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**Innovation in bone technology and artefact types in the Late Upper Palaeolithic of China:
insights from Shuidonggou Locality 12**

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22

23 **Abstract**

24 Information on Palaeolithic bone technology from China is sparse. Here we present the
25 results of a techno-functional analysis of a bone tool assemblage recovered from Shuidonggou
26 Locality 12 (SDG12), layer 11, Northern China, dated to c. 12-11 cal ka BP. Five bone tool
27 artefact types are identified: wedges, awls, spear points, a knife handle, a possible sewing
28 implement, and a notched carpal. Two other artefacts could not be attributed to a specific type.
29 The artefacts are made of *Procapra przewalskii*, *Lepus* sp., *Sus* sp., *Equus przewalskii*, and
30 unidentifiable bone fragments from medium/large size mammals. At least three methods are used
31 to extract blanks: percussion of altered limb bones, longitudinal splitting of *Sus* sp. canine and
32 large rib, and probably, the groove-and-splinter technique. Grinding and scraping are the
33 dominant shaping techniques together with grooving, notching, polishing, drilling, flaking, and
34 retouching. Tool type variability and function fit the hypothesis according to which the SDG12
35 and similar sites would be residential camps in which hunter-gatherers produced artefacts
36 enabling them to cope with cold environmental conditions. Our results, however, indicate that not
37 all bone tools match the expectations associated with a serial specialist production. Expedient
38 wedges and awls may have been produced by any member of the group, and whenever the need
39 arose. The SDG12 bone tool assemblage provides a significant contribution to our knowledge
40 about hunter-gatherer adaptations to the Tardiglacial environments of Northern China.

41

42 **Keywords:** Bone Tools; Specialized tool-kit; Sewing Equipment; Knife handle; Tardiglacial;

Northern China

Highlights

- We analyze the most abundant Tardiglacial bone tool assemblage from Northern China
- Five artefact types and three methods to extract blanks are identified
- Blanks were shaped into tools with eight different techniques
- Typological and functional variability fits the specialized tool-kit hypothesis
- Artefacts are interpreted as part of a cultural adaptation to cold conditions

1. Introduction

Formal bone tools are defined as objects that were cut, carved, polished, or otherwise modified to produce fully shaped implements such as points, awls, harpoons, and wedges (Klein, 1999). Prior to 45 ka BP, only a handful of African and Australian sites have yielded formal bone tools (Brooks et al., 1995; Yellen et al., 1995; McBrearty and Brooks, 2000; Henshilwood et al., 2001; Jacobs et al., 2006; d'Errico and Henshilwood, 2007; Backwell et al., 2008; d'Errico et al., 2012a,b; Campmas et al., 2015; Backwell and d'Errico, 2016; Langley et al., 2016). After 45 ka BP, formal bone tools are found in Eurasia and are particularly abundant in European Upper Palaeolithic toolkits (e.g., Conard and Bolus, 2003; d'Errico et al., 2003, 2012c). Instances of complex bone technologies in other regions of Eurasia, such as China, are rare (Zhang et al., 2016a). Clear evidence for the production of formal bone tools in Northern China comes from Zhoukoudian Upper Cave (Pei, 1939), Xiaogushan (Zhang et al., 1985; Huang et al., 1986;

Zhang et al., 2010), Shizitan (Song et al., 2016), and Shuidonggou (Guan et al., 2012; Pei et al., 2012; Yi et al., 2013). Sites that yielded formal bone tools in Southern China include Chuandong (Zhang, 1995; Mao and Cao, 2012), Maomaodong (Cao, 1982), Zhadong (Chen et al., 2004), and Ma'anshan Cave (Zhang et al., 2016a), etc. The technology of these early bone artefacts is often insufficiently documented and their function remains hypothetical (Mao and Cao, 2012 and references therein). In China, the newly published analysis of the bone tools from Ma'anshan Cave, Guizhou province, represents one of the first attempts to describe in detail this category of Palaeolithic material culture (Zhang, et al., 2016a). It identifies evolutionary trends in bone technology from 35 to 18 ka BP, and records the earliest known barbed points outside Africa.

In this paper, we analyze another key bone tool assemblage from China, recovered from Shuidonggou Locality 12 (SDG12). Dated to between 12.2 and 11.1 ka BP, this assemblage is exceptional for its excellent state of preservation and the variety of tool types it comprises. Photographs of selected artefacts from this assemblage appeared in the literature (Yi et al., 2013, 2014; Zhang et al., 2016b). However, no detailed technological analysis of key artefact types has been published except for some needles (Zhang et al., 2016b). Our analysis highlights technological features peculiar to the Ordos Plateau and artefact types previously unrecorded at Palaeolithic sites from Asia. It also represents a unique opportunity to document formal bone tool types found in association with microlithic technologies (*cf.*, Wang, 2005).

It has been proposed that microblade technologies, grindstones, and specific bone tools found at this and other sites represent an adaptation to the cold environments of the LGM and the Younger Dryas in the loessic landscapes of Northeast Asia (Chen, 1983; Yi et al., 2013). Slotted

bone handles fitted with microblades, bone needles, awls, and technologies devoted to the manufacture of hunting nets would have been used to procure rabbit skins and produce sophisticated winter clothing (Yi et al., 2013). As far as bone technology is concerned, this interpretation is only based on a preliminary description of a few bone tools without documenting the technologies and know-how involved in the production of the bone artefacts found at the site. The aim of the present paper is to reconstruct these aspects of human behaviour and identify the function for key categories of bone artefacts recovered at SDG12. This will allow us to test, on a category of material culture other than lithics, the pertinence of the “serial specialist” hypothesis (Binford, 1980, p. 17), i.e., the idea that the SDG12 hunter-gatherers subsistence strategy would have relied on standardized tool production to face seasonal challenges in the Tardiglacial environments of Northern China (Yi et al., 2013).

2. Archaeological context

2.1 Site location, stratigraphy, and chronology

Located on the second terrace of the Biangou River floodplain (Ningxia Hui Autonomous Region, Northern China), 3 km south-east from the well known Shuidonggou Locality 1 (Licent and Teilhard de Chardin, 1925; Boule, 1928; Pei et al., 2012), SDG12 is an open-air site discovered in 2005 during an archaeological survey of the exposed river bank (Liu et al., 2008; Gao et al., 2009; Pei, et al., 2012; Yi et al., 2013). In 2007, salvage excavation was carried out over a 12-m² area and a depth greater than 9 m. A total of twelve geological layers were identified based on granulometry and sediment colour (Fig. 1). Archaeological material was only

recovered from the c. 50-centimetre-thick ashy layer 11, all other layers being sterile. Sediments from this layer were sieved with a 2-millimetre mesh. The layer was further subdivided into five sub-levels, level 1 (youngest) to 5 (oldest). Lithics from these sub-levels are typologically and technologically similar, and are considered as a single assemblage (Yi et al., 2013). The dating of a charcoal from the middle part of layer 11 provided a ^{14}C age of $9,797 \pm 91$ BP (11,164 – 11,378 cal BP). OSL ages from layers 10 and 12 are consistent with the ^{14}C determination when the standard error is taken into account (Liu et al., 2008). These ages suggest that the site was occupied toward the end of, or immediately after, the Younger Dryas Cold Event (c. 12,900 – 11,700 cal BP; Rasmussen et al., 2014).

2.2 Lithic Technology

The SDG12 lithic assemblage, comprising more than 9,000 pieces, is typical of the Late Pleistocene microlithic industries found in China (Gao et al., 2009; Pei et al., 2012; Yi et al., 2013, 2016) and in adjacent regions from Central Asia to Alaska (Goebel, 2002; Brunet, 2012; Gómez Coutouly, 2012; Tabarev, 2012; Takakura, 2012; Kato, 2014). It is dominated by microblade cores and highly standardized microblades, which were likely obtained by pressure flaking (Pelegrin, 2012), but also includes end-scrapers, notches, points, borers, and burins (Gao et al., 2013; Yi et al., 2013). A variety of grinding tools are represented (Yi et al., 2013). A fragment of an axe and small discs, shaped by grinding, were also found as well as a large number (>13,000) of burnt stone fragments (Gao et al., 2013). The lithic assemblage composition indicates that stone knapping, osseous tool shaping, plant processing, and woodworking were

carried out at the site (Yi et al., 2013, 2014).

