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Lingjing is an open-air archaic hominin site in northern China where, apart from two incomplete Human skulls, thousands of lithic artefacts as well as abundant, well-preserved mammalian remains with and OSL ages ranging between ≈105 ka and ≈125 ka. It has been excavated yearly since 2005. The mammalian faunal assemblage from the site is very diverse with 22 different taxa. Equids and a large bovid Bos primigenius dominate the fauna; the mortality profiles of these herbivores indicate hominin/human hunting. Detailed taphonomic analyses demonstrate that Lingjing is a kill-butchery site and not a base camp.

The Lingjing fauna and bone tool record shows remarkable similarities with the archaeological record from the Lower Paleolithic site of Schöningen 13 II-4, Germany, i.e., the Schöningen Spear Horizon, which is ca. 200 ka older than the Lingjing site. Both sites yielded well-preserved material, a very diverse fauna and a large amount of bone tools with identical features.

Keywords: Stone tools, bone tools, mammalian fauna, kill-butchery site.

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1. Introduction

In 1965, the Middle Palaeolithic site of Lingjing was discovered when microblades and microcores, as well as mammalian fossils were collected on the surface of an open-air site (Zhou 1974) and, in 2005, researchers from the Henan Provincial Institute of Cultural Relics and Archaeology started to excavate the site. The site is situated in a transitional area between the eastern foot of the Songshan Mountains and the Huang-Huai Plain, at the southern end of the North China Plain, about 120 south of the Yellow River; it is located in the western part of Lingjing town, ca. 15 km to the northwest of Xuchang, Henan Province, $34^{0}04$'N, $113^{0}41$'E (figure 1) at an elevation of 121 meters above sea level (Li *et al.* 2017a).

Since 2005, more than 550 m^2 were excavated; most of the area to a depth of ca. 9 meters. Eleven geological layers are identified (figure 1) (Li *et al.* 2017a) and three archaeological horizons yielded cultural remains. Layers 1-4 (Holocene in age) yielded cultural materials representing the Neolithic to the Shang-Zhou Bronze Age. Layer 5, dated to ca. 13,500 ± 406 BP, contains microblade technology, microcores, bone artefacts, perforated ostrich, eggshells, ochre, faunal remains, and the first evidence of pottery appearing in the region (Li and Ma 2016; Li *et al.* 2017a; 2017b). Layers 6-9 are sterile; they do not yield stone artefacts or bone material. Layers 10 and 11 were deposited during the early Late Pleistocene. At the base of layer 10, a relatively small number of lithic artefacts, animal bones and small pebbles were

