Quaternary International 400 (2016) 202–211

Contents lists available at ScienceDirect

Quaternary International

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

Magnetostratigraphic dating of the Shanshenmiaozui mammalian fauna in the Nihewan Basin, North China

Ping Liu [a, b, *], Zhijun Wu [c], Chenglong Deng [d, *], Haowen Tong [e], Huafeng Qin [d], Shihu Li [d], Baoyin Yuan [d], Rixiang Zhu [d]

[a] Key Laboratory of Computational Geodynamics, Chinese Academy of Sciences, Beijing, 100049, China
[b] University of Chinese Academy of Sciences, Beijing, 100049, China
[c] Nihewan National Reserve, Zhangjiakou, 075000, Hebei Province, China
[d] State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, 100029, China
[e] Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences, Beijing, 100044, China

ARTICLE INFO

Article history:
Available online 6 November 2014

Keywords:
Nihewan Basin
Nihewan formation
Nihewan faunas
Magnetostratigraphy
Shanshenmiaozui mammalian fauna

ABSTRACT

Timing of the mammalian faunas in the Nihewan Basin, North China has provided insights into our understanding of Quaternary biochronology and biostratigraphy in East Asia. Here we contribute to this topic with detailed magnetostratigraphic investigation, coupled with mineral magnetic measurements on a fluvio-lacustrine sequence in this basin, which contains the Shanshenmiaozui mammalian fauna. Magnetite and hematite were identified as the main carriers for the characteristic remanent magnetizations. Magnetostratigraphic results show that the Shanshenmiaozui sedimentary sequence recorded the Brunhes chron, the Jaramillo subchron, and the late Matuyama chron. Stratigraphic correlation in terms of lithology, magnetic susceptibility and magnetic polarity sequences between the Shanshenmiaozui, Xiaochangliang and Dachangliang sections indicates that the Shanshenmiaozui mammalian fossil layer is younger than the Xiaochangliang and Dachangliang artefact layers, which have been previously estimated to be about 1.36 Ma. The age of the Shanshenmiaozui mammalian fossil layer at the bottom of the section is estimated to be about 1.2 Ma. The new magnetostratigraphy of the Shanshenmiaozui section provides useful constraints on lithostratigraphic and biostratigraphic correlations in the Nihewan Basin.

1. Introduction

The Nihewan Basin lies approximately 150 km west to Beijing, and is located in the transition zone between the North China Plain and the Inner Mongolian Plateau (Fig. 1). The basin is a downfaulted basin filled with Pliocene to Holocene lacustrine, fluvial and wind-blown deposits (Wei, 1985; Chen, 1988; Zhou et al., 1991; Zhu et al., 2007; Deng et al., 2008). The fluvio-lacustrine sedimentary sequences have been named the Nihewan Beds (Barbour, 1924). Numerous Paleolithic sites and mammalian faunas have been found in the sequences (Zhou et al., 1991; Wei, 1997; Chen, 1988; Zhu et al., 2003, 2007; Xie, 2006; Xie et al., 2006; Deng et al., 2008). Especially, the mammalian fossils preserved in the Nihewan sedimentary sequence, known as the Nihewan faunas (sensu lato). In particular, the mammalian fossils collected near the Nihewan village and reported by Teilhard de Chardin and Piveteau in 1930s comprise the typical early Pleistocene mammalian fauna in North China, known as the Xiashagou Fauna or the Nihewan Fauna (sensu stricto) and traditionally corresponding to the Villafranchian Fauna in Europe (Barbour, 1925; Teilhard de Chardin and Piveteau, 1930; Qiu, 2000). Many efforts have been made to date and correlate the sedimentary sequences in the Nihewan Basin through magnetostratigraphical, paleontological, sedimentological, rock magnetic, geochemical, and palynological investigations, which have contributed significantly to our understanding of chronological framework of the complex stratigraphy and depositional systems in the basin (Barbour, 1924; Teilhard de Chardin and Piveteau, 1930; Li and Wang, 1982; Yuan et al., 1996; Wei, 1997; Qiu, 2000; Lovlie et al., 2001; Zhu et al., 2001, 2003, 2004, 2007; Wang et al., 2004, 2005, 2008; Deng et al., 2006a, 2007, 2008; Li et al., 2008; Liu

* Corresponding authors. Key Laboratory of Computational Geodynamics, Chinese Academy of Sciences, Beijing, 100049, China.
E-mail addresses: liuping@mail.iggcas.ac.cn (P. Liu), cldeng@mail.iggcas.ac.cn (C. Deng).