2.3 Faunal Assemblage and Taphonomy

The faunal assemblage comprises more than 10,000 remains, 1,821 of which were identified to species, or to order for microfauna. *Lepus* sp. (57.4%) dominates the faunal spectrum followed by *Procapra przewalskii* (22.2%), *Bubalus* sp. (6.8%), *Meles meles* (5.7%), *Equus przewalskii* (2.9%), and birds (2.9%). The remaining 2.1% of the NISP is composed of Cervidae, *Sus* sp., *Felis microtus*, rodents and a single remain of a reptile (Zhang et al., 2013). Cut-marks are present on 5.1% of the NISP, a proportion similar to that observed at other Chinese Late Pleistocene sites analyzed with comparable methods, e.g., Ma'anshan Cave (Zhang et al., 2010). Carnivore and rodent modifications were only detected on four pieces. This combined evidence suggests that the faunal assemblage is mainly the result of anthropogenic activities. Root etching is the main post-depositional alteration. Although fluvial action is considered a key factor in the formation of this site (Liu et al., 2008) no obvious modification produced by this process were detected on the faunal remains.

3. Materials and methods

The osseous industry from SDG12 is curated at the Institute of Vertebrate Palaeontology and Palaeoanthropology of China, Beijing.

Each bone artefact was studied with a Nikon SMZ1500 stereomicroscope at magnifications ranging from 7.5x and 112.5x. Anthropogenic modifications were distinguished from natural

ones on the basis of criteria known in the literature (Shipman and Rose, 1983; Behrensmeier et al., 1986; Lyman, 1994; Fisher, 1995). Identification of manufacturing techniques and use-wear traces was based on observation of ethnographic, experimental, and archaeological bone tools (LeMoine, 1994; Malerba and Giacobini, 2002; d'Errico et al., 2003; Karavanić and Šokec, 2003; Backwell and d'Errico, 2004; Christidou and Legrand, 2005; Griffiths, 2006; d'Errico and Henshilwood, 2007; Legrand and Sidéra, 2007; Gates Saint-Pierre and Walker, 2007; Legrand and Radi, 2008; Mozota Holgueras, 2008, 2009, 2012; Bradfield and Lombard, 2011; Buc, 2011; Byrd, 2011; Bradfield, 2012; Jéquier et al., 2012; Mallye et al., 2012; Blasco et al., 2013; Bradfield and Brand, 2013; Daujeard et al., 2014; Hardy et al., 2014; Jéquier, 2014; Moigne et al., 2016; Tejero et al., 2016; Yeshurun et al., 2017). When identifiable, the species and anatomical elements selected as blanks were recorded. Otherwise, an animal size class was estimated from the cortical thickness. Techniques of manufacture, the area where they were applied, and the location and type of use-wear were documented. Morphometric data were collected using digital callipers, and included the maximum length, width, and thickness of the artefact. Identification of tool types has taken into account archaeological and ethnographic data from Europe, Africa, and America, with tentative attributions based on the morphology, size, traces of utilisation, and hafting (LeMoine, 1994; Henshilwood, et al., 2001; d'Errico and Henshilwood, 2007; Gates Saint-Pierre and Walker, 2007; Backwell, et al., 2008; Bradfield, 2010).

4. Results

The specimens analyzed in this paper comprise 16 of the 35 bone artefacts recovered at SDG12 (Table 1). Needles (Zhang et al., 2016b) are excluded from the present study, as they will be the focus of a global comparative study. This number differs from a previous publication (Gao et al., 2013) as it also takes into account fragmentary artefacts identified by two of us (ZS, ZY) during the archaeozoological analysis of the sieved material. Five bone tool types were identified: wedges (4), one of which was also used as a retoucher, awls (4), spear points (3), knife handle (1), possible sewing implement (1), notched carpal (1). Two artefacts could not be attributed to a specific tool type. In the following description, we indicate for each object the figure in which it is illustrated followed by the catalogue number as it appears in Table 1.

4.1 State of preservation

Three objects are complete, seven are represented by mesial fragments, six by distal fragments, and one by a proximal fragment. One of the objects (Figure 2, n. 8, cat. 2859) consists of two non-joining fragments attributed to the same tool based on their morphology, technology, traces of heating, and shade. Although most artefacts (> 76%) bear traces of root etching, the surfaces not affected by this natural modification are exceptionally well preserved and allow a precise identification of anthropogenic modifications. No traces produced by other non-human taphonomic agents were detected.

4.2 Osseous Technology

4.2.1 Wedges and a retoucher

Four different artefacts are attributed to this tool category. The first, almost complete, shows

recent marginal breaks affecting its proximal and mesial edges (Figure 2 n. 1, cat. 132). The second, also almost complete, displays an ancient proximal break (Fig. 2 n. 2, cat. 4008). The third is incomplete and made of compact bone (Fig. 2, n. 3, cat. 3091). It has a triangular section and tapers to the distal end creating a convex bevel. The fourth is a small distal fragment, bearing recent longitudinal and proximal fractures, but retaining a portion of its original bevel (Figure 2 n. 4, cat. 2857). The blank to produce the first artefact comes from a *Procapra przewalskii* long bone, possibly the posterior aspect of a radius. The other three wedges were manufactured out of an undetermined long bone from a small/medium size mammal.

The blank used to manufacture the wedges were likely obtained by fracturing a weathered bone, as indicated by their longitudinal outline and morphology of the fractures (Lyman, 1994: 315-353). Both scraping and grinding were applied to shape the first tool (Fig. 3a, cat. 132). Scraping was used to regularize the lateral edges (Fig. 3b, cat. 132). The periosteal surface of the bevel was ground following different directions. The endosteal surface was ground obliquely. After utilisation, grinding was applied again, this time parallel to the tool main axis, to resharpen the bevel. Obvious traces of utilisation are detected on the bevel. They take the form of a polish covered by a palimpsest of microstriations perpendicular or slightly oblique to the edge, which is characteristic of an action against sorted abrasive particles (Fig. 3c, cat. 132). A more discrete polish, observed on the lateral edge of the tool, may result from handling or hafting. A group of aligned impact scars, present on the endosteal face close to the proximal fracture, suggests that the tool may have also been used, in a single instance, as a retoucher (Karavanić and Šokec, 2003; Mozota Holgueras, 2008, 2009, 2012; Mallye et al., 2012).

The blank used to manufacture the second wedge was only slightly modified by removing a series of adjacent microflakes on its right edge (Fig. 2, n. 2, cat. 4008) and by marginally scraping the left edge. The bevel displays a highly polished convex facet on the periosteal surface (Fig. 3d, cat. 4008) and imbricated stepped tangential scars with highly polished ridges on the endosteal surface (Fig. 3e, cat. 4008). The bevel edge features a crenulated outline with tightly closed incipient fractures. The above features likely result from the use of the tool as a wedge exerting either pressure or percussion on hard material. The proximal fracture may have resulted from the break of the tool during its use.

The third wedge was entirely shaped by grinding, including a small facet blunting the proximal end (Fig. 4a, cat. 3091). The presence of tangential flake scars originating from this end, partially removed by this facet, suggests that the facet was ground to avoid further breakage owing to percussion exerted during use (Fig. 4b, cat. 3091).

The bevel of the fourth wedge was shaped by vigorously grinding the blank end with an oblique motion (Fig. 3f, cat. 2857). Contrary to the traces of grinding on piece SDG12-132, consisting of individual spindle-like striations resulting from grindstone releasing abrasive particles during the work, those on piece SDG12-2857 are coarser and reminiscent of an abrasion against a harder rock such as quartzite. Polish resulting from utilisation covers the bevel edge and the ridges of the grinding striations. The edge displays, as with SDG12-4008, a crenulated outline, probably resulting from a similar utilisation (Fig. 3f, cat. 2857).