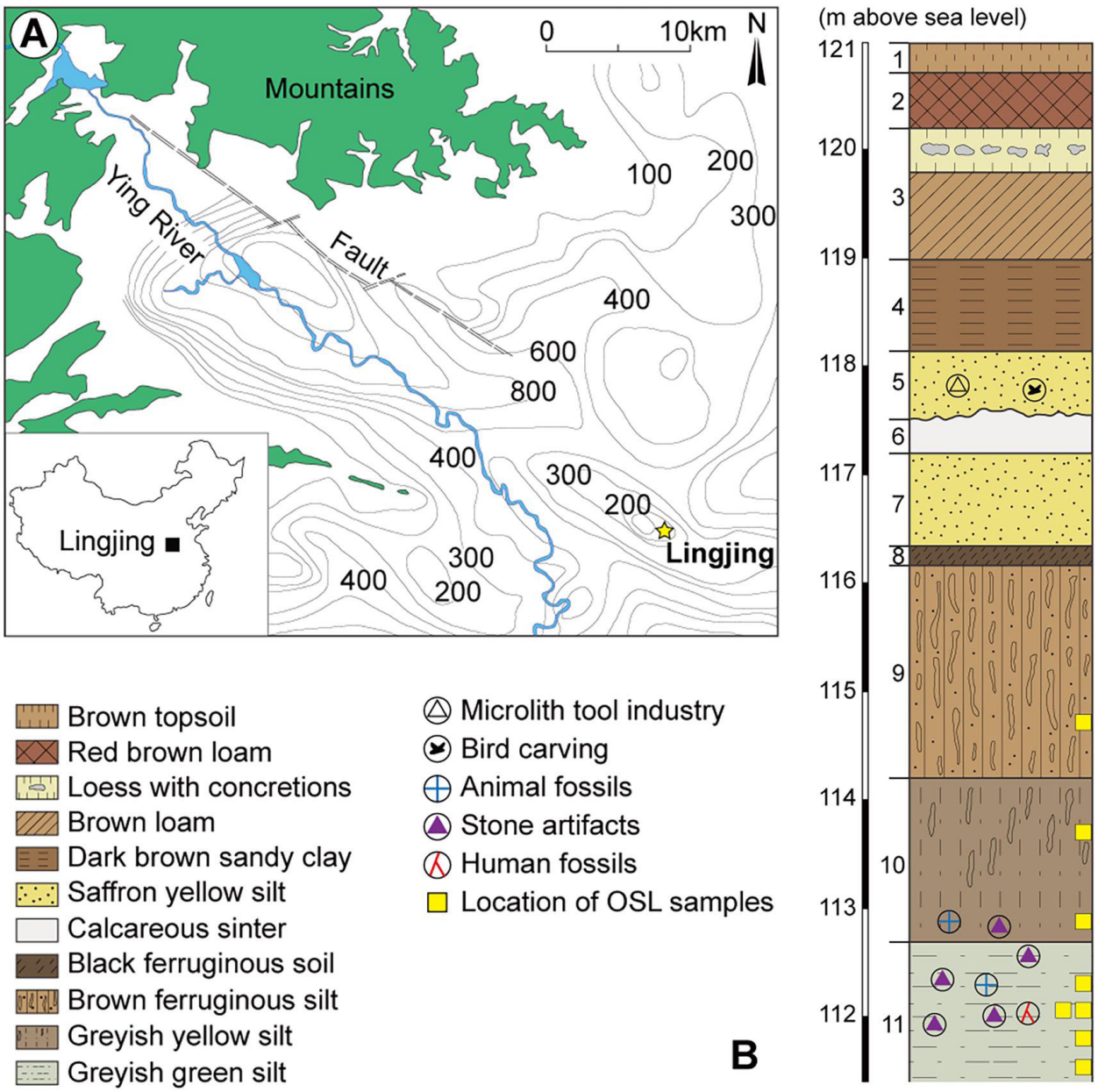

Figure 1: a) Location of Lingjing (Henan, China); b) Stratigraphy indicating the geological and cultural layers (after Doyon *et al*. 2018).

unearthed. Two OSL samples collected from layer 10 were dated between ~96 ± 6 ka and ~102 ± 2 ka (Nian *et al.* 2009). Layer 11 yielded so far more than 50,000 finds, the largest archaeological assemblage, and includes archaic human remains, abundant lithic artefacts and animal bones, some of which were used as tools (Li *et al.* 2017a; Doyon *et al.* 2018, 2019). OSL samples from Layer 11 are dated to between ≈105 ka and ≈125 ka, corresponding to the early Marine Isotope Stage 5 (MIS 5; MIS 5e to 5d) and the last interglacial paleosol S1 in the Loess Plateau of China (Nian *et* al. 2009; Li *et al.* 2017a).

This paper focusses on the finds from Layer 11 excavated since 2005. The faunal assemblages excavated in 2005 and 2006 were studied in detail and the results are presented in a number of publications

(a.o. Li and Dong 2007; Dong and Li 2009; Wang *et al.* 2015; Zhang 2009; Zhang *et al.* 2009; 2011a; 2011b; 2012). The hominin remains were described in *Science* in 2017 (Li *et al.* 2017a). Recently, a detailed investigation of material excavated during the period 2007 – 2017 has started. The aim of the present paper is to provide an overview of the published (archaeological as well as palaeontological) data from Layer 11, and supplement it with preliminary new data obtained during the latest investigations of the faunal remains. Data that will, after detailed analyses, give a better idea about: a) the age of the archaic human remains, b) the environment in which Xuchang Man operated and c) Xuchang Man's subsistence and behaviour

