Journal of Paleolithic Archaeology (2022) 5:15
https://doi.org/10.1007/s41982-022-00125-9

The Antler, Ivory, and Bone Artefacts from Maszycka Cave (Southern Poland). New Signals from a Late Upper Palaeolithic Key Site

Sebastian J. Pfeifer[1]

Accepted: 7 October 2022

Abstract

The well-known Late Upper Palaeolithic cave site of Maszycka (southern Poland), excavated in the end of the nineteenth century as well as in the 1960s, furnished a collection of 89 osseous artefacts manufactured from cervid antler, mammoth ivory, and mammal long bone. The great majority are finished tools, mostly projectile points, while raw material blocks, pre-forms, and production waste are represented by only a few pieces. Based on the presence of the characteristic double-split antler tools, distinct projectile morphologies, and recurring ornaments, the assemblage from Maszycka can be assigned to the early Middle Magdalenian facies *à navettes* which dates to around 19 - 17.5 ka cal. BP. Compared to the western European sites, which also belong to this facies, Maszycka is characterised by a high proportion of ivory tools, reflecting the abundance of this favourable raw material in eastern central Europe, as well as an unusually high proportion of decorated tools, which may relate to an increased need for symbolic communication within the small and geographically isolated Magdalenian group. Both the remarkable typo-technological similarities of the bone industry from Maszycka to contemporary assemblages in France and the gap in the central European archaeological record between 22 and 19 ka cal. BP speak in favour of a direct immigration of Magdalenian hunter-gatherers from western Europe immediately after the end of the Last Glacial Maximum. Their relations to the bearers of the Epigravettian adjacent to the east and south remain to date poorly understood.

Keywords Late Upper Palaeolithic · Central Europe · Magdalenian · Navettes · Osseous artefacts · Recolonization

✉ Sebastian J. Pfeifer
Sebastian.pfeifer@uni-jena.de

[1] Friedrich Schiller University Jena, Löbdergraben 24a, 07743 Jena, Germany

Published online: 03 November 2022

Introduction and Objectives

Maszycka cave site in southern Poland is well-known in central European Palaeolithic research for several reasons (Allain et al., 1985; Kozłowski et al., 2012, 2017; Maier, 2015, 2017a and b; Maier et al., 2020; Nerudová & Neruda, 2015; Orschiedt et al., 2017; Otte, 2012; Połtowicz-Bobak, 2013; Terberger, 2013; Wiśniewski et al., 2017). First, it furnished a small but highly diverse and excellently preserved inventory of lithic and osseous artefacts, animal bones, and human remains from the Late Upper Palaeolithic (henceforth, LUP) (Kozłowski et al., 1993). Second, owing to characteristic typological and ornamental features, it is assigned to the distinct early Middle Magdalenian facies *à navettes*, which otherwise is only attested to in France (Allain et al., 1985; Sécher, 2020). Third, after Munzingen in the Upper Rhine Plain (Pasda, 2017), Maszycka is currently the second-oldest well-dated site in the northern mid-latitudes posterior to the Last Glacial Maximum (henceforth, LGM) and the earliest one in their eastern part (Kozłowski et al., 2012; Maier et al., 2020). Fourth, it is located at the eastern border of the distribution area of the Magdalenian technocomplex along the Vistula and San valleys and at the same time at the western margins of the Epigravettian sphere (Połtowicz-Bobak, 2013).

Presentation of the Site

Maszycka is situated in the Polish Jura, 20 km north of the city of Cracow (woj. małopolskie, Poland) (Fig. 1). The small cave is located above the stream Prądnik, a tributary to the Vistula, and about 13 m long with a SSW-oriented, 6 m wide

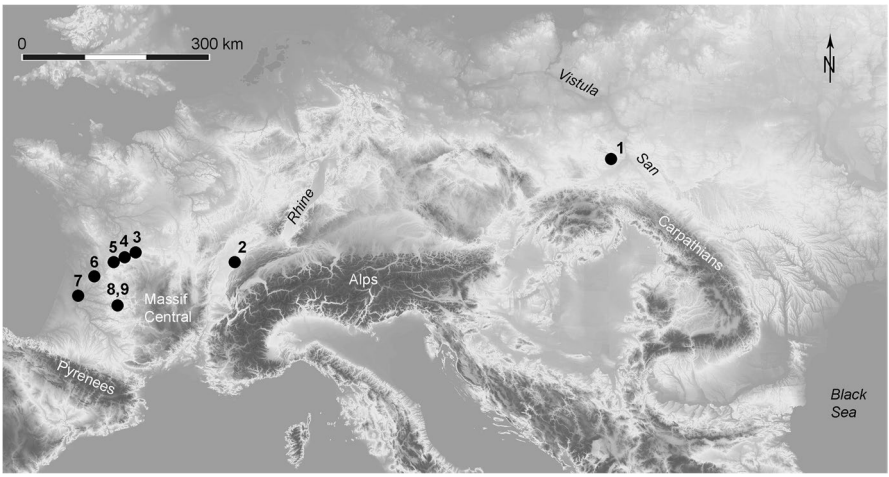

Fig. 1 Situation of Maszycka cave and other *navette*-bearing sites. 1: Maszycka, 2: Grappin, 3: Garenne, 4: Piscine, 5: Chaffaud, 6: Placard, 7: Roc-de-Marcamps, 8.9: Laugerie-Basse & Laugerie-Haute. European Environment Agency. Modified by the author. https://www.eea.europa.eu/data-and-maps/figures/elevation-map-of-europe

entrance. It was first excavated in 1883 by the geologist G. Ossowski, who emptied out the cave itself and a small part of its front area in a single campaign. From a well-recognisable Pleistocene loess layer ("mammoth clay"), located below thick Holocene sediments with some Neolithic finds, Ossowski recovered a rich collection of lithic and osseous artefacts, animal remains, and human bones (Ossowski, 1885).

Between 1962 and 1966, the remaining large part of the front area was investigated in several field seasons by the University of Warsaw under the direction of S. K. Kozłowski, exposing 51 m^2 down to the bedrock, which lay up to 4 m below the surface. A seven-layer stratigraphy was recorded, from bottom to top: (1) a clay with rubble on top of the bedrock, (2) aeolian loess with rubble and closer to the cave entrance, (3) an erosional channel filled with soliflucted clay, (4) loess with rubble and dendrites, (5) thin colluvial loess, (6), degraded loess, and finally (7), forest soil with Neolithic and younger artefacts. Most Palaeolithic finds were recovered from 5–10 cm thick layer 5, but a few finds also originate from layers 2 and 3, respectively. It is of note that the archaeological assemblage was partly encountered in a "narrow solifluction stream, meandering towards the valley" (Kozłowski et al., 1993, 116; Fig. 3).

In 2013, the University of Rzeszów resumed excavations at Maszycka during the course of which it was possible to locate the backdirt from Ossowski's campaign. These investigations are still ongoing (Kozłowski et al., 2017).

Assemblages

The most detailed overview of the finds from the cave and the front area is provided by Kozłowski et al., (1993). The chipped flint industry comprises around 300 pieces and is dominated by un-retouched flakes and blades, removed from comparatively big cores. Endscrapers are the most frequent tool type, followed by laterally retouched pieces, burins, backed bladelets, and a single borer (ibid. 123–147). The recent excavations contributed another 200 small flakes and chips from the backdirt (Kozłowski et al., 2017). The raw material is largely of local origin, but single specimens of Plattensilex, Volhynian flint, chocolate flint, and radiolarite indicate a procurement area extending 600 km to the west, 300 km to the east, and 100 km to the north and south, respectively (Kozłowski et al., 2017; Fig. 14).

The osseous artefact spectrum is widely recognised for richly decorated projectile points, a phallic perforated rod, several *navettes*, and a slotted decorated rib (Kozłowski et al., 1993, 147–161). Five fossil molluscs of local origin served as personal ornaments (ibid. 163).

The faunal assemblage contains bones of caballine horse (*Equus* sp), reindeer (*Rangifer tarandus* Linnaeus), red deer (*Cervus elaphus* Linnaeus), saiga antelope (*Saiga tatarica* Linnaeus), bovids (*Bos* vel *Bison*), brown bear (*Ursus arctos* Linnaeus), and woolly rhino (*Coelodonta antiquitatis* Blumenbach) (ibid. 231–240). The presence of a few cave bear (*Ursus spelaeus* Rosenmüller), aurochs (*Bos primigenius* Bojanus), and wild boar (*Sus scrofa* Linnaeus) bones is not in accordance with the LUP occupation but reflects older and younger intrusions into the find

horizon. Of note are 50 fragmented human remains, mostly skulls, many of which bear anthropic modifications. These bones belong to at least four adults and five children (Orschiedt et al., 2017).