4.2.2 Awls

Two objects attributed to this bone tool type are almost complete (figure 2 n. 5 and 6, cat.

130 and 2850) although the mesial portion of SDG-130 is heavily eroded; they were respectively manufactured from the proximal epiphysis (Figure 2, n. 6, cat. 2850) and the diaphysis (Figure 2, n. 5, cat. 130) of *Procapra przewalskii* metatarsals. The third artefact comes from a diaphysal fragment of a *Lepus* sp. long bone (Figure 2, n. 7, cat. 1208). Its proximal portion is missing. A fourth object, shaped on a shaft fragment of a juvenile medium size herbivore, comprises two non-joining mesial-distal fragments (Fig. 2 n. 8, cat. 2859).

The orientation and morphology of the fractures on SDG12-130 suggest that the blank was extracted from a weathered bone in order to obtain an elongated, thin splinter. The resulting blank was slightly shaped at one end by flaking. The other end was scraped and subsequently ground obliquely to the tool axis (Fig. 5a, cat. 130). Its prolonged use as an awl developed on the tip a use wear consisting of a heavy polish, which partially removed the striations produced by grinding (fig 5b, cat. 130). The blank of SDG-2859 comes from a weathered bone, as indicated by the morphology and orientation of the fracture visible on the endosteal face. The tool was manufactured by longitudinal scraping, confined to its distal portion, followed by grinding applied to the edges and all over the object surface near the tip (Fig. 5c, cat. 2859). Transversal white streaks, resulting from exposure to heat, cover the left half of the periosteal surface (Fig. 5d, cat. 2859). White, isolated spots caused by the same process are also visible on both fragments. The blank of SDG-1208 was probably also extracted by percussion, before regularising the edges and the tip of the bone flake by perpendicular grinding (Fig. 5e-f, cat. 1280). The tip may have been deliberately heated to harden it. Subsequent use as an awl has smoothed the traces of grinding. Longitudinal striations on the smoothed ground surfaces may be

247 due to a gentle resharpening of the tip by scraping or utilisation. The manufacture of
248 SDG12-2850 entailed production of the blank by percussion and, subsequently, grinding the
249 edges and a portion of the periosteal surface. The grinding was exerted perpendicularly and
250 obliquely to the object axis (Fig. 5g, cat. 2850). The constricted morphology of the tip was
251 obtained with the same technique.

252 4.2.3 Projectile points

253 The three specimens interpreted as projectile points comprise a mesial-distal (Fig. 2, n. 9,
254 cat. 1211), a mesial (Fig. 2, n. 10, cat. 2854), and a proximal (fig; 2, n.11, cat. 2858) fragment.
255 Long bone diaphyses of medium size herbivores were selected for the manufacture of the first
256 two objects. A rib from a similar size class mammal, likely juvenile, was used for the third.
257 SDG12-1211 was manufactured by obliquely grinding the blank with the exception of the
258 medullary canal. Traces of grinding were partially obliterated, close to the tip, by longitudinal
259 scraping resulting in elongated facets (Fig. 6a, cat. 1211). SDG12-2854 was instead shaped by
260 longitudinally scraping the whole surface (Fig. 6b, cat. 2854) and slightly modifying an area
261 close to the proximal fracture by grinding (Fig. 6c, cat. 2854). The shaft of SDG12-2858 was
262 exclusively manufactured by longitudinal scraping (Fig. 6e, cat. 2858). Diagnostic traces of
263 manufacture are absent on the flat base (Fig. 6d, cat. 2858). However, its morphology and outline
264 suggest that this area of the object was manufactured by grinding. At the opposite end, the step
265 fracture is typical of damage resulting from use as projectile point (Pétillon, 2006; Bradfield,
266 Lombard, 2011; Bradfield and Brand, 2013; Doyon and Knecht, 2014).

267 4.2.4 Possible sewing implement

268 This artefact presents one pointed and one curved end, partially removed by an ancient scar
269 (Fig. 2, n. 12, cat. 1213). Its thickness indicates that the blank was extracted from the limb bone
270 of a medium/large size mammal. Four techniques were used to manufacture the tool. The
271 preform was given a spindle shape by longitudinal scraping (Fig. 7a, cat. 1213). A perforation
272 was then made close to one end by drilling both sides of the object. The section of the hole and
273 the concentric striations covering its surface indicate that the perforation was likely made with a
274 hafted lithic point (Fig. 7b, cat. 1213). A deep longitudinal groove was subsequently incised,
275 starting from the hole, and enlarged on both faces until an elongated eye was produced. On both
276 faces, the groove terminations diverge toward the right. The resulting rods were given a circular
277 section by scraping. The eye's maximum dimensions are 28.2 mm (length), 4.9 mm (width), and
278 5.7 mm (thickness). Finally, the end close to the hole was ground in order to reduce its length and
279 create a squeezed cone (Fig. 7c-e, cat. 1213). The handling of the object may explain the slight
280 polish that covers the whole surface. The function of the tool is difficult to establish. However,
281 its shape is reminiscent of ethnographic implements used in sewing activities (see discussion).

282 4.2.5. Handle

283 Reconstructed from six fragments, this elongated artefact is almost complete apart from
284 recent fractures affecting one end and, to a lesser extent, both lateral edges (Fig. 2, n.13, cat.
285 141). It was manufactured from a rib of a large mammal, split longitudinally. The artefact bears
286 traces of intense polishing that have obliterated marks left by the shaping of the blank. By
287 comparison with fragments of modified ribs from the same assemblage to produce needles, the
288 object was likely modified by grinding the trabecular tissue and scraping the compact bone

before regularizing the surface by polishing. One edge was carefully grooved, probably to insert straight bladelets (Yi et al., 2013). The groove is 80.9 mm long, 2 mm wide, and 3.5 mm deep. A well-defined longitudinal incision was engraved on each side of the object, a millimetre apart from the opposite edge (Fig. 8a, cat. 141). Two sets of fifty and forty-six equidistant notches were cut between these incisions, creating a ladder-like motif (Fig. 8b, cat. 141). The size and outline of the notches suggest that both sets were made in a single session with the same cutting edge. They are heavily worn by the handling of the tool. Their cross-section is too superficial to be documented.

4.2.6. Notched carpal

This artefact is a horse (*Equus przewalskii*) left third carpal with a recent break removing a fragment on its posterior aspect (Fig. 2, n. 14, cat. 2855). Root etching has heavily altered its surfaces. However, traces of intentional grinding are visible on the distal articular face of the object and at least seven parallel notches were cut on its anterior proximal margin (Fig. 9a, cat. 2855). Due to its state of preservation and the loose structure of the bone, it is problematic to establish whether the notches were made by a single or by multiple cutting edges. A difference in patina is observed between the outer bone surface and that of the notches suggesting the latter were made when the bone was already partially fossilized.

4.2.7 Undetermined

Piece SDG12-1215 is a refitted mesial fragment of a rod bearing recent proximal, distal, and longitudinal fractures (Fig. 2, n15. cat. 1215). It was manufactured on the diaphysis of a medium size mammal. The object is triangular in section. It bears traces of longitudinal scraping, partially

erased by polishing (Fig. 9b, cat. 1215). Intense grinding has gently tapered one end of the piece (Fig. 9c, cat. 1215).

Piece SDG12-3266 (Fig. 2, n16, cat. 3266) is a mesial fragment of a wild boar (*Sus* sp.) canine with recent fractures on both ends. It is triangular in section with a face retaining the enamel, the second displaying the occlusal wear facet, and the third showing a deliberate modification by intense grinding exerted perpendicularly to the object main axis (Fig. 9d, cat. 3266).

