Journal of Asian Earth Sciences 156 (2018) 180–188

Contents lists available at ScienceDirect

Journal of Asian Earth Sciences

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

Full length article

Sediment records of Yellow River channel migration and Holocene environmental evolution of the Hetao Plain, northern China

Jingzhong Wang[a], Jinglu Wu[b,*], Baotian Pan[c], Hongjuan Jia[a], Xiao Li[a], Hao Wei[a]

[a] Experiment & Practice Teaching Center, Heibei GEO University, Shijiazhuang 050031, China
[b] State Key Laboratory of Lake and Environmental Sciences, Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences, Nanjing 210008, China
[c] Key Laboratory of Western China's Environmental Systems (Ministry of Education), Lanzhou University, Lanzhou 730000, China

ARTICLE INFO

Keywords:
Sediment record
Channel migration
Yellow River
Environmental evolution
Hetao Plain

ABSTRACT

The origin and evolution of lakes in the Hetao Plain, northern China, were influenced by climate variation, channel migration, and human activity. We analyzed a suite of sediment cores from the region to investigate Yellow River channel migration and environmental change in this region over the Holocene. Short sediment cores show that environmental indicators changed markedly around CE 1850, a time that corresponds to flood events, when large amounts of river water accumulated in the western part of the Hetao Plain, giving rise to abundant small lakes. Multiple sediment variables (environmental proxies) from two long cores collected in the Tushenze Paleolake area show that sediments deposited between 12.0 and 9.0 cal ka BP were yellow clay, indicative of fluvial deposition and channel migration. From 9.0 to 7.5 cal ka BP, sand was deposited, reflecting a desert environment. From 7.5 to 2.2 cal ka BP, however, the sediments were blue-gray clay that represents lacustrine facies of Lake Tushenze, which owes its origin to an increase in strength of the East Asian monsoon. At about 2.2 cal ka BP, the north branch of the Yellow River was flooded, and the Tushenze Paleolake developed further. Around 2.0 cal ka BP, the paleolake shrank and eolian sedimentation was recorded. The analyzed sediment records are consistent with the written history from the region, which documents channel migration and environmental changes in the Hetao Plain over the Holocene.

1. Introduction

Climate variation, channel migration, and human activity can lead to a range of environmental problems and are causes for public concern around the world (Hollands et al., 2006; Wang et al., 2007; East et al., 2015). Factors such as the North Atlantic Oscillation (NAO), El Niño–Southern Oscillation (ENSO), and anthropogenically driven global climate change, among others, may provoke catastrophic reductions in the availability of natural resources, which can have dramatic effects on human populations (Stott et al., 2004; Xiao et al., 2008). Studies of channel migration and past floods can be used to track the history of extreme precipitation under different mean climate conditions. For example, studies of overbank flood deposits in river basins of the Iberian Peninsula suggested changes in the frequency of large floods, which are correlated with large-scale atmospheric circulation patterns and paleoclimate conditions recorded in other archives (Thorndycraft and Benito, 2006; Benito et al., 2008). Other records from lacustrine and riverine systems have been used to produce long flood chronologies for many regions (Arnaud et al., 2005; Czymzik et al., 2013). As populations increase, human activities are becoming more important influences on these systems. For example, channel migration of the Middle Yangtze has varied in the past, but has nearly ceased recently, under increasing human influence (Yin et al., 2007).

The Hetao Plain is located in western Inner Mongolia, in the upper reaches of the Yellow River, where it borders the Ulan Buh Desert. The Plain lies in a transitional zone between arid and semi-arid areas of northern China, along the margin of the East Asian monsoon region (Chen et al., 2014; Wang et al., 2015). In the western part of the Hetao Plain, the geomorphology transitioned from desert to fluvial and lacustrine, and back to desert again, over the course of the Holocene (Jia et al., 1998; Zhao et al., 2012). Because of the high erodibility of rock in the desert environment, which releases large amounts of sediment, riverbeds underwent siltation and river channels migrated (Ta et al., 2003, 2013). Outburst flood disasters have occurred often in this region, and river channel stability was threatened repeatedly by human activities between CE 1958 and 2008 (Jia et al., 2011; Yao et al., 2013). Environmental conditions in the region have been affected by monsoon climate, eolian deposition, river channel migration, and anthropogenic activity. Because sediments often accumulate continuously and rapidly in lakes, lacustrine sediment cores can provide high-resolution records

* Corresponding author.
E-mail address: w.jinglu@niglas.ac.cn (J. Wu).

https://doi.org/10.1016/j.jseaes.2018.01.031
Received 14 June 2017; Received in revised form 26 January 2018; Accepted 28 January 2018
1367-9120/

