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# AMS $^{14}$C dating of the hominin archaeological site Chuandong Cave in Guizhou Province, southwestern China

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ABSTRACT

This study presents detailed AMS $^{14}$C dating of charcoals, burned and unburned bones, and teeth from the hominin archaeological site Chuandong Cave, located in Puding County, Guizhou Province, southwestern China. The charcoal samples were pretreated with either the acid–base–acid (ABA) or ORAU–XR method, the unburned bone and teeth samples with ABA-collagen pretreatment, and the burned bone samples with the ORAU–CB method. The AMS $^{14}$C ages of the charcoal samples provide the most reliable results in this study. The AMS $^{14}$C dates of the bone samples are generally younger, possibly due to posterior amino acid contamination. Based on the AMS $^{14}$C ages, we propose the following chronology for the site: Layers 3 to 5 formed between 11.5–12.5 ka BP (all $^{14}$C ages reported in this study are calibrated ages unless stated otherwise. A BP = years before 1950 CE), a period corresponding to the Younger Dryas; Layers 6 to 7 formed between 14–24 ka BP, a period including the Last Glacial Maximum (LGM); and Layers 8–9 likely formed before 34 ka BP corresponding to the late Pleistocene. According to the above chronology, the Chuandong humans (*modern Homo sapiens*) were present at 12 ka BP, i.e., the late Pleistocene. This conclusion differs from the previous estimate at ~9 ka BP, i.e., the early Holocene. Furthermore, the Chuandong Culture likely began as early as 34 ka BP and survived in the region throughout the cold and dry LGM. Detailed studies on the hominin archaeological sites in Guizhou, including Chuandong Cave and Maomaodong Cave, are warranted to better understand hominin evolution in Asia.

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## 1. Introduction

Chuandong Cave (28°18′N, 105°45′E) is located in Houzhai village of Puding County, Anshun City, Guizhou Province in southwestern China (Fig. 1). After the archaeological site Chuandong Cave was found in 1978, three major excavations were organized between 1978 and 1982. The site contained abundant archaeological materials, including two modern *Homo sapiens* skulls, more than ten thousand stone artefacts, more than one thousand horn and bone implements and a large number of animal fossils (Wu and Cao, 1983; Zhang, 1995). All the recoveries are curated by the Guizhou museum. Many archaeological studies on these items have been performed (Yu et al., 1983; Zhang, 1983; Yu, 1984; Huang, 1989; Mao and Cao, 2012). The fourth layer of the Chuandong site contains hominin fossils. Fire residues including charcoals and burned bones preserved in several layers of the archaeological site were caused by human activities (Wu and Cao, 1983; Yu, 1984; Huang, 1989; Zhang, 1995). Conventional radiocarbon dating ($^{14}$C beta decay measured via the liquid scintillation counting method) of bone samples in mid-1980s yielded $^{14}$C ages for the third to fifth layers of 8000–9000 a BP (a BP = years before 1950 CE. All $^{14}$C ages in this paper are calibrated ages) (Li et al., 1987) (Table 1). Thus, the hominin fossils were considered to belong to the early Holocene, when the climate was warm and humid. For the lower part of the Chuandong site, the dating work was rather poor. One conventional $^{14}$C age from an animal bone from the sixth layer was 9610 ± 100 a BP (Li et al., 1987), and another $^{14}$C age of an animal bone from Layers 8–9 was 16,000 years (Zhang, 1988) (Table 1). According to

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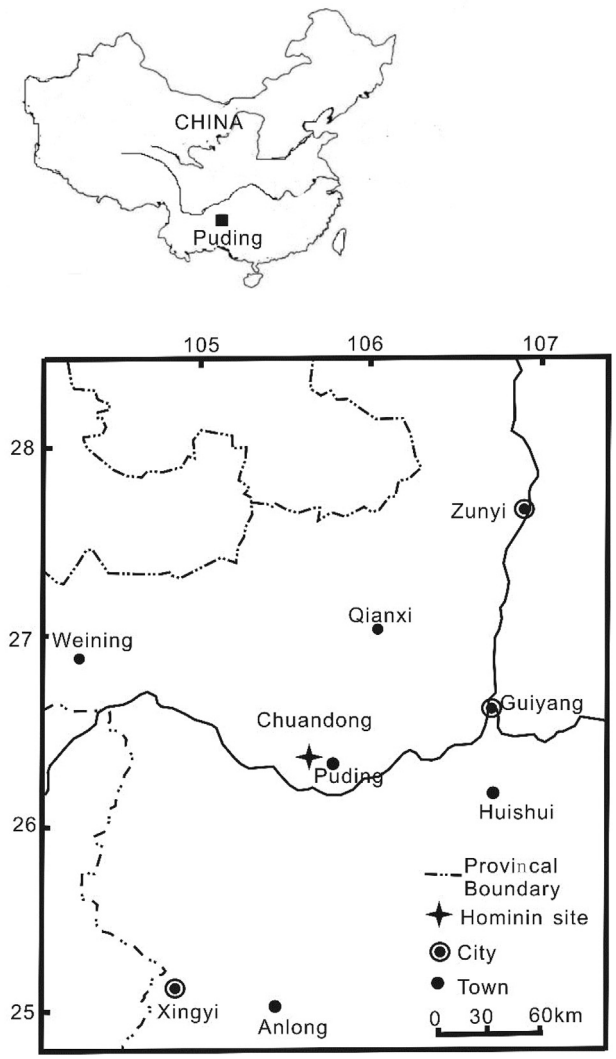