Archaeostratigraphic Position

The archaeological classification of the LUP assemblage from Maszycka was established remarkably early. Already Ossowski (1885) assigned it to the Magdalenian, which was later confirmed by Breuil (1925). During the first decades of the twentieth century, a rather early stage within this techno-complex was proposed by Kostrzewski (1928). J. K. Kozłowski (1963) who republished the assemblage proposed an attribution to the *navette*-bearing Middle Magdalenian III sensu Breuil (1937). The seminal study on the Magdalenian '*à navettes*' by Allain et al. (1985) then placed the Maszycka assemblage in a pan-European context and confirmed its earlier assignment and dating. Defining characteristics of the *navettes* facies are the name-giving double-split antler tool, large double-bevelled points with a longitudinal ventral groove, original artistic expressions—in particular phallic representations and schematised human faces—as well as small carved depressions, referred to as cupules were emphasized as defining features of the navettes facies. Recent studies have pointed out that sites attributed to the French Magdalenian III / early Middle Magdalenian (c. 19.5–17.5 ka cal. BP) and the largely coeval Cantabrian Lower Magdalenian in northern Spain share certain typo-technological characteristics in their osseous industries, like operation chains of antler projectiles, projectile points with single- and double-bevelled bases and rounded or quadrangular cross sections, type 2a spearthrower hooks, and perforated hyoid bones. These supra-regional commonalities are reflected in lithic technology, in particular by shared core concepts and reduction sequences, scalene bladelets and truncated backed bladelets (Chauvière et al., 2017; Gauvrit Roux, 2022; Guy Straus & González Morales, 2020; Langlais, 2020; Maier et al., 2020; Pétillon, 2016; Sécher, 2020). Cultural permeability and efficient communication networks, tangible by the circulation of lithic raw materials (Sécher & Caux, 2017), cetacean bone artefacts (Lefebvre et al., 2021) and certain molluscs (Guy-Straus &f Gonzáles Morales 2020, 193), obviously facilitated a swift dissemination of techno-economical norms across large areas of western Europe (Langlais et al., 2017). At the same time, these works also acknowledge the existence of distinct idiosyncrasies, mainly in terms of typology and artistic convention, and against this background the navettes facies remains widely accepted as an analytical unit. Aside from Maszycka, *navettes* are to date reported from eight sites, all of which located in France: Roc-de-Marcamps (Gironde), Laugerie-Haute and Laugerie-Basse (Dordogne), Le Placard (Charente), Le Chaffaud (Vienne), La Garenne (Indre), Grotte Grappin (Jura), and, recently put forward, La Piscine (Vienne) (Allain et al., 1985; Chauvière et al., 2017). According to available ^{14}C dates, the age of these assemblages is 19 - 17.5 ka cal. BP (Kozłowski et al., 2017; Maier et al., 2020; Sécher, 2020). Between the easternmost *navette*-bearing site in France, Grotte Grappin in the French Jura (Malgarini, 2014; Malgarini et al., 2017), and Maszycka lies a distance of 1,300 km as the crow flies, from where no such

Table 1 Radiocarbon measurements for Maszycka cave site. Calibration performed using OxCal 4.4 implementing the IntCal20 curve (Bronk Ramsey 2021; Reimer et al. 2020)

Lab.nr	Sample	BP	cal. BP 95.4 % probability	Source
Ly-2454	Worked reindeer antler	15,490 ± 310	19,491–18,224	Allain et al., 1985
Ly-2453	Horse bone	14,520 ± 240	19,346–18,275	Allain et al., 1985
KIA 39,225	Antler *navette* (Inv.nr 147)	14,855 ± 60	18,274–18,004	Kozłowski et al., 2012
KIA 39,226	Antler projectile point (Inv.nr 244)	15,025 ± 50	18,623–18,211	Kozłowski et al., 2012
KIA 39,227	Human skull	15,015 ± 50	18,620–18,206	Kozłowski et al., 2012
KIA 39,228	Human mandible	15,115 ± 60	18,649–18,247	Kozłowski et al., 2012

assemblages are known. Recently, some conspicuous osseous artefacts from several central European palimpsests have been presented, which, despite the absence of *navettes*, may also relate to the early Middle Magdalenian, suggesting a much less disrupted spatial distribution pattern (Maier et al., 2020; Pfeifer, 2019; 2020).

Dating

Two conventional ^{14}C dates from the 1980s with high standard deviations supported the typologically supposed, early position of Maszycka within the Magdalenian (Allain et al., 1985) but were not universally accepted (Housley et al., 1997). In 2009, four AMS measurements on osseous artefacts and human bones were performed, which confirmed the older dates and narrowed the occupation to around 15 ka BP (Table 1).

In the light of these AMS measurements, a dating of the LUP occupation of Maszycka between 18.6 and 18 ka cal. BP is conceivable (Kozłowski et al., 2012). This age makes it the oldest universally accepted Magdalenian site in eastern central Europe (e.g., Jöris, 2021; Kozłowski et al., 2017; Maier, 2015, 2017a; Maier et al., 2020, 2021; Pfeifer, 2020; Połtowicz-Bobak, 2013, 2020).

Aim of the Study

This contribution aims to re-evaluate the Maszycka osseous industry. It has been 30 years now since the artefacts of antler, ivory, and bone were last published as part of a comprehensive overview of the site (Kozłowski et al., 1993). Since then, new methods of documentation and analysis have been developed, and the meticulous reconstruction of the processes of raw material selection, production, use, and discard, commonly referred to as *chaîne opératoire* or operation chain, has become as important in research on osseous industries as typology (e.g., Averbouh, 2000; Malgarini, 2014; Pétillon, 2006; Pfeifer, 2016; Wild, 2020), since it is equally valuable for the construction of analytical units of the Upper Palaeolithic (Reynolds, 2020). One aim is therefore to provide a complete record of osseous tool types from Maszycka and to link them to their corresponding operation chains whenever possible. Based on that, the assemblage can

be compared to contemporaneous osseous inventories from western Europe, some of which have recently been re-examined as well, to check the previously proposed similarities with other *navette*-bearing sites. As the osseous industry recovered at Maszycka is the material echo of various activities carried out by its occupants, it will also be possible to evaluate previous statements on LUP palethnography and site function (Kozłowski et al., 1993). Finally, it will be discussed in what way the results of this study can provide new impulses for the current debate about the recolonisation of central Europe after the LGM, in which the site plays a central role (Kozłowski et al., 2012, 2017; Lengyel et al., 2021; Maier, 2015, 2017a and b; Maier et al., 2020; Nerudová & Neruda, 2015; Nerudová et al., 2021; Otte, 2012; Pfeifer, 2020; Połtowicz-Bobak, 2013; Połtowicz-Bobak & Bobak, 2020; Terberger, 2013; Wiśniewski et al., 2017).

Materials and Methods

Today, the osseous material from Maszycka resides in three different collections. The finds from Ossowski's excavations, which represent the largest part of the assemblage, are stored at the Archaeological Museum Cracow. The finds from Kozłowski's excavations at the front area are stored at the University of Warsaw and the State Archaeological Museum Warsaw, respectively.

All objects were observed with the naked eye, a × 5 magnifying glass, and a Dino-Lite Edge™ hand-held digital microscope with × 50 magnification. Eighty-nine osseous objects were identified as artefacts, 72 in Cracow, 15 at the University of Warsaw, and two in the State Archaeological Museum Warsaw. Data were recorded in type-specific attribute-based forms, including preservation, raw material, metrics, technological information, decoration, and secondary modifications (see Supplementary Information S1–4). Each piece was digitally photographed in multiple orientations, and cross sections were drawn.

The preservation state of the osseous artefacts is in general good with smooth, often shiny surfaces and well-recognisable modifications. The assemblage from the front area (excavation Kozłowski) is less well preserved than the finds from the cave interior (excavation Ossowski). Root etching is present on many pieces, but only in eight cases is it so invasive that morphology and metrics are affected. Two antler artefacts bear gnawing marks (comp. Pfeifer, 2016; Wild et al., 2020) (Fig. 2: 13). In objects made on antler blanks, the side where the spongiosa is located is often degraded to some degree due to its lower density, which is typical of archaeological antler artefacts (e.g., Pétillon, 2006; Pfeifer, 2016; Wild, 2020). In mammoth ivory, sedimentary and post-sedimentary lamellar decomposition are a common issue (Wolf, 2015), and thus most objects from this material had been refitted from small fragments. In some cases, neither the original dimensions nor morphology could be reconstructed, which affects both metrics and typological classification. The great majority of osseous artefacts, especially projectile points, display sedimentary and post-sedimentary fractures that had been refitted and glued earlier. This analysis did not contribute any new refits. The measurements were taken on the pieces in their current condition (i.e. in 2021 and 2022).

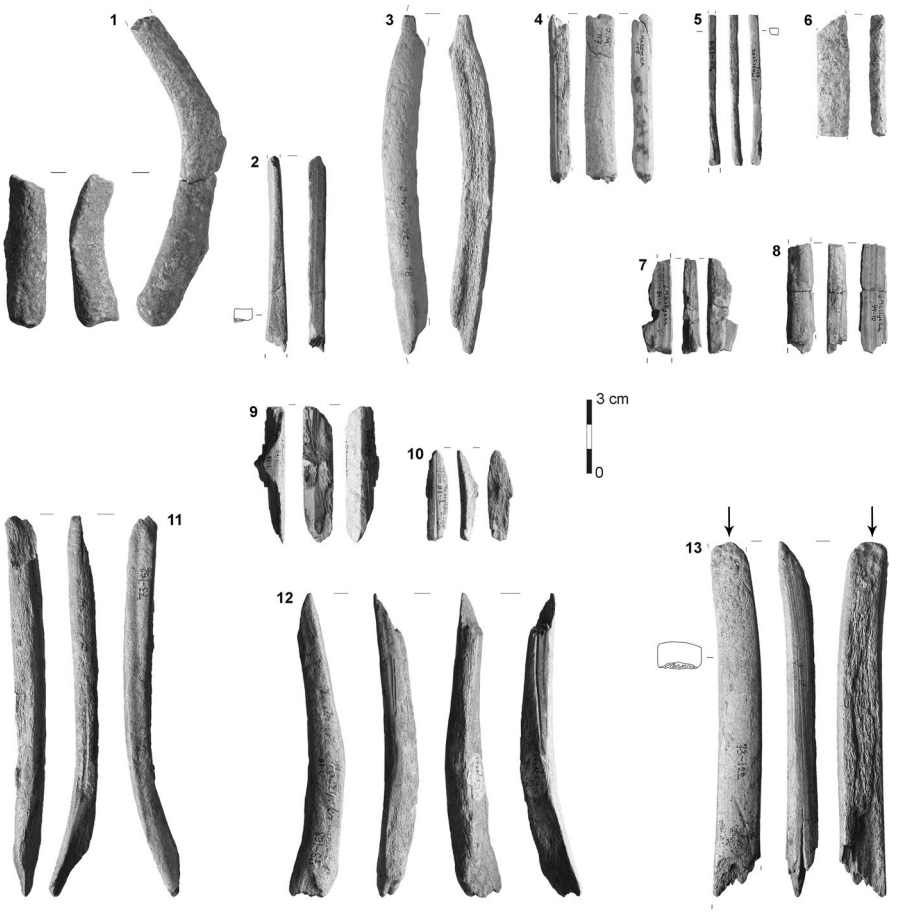

Fig. 2 Raw material blocks (1), prepared blanks (2–5.11–13), undetermined artefacts (6–8), and fracture wedges (9.10). Note the pronounced longitudinal striae on the laterals indicative of the groove-and-splinter technique, and gnawing marks (13—arrows). 1.3.4.6: State Archaeological Museum Warsaw, 2.5.7–13: Archaeological Museum Cracow