Discussion and conclusion

Upper Palaeolithic sites from Northern China have only yielded few bone tools and a limited number of artefact types, e.g., Shizitan Locality 29 (Song et al., 2016), Shuidonggou Locality 2 (Guan et al., 2012), and Xiaogushan (Huang et al., 1986). The paucity of large and well-preserved bone tool assemblages and the loss of the abundant collection from Zhoukoudian Upper Cave (Pei, 1939) offered limited opportunities to conduct technological and functional analyses of this category of prehistoric material culture in this region. The rich assemblage from SDG12 now makes this endeavour possible.

The SDG12 bone tools were manufactured with a wide array of techniques. The few cases in which the species could be identified testify to the selection of skeletal elements from the two predominant taxa in the faunal assemblage, i.e., *Procapra przewalskii* and *Lepus* sp. The cortical thickness and morphology of most of the other bone artefacts indicate that *Procapra przewalskii*

329 long bones may have been used for their manufacture. Four artefacts were produced from
330 skeletal elements of larger mammals, which are marginally represented in the faunal assemblage;
331 this is the case for the ground *Sus* sp. canine, the notched *Equus przewalskii* carpal, the possible
332 sewing implement made out of a robust limb bone, and the handle manufactured from a large rib.

333 At least three methods were used to extract blanks at SDG12. Most of them resulted from the
334 percussion of slightly altered limb bones, which produced elongated blanks. Judging from the
335 morphology of the fractures, this may also be the case for the awl shaped on a proximal fragment
336 of a *Procapra przewalskii* metatarsal (Fig. 2, n. 6). The second technique entails the longitudinal
337 splitting of a large rib. This technique was used to extract the blank employed to manufacture the
338 handle (Fig. 2 n. 13). A similar technique may have been used to reduce the wild boar canine.
339 The canines of suids can be easily split longitudinally by percussion and, when weathered, often
340 already present longitudinal cracks that facilitate this task (d'Errico et al., 2012 c). Finally, few
341 blanks were probably obtained by applying the groove-and-splinter technique (Fig. 2, n. 9, 10, &
342 12). The production of the slot on the handle and the eye on the possible sewing implement
343 indicate that longitudinal grooving, essential for the production of blanks with this technique,
344 was well-mastered at SDG12.

345 Grinding and scraping are the dominant shaping techniques. When it was possible to
346 establish the order in which both were applied, scraping precedes grinding. The only exception is
347 a projectile point (Fig. 2 n. 9) on which marginal scraping applied to the tool tip may be due to its
348 resharpening. The systematic use of grinding documented at SDG12 is consistent with what has

349 been observed at other Asian sites (Rabett and Piper, 2012; O'Connor et al., 2014; Aplin et al.,
350 2016; Perera et al., 2016; Zhang et al., 2016a). In contrast, this technique is virtually absent in the
351 Upper Palaeolithic of Western Europe (Camps-Fabrer, 1976; Langley, 2016), with the possible
352 exception of a single Uluzzian awl from Grotta del Cavallo, layer E III (d'Errico et al., 2012b).
353 Although it has been proposed that grinding was applied to osseous material in the Gravettian of
354 Eastern Europe (Goutas 2004, 2013), supporting evidence is limited. In Africa, grinding is
355 relatively rare in the Middle Stone Age (d'Errico and Henshilwood, 2007; Backwell and
356 d'Errico, 2016; d'Errico et al., 2012a). It becomes common in the Later Stone Age (Yellen, 1998;
357 Bradfield, 2016).

358 Six other shaping techniques are less frequently applied at SDG12: grooving, notching,
359 polishing, drilling, flaking, and retouching. It is worth noticing that the first two techniques are
360 used for very different purposes. Grooving is used both for blank extraction and for shaping
361 specialized tools, i.e., the possible sewing implement and the handle. Notching was applied to
362 produce dozens regularly spaced sets of short incisions on the handle or a short sequence of
363 notches on the edge of a horse carpal. Five artefacts bear evidence for heating. Establishing
364 whether these objects were intentionally treated with heat is problematic. However, for the awl
365 made of rabbit long bone (Fig. 2 n. 7), the heating is limited to its tip, which strengthened this
366 hypothesis.

367 The probable function of some artefact types, such as wedges, awls, and spear points, can be
368 reasonably inferred from their morphology, use wear (see below), and similarity with prehistoric

and ethnographic specimens. The fragmentary state of others (Fig. 2 n. 15 & 16) prevents a functional interpretation. The artefact interpreted as a handle does not show microblades in its groove. However, its strong technological and morphological similarity with known complete, more recent knife handles from Xiliang, dated to c. 8.5 ka BP (Liu, 2007), Shangzhai, dated to 7.9-6.6 ka BP (Cui et al., 2010), and Dadiwan, dated to 7.9-6.0 ka BP (Yi et al., 2013; Bettinger et al., 2015), clearly indicates that we are dealing with the same tool type, which apparently was used almost unchanged for at least 4,000 years in Northern China. If highly standardized microblades are taken as an archaeological proxy for a technological system that includes the production of composite knives, the SDG12 object (Fig. 2 n. 13) may represent a rare instance of a long-term tradition going back to the very appearance of microblades in China. In such technological system, standardized microblades obtained by pressure flaking would facilitate the repair of the knife cutting edge. The minute, careful decoration visible on this object may signal group affiliation or personal ownership (Wiessner, 1983; Barton, 1997; Bar-Yosef, 2002), which, if one accepts the association handle-microblades hypothesis, may have been at work in China as early as 30 ka BP.

We have found no obvious ethnographic comparisons for the possible sewing implement. Shuttles used for net making either bear two opposite deep indentations, or one pointed and one concave end associated with an eye longitudinally crossed by a prong (Keddie, 2010; Bless et al., 2015). Although none of these features are visible on our object, its round shape and the careful application of two manufacturing techniques fit the interpretation of a tool used in domestic

activities, perhaps in combination with needles to produce tight seams, or for net making (Yi et al., 2013). No such tool have been reported from Upper Palaeolithic contexts in Eurasia, where weaving and net making would have used bone tools of different morphology (Soffer, 2004).

Our analysis has revealed that many bone artefacts bear indubitable traces of utilisation. A polish on the active area is the main trace of use recorded on wedges, awls, and the possible sewing implement. A polish possibly due to hafting and handling was recorded on a wedge (Fig. 2, n. 2) and the knife handle respectively (Fig. 2, n. 13). In the case of the possible sewing implement eye, the use wear slightly deformed its original outline (Fig. 2, n. 12). Other traces of use include crenulation of the wedges' active edge (Fig. 2, n. 2 & 4) and tangential flake scars due to percussion (Fig. 2 n. 3). The projectile point made out of a rib (Fig. 2 n. 11) displays a step fracture typical of hafted armature broken on impact. Finally, one wedge was also used as a retoucher in a single occasion (Fig. 2 n. 1). The differences in the types of use-wear recorded on the wedges suggest that a functional distinction must be made for at least one specimen (Fig. 2 n. 1). The polish characteristic of an action against sorted abrasive particles observed on SDG12-132 (Fig. 3d) could indicate it was used as an end-scraper in activities such as hide working (Christidou and Legrand, 2005), while the others (Fig. 2 n. 2-4) were likely used as cleaver as attested by the crenulations and flake scars present on their bevel.

In summary, SDG12 bone assemblage demonstrates a remarkable mastery of the techniques known in prehistory to modify osseous materials and, in a number of respects, a know-how of a complexity comparable to that known in the European Upper Palaeolithic. The technological and

morphological variability observed in typologically analogous tools (e.g., wedges, awls, points) suggests that these artefacts represent instances of a much broader variability. This diversity in tool types and forms gives the impression that we have an incomplete view of the bone artefacts brought to, manufactured, used, and lost or disposed at the site. Some wedges, for example, fall in the category of fully modified formal tools (e.g., end-scraper) while others are better described as expedient tools (e.g., cleavers). Some awls have very sharp active areas while others are sturdier. Very specialized artefacts such as the possible sewing implement, the knife handle, the notched carpal, and the ground *Sus* sp. canine correspond to single instances of clearly distinct artefact types.