**Fig. 1.** The location map of the Chuandong archaeological site in China (Modified from Zhang, 1995).

these previously published ages, Huang (1989) suggested that the upper strata (Layers 3–5) of the Chuandong hominin site belonged to the Neolithic period and that the lower strata (Layers 8–10) was close to the end of the late Palaeolithic period. Furthermore, the morphological features of the hominin skulls from the site were generally modern morphologies but mixed with some archaic features. Based on the previous chronology and fossil features, the Chuandong humans have been classified as a modern type of hominin (Wu and Cao, 1983; Yu, 1984; Huang, 1989; Wu and Wu, 1989).

Limited by dating techniques, many fossils discovered in the last century, especially in earlier studies, lack precise dating results (Bonsall et al., 2015). Consequently, our understanding of the origin of modern humans in East Asia is limited. For instance, the $^{14}$C dating of the Chuandong site used the conventional beta-decay liquid scintillation counting method on bone samples. On one hand, $^{14}$C dating on bone sample is rather complicated due to multiple carbon compounds and their preservations in the deposited bones. Evidence suggests that many late Pleistocene bone dates (perhaps ~70% or more) published in the 1980s-1990s are liable to be underestimates of the true ages (Higham, 2011; Marom et al., 2012). In general, archaeologists prefer direct dating on bone samples because the dating provides clear physical meaning (Keates et al., 2012). However, the $^{14}$C dates of the bone samples from the Chuandong site in the previous studies of Li et al. (1987) may bear large age uncertainties. Fortunately, charcoal samples can be found within the same cultural layer as the bone samples. Based on previous archaeological studies the charcoal grains were from fire use of the Chuandong human. As the site is 26 m higher than the surrounding ground, it was impossible for the ancient people to move large trees (woods) into the cave for the fire. Therefore, the charcoal ages should have good estimation of the cultural layers. Hence, these age constraints of the Chuandong site based on the conventional radiocarbon dating on bones could be improved by obtaining charcoal samples from the site. On the other hand, accelerator mass spectrometry (AMS) $^{14}$C dating is now a mature technique and widely used in archaeology (Kutschera, 2005). The AMS $^{14}$C dating technique can be used to date 1 mg of C, thereby improving the feasibility of using charcoal samples for dating. For these reasons, we collected new materials including charcoals, unburned and burned bones, and teeth from the Chuandong site in 2015 and conducted AMS $^{14}$C dating on the samples. The new dating results can be used to determine whether the Chuandong humans were active during the early Holocene or the late Pleistocene. The new chronology of the hominin site in Chuandong Cave will contribute to our understanding of the evolution of hominins in South China during the late Pleistocene as well as their relationship with hominins in other regions.

## 2. Materials and methods

### 2.1. Site description and sampling

Chuandong Cave is approximately 5 km southwest of the central township of Puding County. The cave is ~30 m in length, 13 m in width and 13 m in height and oriented in a northeast direction (Fig. 2a). The site experiences a humid subtropical monsoon climate, with an annual precipitation of 1393 mm and a mean air temperature of 15.1 °C based on the meteorological data of Anshun City during 1950–2012. With an elevation of 1264 m a.s.l., the site is located on an isolated karst peak that is 26 m higher than the surrounding ground. The deposits of the site were partly dug out for fertilizer by local villagers. However, a part of the fossiliferous section at the entrance of the cave has been preserved. Our sampling work on the fossiliferous section was following the description of the previous excavations. The archaeological section can be divided into 10 layers from top to bottom (Mao and Cao, 2012; Zhang, 1995) (Fig. 2b).

Layer 1 (L1): disturbed grey soil, including polished stone axes, approximately 0.2–0.4 m thick.

Layer 2 (L2): brownish yellow clayey deposits with dolomite gravels, rich in stone and bone artefacts, 0.4–0.6 m thick.

Layer 3 (L3): fine and dense brown clayey deposits with a few small gravels and charcoal grains, but rich in archaeological remains, approximately 0.5–0.7 m thick.

Layer 4 (L4): dark brown clayey deposits, containing a number of stone and bone artefacts. Human fossils were excavated from this layer, approximately 0.4–0.6 m thick.

Layer 5 (L5): sandy clay, with a thin flowstone sublayer at the bottom and containing ash aggregations, a number of burned bones, and a few stone and bone artefacts, approximately 0.4–0.6 m thick.

Layers 6 and 7 (L6 and L7): red and yellow sandy clay, containing big limestone gravels and a thin flowstone sublayer between the sixth and seventh layers. The sediment composition, particle size and colour are the same in both layers, so they can be merged into

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