Table 2 Raw materials of osseous artefacts ($N=89$)

Antler	Ivory	Long bone
60	17	12

Results

Raw Materials and Typological Spectrum

Based on morphology, compact and spongy tissue, and lamellae, the raw material could be identified in all cases (Table 2). Most artefacts are made from antler, which is typical for European LUP osseous assemblages (Averbouh, 2000; Höck, 2000;

Table 3 Osseous artefacts from Maszycka cave ($N=89$)

Tool manufacture ($N=19$)							
Raw material block	Prepared antler blank	Bone needle blank	Pre-form of projectile point	Fracture wedge from projectile point	Undetermined worked fragment		
2	6	1	1	2	7		
Tools ($N=70$)							
Projectile point	Navette	Smoother	Awl	Perforated baton	Wedge	Slotted rib	Other tools
44	9	5	3	1	1	1	6

Pétillon, 2006; 2016; Pfeifer, 2016; Tinnes, 1995; Wild, 2020). Based on the faunal remains and a few artefacts on which the taxon can be determined, it is likely to be reindeer, but there is also the possibility that some pieces were made from red deer antlers, as this species is attested to in the faunal record and was present in eastern central Europe during the LGM, with evidence of red deer antler processing at the open-air site of Kammern-Grubgraben in Lower Austria (Pfeifer, personal observation).

Fifteen percent of the artefacts from Maszycka are of mammoth (*Mammuthus primigenius* Blumenbach) ivory. The absence of mammoth bones in the faunal assemblage speaks in favour of collecting, either from cadavers—mammoth was part of the faunal community in eastern central Europe during GS-2 (Ginter et al., 2005; Kahlke, 2015)—or remains from permafrost (Pfeifer et al., 2019). The third raw material class to be mentioned is long bone from large mammals. In four cases, the dimensions of tools indicate an origin from megaherbivores like bovids or woolly rhino, both of which are present in the faunal record of the site.

The great majority of osseous artefacts from Maszycka are finished tools, whereas only a few pieces relate to the actual manufacturing process (Table 3; Fig. 2). This is probably not the result of find selection by Ossowski, since neither Kozłowski's later excavations on the front area nor the recent screening of the backdirt from the cave have changed that picture. Seven small, elongated antler and ivory fragments with working traces cannot be assigned with certainty to either of these two main categories (Fig. 2: 6–8).

Artefacts Relating to Tool Manufacture

There are only two raw material blocks. The first piece is a medium-sized, shed left antler beam. The piece was not accessible for this study, but a full-size photograph by Kozłowski (1963, pl. 20) shows likely sediment fractures of the brow and bez tines and a clear, chopped semi-circular notch with which the terminal section of the antler was removed. The second piece (Fig. 2: 1) is the proximal–distal part of a small antler beam, the basal part of which had been removed by a circular notch. Transversal sectioning of raw material blocks by means of chopped or sawn notches is ubiquitous in LUP antler working (e.g., Pétillon, 2016; Pfeifer, 2016; Wild, 2020), and similarly prepared pieces are also present at Grappin (Malgarini, 2014) and Laugerie-Basse (Bräem 2008).

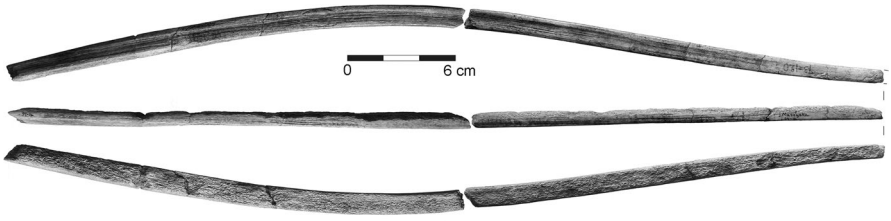

Fig. 3 Pre-form of long antler point with simple incised decoration. Archaeological Museum Cracow

There are six fragments of prepared antler blanks: one distal end (Fig. 2: 2) and two mesial fragments with sediment fractures (Fig. 2: 3.4), as well as three proximal segments with bending fractures at both ends, which have an irregular cross-section in the proximal part and a regular cross-section in the distal part, achieved by longitudinal scraping. (Fig. 2: 11–13). These artefacts relate to projectile point production (Malgarini, 2014, Fig. 137–138; 209; Pfeifer, 2016, 73; pl. 31). Of note is a bone needle blank (Fig. 2: 5), which finds good parallels at Grappin (Malgarini, 2014, Fig. 127; 164). A long pre-form of an antler point with a wide and shallow longitudinal groove accompanied by two incised opposing half-circles (Fig. 3) finds good parallels in a cache of pre-forms recovered at Garenne, which have silhouette, cross section and longitudinal grooves already established, but still lack their base bevels and acute points (Chauvière & Rigaud, 2009). Interestingly, one of these pieces bears a similar decoration like the pre-form from Maszycka (ibid. Figure 3.2).

Projectile points

Finished projectile points are represented by 44 fragments between 34 and 412 mm long (Supplementary Information S1). These pieces are remarkably complete with almost half of them preserved from the basal to distal section. According to raw material, preserved section, metrics, and morphology, the fragments belong to at least 33 individual points (Fig. 4A). The predominant raw material is antler ($N=35$), probably from reindeer, and both compacta thickness and overall dimensions of the points speak for the use of antlers of adult males (comp. Averbouh, 2000; Pétillon, 2016; Pfeifer, 2016) (Fig. 4B). The above-mentioned, fragmented pre-form is over 500 mm long with a maximal compacta thickness of 5 mm and hence was obtained from a big but not particularly massive antler (Fig. 3).

Since the assemblage is lacking raw material blocks with negatives of blank removal, no statement can be made about the procurement of the antlers (collecting or hunting). According to pre-form, blanks and working traces on finished objects, antler projectile points were always made from long blanks, which were prepared by applying the groove-and-splinter technique (henceforth, GST) sensu Clark (1953): two deep and parallel longitudinal grooves were cut into the raw material block to rough out an elongated blank, which was then snapped off by flexing.

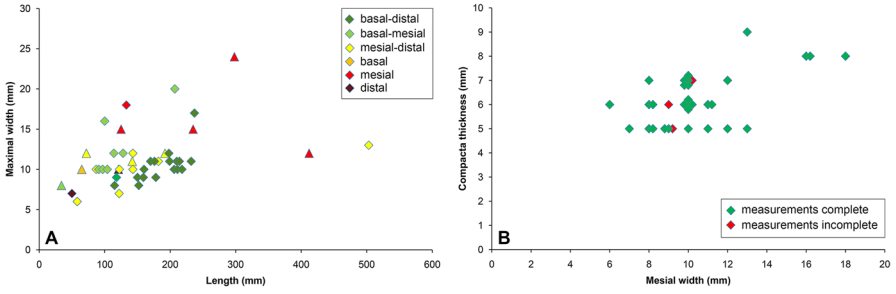

Fig. 4 Metric data of projectile points and the pre-form. **A**: Length and maximal width of all fragments. Diamond: antler, triangle: ivory. $N=45$. **B**: Mesial width and compacta thickness of antler points. $N=35$

By longitudinal scraping of the lateral and ventral sides, the cross section of the extracted blank was regularised and the desired silhouette shaped. Finally, the irregular proximal end of the blank was broken off and discarded (Fig. 2: 11–13), and the pre-form (Fig. 3) was finished into a point by establishing the bevelled base and, if desired, the longitudinal groove. Almost all points were finally polished. This production scheme is a recurrent pattern in the early Middle Magdalenian (Averbouh, 2000; Pétillon, 2016; Malgarini, 2014).

Ten point fragments are of mammoth ivory. This raw material was preferred in larger points (Fig. 4A; 5A), which is common in the Magdalenian (cf. Höck, 2000; Malgarini, 2014, Fig. 155; Müller et al., 2018/19; Tinnes, 1995). As there are no pre-forms and the surfaces of the points have been completely modified by longitudinal scraping and polishing, the manufacturing process of ivory points is not entirely clear. However, another ivory tool shows clear evidence of the GST (Inv.nr 94–19, see below), and therefore, it is reasonable to suppose that the ivory projectile points were also made from cut-out blanks, as attested in the inventories from Grappin (Malgarini, 2014), as well as Andernach-Martinsberg and Kniegrotte in Germany (Höck, 2000; Tinnes, 1995).

Morphology

The projectile points from Maszycka are long and slender, with the greatest width at the base and gently tapering to an acute or flattened point section. Cross sections are predominantly sub-rectangular, less frequently sub-triangular, and in single cases oval or half-round (Table 4).

There are two base geometries: single- and double-bevelled (Fig. 5B). Single bevels are typically cut out concave, which is mechanically favourable in that it allows the bevelled wooden counterpart of the shaft to be convex and hence stronger (Fig. 6). Double bevels, which are much rarer, are flat and require a v-shaped counterpart (Fig. 7). Incised parallel or crisscrossed hafting striations are ubiquitous and typically situated on the upper and lower sides of the base of both single- and double-bevelled varieties. One single-bevelled ivory point (Inv.nr 223; Fig. 6: 6) bears hafting striations on all its four sides.

