

Middle Miocene eolian sediments on the southern Chinese Loess Plateau dated by magnetostratigraphy



Bin Wang^a, Hongbo Zheng^{b,*}, Zhong He^c, Ping Wang^b, Anu Kaakinen^d, Xinying Zhou^e

^a School of Earth Sciences and Engineering, Nanjing University, Nanjing 210093, China

^b School of Geography Science, Nanjing Normal University, Nanjing 210046, China

^c Institute of Soil and Water Conservation, Northwest A&F University, Yangling 712100, China

^d Department of Geosciences and Geography, University of Helsinki, Helsinki 00014, Finland

^e Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing 100044, China

ARTICLE INFO

Article history:

Received 19 February 2014

Received in revised form 25 June 2014

Accepted 7 July 2014

Available online 14 July 2014

Keywords:

Chinese Loess Plateau

Neogene

Eolian sediments

Bahe Formation

Geochemistry

Grain size

ABSTRACT

We present the results of a magnetostratigraphic grain size and geochemical investigation, of a well-preserved sequence of eolian sediments of Miocene age at Duanjiapo, on the southern Chinese Loess Plateau. The paleomagnetic results demonstrate that the basal age of the studied interval is about 11 Ma. The results of the grain size and geochemical analyses show strong similarities between the eolian Miocene silts and the overlying Red Clay and loess units. This leads us to conclude that all formations have a similar eolian origin, although the Miocene silts include evidence of fluvial sediments derived from river originating in the Qinling Mountains, to the south of the study site. Our results indicate that the accumulation of eolian dust in the southern Chinese Loess Plateau area began at least 11 Ma ago.

© 2014 Elsevier B.V. All rights reserved.

1. Introduction

In Northern China, the Cenozoic history of inland desertification and the initiation of the East Asian monsoon are manifested in thick eolian dust deposits, including the Quaternary loess–paleosol and underlying Red Clay in the Chinese Loess Plateau (CLP) (e.g., Liu, 1985; Kukla and An, 1989; Ding et al., 1998; Guo et al., 2002). These eolian deposits constitute a useful proxy for paleoclimatic and paleoenvironmental conditions and have been used to constrain the evolution of the monsoon, the onset of Asian desertification and the tectonic history of the Tibetan Plateau (An et al., 2001; Guo et al., 2002). Age for the inception of eolian deposition is a key question and has been of interest for the last three decades. In the 1980s, studies of the Chinese loess–paleosol sequences demonstrated that eolian dust deposition extended back until at least 2.6 Ma BP (Liu, 1985; Kukla, 1987; Kukla and An, 1989; Ding et al., 1992). In the 1990s, work on the underlying Red Clay sediments demonstrated that they were also of wind-blown in origin, and therefore that the eolian record extended back to 7–8 Ma (Sun et al., 1997, 1998; Ding et al., 1998; An et al., 2001; Qiang et al., 2001).

Guo et al. (2002) confirmed an eolian origin of a 22–6.2 Ma sedimentary sequence in Qin'an, western CLP, thereby further extending the date of initiation of Asian desertification to at least 22 Ma ago. In the

eastern CLP, an 11 Ma Red Clay section was reported in Shilou (Xu et al., 2009). However, there is no published record of an eolian sequence older than 7 Ma in the southern CLP area. Consequently the aims of the present study were to attempt to locate and accurately date loess deposits predating 7 Ma in this area.

Our study focuses on the Duanjiapo section (34°12'N, 109°12'E) (Fig. 1), in Lantian county, southern CLP. The Neogene deposits in Lantian area are an important stratigraphical key site in preserving a record of Late Neogene terrestrial deposition and they have also been a fertile ground for recovery of late Neogene fossil mammals for more than 50 years (e.g. Liu et al., 1960; Zhang et al., 1978; Li et al., 1984). Over the last decade, knowledge about the Lantian sequence has increased considerably as multidisciplinary investigations on geology and vertebrate paleontology were resumed in the area in 1990s (summarized in Zhang et al., 2013). These investigations have contributed significantly to the understanding of sedimentological, stratigraphical, paleoenvironmental and paleontological aspects of the Lantian sequence (Zhang et al., 2002; Kaakinen and Lunkka, 2003; Qiu et al., 2003; Zhang, 2003; Andersson and Kaakinen, 2004; Chen and Zhang, 2004; Qiu et al., 2004a,b; Chen, 2005; Kaakinen, 2005; Li and Zheng, 2005; Zhang, 2005; Zhang and Liu, 2005.; Kaakinen et al., 2006; Qiu et al., 2008; Zhang et al., 2008; Passey et al., 2009; Suarez et al., 2011; Zhang et al., 2013).