2. The archaeological record from Lingjing – Layer 11 and the base of Layer 10

Layers 10 and 11 (figure 2) yielded more than 50,000 finds (bones and lithic artefacts) distributed over an area of ca 550 m^2. Li *et al.* (2016) presented the spatial distribution of the 2014 excavations of Layer 11, which covered a 36 m^2 area. Refits are documented with a distance up to more than 5 meters. The vertical distribution of the finds in that specific area is about 15 cm. Li *et al.* (2018) studied the site formation process of an area of 9 m^2 during the 2017 excavation and spatially recorded 3894 specimens (2148 animal bones and 1746 stone artefacts) from layers 10 and 11. The vertical distribution of the finds is ca. 1 meter. Based on their analyses of the processes that might have influenced the site formation, employing sedimentary indicators, they concluded that disturbance is limited and the assemblage integrity at the Lingjing site is high, which entails that human behavioural information is well preserved (Li *et al.* 2018).

2.1 Human remains

Two fragmented, incomplete human skulls (Xuchang 1 and Xuchang 2) were excavated in Layer 11, in situ between 2007 and 2014 (Li *et al.* 2017a; Trinkhaus and Wu 2017). Xuchang 1 (26 pieces) is the most complete; it retains most of the neurocranial vault and portions of the cranial base, as well as part of the left frontal bone. Xuchang 2 (16 pieces) is less complete with large part of the occipital bone and the temporal bones (see Li *et al.* 2017a). The Xuchang Man skulls derive from young adults and exhibit a mosaic of morphological features with differences from and similarities with their western contemporaries, which suggests complex dynamics between Eastern and Western Eurasian populations at the time. Given their low and broad neurocrania with the maximum breadth inferiorly, they are considered as eastern Eurasian late archaic hominins (Li *et al.* 2017a; Trinkhaus and Wu 2017). Both skulls exhibit external auditory exostoses most pronounced in Xuchang 2 implying conductive hearing loss (Trinkhaus and Wu 2017).

Figure 2: The 2011 excavation at Lingjing (Xuchang, Henan, China): Layer 11, Trench 11.