Longitudinal grooving is rare. It is always executed on the ventral, spongy side of the point and exclusive to points with a sub-rectangular cross section (Table 4; Fig. 7). In two cases (Inv.nr 90–6; 244; Fig. 7: 7.9), a longitudinal ledge is carved from the spongiosa between the base bevel and the groove, which is paralleled in at least one double-bevelled, grooved point from Roc-de-Marcamps (Pétillon, 2016, Fig. 4.7).

Metrics

One complete point is 232 mm long (Inv.nr 90–23; Fig. 6: 4). Otherwise, basal–distal fragments, which only lack a small percentage of their original length measure 120–240 mm; basal–mesial fragments measure 30–210 mm (Fig. 4A; 6; 7). By and large, 150–250 mm can be considered a typical point length, which compares well

Table 4 Morphologies of projectile points ($N=44$)

	Sub-rectangular cross section	Sub-triangular cross section	Oval cross Section	Half-round cross section	Cross section unknown	Longi-tudinal grooving
Single-bevelled base ($N=21$)	6	6	-	-	9	-
Double-bevelled base ($N=5$)	4	-	1	-		5
Base morphology unknown ($N=18$)	11	2	-	1	4	5

to the assemblage from Garenne (Chauvière, 2016, fig. 11.5; Chauvière & Rigaud, 2008, graph. 2). According to some mesial and mesial–distal fragments measuring 200–400 mm, typically manufactured from ivory (Figs. 8 and 9), considerably longer points were made, too.

The majority of points have a mesial width of 8–13 mm and a mesial thickness of 8–11 mm (Fig. 5A). This is within the typical range of Magdalenian points (Chauvière & Rigaud, 2008; Langley, 2015; Pétillon, 2006; 2016; Pétillon et al., 2011; Pfeifer, 2016, 2021; Stodiek, 1993). Few rather tiny specimens, one of which made of ivory (Inv.nr 92–3; Fig. 6: 5), could relate to sub-adult users (Pfeifer, 2012, 2016 and references therein). The longer the point, the sturdier it tends to be, with an ivory point with a mesial cross section of 24 × 22 mm (Inv.nr 94–1) at the upper end of the spectrum.

Bases are 25–61 mm long and 8–20 mm wide, with the double-bevelled specimens being both markedly shorter and wider than the single-bevelled ones (Fig. 5B). Short and wide double-bevelled bases are also typical of the double-bevelled projectile points from Grappin (Malgarini, 2014, Fig. 140).

Combining the morphological and metric data, the projectile points from Maszycka can be attributed to three distinct and mutually exclusive variants:

Type A: Un-grooved, single-bevelled antler and ivory points with a long concave base and sub-rectangular or sub-triangular cross section (Fig. 6).
Type B: Grooved, double-bevelled antler points with a short base and sub-rectangular or, rarely, oval cross section (Fig. 7).
Type C: Un-grooved, large ivory points with a sub-rectangular cross section and unknown base geometry (Figs. 8 and 9).

Points with single-bevelled bases and varying cross sections are the most common osseous projectiles of the early Middle Magdalenian (Angevin, 2017; Chauvière, 2016; Guy Straus & González Morales, 2020; Malgarini, 2014; Pétillon, 2016), and apart from Maszycka are also attested in the *navette*-bearing assemblages of Roc-de-Marcamps (Pétillon, 2016), Garenne (Chauvière & Rigaud, 2008), and Grappin (Malgarini, 2014). Judging by the currently published data, type A points appear to be specific to Maszycka, however, at least one example of that morphology is also attested at Grappin (Malgarini, 2014, fig. 146.1). Type B points, on the other hand, are an index fossil of

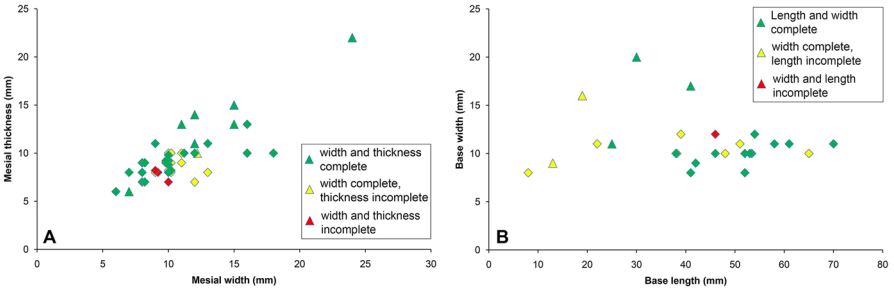

Fig. 5 Metric data of projectile points and the pre-form. **A**: Mesial width and thickness. Diamond: antler, triangle: ivory. $N=45$. **B**: Base length and width. Diamond: single bevel, triangle: double bevel. $N=25$

the *navettes* facies (Allain et al., 1985; Maier et al., 2020; Sécher, 2020), are frequently reported from Roc-de-Marcamps (Pétillon, 2016), Garenne (Allain et al., 1985), and Grappin (Malgarini, 2014). A decorated type C ivory point, measuring over 400 mm

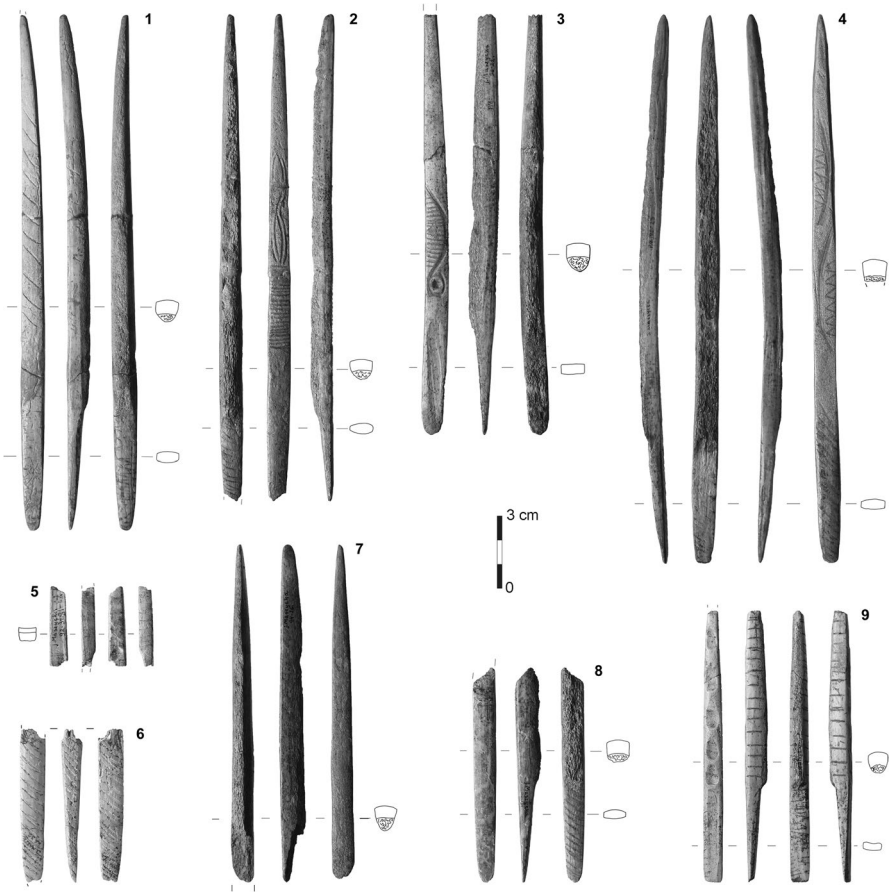

Fig. 6 Un-grooved, single-bevelled projectile points of antler (1–4.7–9) and ivory (5.6). 1–5.7–9: Archaeological Museum Cracow, 6: University of Warsaw

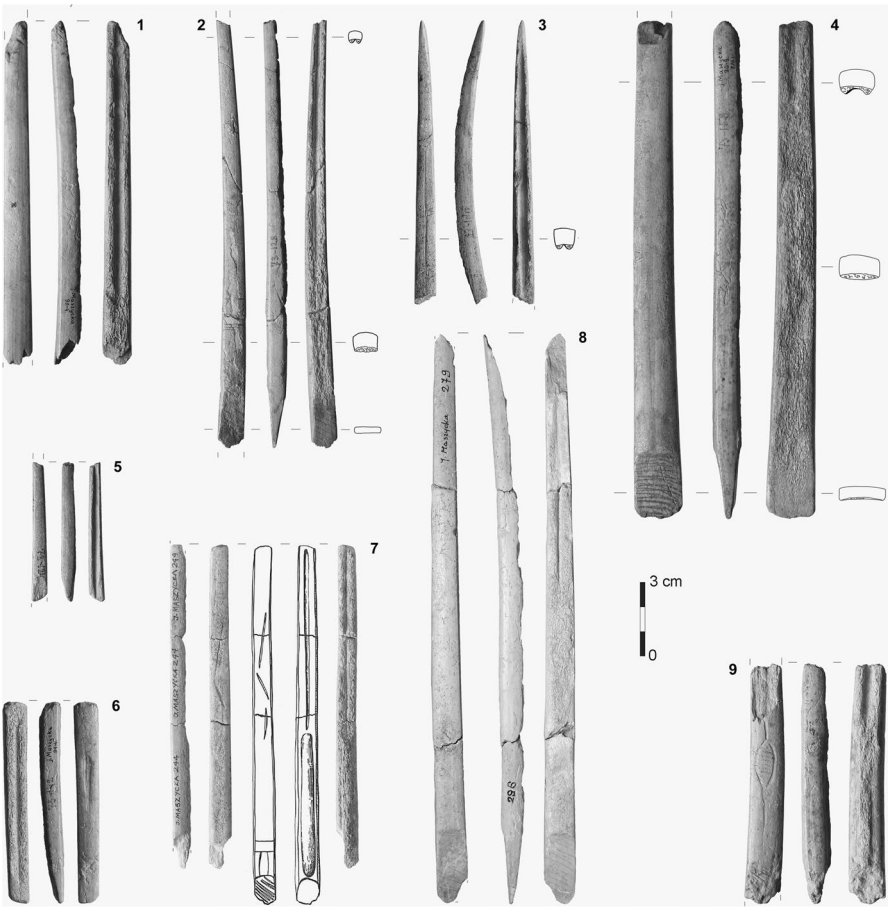

Fig. 7 Grooved, double-bevelled projectile points. Nr 7 was sampled for.^{14}C dating in 2009. 1–6.9: Archaeological Museum Cracow, 7: University of Warsaw, 8: State Archaeological Museum Warsaw

in length, as well as three distal fragments are known from La Croze rock shelter in the French Jura (Malgarini, 2014, Fig. 155.1–4), which is also assigned to the early Middle Magdalenian but not to the *navettes* facies (Malgarini et al., 2017). Another distal fragment of a rather large ivory point is reported from Grappin (Malgarini, 2014, Fig. 155.5).

