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Commentary

Linking spatial grids of the old and new excavations at Zhoukoudian Locality 1, China

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1. Introduction

Zhoukoudian locality 1 (ZKD Loc.1; formally "Choukoutien"), one of the most important *Homo erectus* sites, has attracted a great deal of attention from academic communities and has shed much light on our understanding of human evolution since it was found in the early 20th century (Andersson, 1919). After more than a century of excavation and research, there have been enormous academic achievements, although significant debates such as the anthropogenic use of fire and the formation of the cave system itself still remain unresolved (Binford and Ho, 1985; Binford and Stone, 1986; Weiner et al., 1998; Goldberg et al., 2001; Boaz et al., 2004; Shen et al., 2009; Zhang et al., 2014; Gao et al., 2016; Shen et al., 2016; Zhang et al., 2016a, b; and references therein). In 2004, Boaz and colleagues published a study of the spatial distribution and taphonomy of *Homo erectus* fossils at ZKD Loc.1 (Boaz et al., 2004). They combined a large amount of data including numbers of the specimens, illustrations of the excavation plots, daily working photos and text descriptions from the literature, and presented a three-dimensional plot of the excavations and find-spots of the human fossils. Although they analyzed a comprehensive set of data, they promulgated an error regarding the scale of the excavation trenches themselves. The size of each trench was 2 × 2 m in diggings that were carried out in 1934 and thereafter, but Boaz et al. interpreted them as 1 × 1 m units and concluded that one of the site's principal excavators, Lanpo Jia (Lan-P'o Chia), had made an error in his drawings of the excavation levels reproduced in publications (see also Boaz and Ciochon, 2004). Although this small mistake does not alter the positions of the fossils in the grids, it does change the three-dimensional plot constructed by Boaz et al. (2004), and also potentially influences future interpretations based on spatial analysis. As Boaz and his colleagues have correctly stated, data *must* be accurate. Since Professor Jia risked his life preserving the original Zhoukoudian excavation notes and illustrations during World War II (Jia and Huang, 1984), we feel obligated to correct the record regarding Jia's invaluable work at Zhoukoudian.

Beginning in 2009, a new excavation project has been undertaken at ZKD Loc. 1 by the Institute of Vertebrate Paleontology and Paleoanthropology (IVPP) of the Chinese Academy of Sciences, and the Zhoukoudian Museum (Shen et al., 2016; Zhang et al., 2016a, b). A new excavation grid was constructed referring to the old coordinate system. Here we present those new excavation grids as well as their connections with the old provenience system, and correct Boaz et al.'s (2004) mistake using additional lines of evidence.

2. Materials and methods

Our material consisted of published materials, unpublished drawings of the excavation levels (Jia, n.d.), and excavation work photos which were also used by Boaz et al. (2004). Boaz et al. referred to a book published in English by Jia and Huang (1990) which is a translation of a Chinese edition published six years

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earlier (Jia and Huang, 1984). Meticulous cross-checking of the Chinese and English versions allowed us to clarify Boaz et al.'s misunderstanding of the nature and extent of the 1934 Zhoukoudian excavation.

During excavations from 1934 to 1937, workers painted alphanumeric grids in white directly on the walls of the cave; some are still visible today. In 2009, we used one of the intersections of the old east-west grids on the north wall of the cave (Fig. 1a) as a datum aligned north to construct a new grid system with a total station. We established new 1 m^2 grid squares above the west section. Later, when cleaning the west section of the cave, we found remnants of the original intersections of the south-north grids (Fig. 1b) which allowed us to merge the old trench plans into the new grid system.

3. Results

Plans and sections of different geological and cultural levels drawn during the 1934–1937 excavations at Zhoukoudian were reproduced by Lanpo Jia in 1941 (Jia and Huang, 1984, 1990; Jia, 1999). There are 27 levels with plans, and the scale included on the drawings is two meters (Jia, n.d.; Fig. 2). However, two factors caused Boaz et al. (2004: 522) to conclude that "this is clearly erroneous": 1) there were some inconsistences in the grids painted on the excavation floors and cave walls; and 2) confusion between the units of measure and the size of sediment blocks excavated. They stated "photographs of the excavation in progress show the 2 × 2 m excavation units, but also document that horizontal and vertical gridlines painted on the excavation walls and floor were in 1-m units" (Boaz et al., 2004: 522). We rechecked the photos published by Jia and Huang (1984, 1990), and the units painted on the floor and walls are clearly 2 × 2 m based on the relative scale of the excavators standing inside the units. The average shoulder breadth of an adult is around 37.6 cm (China State Bureau of Quality and Technical Supervision, 1989), and there are two people visible in most of the units in Figure 1c which occupied less than half of one side of the units. Thus, the excavation units are clearly 2 × 2 m in plan. The excavators painted 2 × 2 m grids on the walls of the cave and each grid represented two levels which are shown in contemporary photographs (Jia and Huang, 1990: 90) and are also indicated by the preserved numbers of the levels on the cave wall (Fig. 1a). Another piece of even less persuasive evidence that Boaz et al. (2004) cited to support their conclusion is an isolated phrase parsed from Jia and Huang's book that this grid "was twice the size originally conceived, due to the stony earth structure" (Boaz et al., 2004: 522). Boaz and his colleagues speculated that although Jia and Huang stated the excavators removed 2-m-cube blocks of sediments at a time, they actually dug 1 m × 1 m trenches. However, when Jia and Huang's words are put back into context, it is clear that Boaz and his colleagues misunderstood their intended meaning. Jia and Huang (1984: 60; 1990: 86) originally indicated that at the beginning of the 1934 field season excavators planned to apply an excavation method employing 1 × 1 m units and 0.5 m levels following their experiences in the Upper Cave (Shandingdong) at Zhoukoudian. However, they failed because of the hard, course and stony sediment predominant ZKD Loc. 1. Therefore, in Locality 1, they doubled the size of the excavation units and levels used in the Upper Cave.