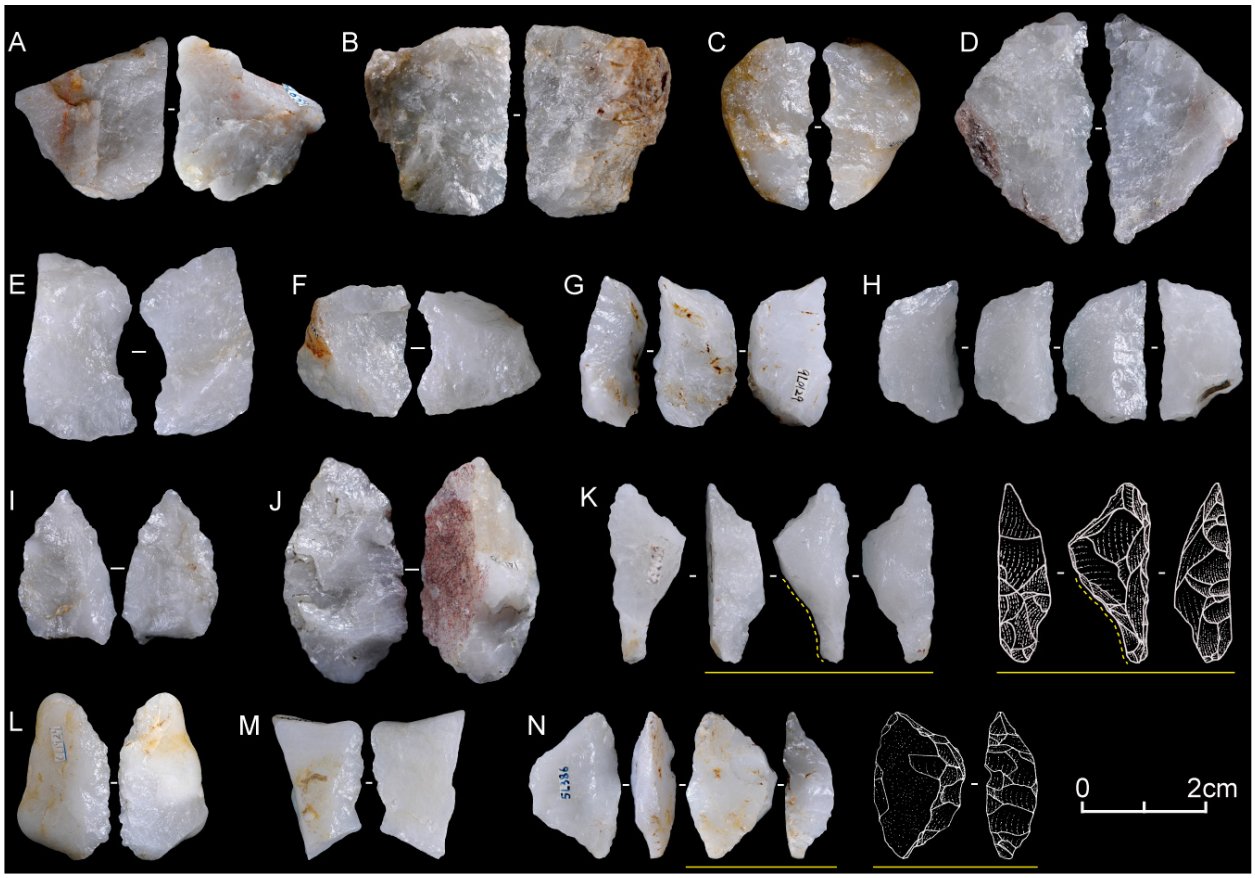

Figure 3: Formal tools at Lingjing. Examples of scrapers (a, b), denticulates (c, d), notches (e, f), borers (g, h), points (i-k), tools made on pebble blanks (l, m), and an example of a backed tool (n). Yellow underlines show specimens with drawings, dashed yellow lines indicate the likely basal retouch for hafting. (after Li *et al*. 2019).

2.2 Lithics

Stone artefacts including cores, flakes, formal tools (i.e., scrapers, notches, denticulates, borers, points, choppers, etc.) made of quartz and quartzite dominate (>99%) the lithic assemblage (figure 3) (Li *et al.* 2019). Chert is marginally represented (<1%). The abundance of debitage flakes and evidence for use wear on lithic artefacts suggests that the manufacture, use, re-sharpening and discard of lithic tools occurred at the site (Doyon *et* al. 2019; Li 2007; Li *et al*. 2019). Despite the absence of Levallois debitage, discoidal core preparation akin to the penecontemporaneous Western Eurasian assemblages is documented in layer 11 which, combined with the presence of bone tools, allows its attribution to Chinese Middle Palaeolithic (Doyon *et al.* 2018; 2019; Li *et al.* 2019).

2.3 Animal bones

The more than 40,000 faunal remains from the lower part of Level 10 and from Level 11 represent a variety of mammalian species (table 1). The faunal analyses of the finds excavated in 2005 and 2006 (Li and Dong 2007; Zhang 2009) resulted in an extensive list of 18 taxa; recently three “new” taxa could be added after a quick scan of the finds excavated since 2006. The carnivore guild from Lingjing is diverse. The larger carnivores *Ursus* sp., *Panthera* cf., *Tigris* and *Pachycrocuta* cf. *sinensis* are represented by cranial/dental as well as post-cranial material. Dozens of coprolites from a medium-sized carnivore, most likely a hyaena, have been recovered from the site. Wang et al. (2015) describe the identification of microbiological remains (parasites, fungi and hairs) preserved in the coprolites. This data provides information on the diet and health of ancient hyaena species.

Rodentia	
Rodentia fam. gen. et sp. indet. 1	x
Rodentia fam. gen. et sp. indet. 2	x
Lagomorpha	
Lagomorpha fam. gen. et sp. indet.*	x
Carnivora	
Canis cf. *lupus**	xx
Vulpes sp.*	xx
Ursus sp.	xx
Meles sp.*	x
Panthera cf. *tigris**	xx
Pachycrocuta cf. *sinensis*	xxx
Proboscidea	
Palaeoloxodon sp.	x
Perissodactyla	
Coelodonta antiquitatis	xxxx
Dicerorhinus mercki	x
Equus przewalskii	xxx
Equus hemionus	xxxxx
Artiodactyla	
Sus lydekkeri	xxx
Hydropotes pleistocenica	x
Cervus (Sika) sp.*	xx
Cervus (E.) elaphus	xxx
*Elaphurus davidianus**	x
Sinomegaceros ordosianus	x
Bos primigenius	xxxxx
Procapra przewalskii	xxx