Longitudinal grooves probably assisted the hafting of lithic cutting insets, typically backed bladelets (Bosinski, 2009; Gauvrit Roux et al., 2020; Houmard, 2003; Pétillon et al., 2011; Wood & Fitzhugh, 2018). Type B can thus probably be reconstructed as a composite point with a single row of backed bladelets on its lower side. Whether the ungrooved type A and C points had lithic insets or not is a challenging question. Composite projectile points do not require grooves. In the Upper Magdalenian, grooved points become rare (Pétillon, 2016; Pfeifer, 2016, 2021), and yet backed bladelets are ubiquitous in Upper Magdalenian lithic assemblages (Maier, 2015). At Maszycka, however,

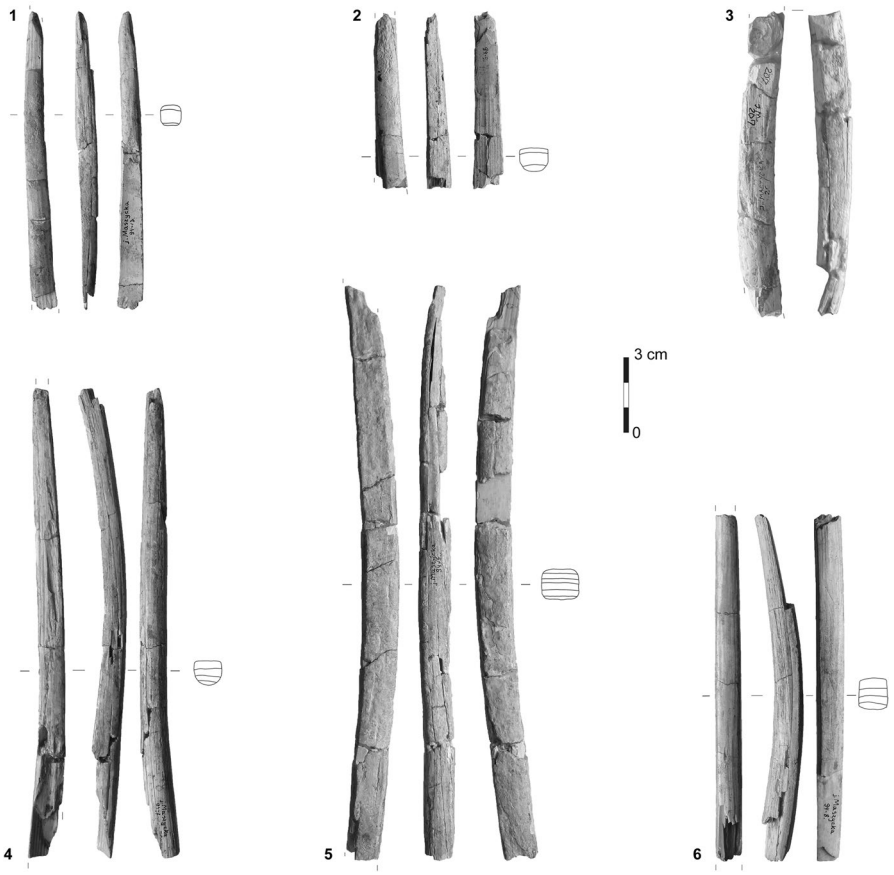

Fig. 8 Mammoth ivory projectile points with unknown base morphology. 1.2.4–6: Archaeological Museum Cracow; 3: State Archaeological Museum Warsaw

the number of backed bladelets is remarkably low, even after the screening of the backdirt (Kozłowski et al., 2017, Fig. 12), which speaks for an initially low number of tools equipped with these disposable elements. Big organic points without lithic insets can be effective hunting weapons, especially when married to heavy main shafts (Milks, 2020; Nikolskiy & Pitulko, 2013), but even smaller specimens can inflict deep puncture wounds on large mammals (Pétillon, 2006; Stodiek, 1993; Wood & Fitzhugh, 2018). Without being able to conclude on that matter, it can be assumed that both composite and plain points of various calibres were present in the hunting equipment of the Maszycka occupants.

Decoration

With 28 of 44 pieces carrying elaborate decoration (Fig. 10), Maszycka has by far the highest proportion of decorated osseous projectile points in central Europe

Fig. 9 Mesial fragment of a particularly big ivory projectile point with use-related bevelled breaks at both ends. Archaeological Museum Cracow

(Pfeifer, 2021) and also 'outshines' the western European assemblages assigned to the Magdalenian à *navettes*, which in and of itself is a taxonomic unit particularly rich in ornaments (comp. Allain et al., 1985; Malgarini, 2014; Sécher, 2020).

Main techniques are incising and carving, which are often used in combination. In regards to composition and execution, the motives from Maszycka display a high degree of individuality (Svoboda, 1976). Nevertheless, three recurrent themes can be observed: (a) incised rows of pointed ovates, often filled with bundles of parallel lines (Fig. 10: 1.2.7.10–12.14.15); (b) carved elongated ledges (Fig. 10: 15); and (c) carved-out depressions which are also referred to as *cupules* (Fig. 10: 3.6.13). These three themes find numerous parallels in western European *navette*-bearing assemblages (Allain et al., 1985; Fuentes et al., 2017; Malgarini, 2014) as well as at some central European sites that may have hosted contemporaneous occupations (Maier et al., 2020; Pfeifer, 2020). A remarkable parallel to a rather complex ornament on a single-bevelled point, composed of two triangles, which are

Fig. 10 Details of ornamented projectile points. Note that differential lighting may cause chromatic misinterpretations. 1: University of Warsaw, 2–15: Archaeological Museum Cracow

filled with hatched lines and connected by a central line (Fig. 10: 4) is found on a double-bevelled point from Garenne (Allain et al., 1985, Fig. 37.7). The motif of angles connected by a line reappears at Roc-de-Marcamps (Fuentes et al., 2017, figs. 8; 13) and Chaffaud (Allain et al., 1985, Fig. 72), where it is sometimes combined with two cupules to resemble a schematised human face with eyes, nose, and mouth. Rows of pointed ovates are such a widespread theme within the *navettes* facies (Svoboda, 1976) that a commonly shared symbolic meaning is very likely. Allain et al. (1985, 96 f.) propose an interpretation as stylised fish, which is also favoured by Marshack (Kozłowski et al., 1993, 210 ff.), as it agrees well with the proposed interpretation of the also very frequent wave and zigzag motifs as flowing water/stream. The strongly preferred orientation of central European Magdalenian settlement activities along first and second order rivers (Maier, 2015) supports such a reading.

Function and Use-Related Fractures

Magdalenian un-barbed osseous points are universally regarded as heads of delivered projectiles (Langley et al., 2016; Pétillon, 2006; 2016; Pétillon et al., 2011; Pfeifer, 2016; Stodiek, 1993). With basal widths of 8–20 mm, corresponding to the distal diameters of the wooden spear shafts, the Maszycka points are in the size range of throwing spears from ethnographic and archaeological contexts (e.g., Allen & Akermann, 2015; Cattelain, 1997; Clarkson, 2016; Hare et al., 2004, 2012; Helwig et al., 2021; Pettigrew, 2015), as well as of successful experimental replicas (e.g., Coppe et al., 2019; Gauvrit Roux et al., 2020; Pétillon, 2006; Pétillon et al., 2011; Pettigrew, 2015; Stodiek, 1993) used with spearthrowers. Spearthrower hooks made of antler are rare but regular finds in western European assemblages (Stodiek, 1993). Type 2 hooks reported from Roc-de-Marcamps, Garenne, and Placard testify to the knowledge of this technology within the *navettes* facies (Cattelain, 2017). Outside western Europe, however, spearthrower hooks strongly decrease in frequency, and the only isolated, likely late Middle/early Upper Magdalenian, specimen east of the Rhine is reported from Teufelsbrücke cave site in central Germany (Feustel, 1980; Maier et al., 2020). It is therefore assumed that spearthrowers were also used in central Europe, but were made without separate osseous hooks (Stodiek, 1993, 155).

One particularly large type C ivory point with a mesial cross section of 24×22 mm is a clear outlier (Fig. 5A; 9). Only in rare cases has it been reported from ethnographic records that such large projectiles were used in conjunction with spearthrowers to hunt terrestrial prey (Cattelain, 1997; Clarkson, 2016; Frison, 1989). This point therefore probably belonged either to a heavy spear thrown unassisted by hand (cf. Milks, 2020 for ethnographic examples) or it was part of a thrusting lance.

