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## Re-dating Zhoukoudian Upper Cave, northern China and its regional significance

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### ABSTRACT

Due to the presence of multiple partial modern human skeletons thought to have been interred along with a diversity of evidence of symbolic behavior, Zhoukoudian Upper Cave (ZKD UC; formally “Choukoutien”) from northern China has long been a critical site for understanding Late Quaternary human evolution and particularly the role eastern Asia played. Unfortunately, uncertainty regarding ZKD UC's chronology has long hindered determination of its importance in the debate over modern human origins. This situation has been particularly problematic because dates from the primary archaeological layers of ZKD UC have ranged from the Late Pleistocene to the Early Holocene (~34–10 ka), with clearly different implications depending on which age is used. Here, we present a new set of accelerator mass spectrometry radiocarbon dating results from ZKD UC. Based on this new set of dates and further re-evaluations of the previous dating analyses, archaeological materials, published excavation reports and stratigraphy, we conclude that the ZKD UC archaeological layers minimally date to 35.1–33.5 ka. Given the similarities between the human fossils and archaeology between ZKD UC and western Eurasia, it is likely that the ZKD UC human foragers were part of dispersal events across northern Eurasia toward Siberia and eventually reaching into northern China.

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### 1. Introduction

Eastern Asia, particularly China, has played a pivotal role in the debate about modern human dispersals as they moved through the region in order to eventually colonize places like the Japanese archipelago and eventually the New World (e.g., Wolpoff et al., 1984; Jin and Su, 2000; Karafet et al., 2001; Wu, 2006; Norton and Jin, 2009; Gao et al., 2010; Norton et al., 2010; Di and Sanchez-Mazas, 2011; Rosenberg and Wu, 2013; Kaifu et al., 2015; Bae, 2017; Bae et al., 2017a,b). Although most of the earlier modern human fossils