Table 1: List of mammalian taxa represented in the faunal assemblage from Lingjing Layer 11 and the base of Layer 10. The list is based on the faunal analyses of the finds excavated in 2005 and 2006 (Li and Dong 2007; Zhang 2009). In more recent excavations additional species, indicated with a *, are represented. x=1-5 specimen; xx=6-20 specimen; xxx=21-100 specimen; xxxx=201-500 specimen; xxxxx=more than 501 specimen.

A limited number of remains (a molar as well as tusk and bone fragments) of the elephant *Palaeoloxodon* sp. have been identified so far. The Perissodactyla are represented by four different taxa: *Coelodonta antiquitatis, Dicerorhinus mercki, Equus przewalskii* and *Equus hemionus*. The woolly rhinoceros *Coelodonta antiquitatis* remains include at least 9 different individuals (the majority juvenile). The occurrence of *Dicerorhinus mercki* is based on the identification of a single lower molar (Li and Dong 2007). The equids, together with the bovid *Bos primigenius*, dominate the faunal assemblage. Dental as well as postcranial remains of *Equus przewalskii* and *Equus hemionus* are abundant. Based on the dimensions of the fossil remains it is apparent that the majority of the equid remains correspond to the more slender Onager or Asiatic wild ass *Equus hemionus*.

The group of Artiodactyla is very diverse with eight species (*Sus lydekkeri, Hydropotes pleistocenica, Cervus (Sika)* sp., *Cervus (E.) elaphus, Elaphurus davidianus, Sinomegaceros ordosianus, Bos primigenius, Procapra przewalskii*). The aurochs *Bos primigenius* is by far the most dominant species. Hundreds of molars, horn cores as well as abundant cranial and postcranial remains have been excavated. Other taxa, e.g., the suid *Sus lydekkeri*, the red deer *Cervus (E.) elaphus* and the gazelle *Procapra przewalskii*, are also well represented but less abundant. The remaining Artiodactyla taxa are relatively rare.

3. Human impact

Given the mortality patterns, skeletal element profiles, and bone surface-modifications it is obvious that humans have an important impact on the Lingjing assemblage from Layer 11 and the base of Layer 10 (Zhang *et al.* 2009; 2011a; 2011b; 2012). The fossil assemblage is dominated by bone elements from body parts with lower nutritional value, such as teeth and lower limb bones (Zhang *et al.* 2011a; 2011b). Finally, the mortality profile of the two dominant prey species, i.e., the Onager *Equus hemionus* and the Aurochs *Bos primigenius*, is almost exclusively represented by prime-adult individuals (Zhang *et al.* 2009; 2011a; 2011b), a feature that demonstrates the focussed hunting strategy of Xuchang Man.

Zhang *et al.* (2011a; 2011b) concluded based on the analyses of the 2005 and 2006 record that the Lingjing site was a kill-butchery site rather than a home base for early humans. The taphonomic and zooarchaeological characteristics of the animal remains, *i.e.* species richness, mortality patterns, skeletal element profiles,

and bone surface-modifications support this conclusion. The natural component in the accumulation of the faunal material is most probably very limited.

Li *et al.* (2018) concluded, based on their studies of the formation processes of the site, that the uninterrupted vertical distribution (up to >1 m) of the remains throughout the sequence along with the large number of faunal remains representing different taxa, demonstrates that the site was occupied by humans repeatedly over a relatively long period.

Cut marks are very abundant, in particular on the upper and lower limb bones, indicating disarticulation and meat exploitation. There are no scraping marks on the bones of the 2005 and 2006 excavations, which indicates a non-intensive processing technique (Zhang et al. 2011a). The number of complete bones in the Lingjing assemblage is very limited. The vast majority of the bones are fragmented and the breakage pattern shows that we are dealing with green-bone fractures, which suggests the human exploitation of marrow. However, it is well-known that hyenas also have the capacity to break bones. Future analyses of the faunal assemblage, focussing on the bone breakage patterns and the occurrence of surface modifications by carnivores should clarify the role of the large carnivores in the fragmentation of the Lingjing bone assemblage.