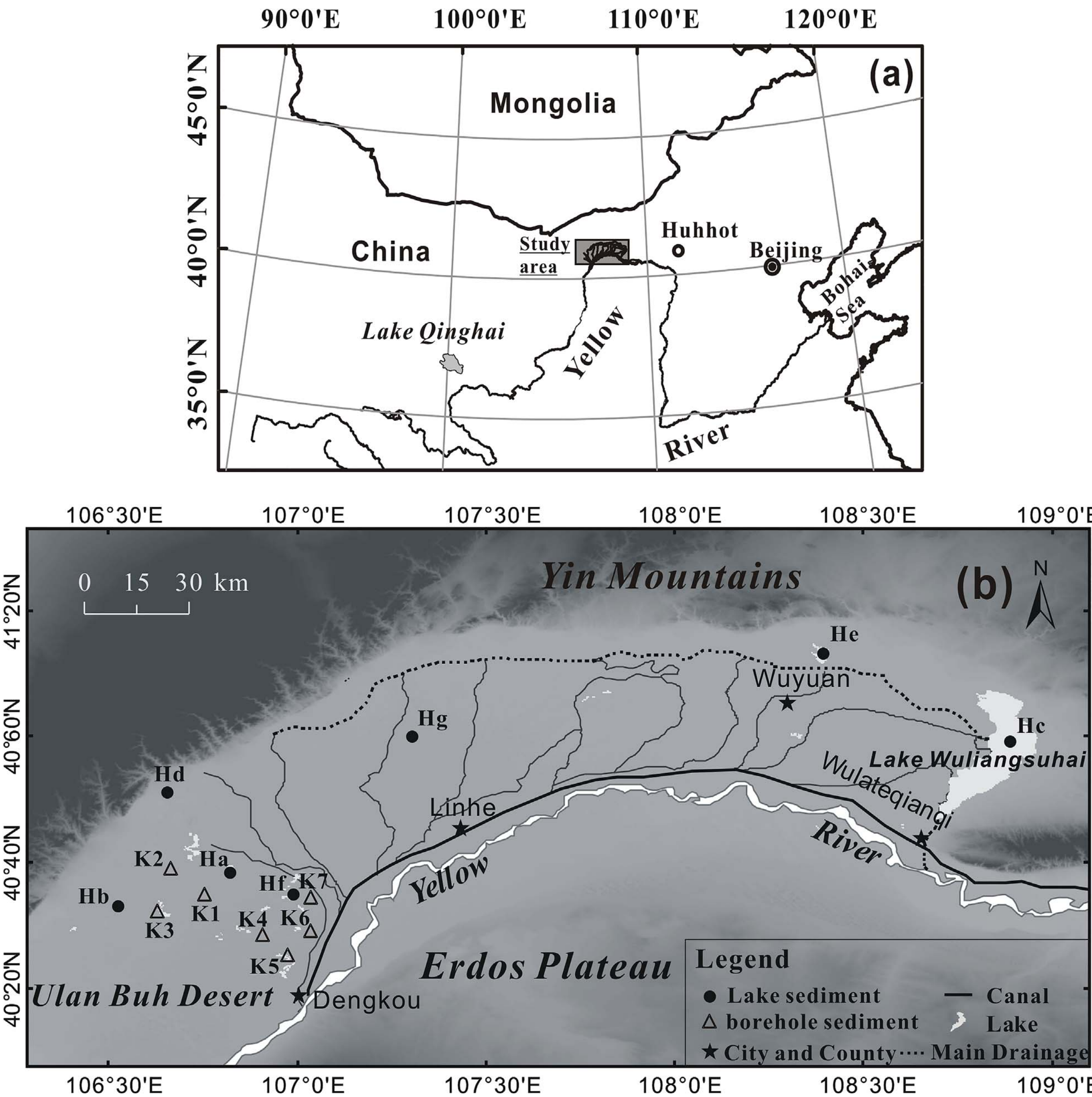

Fig. 1. Sketch map of (a) the study area in the Hetao Plain, (b) geographic location of the Hetao Plain and coring sites: Ha = Lake Chenpu, Hb = Lake Dongqing, Hc = Lake Wuliangsu, Hd = Lake Taiyangmiao, He = Lake Muyang, Hf = Lake Beihai, Hg = Lake Heiluju, and K3–K7 were obtained from Jia and Yin (2004).

of past climate and environmental changes (Battarbee, 1999; Alve et al., 2009).

We analyzed variables in a suite of short and long sediment cores from the Hetao Plain to infer past environmental conditions in the region. We measured grain-size parameters and element composition in a short core from Lake Chenpu, and compared the results with those from cores collected from other lakes in the study area. Analysis of the short cores served as the basis for examination of two longer sediment cores. We had two major goals in this project: (1) recover information on spatial landforms across the Hetao Plain for the time period since ca. CE 1850, and (2) infer environmental changes in the region over the Holocene, especially the relationship between the Yellow River and the Tushenze Paleolake.

2. Materials and methods

2.1. Geographic setting

The Hetao Plain is located in the western part of the Inner Mongolia Autonomous Region of China (Fig. 1a). It has an area of 13,000 km^2 and a population of 900,000 inhabitants. The basin is relatively flat, with elevations from 1010 to 1107 m above sea level. It extends ~60 km from north to south and ~200 km from east to west, and consists mostly of alluvial and lacustrine sediments along the northern banks of the Yellow River. In general, elevation is slightly higher in the southwest than in the northeast. The basin is bounded by the Yin Mountains to the north, by the Ordos Plateau to the south, and by the Ulan Buh Desert to the west (Fig. 1b).

Previous studies suggested that in the Pre-Qin Period, i.e. before 221 BCE, there was a large ancient lake in the northern part of the Ulan Buh Desert, called Tushenze Paleolake, with an area of about 700 km^2. This