

## Magnetostratigraphic dating of the Donggutuo and Maliang Paleolithic sites in the Nihewan Basin, North China

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### Abstract

A detailed magnetostratigraphic investigation, coupled with rock-magnetic studies, was carried out on a lacustrine sequence in the eastern Nihewan Basin, Northern China, which contains the Donggutuo and Maliang Paleolithic sites. Magnetite and hematite were identified as the main carriers for the characteristic remanent magnetizations. Magnetostratigraphic results show that the lacustrine sequence recorded the late Matuyama and Brunhes chrons. Furthermore, the Maliang artifact layer occurs just below the Brunhes/Matuyama boundary, and the Donggutuo artifact layer is just below the Jaramillo onset. Therefore, the age of the Maliang and Donggutuo artifact layers can be definitely estimated to be about 0.78 myr and 1.1 myr, respectively. These two paleomagnetic ages, coupled with previously obtained paleomagnetic data of the Majuangou, Xiaochangliang, Banshan, Lantian, and Xihoudu Paleolithic sites, suggest an expansion and lengthy flourishing of human groups from northern to north-central China during the entire Early Pleistocene.

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### Introduction

During the late Pliocene or early Pleistocene, hominins began to spread out of Africa (Antón and Swisher, 2004; Bar-Yosef and Belfer-Cohen, 2001; Dennell, 2003). Asia was the first continent that early humans inhabited when they dispersed from Africa (Bar-Yosef and Belfer-Cohen, 2001). China has proven to be a laboratory for the study of human evolution in a temperate/subtropical setting (An and Ho, 1989; Hou et al., 2000; Huang et al., 1995; Zhu et al., 2001b, 2003, 2004). In particular, the Nihewan Basin in northern China serves as a key area for research into human occupation in the Old World after the initial expansion of early humans out of Africa (Zhu et al., 2001b, 2003, 2004).

A reliable migration chronology is critical for assessing the patterns of human evolution and dispersal in North China, and even in northeast Asia. Thus, the timing of human occupation and stone technologies in different regions of the world has been, and continues to be, a topic of common interest. Toward this end, dating by way of magnetic polarity chronostratigraphy has proved very useful in establishing temporal control of hominin-bearing strata over the world (Abbate et al., 1998; Gabunia et al., 2000; Goren-Inbar et al., 2000; Huang et al., 1995; Hyodo et al., 2002; Oms et al., 2000; Swisher et al., 1994), especially in North China (An and Ho, 1989; Li and Wang, 1982; Zhu et al., 2001b, 2003, 2004).

Most of the few hominin or Paleolithic sites in northern China from the early Pleistocene have been well investigated, such as the Gongwangling site in the southern Loess Plateau (An and Ho, 1989), the Xihoudu site in the Sanmenxia Basin (Zhu et al., 2003), and the Xiaochangliang (Zhu et al., 2001b) and Majuangou and Banshan sites in the

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Nihewan Basin (Zhu et al., 2004). Considerable progress has been made towards paleomagnetically dating these sites. Indeed, magnetochronological consensus of these sites has been reached.

The Donggutuo and Maliang Paleolithic localities are two of the early Paleolithic sites in the Nihewan Basin (Hou, 2000; Schick et al., 1991; Wei, 1997; Wei et al., 1985). A preliminary paleomagnetic study of the Donggutuo sequence was conducted more than two decades ago by Li and Wang (1982), who claimed that the artifact layer is located about 5 m below the Jaramillo subchron. They then estimated the age of the Donggutuo site to be about 1.1 myr, an age estimate that has been supported by the later paleomagnetic analysis of Schick and Dong (1993). However, this later work has proven difficult to evaluate because only unpublished paleomagnetic results were cited and no paleomagnetic data appeared in the paper. Here we present a comprehensive investigation, in which detailed rock-magnetic and magnetostratigraphic studies were combined, of the lacustrine sequence in the Donggutuo section, which bears the Donggutuo and Maliang artifact layers. Our findings contribute to a better understanding of the chronological framework of early human occupation at high northern latitudes (40°N) in northeast Asia.

## Geological, archeological settings and sampling

### Geological setting and sampling

The Nihewan Basin is a downfaulted basin, which is located in the transition zone between the North China Plain and the Inner Mongolian Plateau (Fig. 1). It has significantly contributed to our understanding of early human adaptability to northern climates (Zhu et al., 2001b, 2003, 2004).