These observations are only partially consistent with the recently proposed hypothesis according to which the SDG12 toolkit would reflect a cultural adaptation to the cold environments of the Tardiglacial. According to this hypothesis, SDG12 is interpreted as a residential camp site in which hunter-gatherers would have prepared themselves for winter by carrying out a variety of activities (e.g., hunting, carcass processing, sewing clothes, net making, processing plants, etc.). The production of specialized highly effective cultural items would have been guaranteed by “serial specialists” i.e., members of the group detaining the know-how allowing them to produce highly standardized artefacts such as microblades (Yi et al., 2013). The technology used to manufacture a number of tools involved shaping by grinding, which may have been performed on the numerous grinding tools found at the site. The functions for which the SDG12 bone tools were likely used (e.g., hunting, skin cutting and processing, sewing

clothes, net knitting, etc.) fit the residential hypothesis and the idea that the osseous toolkit was an effective adaptation to the cold environment (Goebel, 2002). However, not all bone tools match the expectations associated with a serial specialist production, i.e., highly standardized tool produced, possessed, and transported by a specialist. While the knife handle and the possible sewing implement could fit this interpretation, any member of the group could have produced the expedient wedges and awls whenever the need for such tools arose. This distinction can be explained by the fact that high quality lithic raw material for the manufacture of microblades were transported to the site and processed by specialized knappers, while many bone tools were likely manufactured from readily available carcasses, then used and discarded at the site. We are clearly witnessing a complex technical system in which different know-hows are required to accomplish a wide variety of tasks. In order to better understand the behavioural complexity necessary for the production and use of bone tools in these tasks, we would need a richer bone assemblage including a greater number of specimens for each tool type and, ideally, by-products of their manufacture. The SDG12 bone tool assemblage nevertheless provides a significant contribution to our knowledge on hunter-gatherer adaptation to the Tardiglacial environments of the Ordos Plateau of China.

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Reference cited

Aplin, K., O'Connor, S., Bulbeck, D., Piper, P.J., Marwick, B., Pierre, E.S., Aziz, F., 2016. The Walandawe Tradition from Southeast Sulawesi and Osseous Artifact Traditions in Island Southeast Asia. In: Langley, M.C. (Ed.), *Osseous Projectile Weaponry: Towards an Understanding of Pleistocene Cultural Variability*. Springer Netherlands, Dordrecht, pp. 189-208.

Backwell, L.R., d'Errico, F., 2004. The first use of bone tools: a reappraisal of the evidence from Olduvai Gorge, Tanzania. *Palaeontol. Afr.* 40 (9), 95-158.

Backwell, L., d'Errico, F., 2016. Osseous Projectile Weaponry from Early to Late Middle Stone Age Africa. In: Langley, M.C. (Ed.), *Osseous Projectile Weaponry: Towards an Understanding of Pleistocene Cultural Variability*. Springer Netherlands, Dordrecht, pp. 15-29.

Backwell, L., d'Errico, F., Wadley, L., 2008. Middle Stone Age bone tools from the Howiesons Poort Layers, Sibudu Cave, South Africa. *J. Archaeol. Sci.* 35 (6), 1566-1580.

Bar-Yosef, O., 2002. The upper paleolithic revolution. *Annu. Rev. Anthropol.* 31 (1), 363-393.

Barton, C.M., 1997. Stone tools, style, and social identity: an evolutionary perspective on the archaeological record. *Arch. P. Amer. Ant. Asso.* 7 (1), 141-156.

469 Behrensmeyer, A.K., Gordon, K.D., Yanagi, G.T., 1986. Trampling as a cause of bone surface
 470 damage and pseudo-cutmarks. *Nature* 319 (6056), 768-771.

471 Bettinger, R.L., Morgan, C., Barton, L., 2015. The North China Nanolithic. In: Goodale, N.,
 472 Andrefsky, J.W. (Eds.), *Lithic Technological Systems and Evolutionary Theory*.
 473 Cambridge University Press, New York, pp. 100-116.

474 Binford, L.R., 1980. Willow smoke and dog's tails: hunter-gatherer settlement systems and
 475 archaeological site formation. *Amer. Ant.* 45, 4–20.

476 Blasco, R., Rosell, J., Cuartero, F., Peris, J.F., Gopher, A., Barkai, R., 2013. Using bones to shape
 477 stones: MIS 9 bone retouchers at both edges of the Mediterranean Sea. *PLoS ONE* 8 (10),
 478 e76780.

479 Bless M., Fernández N.C., Adovasio J.M., 2015. Did our Late Palaeolithic ancestors use stick
 480 shuttles for weaving and netting?. *Antiquity* 89, 347 [online].
 481 <http://archive.antiquity.ac.uk/projgall/bless347>.

482 Boule, M., Breuil, H., Licent, E., Teilhard de Chardin, P. 1928. *Le Paléolithique de la Chine*.
 483 Archives de l'Institut de Paléontologie Humaine, Vol. 4, Paris..

484 Bradfield, J., 2010. The evolution of bone points as hunting weapons in South Africa. Master's
 485 Dissertation. University of the Witwatersrand, Johannesburg.

486 Bradfield, J., 2012. Macrofractures on bone-tipped arrows: analysis of hunter-gatherer arrows in
 487 the Fourie collection from Namibia. *Antiquity* 86 (334), 1179-1191.

488 Bradfield, J., 2016. Bone Point Functional Diversity: A Cautionary Tale from Southern Africa.
 489 In: Langley, M.C. (Ed.), *Osseous Projectile Weaponry: Towards an Understanding of*

490 Pleistocene Cultural Variability. Springer Netherlands, Dordrecht, pp. 31-40.

491 Bradfield, J., Brand, T., 2013. Results of utilitarian and accidental breakage experiments on bone
492 points. *Archaeol. Anthropol. Sci.* 1-12.

493 Bradfield, J., Lombard, M., 2011. A macrofracture study of bone points used in experimental
494 hunting with reference to the South African Middle Stone Age. *S. Afr. Archaeol. Bull.*
495 66, 67-76.

496 Brooks, A.S., Helgren, D.M., Cramer, J.S., Franklin, A., Hornyak, W., Keating, J.M., Klein,
497 R.G., Rink, W.J., Schwarcz, H., Smith, J., 1995. Dating and context of three Middle
498 Stone Age sites with bone points in the Upper Semliki Valley, Zaire. *Science* 268 (5210),
499 548-553.

500 Brunet, F., 2012. The Technique of Pressure Knapping in Central Asia: Innovation or Diffusion?.
501 In: Desrosiers, P.M. (Ed.), *The Emergence of Pressure Blade Making-From Origin to*
502 *Modern Experimentation*. Springer, pp. 307-328.

503 Buc, N., 2011. Experimental series and use-wear in bone tools. *J. Archaeol. Sci.* 38 (3), 546-557.

504 Byrd, J.C., 2011. Archaic bone tools in the St. Johns River Basin, Florida: microwear and
505 manufacture Traces. Master's Dissertation. Florida State University, Florida.

506 Campmas, E., Michel, P., Costamagno, S., Amani, F., Stoetzel, E., Nespoulet, R., Hajraoui,
507 M.A.E., 2015. Were Upper Pleistocene human/non-human predator occupations at the
508 Témara caves (El Harhoura 2 and El Mnasra, Morocco) influenced by climate change? *J.*
509 *Hum. Evol.* 78, 122-143.

510 Camps-Fabrer, H., 1976. Le travail de l'os. In: *La préhistoire française t.I.* CNRS, Paris, pp.

511 717-722.

512 Cao, Z.T., 1982. The preliminary study of bone tools and antler spades from the rock shelter site
513 of Maomaodong. – *Acta Anthropol. Sinica* 1 (1), 36-41 (in Chinese).

514 Chen C., 1983. Preliminary exploration of the typology and technology of microcore in
515 China—also of the culture relationship between Northeast Asia and Northwestern North
516 America. – *Acta Anthropol. Sinica* 2 (4), 331–341 (in Chinese).