Owing to the good surface preservation, it is possible to recognise typical use-related macro fracture patterns (Pétillon et al., 2016) (Fig. 11). With a considerable proportion of use-damaged pieces, with fractures occurring on both small and large cross-sections (Fig. 11A), the assemblage from Maszycka is consistent with observations made elsewhere on Magdalenian osseous projectile points (Langley,

2015; Pétillon et al., 2016; Pfeifer, 2016). Two main categories can be distinguished: bevelled breaks with oblique or serrated fracture planes of varying angles ($N=18$) (Fig. 11B: 1.4–8), and crushing of the very tip section ($N=2$) (Fig. 11B: 2.3). Frequently, a point displays several fractures. The mesial section is most often affected by fractures, followed by the distal one. Only in one instance, the base was fractured.

Since low temperatures are rather unlikely to increase fracturing of antler points (Adams & Andrefsky, 2019), the observed damage pattern on points probably results from missed shots into frozen soil or gravel, as well as from the stress imposed by hitting large, moving mammals with heavy, oscillating projectiles (Pétillon et al., 2016). According to the faunal assemblage, not only horse, reindeer, and saiga were targeted but possibly also bovids and woolly rhino. The long, thick, and heavy ivory points appear to be particularly suited for that task. A replica of a single-bevelled ivory point from LUP Gönnersdorf site (Pfeifer, 2021: Gönnersdorf) made by the author from high-quality permafrost mammoth ivory is 310 mm long, 13 mm thick, and weighs 70 g without its lithic insets (Fig. 12). This corresponds to the total weight of some ethnographic darts (cf. Allen & Akerman, 2015).

The particularly big ivory point from Maszycka, possibly a lance head, features catastrophic bevelled breaks at both ends (Fig. 9). Of all prehistoric projectiles, thrusting lances applied with a jumping gesture, with the whole body weight put behind, deliver by far the highest kinetic energy into the target (Coppe et al., 2019), and thus breaking of even such large cross sections appears possible. Sometimes, the fracturing of antler and ivory projectile points upon impact produces small triangular fracture wedges (Pétillon, 2006, Fig. 94; Pfeifer, 2016, Fig. 80.7), two examples of which are also present in the Maszycka assemblage (Table 3; Fig. 2: 9.10).

There is no evidence of repair of damaged points, which is in sharp contrast to the high frequencies of point rejuvenation in other Middle to Upper Magdalenian assemblages, both from central and western Europe (Langley, 2015; Pétillon, 2006; Pfeifer, 2016, 2021). In one instance, a decorated, grooved point was recycled into a small wedge (Inv.nr 94–4; Fig. 7: 6), which, again, has parallels at Garenne and Grappin (Allain et al., 1985, Fig. 39; Malgarini, 2014, Fig. 144; 150; 152).

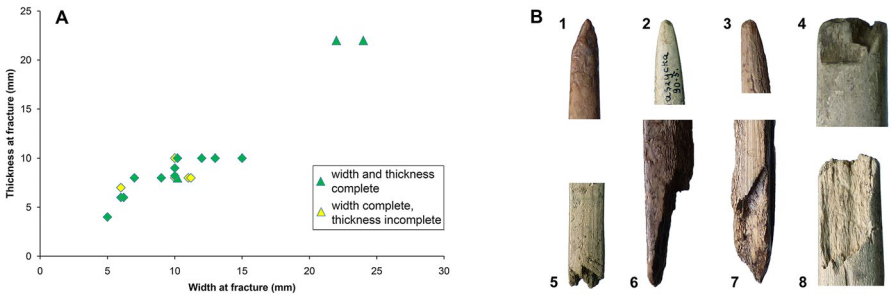

Fig. 11 Use-related fractures of projectile points. **A** Width and thickness at fracture. Diamond: antler, triangle: ivory. $N=19$. **B** Details of fracture morphologies (1.4–8: bevelled breaks; 2.3: crushing of the tip). The lower ends are oriented towards the base of the point. Note that differential lighting may cause chromatic misinterpretations

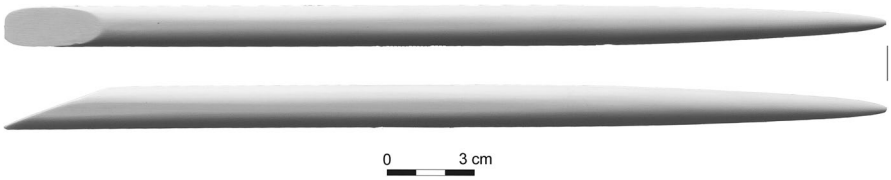

Fig. 12 Replica of a single-bevelled, un-grooved mammoth ivory projectile point from Gönnersdorf (D)

Navettes

Maszycka yielded fragments of six finished *navettes* (Fig. 13: 1.3–5.7.8), one semi-finished piece (Fig. 13: 9), one mesial fragment of a finished or semi-finished *navette* (Fig. 13: 2), and one languet (Fig. 13: 6) (Supplementary Information S2).

All *navettes* were manufactured from small transversal segments of antler (*en volume*), obtained either from a small main beam like one of the raw material blocks (Fig. 2: 1) or from brow/bez tines. The surfaces and diameters of the segments were first regularised by invasive longitudinal scraping. Subsequently, opposing incisions were cut into either end and then enlarged by longitudinal grooving to create deep, v-shaped slots, and languets with half-round cross sections (comp. Malgarini, 2014, Fig. 171). The surfaces of the *navettes* are frequently polished. One specimen bears a decoration consisting of a pointed ovate filled with a *cupule* (Fig. 13: 8), another one is decorated with a group of v-shaped incisions (Fig. 13: 5), and a third one features a short incised line (Fig. 13: 4). One of the decorated pieces also bears incised parallel hafting striations on one slotted end akin to the projectile points (Fig. 13: 5).

Similar *navettes*, semi-finished objects and single languets, many of which bear hafting striations, are known from contemporary French assemblages, with the highest number at Garenne with around 70 fragments (Allain et al., 1985; Chauvière et al., 2017; Malgarini, 2014). *Navettes* are commonly regarded as hafting devices with an emphasis on lithic tools (Allain et al., 1985). An alternative interpretation as foreshafts, to connect projectile points with double-bevelled bases, with which they are typically associated, to the wooden main shaft (Chauvière, 2016, 162; Kozłowski et al., 1993, 161) is less favoured due to the narrowness of the notches. Since such antler languets are flexible to a certain degree and not all notches are that narrow, some *navettes* seem suitable to accommodate a double-bevelled base. In any case, frequent use-related breaks of the languets account for a rather robust mechanical function of these tools (Allain et al., 1985, Fig. 13).

Smoothers

Smoothers, or *lissoirs*, are represented by five fragmented specimens, all of which are made from large mammal ribs (Fig. 14: 11–14) (Supplementary Information S3). One big piece is made from a transversal segment of bovid or rhino size, with the spongiosa completely enclosed (Fig. 15). The others are made from halved ribs with a compact, rounded upper side and a spongy, flat lower side. In all cases, the surfaces are highly polished from manufacture or use. Two smoothers are decorated.

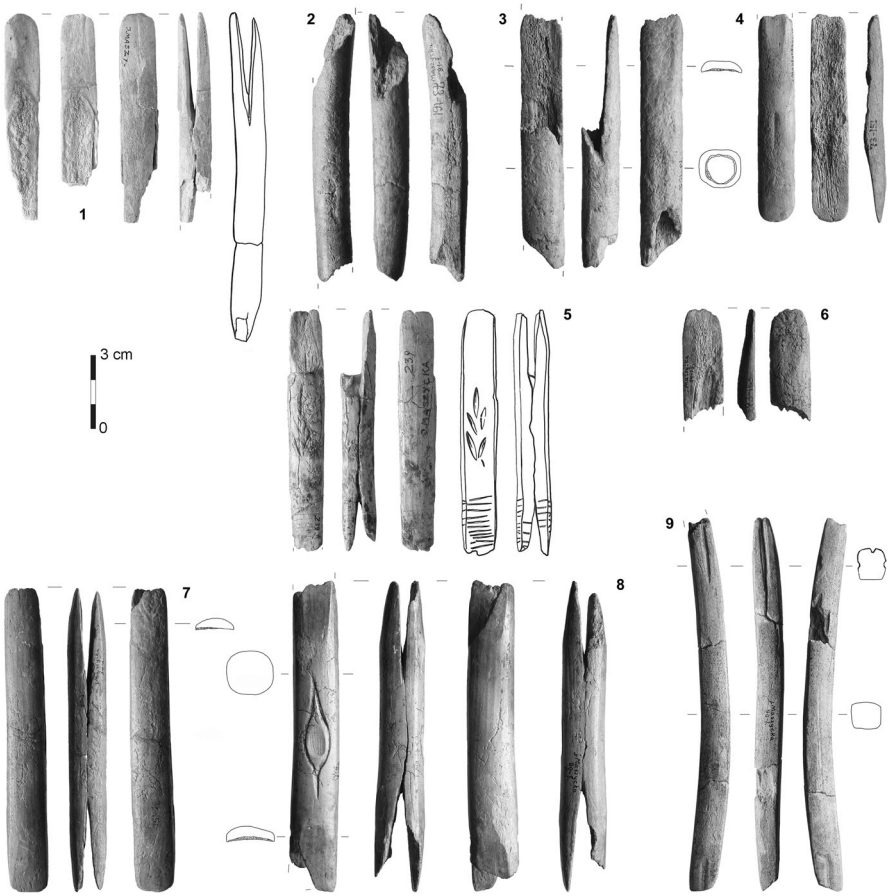

Fig. 13 Navettes. Black-and-white drawings of 1 and 5 from Kozłowski et al., 1993. Nr 1 was sampled for.^{14}C dating in 2009. 1.5: University of Warsaw, 2–4.6–9: Archaeological Museum Cracow

The first piece bears groups of short, incised lines and zigzag patterns on the edges of both upper and lower sides, as well as shallow curved lines of no identifiable pattern (Fig. 14: 11). The second piece bears groups of short, incised lines on the edges of its upper side (Fig. 14: 14). A series of morphologically similar smoothers made from halved ribs is known from Grappin (Malgarini, 2014, Fig. 174).