In Lantian, the late Neogene sediments underlying the Pleistocene loess–paleosol deposits are grouped to the Bahe and Lantian formations.

* Corresponding author. Tel./fax: +86 25 85891259.
E-mail address: zhenghb@njnu.edu.cn (H. Zheng).

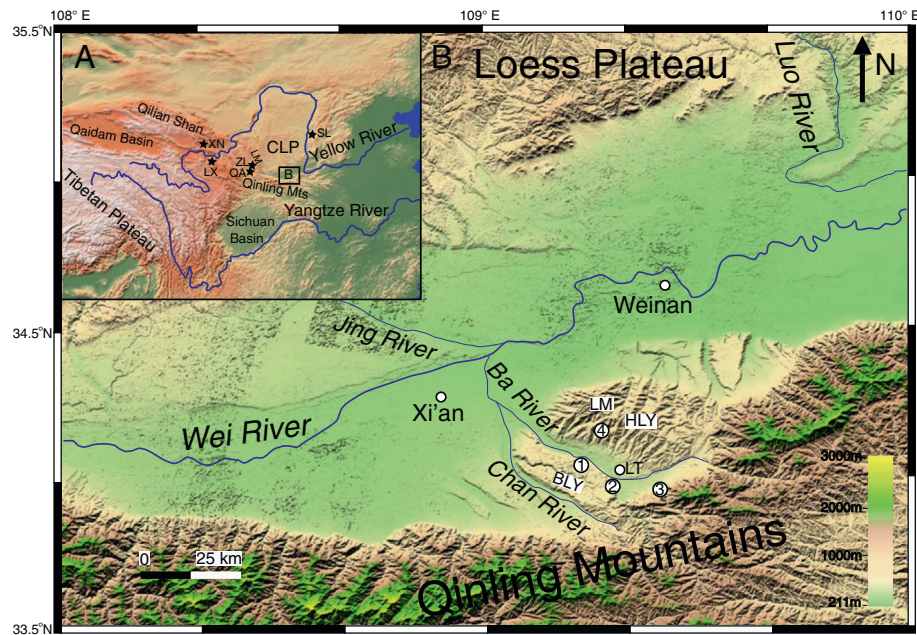


Fig. 1. A. Location of the Chinese Loess Plateau, Weihe Basin and the main study sites. B. Location of the Duanjiapo (DJP) section in the Lantian region on the southern Loess Plateau. CLP—Chinese Loess Plateau; LM—Liupan Mountains; QA—Qin'an; SL—Shilou; LX—Linxia; ZL—Zhuanglang; BLY—Bailuyuan; HLY—Henglingyuan; LM—Lishan Mountain; ①—Duanjiapo; ②—Liujiapo; ③—Gongwangling; ④—Chenjiawo.

The relatively thick and continuous sequence of reddish clay-silt sized sediments in the Lantian Formation has been studied intensively and is shown to represent eolian Red Clay (Yue, 1989; Zheng et al., 1992; Sun et al., 1997; An et al., 2000). Stratigraphy and sedimentology of the underlying Bahe Formation are generally well-constrained (see Kaakinen and Lunkka, 2003; Kaakinen, 2005; Zhang et al., 2013 and references therein), but detailed studies of the fine-grained deposits in the Bahe Formation remain under-represented—although they constitute volumetrically significant proportion of the formation. In order to assess the origin of the fine-grained facies in the late Miocene Bahe Formation, this paper presents the results of a comparison of its grain size and geochemical characteristics with the overlying Red Clay and loess deposits. We also present a detailed magnetostratigraphic investigation of the Bahe Formation to provide an independent magnetic age determination for the sequence and for calibrating the precise ages for the sampled horizons. Our overall aim is to improve the understanding of the sedimentary processes, and especially eolian activity and its spatial variability, over the last 11 Ma of the CLP.