517 Chen, Q., Wang, S., Zhang, D., 2004. A Study of the Faunal Remains from the Qingjiang
518 River. Science Press, Beijing (in Chinese).

519 Christidou, R., Legrand, A., 2005. Hide working and bone tools: experimentation design and
520 applications. In: L. Heidi, C. Alice M., B. Collen E. and L. Lembi (Eds.), *From Hooves*
521 to Horns, from Mollusc to Mammoth, Manufacture and Use of Bone Artifacts from
522 Prehistoric Times to the Present-Proceedings of the 4th Meeting of the (ICAZ) Worked
523 Bone Research Group. Muinasaja teadus, Tallin, pp. 385-396.

524 Conard, N.J., Bolus, M., 2003. Radiocarbon dating the appearance of modern humans and timing
525 of cultural innovations in Europe: new results and new challenges. *J. Hum. Evol.* 44 (3),
526 331-371.

527 Cui, T., Yang, Q., Yu, J., Zhou, S., Zhao, C., 2010. Microwear analysis of a bone-handled
528 microblade excavated at Shangzhai site in Beijing: Evidences from ESEM. *Sci. China*
529 Earth Sci. 53 (9), 1335-1342.

530 d'Errico, F., Backwell, L.R., Wadley, L., 2012a. Identifying regional variability in Middle Stone
531 Age bone technology: The case of Sibudu Cave. *J. Archaeol. Sci.* 39 (7), 2479-2495.

532 d'Errico, F., Borgia, V. and Ronchitelli, A., 2012b. Uluzzian bone technology and its
 533 implications for the origin of behavioural modernity. *Quat. Int.* 259, 59-71.

534 d'Errico, F., Backwell, L., Villa, P., Degano, I., Lucejko, J.J., Bamford, M.K., Higham, T.F.G.,
 535 Colombini, M.P., Beaumont, P.B., 2012c. Early evidence of San material culture
 536 represented by organic artifacts from Border Cave, South Africa. *Proc. Natl. Acad. Sci.*
 537 109 (33), 13214-13219.

538 d'Errico, F., Henshilwood, C.S., 2007. Additional evidence for bone technology in the southern
 539 African middle stone age. *J. Hum. Evol.* 52 (2), 142-163.

540 d'Errico, F., Julien, M., Liolios, D., Vanhaeren, M., Baffier, D., 2003. Many awls in our
 541 argument. Bone tool manufacture and use in the Châtelperronian and Aurignacian levels
 542 of the Grotte du Renne at Arcy-sur-Cure. In: Zilhao, J., d'Errico, F. (Eds.), *The*
 543 *Chronology of the Aurignacian and of the Transitional Technocomplexes: Dating,*
 544 *Stratigraphies, Cultural Implications: Proceedings of Symposium 6.1 of the XIVth*
 545 *Congress of the UISPP (University of Liège, Belgium, September 2-8, 2001). Instituto*
 546 *Português de Arqueologia, Lisbon, pp. 247-270.*

547 Daujeard, C., Moncel, M.-H., Fiore, I., Tagliacozzo, A., Bindon, P., Raynal, J.-P., 2014. Middle
 548 Paleolithic bone retouchers in Southeastern France: Variability and functionality. *Quat.*
 549 *Int.* 326, 492-518.

550 Doyon, L., Knecht, H.K., 2014. The Effects of Use and Resharpening on Morphometric
 551 Variability of Aurignacian Antler Projectile Points. *Mitteilungen der Gesellschaft für*
 552 *Urgeschichte* 23, 83-101.

553 Fisher, J.W., 1995. Bone surface modifications in zooarchaeology. *J. Archaeol. Method. Th.* 2
554 (1), 7-68.

555 Gao, X., Wang, H., Pei, S., Chen, F., 2013 Shuidonggou—Excavation and research (2003-2007)
556 report. Science Press, Beijing (in Chinese)..

557 Gao, X., Wang, H.M., Liu, D.C., Pei, S.W., Chen, F.Y., Zhang, X.L., Zhang, Y., 2009. A study
558 of fire use activities at Shuidonggou Locality 12. *Acta Anthropol. Sinica* 28 (4), 329-336.

559 Gates Saint-Pierre, C., Walker, R.B., 2007. Bones as tools: current methods and interpretations in
560 worked bone studies. *British Archaeological Reports* 1622, Oxford: Oxbow, Oxford.

561 Goebel, T., 2002. The “microblade adaptation” and recolonization of Siberia during the Late
562 Upper Pleistocene. *Arch. P. Amer. Ant. Asso.* 12 (1), 117-131.

563 Gómez Coutouly, Y.A.G., 2012. Pressure microblade industries in Pleistocene-Holocene interior
564 Alaska: current data and discussions. In: Desrosiers, P.M. (Ed.), *The Emergence of*
565 *Pressure Blade Making-From Origin to Modern Experimentation*. Springer, pp. 347-374.

566 Goutas N., 2004. Fiche d’exploitation des matières dures d’origine animale au Gravettien. In:
567 Ramseyer D. (Ed.), *Fiches de la Commission de nomenclature sur l’industrie de l’os*
568 *préhistorique-Cahier XI: Matières et techniques*. Paris, Éditions Société Préhistorique
569 Française, p. 53-74.

570 Goutas N., 2013. Nouvelles données sur l’industrie osseuse des grottes du Renne et du Trilobite à
571 Arcy-sur-Cure (Yonne, France) : vers l’identification de nouveaux marqueurs techniques
572 et culturels du Gravettien moyen à burins du Raysse . In: Bodu, P., Chehmana, L.,
573 Klaric, L., Mevel, L., Soriano, S., Teyssandier, N. (Eds.), *Le Paléolithique supérieur*

574 ancien de l'Europe du Nord-Ouest. Réflexions et synthèses à partir d'un projet collectif
 575 de recherche sur le centre et le sud du Bassin parisien. Actes du colloque de Sens (15-18
 576 avril 2009), Paris, Société préhistorique française (coll. Mémoire de la Société
 577 Préhistorique française, LVI), p. 89-116.

578 Griffiths, J.L., 2006. Bone tools and technological choice: change and stability on the Northern
 579 Plains. Ph.D. Dissertation. University of Arizona, Arizona.

580 Guan, Y., Gao, X., Li, F. and Pei, S.W., 2012. Modern human behaviors during the late stage of
 581 the MIS 3 and the Broad Spectrum Revolution: Evidence from a Shuidonggou Late
 582 Paleolithic site. Chinese Sci. Bull. 57 (4), 379-386.

583 Hardy, M., Bouchard, G.P., Doyon, L., 2014. Un outil en os à usages multiples dans un contexte
 584 moustérien. Bull. Soc. Préhist. Fr. 111 (4), 741-744.

585 Henshilwood, C.S., d'Errico, F., Marean, C.W., Milo, R.G., Yates, R., 2001. An early bone tool
 586 industry from the Middle Stone Age at Blombos Cave, South Africa: implications for the
 587 origins of modern human behaviour, symbolism and language. J. Hum. Evol. 41 (6),
 588 631-678.

589 Huang, W.W., Zhang, Z.H., Fu, R.Y., Chen, B.F., Liu, J.Y., Zhu, M.Y., Wu, H.K., 1986. Bone
 590 artifacts and ornaments from Xiaogushan site of Haicheng, Liaoning Province. Acta
 591 Anthropol. Sinica 5 (3), 259-266 (in Chinese)..

592 Jacobs, Z., Duller, G.A., Wintle, A.G., Henshilwood, C.S., 2006. Extending the chronology of
 593 deposits at Blombos Cave, South Africa, back to 140ka using optical dating of single and
 594 multiple grains of quartz. J. Hum. Evol. 51 (3), 255-273.

595 Jéquier C.A., 2014. Techno-économie des industries en matières dures d'origine animale entre le
 596 Paléolithique moyen et supérieur en Italie orientale et Slovénie. Ph.D Dissertation.
 597 Università degli Studi di Ferrara, Ferrara.