Awls

Maszycka furnished three awls (Supplementary Information S3). The largest piece is made on a blank, obtained from a long bone by using the GST (Fig. 14: 10). Two other pieces are made from small bone splinters (Fig. 14: 5.6). The points of the awls are highly polished, presumably from use. Awls are also present at Middle Magdalenian sites in eastern France (Malgarini, 2014, Fig. 176).

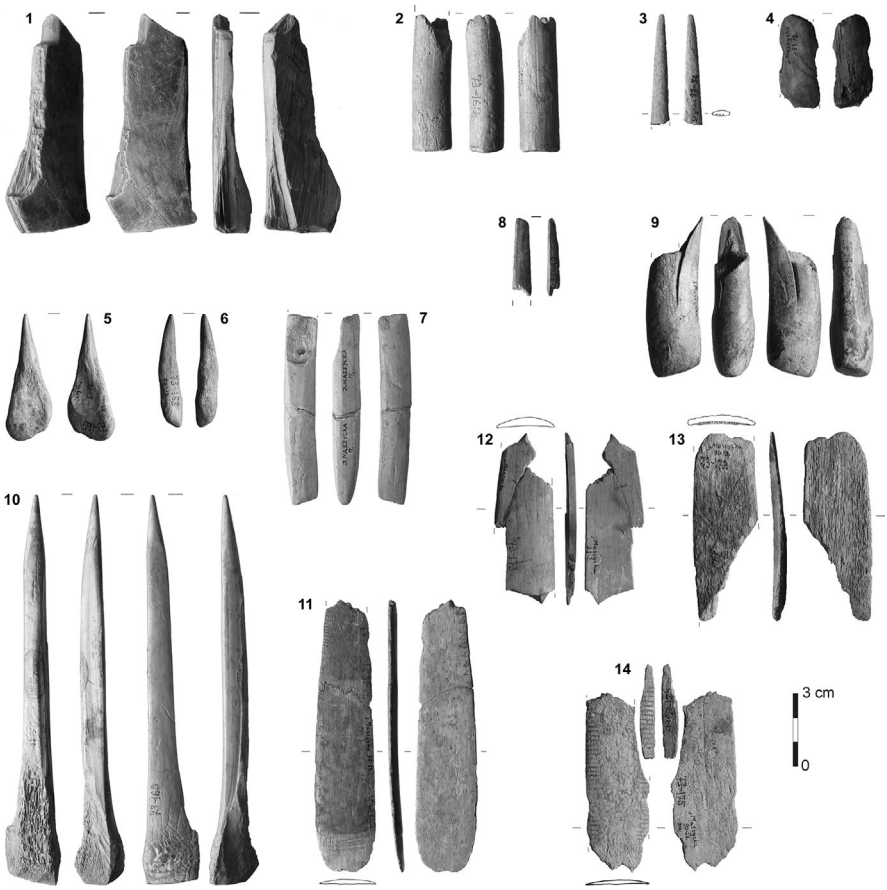

Fig. 14 Smoothers (11–14), awls (5.6.10), wedge (7), and unspecified tools (1–4.8.9). Nr 7 was sampled for.^{14}C dating in 2009. 1–6.8–14: Archaeological Museum Cracow, 7: State Archaeological Museum Warsaw

Wedge

The small wedge was made from a transversal antler segment and is 80 mm long (Fig. 14.7) (Supplementary Information S3). Its proximal section ends in a short, convex double bevel, and the distal section is missing. A short line is incised on its upper side. This artefact was sampled by drilling in 2009 but did not yield enough collagen for AMS dating (Kozłowski et al., 2012). Owing to two small associated fragments, which do not directly fit onto the large fragment, this piece was previously interpreted as *navette* (Allain et al., 1985, 91; Kozłowski et al., 1993, 155). The small fragments, however, do not feature the typical morphology and working traces of *navette* languets, and when paired do not give a slotted morphology. Similar double-bevelled wedges made from transversal antler segments are also reported from Garenne (Allain et al., 1985, Fig. 39).

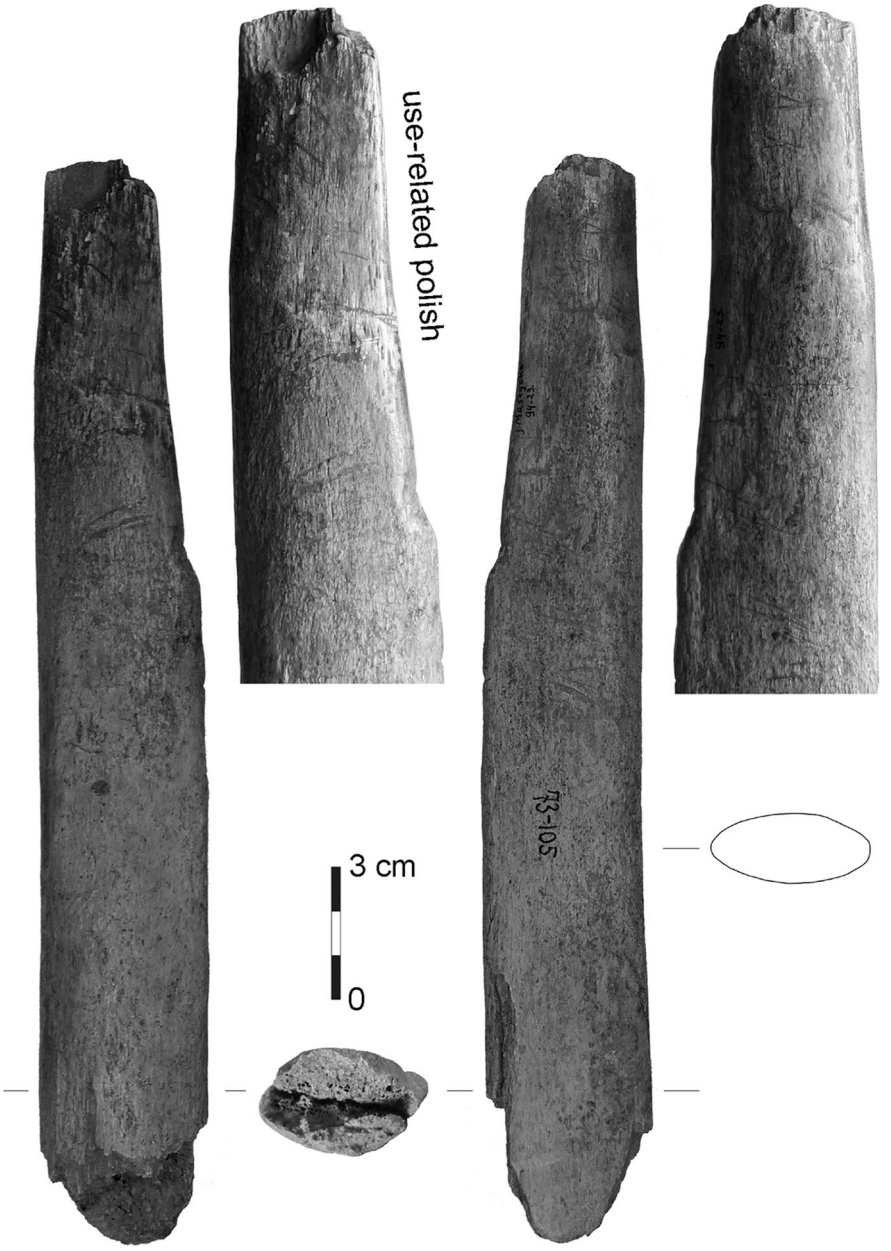

Fig. 15 Smoother on transversal segment of megaherbivore rib. Archaeological Museum Cracow

Slotted rib

The slotted rib, which was recovered during Kozłowski's excavations, has attracted some attention (Kozłowski et al., 1993, 2012, 2017; Maier et al., 2020). It is made

from the rib of a megaherbivore, probably bovide, and is 422 mm long, 35 mm wide, and 17 mm thick (Fig. 16) (Supplementary Information S3). One end is sediment-fractured; the other one features a bevelled break in fresh condition, giving it the shape of a dull point. The rib bears deep longitudinal slots on both laterals, which according to clearly visible striae were established by longitudinal movement of the cutting tool. As the bevelled break superimposes the slots, the artefact was originally longer.

The slotted rib bears a complex incised geometric decoration, composed of interrupted bundles of lines, zigzag lines and a curved hatched line on its upper side, and two incised circles on its lower side. A. Marshack, who described both manufacture and composition of the decoration in detail (Kozłowski et al., 1993, 206–212), suggests a 'water-related' connotation of the geometric motif, which corresponds well to one possible reading of symbols on the projectile points (see above). The uniqueness and strictly geometric nature of the decoration on the rib has also fostered speculations about influences of the eastern European Epigravettian (Kozłowski et al., 2017). Although unique as an ensemble, the generic stylistic components and techniques of the ornament, like incised zigzag lines, bundles of lines and hatched lines, are widely known from the early Middle Magdalenian (Allain et al., 1985; Kozłowski et al., 1993, 206–211; Maier et al., 2020; Malgarini, 2014) and therefore need not be sought in the Epigravettian.

