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Coupled ESR and U-series dating of fossil teeth from Yiyuan hominin site, northern China



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ABSTRACT

Coupled ESR and U-series analyses of mammalian fossil teeth were carried out on two localities of Yiyuan hominin site (Locality 1 and 3) in northern China. The U-migration history of the fossil samples could be reconstructed by the combination of the two techniques, and overcome the limitation of stand-alone ESR and U-series age estimation. We obtained a combined ESR/U-series age (AU model) range from ~420 to 320 ka from nine teeth recovered from the two localities, which pinpoints the deposition of hominin layer of Yiyuan site to MIS 11 to 9. The age results in this study places Yiyuan site at the same time range of Zhoukoudian Locality 1 and Hexian *Homo erectus* sites. Comparing with other hominin sites, this study of Yiyuan *Homo erectus* site highlights the possibility of coexistence between *Homo erectus* and archaic *H. sapiens* in China.

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1. Introduction

In 1981 and 1982, a fragment of human cranial vault bone, two fragments of supraorbital part of the frontal bone and seven human teeth were discovered from the two localities of Yiyuan site – Yiyuan Locality 1 (YYI) and Locality 3 (YYIII, ~56 m south of YYI) during the excavation in a fissure deposit on Qizianshan limestone hill, Yiyuan County, Shandong Province, China (118°09'E, 36°12'N) (Lu et al., 1989; Wu and Poirier, 1995) (Fig. 1). The cranial fragment from YYI was recovered from small fragments of the parietals, frontal, and the occipital bones. Based on a morphological comparison, Lu et al. (1989) suggesting that both Yiyuan cranial

fragments and teeth are similar to those of Zhoukoudian, and were attributed to *Homo erectus*. Additionally, a recent study of interproximal grooves on Yiyuan human teeth shows the evidences of tooth-picking behavior, probably as one of the earliest in eastern Asia (Sun et al., 2014).

YYI is a small limestone cave site filled with fluvial deposits, and YYIII nearby is a fissure site with the same kind of deposition as YYI. Five out of seven human teeth were unearthed from YYIII during the excavation in 1980s (Lu et al., 1989). However, due to road construction, the section of YYIII is completely covered by modern sediments, only YYI could be observed at the present time. Lu et al. (1989) made a detailed description of each layer of two localities, and pointed out that the stratigraphy of YYI and YYIII could be correlated. Five stratigraphic layers were hence recognized at the two localities (Fig. 2). The human remains and abundant faunal remains were unearthed from layer 3. The association of Bovinae, *Ursus arctos*, *Equus sanmeniensis*, *Sus lydekkeri* and *Megaloceros pachyosteus* in the Yiyuan hominin layer was also recognized at