598 Jéquier, C.A., Romandini, M., Peresani, M., 2012. Les retouchoirs en matières dures animales:
 599 une comparaison entre Moustérien final et Uluzzien. C. R. Palevol. 11 (4), 283-292.

600 Karavanić, I., Šokec, T., 2003. The Middle Paleolithic percussion or pressure flaking tools? The
 601 comparison of experimental and archaeological material from Croatia. Prilozi Instituta za
 602 arheologiju u Zagrebu 20 (1), 5-14.

603 Kato, S., 2014. Human dispersal and interaction during the spread of microblade industries in
 604 East Asia. Quat. Int. 347, 105-112.

605 Keddie, G., 2010. Netting Needles of British Columbia. The Midden 42 (3), 9-11.

606 Klein, R.G., 1999. The Human Career: Human Biological and Cultural Origins . 2nd ed.
 607 University of Chicago Press, Chicago.

608 Langley, M.C., 2016. Osseous Projectile Weaponry- Towards an Understanding of Pleistocene
 609 Cultural Variability. Springer Netherlands, Dordrecht.

610 Langley, M.C., O'Connor, S., Aplin, K., 2016. A > 46,000-year-old kangaroo bone implement
 611 from Carpenter's Gap 1 (Kimberley, northwest Australia). Quat. Sci. Rev. 154, 199-213.

612 Legrand, A., Radi, G., 2008. Manufacture and use of bone points from Early Neolithic Colle
 613 Santo Stefano, Abruzzo, Italy. J. Field Archaeol. 33 (3), 305-320.

614 Legrand, A., Sidéra, I., 2007. Methods, means and results when studying European bone

615 industries. In: Gates Saint-Pierre, C., Walker, R. (Eds.), *Bones as Tools: Current*
 616 *Methods and Interpretations in Worked Bone Studies*. BAR International Series 1622.
 617 Oxbow, Oxford, pp. 291-304.

618 LeMoine, G.M., 1994. Use wear on bone and antler tools from the Mackenzie Delta, Northwest
 619 Territories. *Amer. Ant.* 59 (2), 316-334.

620 Licent, E., Teilhard de Chardin, P., 1925. Le Paleolithique de la Chine. *L' Anthropologie* (35),
 621 201-234.

622 Liu, D.C., Chen, F.Y., Zhang, X.L., Pei, S.W., Gao, X., Xia, Z.K., 2008. Preliminary comments
 623 on the paleoenvironment of the Shuidonggou Locality 12. *Acta Anthropol. Sinica* 27 (4),
 624 295-303 (in Chinese).

625 Liu, G., 2007. The Xinglongwa culture in relation to other cultures. In: Hu, Y. (Ed.), *The Origins*
 626 *of Jades in East Asia: Jades of the Xinglongwa Culture*. The Center for Chinese
 627 *Archaeology and Art at the Chinese University of Hong Kong*, Hong Kong, pp. 40–51.

628 Lyman, R.L., 1994. *Vertebrate Taphonomy*. Cambridge University Press, Cambridge.

629 Malerba G., Giacobini G., 2002. Fiche éclats diaphysaires. In: Patou-Mathis M. (Ed.),
 630 *Retouchoirs, Compresseurs, Percuteurs. Os à impressions et éraillures. Fiches de la*
 631 *Commission de Nomenclature sur l'Industrie de l'Os Préhistorique*. Cahier X, Paris,
 632 *Éditions de la Société Préhistorique Française*, pp. 29-38.

633 Mallye, J. B., Thiébaud, C., Mourre, V., Costamagno, S., Claud, É., Weisbecker, P., 2012. The
 634 *Mousterian bone retouchers of Noisetier Cave: experimentation and identification of*
 635 *marks*. *J. Archaeol. Sci.* 39, 1131-1142.

636 Mao, Y.Q., Cao, Z.T., 2012. A preliminary study of the polished bone tools unearthed in 1979
637 from the Chuandong site in Puding County, Guizhou. *Acta Anthropol. Sinica* 31 (4),
638 335-343 (in Chinese).

639 McBrearty, S., Brooks, A.S., 2000. The revolution that wasn't: a new interpretation of the origin
640 of modern human behavior. *J. Hum. Evol.* 39 (5), 453-563.

641 Moigne, A.-M., Valensi, P., Auguste, P., García-Solano, J., Tuffreau, A., Lamotte, A., Barroso, C.,
642 Moncel, M.H., 2016. Bone retouchers from Lower Palaeolithic sites: Terra Amata,
643 Orgnac 3, Cagny-l'Épinette and Cueva del Angel. *Quat. Int.* 409, 195-212.

644 Mozota Holgueras, M., 2008. Estudio tafonómico y tecnológico de un útil doble
645 “cincel/retocador”, proveniente del nivel C (Musteriense) de Axlor–Dima, Bizkaia.
646 *Zephyrus*, 61, 217-224.

647 Mozota Holgueras, M., 2009. El utillaje óseo musteriense del nivel “D” de Axlor (Dima,
648 Vizcaya): análisis de la cadena operativa. *Trabajos de Prehistoria*, 66, 28-46.

649 Mozota Holgueras, M., 2012. El hueso como materia prima: El utillaje óseo del final del
650 Musteriense en el sector central del norte de la Península Ibérica. Ph.D. Dissertation.
651 Universidad de Cantabria, Santander.

652 O'Connor, S., Robertson, G., Aplin, K.P., 2014. Are osseous artefacts a window to perishable
653 material culture? Implications of an unusually complex bone tool from the Late
654 Pleistocene of East Timor. *J. Hum. Evol.* 67, 108-119.

655 Pei, S.W., Gao, X., Wang, H.M., Kuman, K., Bae, C.J., Chen, F.Y., Guan, Y., Zhang, Y., Zhang,
656 X.L., Peng, F., Li, X.L., 2012. The Shuidonggou site complex: new excavations and

657 implications for the earliest Late Paleolithic in North China. *J. Archaeol. Sci.* 39 (12),
 658 3610-3626.

659 Pei, W.C., 1939. The Upper Cave industry of Choukoutien. *Palaeont. Sinica* (Ser. D) 9, 1–58.

660 Pelegrin, J., 2012. New experimental observations for the characterization of pressure blade
 661 production techniques. In: Desrosiers, P.M. (Ed.), *The Emergence of Pressure Blade*
 662 *Making-From Origin to Modern Experimentation*. Springer, pp. 465-500.

663 Perera, N., Roberts, P., Petraglia, M., 2016. Bone Technology from Late Pleistocene Caves and
 664 Rockshelters of Sri Lanka. In: Langley, M.C. (Ed.), *Osseous Projectile Weaponry:*
 665 *Towards an Understanding of Pleistocene Cultural Variability*. Springer Netherlands,
 666 Dordrecht, pp. 173-188.

667 Pétillon, J.M., 2006. Des Magdaléniens en armes: Technologie des armatures de projectile en
 668 bois de cervidé du Magdalénien supérieur de la Grotte d'Isturitz (Pyrénées-Atlantiques),
 669 Éditions du Cedarc, Treignes, Belgique (Coll. Artefacts, 10).

670 Rabett, R.J., Piper, P.J., 2012. The emergence of bone technologies at the end of the Pleistocene
 671 in Southeast Asia: regional and evolutionary implications. *Camb. Archaeol. J.* 22 (01),
 672 37-56.

673 Rasmussen, S. O., Bigler, M., Blockley, S P., Blunier, T., Buchardt, S. L., Clausen, H B.,
 674 Cvijanovic, I., Dahl-Jensen, D., Johnsen, S. J., Fischer, H., Gkinis, V., Guillevic, M.,
 675 Hoek, W. Z., Lowe, J. J., Pedro, J. B., Popp, T., Seierstad, I. K., Steffensen, J. P.,
 676 Svensson, A. M., Vallelonga, P., Vinther, B. M., Walker, M.J.C., Wheatley, J., Winstrup,
 677 M., 2014. A stratigraphic framework for abrupt climatic changes during the Last Glacial

678 period based on three synchronized Greenland ice-core records: refining and extending
679 the INTIMATE event stratigraphy. *Quat. Sci. Rev.* 106, 14-28.