http://dx.doi.org/10.1016/j.quaint.2014.09.024
1040-6182/

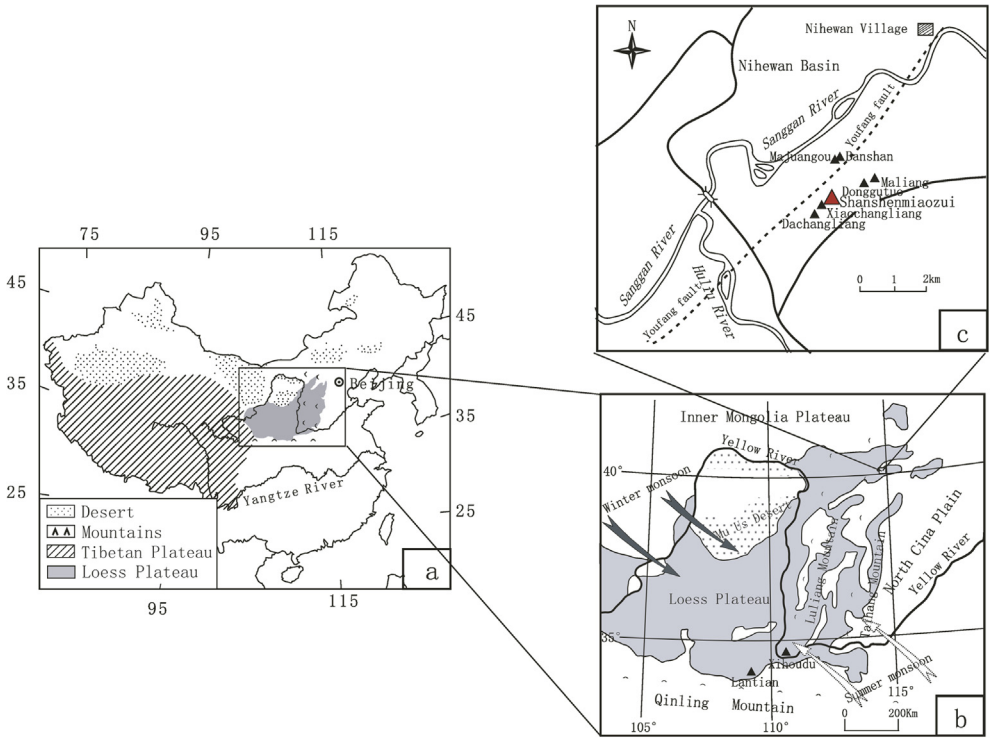

Fig. 1. Schematic map showing the Loess Plateau, the Nihewan Basin, the Shanshenmiaozui mammalian fossil site (red triangle) and other mammalian fossil sites (black triangles) mentioned in this paper (modified from Guo et al.(2002), Deng et al. (2006a), Liu et al. (2010)). (For interpretation of the references to colour in this figure legend, the reader is referred to the web version of this article.)

et al., 2010, 2012; Ao et al., 2013a,b). However, detailed magnetostratigraphic investigations on some newly found and excavated mammalian fossil sites remain requisite.

The Shanshenmiaozui mammalian fossil site bears the richest and best preserved fauna recovered in the Nihewan Basin during the past decades (Tong et al., 2011, 2012). It is very useful to understand the chronology of the Nihewan faunas (sensu lato) and the evolution of some important taxa. In this study, we carried out a detailed magnetostratigraphic investigation coupled with rock magnetic data on the Shanshenmiaozui section. The results of our study contribute to a better understanding of stratigraphic correlation and chronologic sequence of the mammalian faunas in the Nihewan Basin.

2. Geological setting and sampling

The Shanshenmiaozui mammalian fossil site (40°13′3.1″N, 114°39′51.5″E) in the eastern margin of the Nihewan Basin lies about 200 m southeast of the well-known Xiaochangliang Paleolithic site. Here, the sediments have a thickness of 62.8 m, capped by late Quaternary loess sediments and underlain by Jurassic volcanic breccia. The fluvio-lacustrine sequence in the Shanshenmiaozui section contains mainly grayish-yellow and grayish-green silty clays, silts, and sandy silts. The Shanshenmiaozui mammalian fossils are found near the bottom of the section.

The Shanshenmiaozui mammalian fossil site was discovered by Geoffrey Pope and Susan Keates and excavated in 1994 by Qi Wei (Wei et al., 2011), who discovered some mammalian fossils and stone artifacts and offered some important clues of big mammalian fossils. Haowen Tong (Tong et al., 2011) formally excavated the site during the years 2006–2008, resulting in the discovery of abundant mammalian fossils. A list of the mammalian faunas are presented in Table 1.

Table 1
Comparison of the fossil list of the Shanshenmiaozui and Xiaochangliang faunas in the Nihewan Basin. SSMZ, Shanshenmiaozui; XCL, Xiaochangliang.

SSMZ (Tong et al., 2011; Wei et al., 2011)	XCL (You et al., 1980; Tang et al., 1995)
Leporidae gen. et sp. indet.	*Allophaiomys* cf. *A. pliocaenicus*
Ochotona sp.	*Mimomys chinensis*
Canis chihliensis sp.	*Pachycrocuta licenti*
Ursus sp.	*Martes* sp.
Pachycrocuta sp.	*Palaeoloxodon* sp.
Felidae gen. et sp. indet.	*Hipparion* sp.
Mammuthus trogontherii	*Proboscidipparion sinensis*
Proboscidipparion sp.	*Equus sanmeniensis*
Equus sanmeniensis	*Coelodonta antiquitatis*
Coelodonta nihowanensis	*Cervus* sp.
Elasmotherium sp.	*Gazella* sp.
Sus sp.	Bovinae indet.
Cervus sp.	
Eucladoceros sp.	
Spirocerus sp.	
Gazella sinensis	
Bovinae gen. et sp. indet.	

Total 290 block samples oriented by magnetic compass in the field were collected at 20-cm intervals. Cubic specimens of 20 mm × 20 mm × 20 mm were obtained from those block samples in the laboratory for rock-magnetic and magnetostratigraphic studies.

3. Methods

To check the reliability of the sediments, anisotropy of magnetic susceptibility (AMS) measurements were performed using a KLY-4s Kappabridge (Agico Ltd., Brno) before any thermal demagnetization was conducted. In order to monitor changes in magnetic mineral