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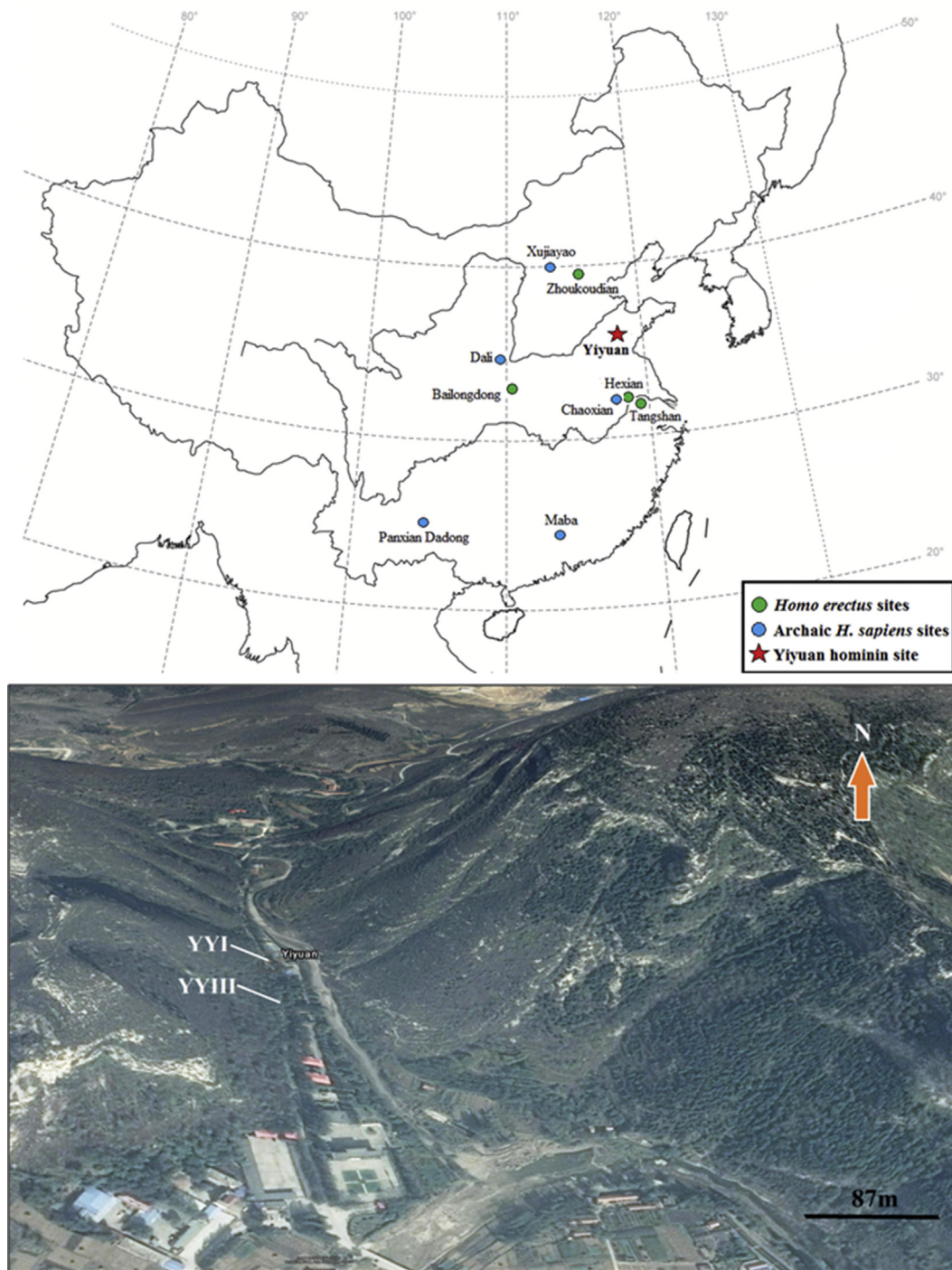


Fig. 1. Location of Yiyuan site and other hominin sites mentioned in this study (Bird's-eye view of Yiyuan Locality 1 and Locality 3 came from Google Earth Pro).

Hexian and in layers 4–5 of Zhoukoudian locality 1, indicating a Middle Pleistocene age (Lu et al., 1989).

Despite the significance of the Yiyuan site, few chronological studies were carried out, and no numerical dating results were present since the discovery of the site. ESR/U-series method is a useful tool for dating fossil teeth from early human sites, as it could reconstruct the uranium migration history in the fossil teeth. Grün et al. (1988) proposed to couple ESR and U-series data to describe

the U-uptake history in the different dental tissues (US-ESR model). The US-ESR model allows the calculation of an U-uptake parameter (p -value) for each dental tissue, but it is restricted to $p \geq -1$, i.e. U-loss could not be modeled (Grün, 2009). In the case of U-leaching, an Accelerating Uptake (AU) model (Shao et al., 2012) was recently introduced which describes the U-uptake into dental tissue as an accelerating process. This model is able to reconstruct a process combining incorporation followed by

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