680 Shipman, P., Rose, J., 1983. Early hominid hunting, butchering, and carcass-processing
681 behaviors: Approaches to the fossil record. *J. Anthropol. Archaeol.* 2 (1), 57-98.

682 Soffer, O., 2004. Recovering perishable technologies through use wear on tools: preliminary
683 evidence for Upper Paleolithic weaving and net making. *Curr. Anthropol.* 45 (3), 407-413.

684 Song, Y., Li, X., Wu, X., Kvavadze, E., Goldberg, P., Bar-Yosef, O., 2016. Bone needle
685 fragment in LGM from the Shizitan site (China): Archaeological evidence and
686 experimental study. *Quat. Int.* 400, 140–148.

687 Tabarev, A.V., 2012. Blades and microblades, percussion and pressure: Towards the evolution of
688 lithic technologies of the stone age period, Russian Far East. In: Desrosiers, P.M.
689 (Ed.), *The Emergence of Pressure Blade Making-From Origin to Modern*
690 *Experimentation*. Springer, pp. 329-346.

691 Takakura, J., 2012. Emergence and development of the pressure microblade production: a view
692 from the Upper Paleolithic of Northern Japan. In: Desrosiers, P.M. (Ed.), *The*
693 *Emergence of Pressure Blade Making-From Origin to Modern Experimentation*. Springer,
694 pp. 285-306.

695 Tejero, J.M., Arrizabalaga, Á., Villaluenga, A., 2016. The Proto-Aurignacian and Early
696 Aurignacian retouchers of Labeko Koba (Basque Country, Spain). A techno-economic
697 and chrono-cultural interpretation using lithic and faunal data. *C. R. Palevol.* 15 (8),
698 994-1010.

699 Wang, Y., 2005. The roots of Pleistocene hominids and cultures in China. Science Press, Beijing
700 (in Chinese).

701 Wiessner, P., 1983. Style and social information in Kalahari San projectile points. *Amer. Antiq.*
702 48 (2), 253-276.

703 Yellen, J.E., 1998. Barbed Bone Points: Tradition and Continuity in Saharan and Sub-Saharan
704 Africa. *Afr. Archaeol. Rev.* 15 (3), 173-198.

705 Yellen, J.E., Brooks, A.S., Cornelissen, E., Mehlman, M.J., Stewart, K., 1995. A Middle
706 Stone-Age worked bone industry from Katanda, Upper Semliki Valley, Zaire. *Science*
707 268 (5210), 553-556.

708 Yeshurun, R., Tejero, J.M., Barzilai, O., HersHKovitz, I., Marder, O., 2017. Upper Palaeolithic bone
709 retouchers from Manot Cave (Israel): A preliminary analysis of a (yet) rare phenomenon
710 in the Levant. In: Hutson, J.H., Gaudzinski-Windheuser, S., (Eds.), *The Origins of Bone*
711 *Tool Technologies* (Römish-Germanisches Zentralmuseums, 2017), pp.1-9.

712 Yi, M., Barton, L., Morgan, C., Liu, D., Chen, F., Zhang, Y., Pei, S., Guan, Y., Wang, H., Gao,
713 X., Bettinger, R.L., 2013. Microblade technology and the rise of serial specialists in
714 north-central China. *J. Anthropol. Archaeol.* 32 (2), 212-223.

715 Yi, M., Bettinger, R.L., Chen, F., Pei, S., Gao, X., 2014. The significance of Shuidonggou
716 Locality 12 to studies of hunter-gatherer adaptive strategies in North China during the
717 Late Pleistocene. *Quat. Int.* 347, 97-104.

718 Yi, M., Gao, X., Li, F., Chen, F., 2016. Rethinking the origin of microblade technology: A
719 chronological and ecological perspective. *Quat. Int.* 400, 130-139.

720 Zhang, J.F., Huang, W.W., Yuan, B.Y., Fu, R.Y., Zhou, L.P., 2010. Optically stimulated
 721 luminescence dating of cave deposits at the Xiaogushan prehistoric site, northeastern
 722 China. *J. Hum. Evol.* 59 (5), 514-524.

723 Zhang, S., d'Errico, F., Backwell, L.R., Zhang, Y., Chen, F., Gao, X., 2016a. Ma'anshan cave and
 724 the origin of bone tool technology in China. *J. Archaeol. Sci.* 65, 57-69.

725 Zhang, S.S., 1995. A brief study on Chuandong prehistoric site (excavated in 1981). *Acta*
 726 *Anthropol. Sinica* 14 (2), 132-146 (in Chinese).

727 Zhang, Y., Gao, X., Pei, S., Chen, F., Niu, D., Xu, X., Zhang, S., Wang, H., 2016b. The bone
 728 needles from Shuidonggou locality 12 and implications for human subsistence behaviors
 729 in North China. *Quat. Int.* 400, 149-157.

730 Zhang, Y., Stiner, M.C., Dennell, R., Wang, C.X., Zhang, S.Q., Gao, X., 2010.
 731 Zooarchaeological perspectives on the Chinese Early and Late Paleolithic from the
 732 Ma'anshan site (Guizhou, South China). *J. Archaeol. Sci.* 37 (8), 2066-2077.

733 Zhang, Y., Zhang, S.Q., Xu, X., Liu, D.C., Wang, C.X., Pei, S.W., Wang, H.M., Gao, X., 2013.
 734 Zooarchaeological perspective on the Broad Spectrum Revolution in the
 735 Pleistocene-Holocene transitional period, with evidence from Shuidonggou Locality 12,
 736 China. *Sci. China Earth Sci.* 56 (9), 1487-1492.

737 Zhang, Z.H., Fu, R.Y., Chen, B.F., Liu, J.Y., Zhu, M.Y., Wu, H.K., Huang, W.W., 1985. A
 738 preliminary report on the excavation of Paleolithic site at Xiaogushan of Haicheng,
 739 Liaoning Province. *Acta Anthropol. Sinica* 4 (2), 78-92(in Chinese).

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741 **Legends of figures and table**

742 Figure 1: a: location of Shuidonggou Locality 12; b: photo of the stratigraphy indicating the
743 geological layers and their limits (b, modified after Pei et al. 2012)

744 Figure 2: Osseous artefacts from SDG12 layer 11 analysed in this study. Scales = 1 cm. See table
745 1 for additional information

746 Figure 3: Traces of manufacture and use on SDG12 wedges; a-c: 132; d-e: 4008; f: 2857. Scales:
747 a, b = 1mm; c = 200 μ m; d~f = 500 μ m

748 Figure 4: Traces of manufacture on wedge SDG12-3091. Scales: a = 1000 μ m; b = 500 μ m.

749 Figure 5: Traces of manufacture and use on SDG12 awls; a-b: 130; c-d: 2859; e-f: 1208; g: 2850.
750 Scales: a, d g = 1 mm; b, c = 500 μ m; e, f = 250 μ m

751 Figure 6: Traces of manufacture and use on SDG12 projectile points; a: 1211; b-c: 2854;
752 d-e: 2858. Scales: a, c = 1 mm; b = 500 μ m; d, e = 250 μ m

753 Figure 7: Traces of manufacture and use on possible sewing implement SDG12-1213. Scales: a, c,
754 d, e = 1 mm; b = 20 μ m

755 Figure 8: Traces of manufacture on the knife handle SDG12-141. Scales: a = 1 cm; b = 1 mm

756 Figure 9: Traces of manufacture on SDG12 artefacts; a: 2855; b-c: 1215; d: 3266. Scales: a =
757 500 μ m; b~c = 1mm; d = 500 μ m. The oblique bar in *a* indicates the area enlarged at the
758 bottom of the figure

759 Table 1: Descriptive, technological, and morphometric data on SDG12 (layer 11) bone artefacts.