 of Lucaogou, we found a small ash pit (about 20 cm high by 25 cm wide) in the southeast corner (Fig. 2f and g). At the Paoyaoshu site, we found a 5 cm thick cultural layer (Fig. 2h). At the Xishawo site, we found a cultural layer (10 cm thick) and two ash pits, approximately 25 cm high by 30 cm wide. In order to prevent sample contamination, we cleaned off the surface of the ash pit and culture layer before collecting each sample. In total, we collected twelve samples from these each ash pit and cultural layers for floatation and radiocarbon dating.

We floated each sample using the manual bucket flotation technique. Carbonized remains were collected with a sieve with #80 mesh (aperture size of 0.2 mm) and then air dried. Charred plant seeds were identified in the Paleoethnobotany Laboratory, Institute of Archaeology, Chinese Academy of Social Sciences. Charcoal was collected by flotation using sieves to collect the light fractions. After drying and sorting, all samples were prepared with a razor blade to produce fresh, clean surface presenting transverse, radial, and tangential section. Then, samples were examined under a 5×, 10×, 20×, and 50×metallurgical microscope. The taxa were identified, using the *China Timber Atlas* (Chen et al., 1992) and *China's Major Timber Structure* (Yao, 1988) as guides. Furthermore, a typical sample of each type was photographed under a scanning electron microscope (SEM) to enhance identification. For samples of fragments fewer than 100, each piece was identified. A minimum of 100 fragments were identified for samples of fragments more than 100. Then, the percentage of a certain species in the total fragments and the frequency of samples containing certain taxa were calculated.

In total, we dated seven samples retrieved from the twelve floatation samples (Table 1). All samples were prepared with the