The coordinate system devised for the new excavations was constructed based upon the old grid system from the 1934–1937 excavations. We used North and the intersection of Units L and M on an east-west axis, and Level 19–20 painted on the cave wall as a datum from which to construct a local coordinate system (Fig. 1a). Our new trenches are situated on top of the west section preserved in the old excavations, and they are numbered N113–N122 from south to north and E67–E73 from west to east. The total area excavated varied at different depths, adjusting to the incline of the stratigraphy and the overall shape of the cave (Fig. 3a and c) (Zhang et al., 2016a, b). The east-west axis of the new grid corresponds with its 1930's counterpart, but the relation of the north-south axes of the old and new grids was initially unknown. Fortunately, as work progressed, we found signs of the original north-south boundary of units painted on the west profile. According to its distance from the cave's north wall, this boundary was confirmed as the one between −4 and −5 m (Fig. 1b). By locating the north-south coordinates of this boundary, we linked the north-south axis of the old grid with the new provenience system. After plotting plan views of Levels 20 and 21 of the old excavations with a 2-m scale (Fig. 3b), the position of the west section in Jia's Levels 20 and 21 corresponded almost perfectly with the location of the west section at the same level in the new coordinate system (Fig. 3). Consequently, the size of the 1934–1937 excavation trenches was unlikely to have been only 1 × 1 m.

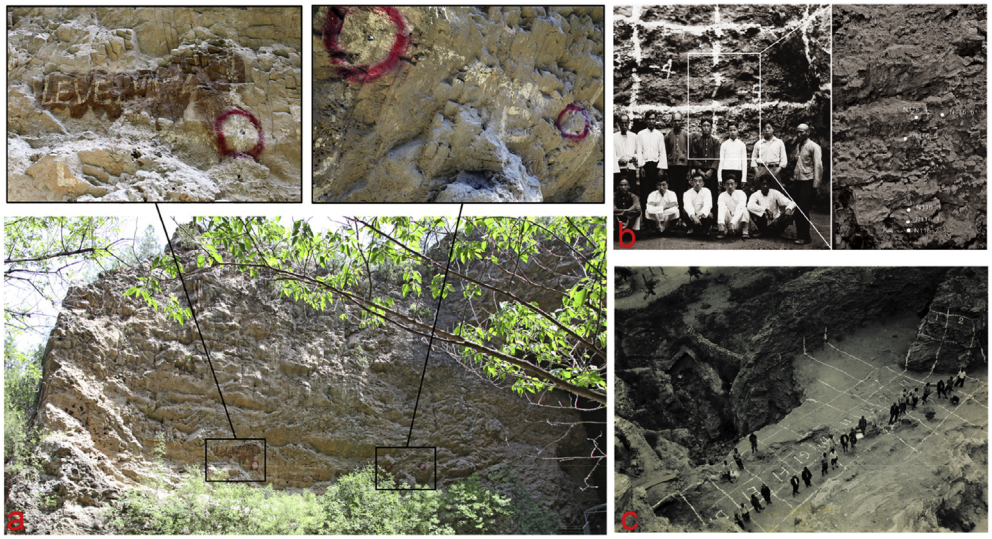

Figure 1. Zhoukoudian Locality 1: grid squares painted on the cave's north wall (a), west profile (b), and the excavation floor (c).