This basin is filled with Pliocene to Pleistocene lacustrine and fluvial deposits, which have been named the Nihewan Beds (Barbour, 1924). The Nihewan Formation, which represents the type section of the early Pleistocene in North China (Young, 1950), was restricted to the lower portion of the Nihewan Beds. Today, the Pleistocene sediments, capped with the Holocene soil (S0), the last glacial loess (L1) and the last interglacial soil (S1) (Zhu et al., 2001b, 2003), are dissected along a southwest–northeast track by the Sanggan River (Fig. 1c).

The basin studied by Barbour et al. (1927) was limited to the east margin of the Yangyuan county, and covers an area of roughly 150–200 km<sup>2</sup>. It provides extensive sedimentary exposures consisting of well-developed late Cenozoic lacustrine deposits rich in mammalian fossils known as the Nihewan Fauna. These fossils correspond to the Villafranchian Fauna in Europe (Barbour, 1925; Teilhard de Chardin and Piveteau, 1930). During the past two decades, a series of magnetostratigraphical, sedimentological, geochemical, paleontological, and palynological studies (Chen, 1988; Tang et al., 1995; Yuan et al., 1996; Wei, 1997; Wang et al., 2004; Zhu et al., 2001b, 2003, 2004) have contributed significantly to our understanding of the complex stratigraphy and depositional systems in the Nihewan Basin.

Specifically, the Cenjiawan (Cheng-chia-wan) platform in the eastern margin of Nihewan Basin, predominantly consisting of lacustrine sediments, covers an area of some 20 km<sup>2</sup> and has a relative height of more than 120 m. This platform has yielded a number of fossil-containing and archeological localities, including Majuangou, Xiaochangliang, Donggutuo, Maliang, Cenjiawan, Huojiadi, and Banshan (Fig. 1c) (Feng and Hou, 1998; HPICR, 1998; Hou, 2000; Schick et al., 1991; Wei, 1994; You et al., 1980). With the exceptions of Cenjiawan and Maliang, these sites

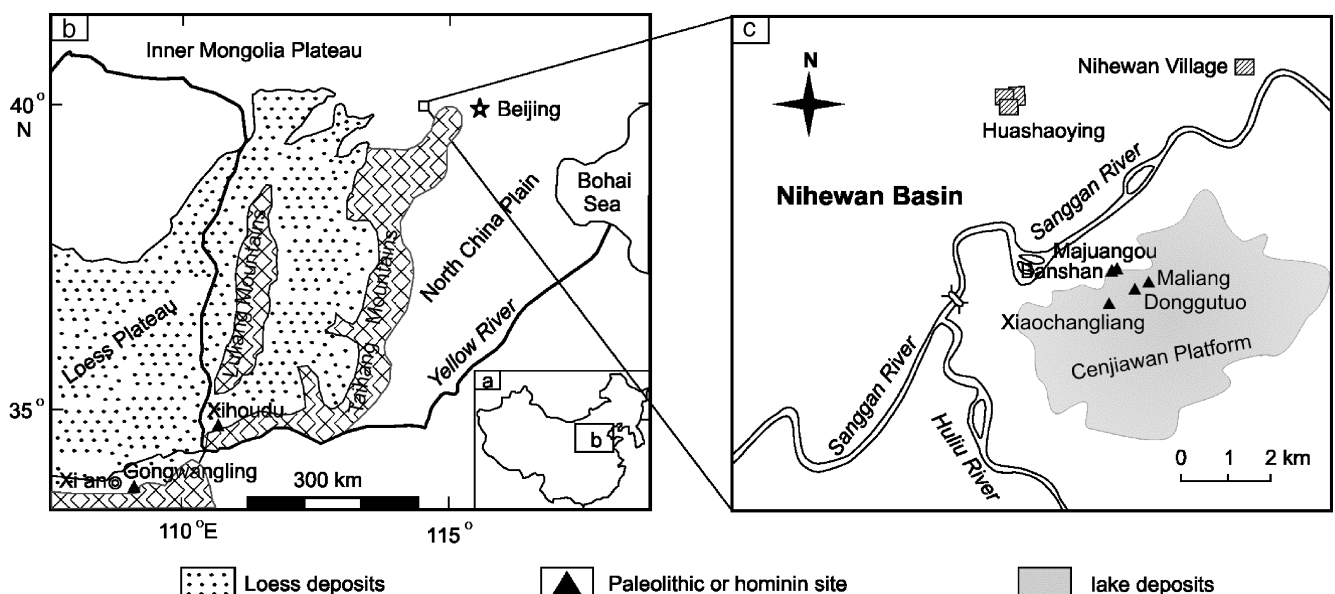


Figure 1. Schematic map of the Nihewan Basin and the Paleolithic/hominin sites mentioned in this paper.

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