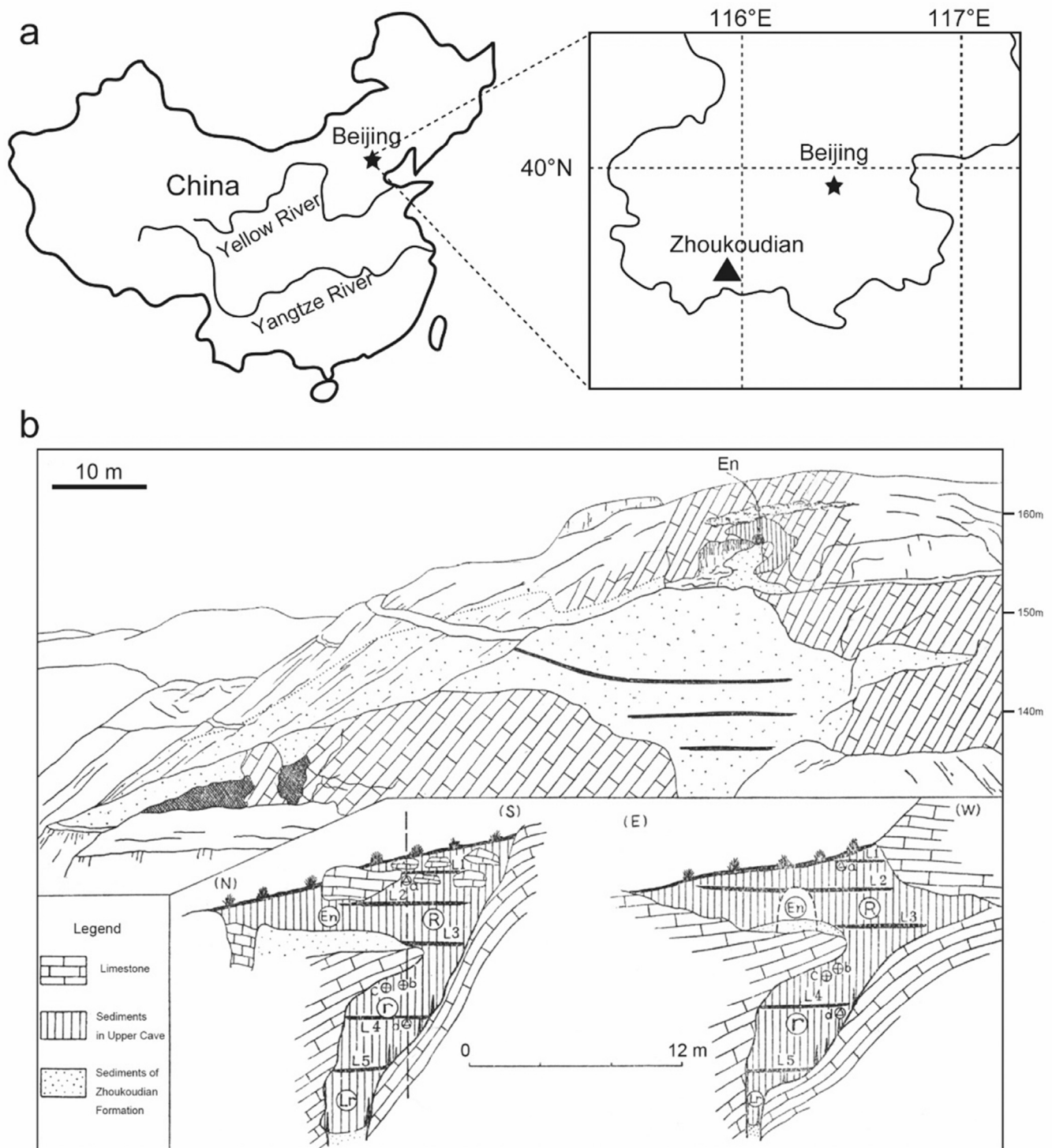
have been reported from central and southern China (see Liu et al., 2016; Martínón-Torres et al., 2017 for recent reviews), a site that has traditionally played a critical role in the debate of modern human origins in northern China is Zhoukoudian Upper Cave (ZKD UC), also known as ZKD Locality 26 (Weidenreich, 1939a,b; Wu, 1961; Wolpoff et al., 1984; Norton and Gao, 2008; Shen et al., 2016).

ZKD UC (N 39° 41'37.4"; E 115° 55'26.8") is the second best known locality besides Locality 1 (the “Home of Peking Man”) from Zhoukoudian, located 50 km southwest of Beijing (Fig. 1a). It is a north-south-oriented cave situated directly above Zhoukoudian Locality 1. It was discovered in 1930 during excavations of Locality 1 and excavated in 1933 and 1934 (Pei, 1934, 1939). Two aspects from ZKD UC that are especially important to paleoanthropology are the human fossils, considered to have been interred, and the associated archaeological materials that are thought to represent evidence of

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**Figure 1.** Location (a) and stratigraphy (b) of Zhoukoudian Upper Cave (modified after Norton and Gao (2008), and Pei (1939)). En: Entrance, R: Upper Room, r: Lower Room, Lr: Lower Recess; a: bone needle, b & c: human skulls, d: perforated marine shells.

modern human behaviors (Pei, 1934, 1939; Norton and Gao, 2008; Norton and Jin, 2009). The human fossils have contributed to debates focusing on population affinities, particularly whether in situ evolution occurred or whether the fossils may have originated from a different region(s) of western Eurasia (Weidenreich, 1939a,b; Wu, 1961; Kamminga and Wright, 1988; Brown, 1999; Cunningham and

Wescott, 2002; Liu et al., 2006; Harvati, 2009). The burials, ochre, and perforated stones, teeth, and shells are clear evidence of symbolic behavior in the region (Pei, 1939; Norton and Jin, 2009).

Four spatial subdivisions (Entrance, Upper Room, Lower Room, and Lower Recess) and five “cultural layers” (L1–L5) with a total thickness of over 10 meters were identified by Pei (1939) at ZKD

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