In the Lingjing assemblage there is convincing evidence that bones and bone fragments are used as tools. Luc Doyon investigated a randomly selected sample of 4,604 bone fragments from Layer 11 and the base of Layer 10 (the 2005-2017 excavations), discovered 10 bone retouchers; one organic soft hammer, one active as well as one passive pressure flakers used to shape stone tools (Doyon *et al.* 2018; 2019). In addition to representing the earliest evidence for pressure flaking in the world, these tools indicate the Lingjing hominin possessed an extensive knowledge of the mechanical properties of bone materials, and knew how to take advantage of them in their knapping activities. This conclusion is further supported by a recent screening of a larger sample of the excavated bone material, which indicates that the actual number of bone retouchers in the Lingjing assemblage is much higher than originally described by Doyon *et al.* (2018; 2019). This is also supported by the more recent discovery of a large number of metapodial bone hammers. Aurochs metapodials, but also a restricted number of equid metapodials, show unusual flaking and percussion damage on the distal ends. The metapodials with flaked and rounded epiphyses are interpreted as hammers used to break marrow bones akin to those from Schöningen 13 II-4 (van Kolfschoten *et al.* 2015a).

Finally, layer 11 has also yielded two bone fragment, probably ribs of large-sized mammals, bearing each 10 and 13 sub-parallel lines. The morphology of the bone surface and of the incisions indicate that the two fragments were engraved with a sharp point on weathered bone. On one of the two, residue analyses identified the presence of hematite, which suggests the Lingjing hominin smeared ochre to highlight the engraved pattern (Li *et al*. in press). This discovery represents the oldest known engravings and the earliest use of ochre for non-utilitarian purposes in East Asia.

4. Discussion and Conclusions

The Middle Palaeolithic site of Lingjing is unique not only because of the discovery of the human skulls but also for the richness of its faunal and lithic assemblages. The surface of the bones is, in most cases, very well preserved and shows a variety of anthropogenic modifications (*e.g.* cutmarks) that give insights in past hominin/human behaviours and subsistence activities.

The Lingjing site has much in common with the Lower Palaeolithic site Schöningen 13 II-4, the so-called Schöningen Spear Horizon (Germany), with an age of ca. 300 ka (van Kolfschoten 2014; Serangeli *et al.* 2015). The preservation of the material at both sites is excellent, the encountered faunas at both sites show many similarities. The faunal lists of both sites include a diverse carnivore guild, an elephant, two different rhinoceros species, two different equids, different cervids and large bovids (van Kolfschoten *et al.* 2015b). Both sites also yield a large amount of bone retouchers as well as a unique amount of bone hammers that show identical, unusual flaking and percussion damage. These similarities are remarkable if one takes into account the difference in age (ca. 200 ka) and the geographical distance of ca. 8000 km between the two. Detailed investigation of the battering damage observed at the distal ends of the metapodials from Schöningen indicated that the bone tools have not been used for the percussion of stones; stone (flint) particles are not embedded in the damaged bone cortex (van Kolfschoten *et al.* 2015a). The authors suggest that the damage reflect the use of bone hammers to extract marrow from the limb bones and the mandibles. The battering damage at the Lingjing bone hammers show almost identical features for example the lack of stone particle in the damaged bone cortex. We, therefore, assume that the Lingjing bone hammers are also used in the marrow exploitation process. We assume that

the observed similarities show more or less identical, opportunistic behaviour at both sites. This, combined with the comparable taphonomic circumstances of the two sites, results in the fact that Lingjing and Schöningen have so much in common.

Most of the data published on Lingjing are based on faunal remains excavated in 2005 and 2006. The analyses of the more recently excavated finds are in progress and the combined old and new data will result in a large dataset that will surely result in making Lingjing a site of reference for Middle Palaeolithic research in East Asia. The analyses of the data will also result in detailed knowledge of human behaviours and subsistence in northern China during the earliest Late Pleistocene, a period that is linked to the dispersal of modern humans out of Africa (Bae *et al.* 2017). This makes the Lingjing site significant in the discussion of the evolutionary background of modern humans in northern China (Li *et al.* 2018).

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