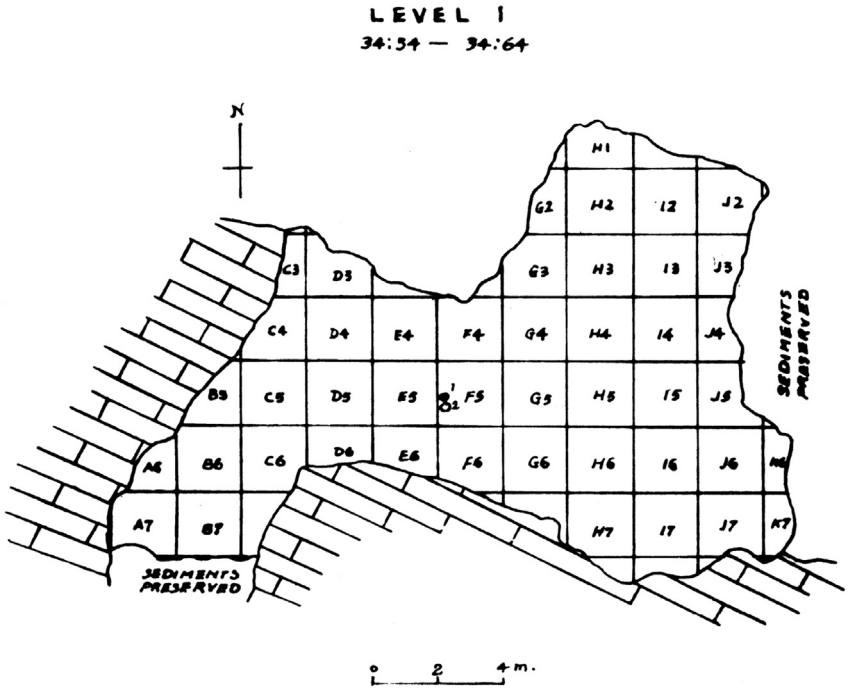

Figure 2. Plan of Level 1 at Zhoukoudian Locality 1 (after Jia, n.d.). Scale drawing by Lanpo Jia.

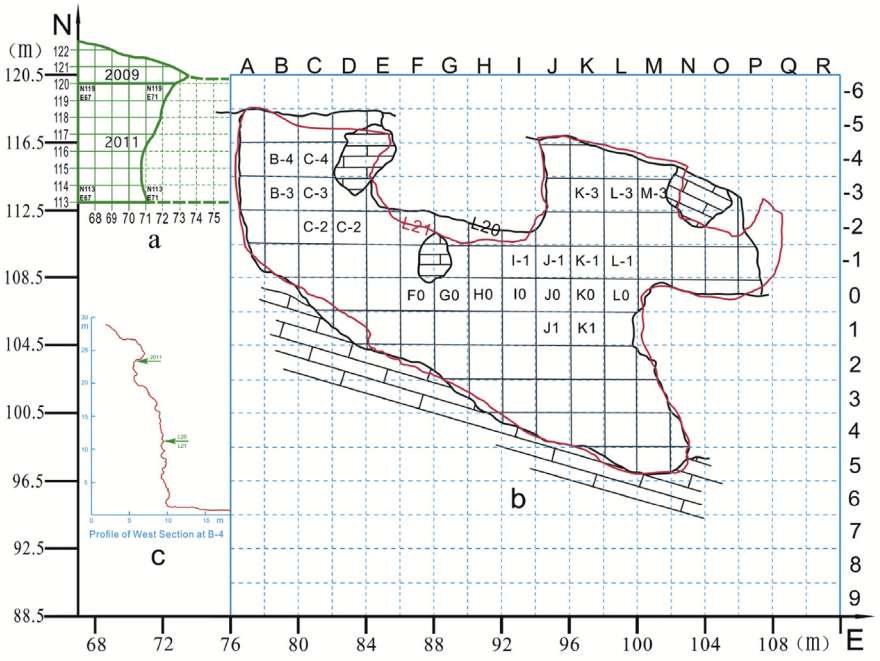

Figure 3. Zhoukoudian Locality 1 excavation grid: a merged map of the new (a) and old (b) excavation units and profile of the west section with the positions of the 2011's excavation plan and Levels 20 and 21 indicated (c).

4. Discussion and conclusion

Spatial scale is vital in archaeological interpretations, and the published incorrect trench sizes have the potential to affect our understanding of the behavior of *Homo erectus* at ZKD Loc. 1. A total of 15 *Homo erectus* loci at ZKD Loc. 1 have been reconstructed in Figures 2 and 3 of Boaz et al. (2004), several of which show close stratigraphic and horizontal association of stone artifacts with *Homo erectus* and other vertebrate remains. With the corrected trench sizes, these materials with close associations are much less clustered than when shown at a one meter scale. For example, Locus G with abundant stone artifacts and presumed evidence of fire was mapped into two trenches (2 m^2) in Figure 2 of Boaz et al. (2004), which could imply a behaviorally significant concentration. However, it is much less concentrated if they were actually distributed in an area of 8 m^2.

In conclusion, the size of the 1934–1937 excavation units at ZKD Loc. 1 was 2 × 2 m and the thickness of each excavated level was 1 m. All the illustrations of different levels and stratigraphic sections redrawn by Lanpo Jia are accurate.

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