2. Regional geological background

The Lantian area, located at the southernmost edge of the CLP and on the northern flank of the Qinling Mountains (Fig. 1), is well known for the discovery of the remains of *Homo erectus* found at the Gongwangling and Chenjiawo sites, and for the rich assemblages of mammalian fossils within the Cenozoic sequences (Liu et al., 1960; An and Ho, 1989; Zhang et al., 2002; Qiu et al., 2003; Zhang et al., 2008, 2013).

A more than 1000 m thick sequence of terrestrial clastic sediments has been deposited along the flanks of Lishan Mountain as a result of the uplift of the Qinling and Lishan mountains during the Cenozoic era, and a large number of outcrops have been incised and exposed by the rivers and natural streams (Zhang et al., 1978; Porter et al., 1992; Kaakinen, 2005). Although the Neogene deposits are frequently overlain by Quaternary loess, they are occasionally exposed in the many erosional gullies.

During the 1960s, the Institute of Vertebrate Paleontology and Paleoanthropology and the Institute of Geology, Chinese Academy of Sciences, conducted detailed stratigraphic studies and established a lithostratigraphic framework for the region: Liu et al. (1960) and Jia

et al. (1966) subdivided the Cenozoic strata into the Honghe, Bailuyuan, Lengshuigou, Koujiacun, Bahe and Lantian Formations, capped by the loess–paleosol sequence and spanning from Eocene through Pleistocene (Zhang et al., 1978; Fig. 2). More recent studies (Zhang et al., 2002; Kaakinen and Lunkka, 2003; Kaakinen, 2005; Zhang et al., 2013) have refined the stratigraphic scheme for the Bahe and Lantian formations and provided well-resolved ages for the deposits and faunas.

The Bahe and Lantian formations have proven to cover one of the most complete late Miocene sequence in China with diversified fossil faunas representing typical elements of late Miocene “*Hipparion* fauna” (cf. Schlosser, 1903; Kurtén, 1952). The recent work (as summarized in Zhang et al., 2013) recognized three stratigraphically superpositioned mammalian assemblages (biozones) of the Late Miocene and showed the Bahe *Hipparion* fauna (biozones BH1 and BH2 of the Bahe Formation) to be distinct from and predate the Baode *Hipparion* faunas that are present in the Lantian Fm (biozone BD). These biozones can tentatively be correlated with the European Vallesian “age” (land-mammal based faunal unit), early to middle Turolian, and late Turolian, respectively.

In the present study, we focus on the Late Neogene strata at Duanjiapo, in the Bailuyuan Plateau. From the top of the Bailuyuan to the base near the Ba River, there is a sedimentary record which includes the Pleistocene loess–paleosol sequence, the Lantian Formation and the Bahe Formation (Liu et al., 1960; Jia et al., 1966; Zhang et al., 1978; Fig. 2). However, the upper part of the Bahe Formation was not exposed in Duanjiapo, and therefore we sampled the upper part at Liujiapo, 5 km east of Duanjiapo. Overall, the entire section examined is 438 m thick and contains 3 lithological units: the lower part is the Bahe Formation with a thickness exceeding 246 m; the central part comprises the 60 m thick Lantian Formation (Red Clay); and the uppermost part is a 132 m thick Quaternary loess–paleosol sequence.

2.1. The Bahe Formation

The Bahe Formation is well preserved in the Lantian region, and is about 300 m thick in the Bailuyuan Plateau. Liu et al. (1960) and Zhang et al. (1978) divided the Bahe Formation into two parts: the upper part being dominated by red-brown and yellowish mudstones

Download English Version:

<https://daneshyari.com/en/article/6350062>

Download Persian Version:

<https://daneshyari.com/article/6350062>

[Daneshyari.com](https://daneshyari.com)