Due to the pointed end and the lateral slots, it has been proposed that the artefact functioned as a kind of 'dagger', with cutting lithic insets formerly embedded in the slots (Kozłowski et al., 1993, 2012, 2017). There are three main objections to

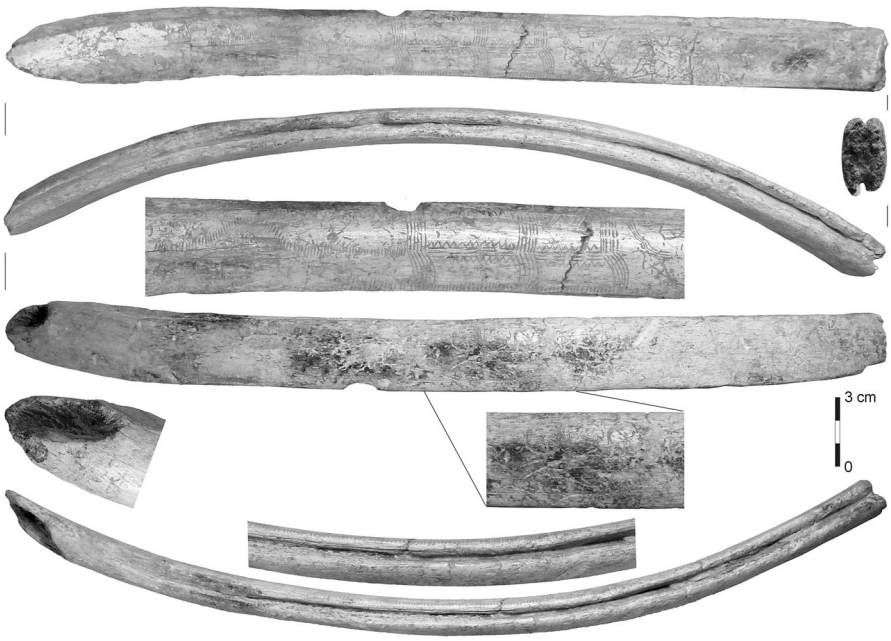

Fig. 16 Double-slotted, decorated rib. State Archaeological Museum Warsaw

that interpretation. First, the dull point on one end is not part of the original design but the result of fracturing after the slotted morphology was established. Second, as the artefact was made from a rib, it is notably curved and therefore ill-suited for energy transmission with a stabbing gesture, be it as a dagger or point. Raw material, dimensions, and the spongious interior make it very unlikely that the rib was ever straightened or intended to be. Third, as suggestive as it seems, there is no evidence that the grooves once housed lithic insets.

Therefore, an alternative interpretation of this conspicuous osseous artefact is proposed: a raw material block for the production of smoothers. The smoothers from Maszycka were all made from large mammal ribs, in three cases halves. To obtain halves from ribs, the use of the GST, which is the single most important method for longitudinal osseous debitage at the site, suggests itself as the nearest approach. In that reading, the juxtaposed grooves on the rib are not housings for lithics but traces of the process of cutting it in halves by controlled longitudinal grooving, a procedure which is also documented at Grappin (Malgarini, 2014, Fig. 174). That work, however, was not finished. The elaborate decoration on the rib may have been added after it was abandoned as a raw material block and used differently. On the other hand, decorations sometimes also appear on pre-forms of points (see above).

Perforated baton

The famous perforated baton from Maszycka was made from the left antler of an adult reindeer bull (Fig. 17) (Supplementary Information S4). Due to the intense modification, no informed statement on its origin (shed or un-shed) can be made. The compacta thickness at the proximal end is 10 mm which is quite substantial by LUP and recent standards (comp. Pfeifer, 2016). The artefact was manufactured from the basal–proximal section of the main beam and parts of the bez tine. The proximal end bears clear chopping traces of a circular groove, by which the antler was sectioned. The distal end is partially damaged, but the overall length of the baton is nevertheless complete with 288 mm. Its greatest width is 95 mm and its greatest thickness 32 mm. The perforation was initiated from either side, resulting in an hourglass-like profile. The surfaces of the perforation are polished. The piece is now covered by a glossy lacquer. The whole surface is meticulously modified and smoothed, and the ends are accentuated by phallic carvings. As index fossils of the Magdalenian *à navettes*, perforated batons with phallic decorations, sometimes very explicit, are also reported from Laugerie-Basse, Roc-de-Marcamps and Garenne (Allain et al., 1985; Sécher, 2020).

Other tools

Six tools cannot be attributed to common typological categories (Supplementary Information S3): (1) irregular, flat ivory tool obtained by using the GST with rounded and polished edges and multiple cut marks on the upper side (Inv. nr 94–19; Fig. 14: 1), (2) fragment of a transversal segment detached by a narrow

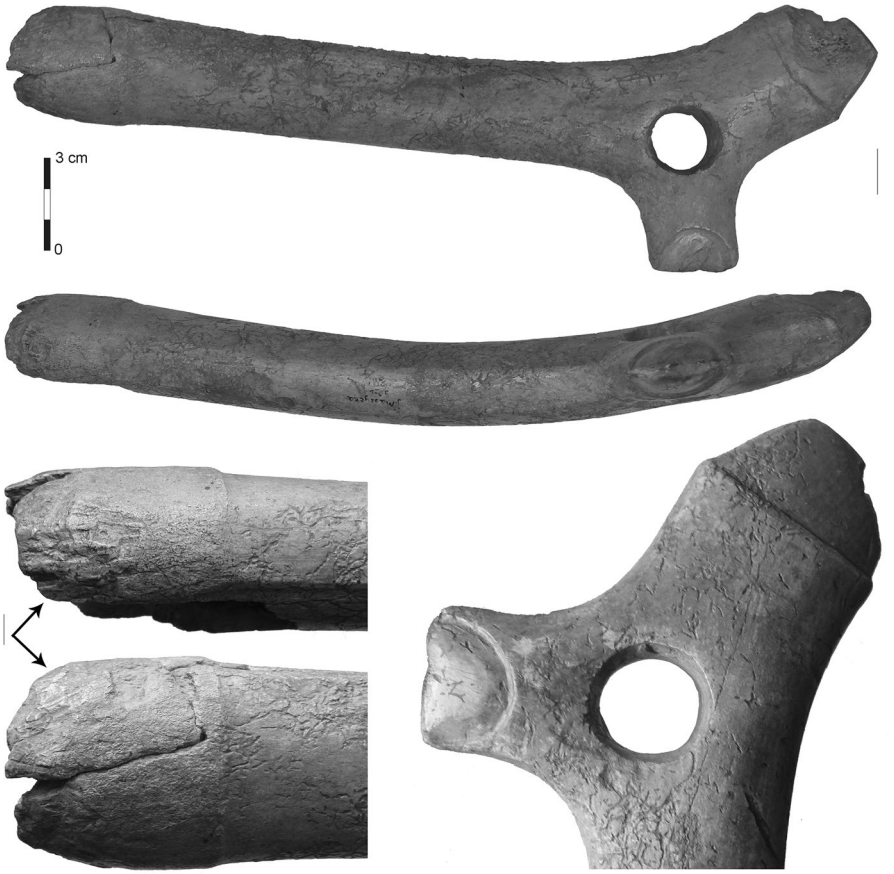

Fig. 17 Phallic perforated baton. Note light root etching and chopped circular groove (arrows). Archaeological Museum Cracow

circular notch with one end polished from use (Inv.nr 94–21; Fig. 14: 2) (3) distal part of a small pointed bone tool (Inv.nr 93–12; Fig. 14: 3), (4) small mesial fragment of a tool made from a transversal rib fragment with smoothed surfaces and multiple cut marks (Inv.nr 93–13; Fig. 14: 4), (5) distal part of an antler tool with rounded tip (Inv.nr 93–8; Fig. 14: 8), (6) antler tool made from a transversal segment with a v-shaped notch obtained by two opposing longitudinal grooves (Inv.nr 93–11; Fig. 14: 9). One languet is sediment-fractured. The manufacturing of the groove and morphology of the preserved languet exactly correspond to the *navettes*, and hence a similar function as hafting device is proposed. The other end is meticulously shaped, smoothed, and polished to a slightly phallic shape which is paralleled by finds from Garenne and Roc-de-Marcamps (Allain et al., 1985, Fig. 29; 38).

Discussion

The analysis of osseous artefacts from Maszycka cave contributes new facets to our present knowledge of human activities in eastern central Europe immediately after the LGM. First, the archaeostratigraphic position of the assemblage can be further specified; second, the palethnography of the site can be reconstructed and discussed in more detail; and third, the current models for the recolonisation of the region by LUP hunter-gatherers can be supplemented by that new information.

Archaeostratigraphic Classification of the Assemblage

As previously suggested on typological grounds and backed up by radiometric age determinations, the osseous assemblage from Maszycka, containing projectile points, *navettes*, smoothers, awls, a wedge, a needle blank, and a perforated baton, is clearly attributable to the Magdalenian. The technological analysis, which attests transversal sectioning of antler beams by chopped notches and blank production exclusively by the GST, further corroborates that notion. Obvious parallels to the reference sites in France, which are particularly striking in the recently presented osseous industry of Grappin in the French Jura (Malgarini, 2014), support the earlier assignment of Maszycka to the early Middle Magdalenian *navettes* facies as defined by Allain et al. (1985).

Compared to the western European sites, Maszycka is distinguished, firstly, by the importance of ivory for tool manufacture. Ivory also played a certain role in the western European early Middle Magdalenian, especially in the French Jura (Malgarini et al., 2017), but it was used to a much lesser extent. Unlike in western Europe (Gaudzinski et al., 2005), mammoth ivory remained relatively abundant in eastern central Europe throughout GS-2 (Pasda & Pfeifer, 2019; Pfeifer et al., 2019) and was still frequently used as raw material in the territory of Poland in the Upper Magdalenian (Boroń, 2010). The second particularity of Maszycka is the dominance of ungrooved, single-bevelled points with rectangular and triangular cross sections (type A, see above). Apart from a single specimen at Grappin, this morphology seems not to be present in other *navettes*-bearing assemblages in the west. However, as Allain et al. (1985) and Sécher (2020) point out, the Magdalenian *à navettes* is not a homogeneous entity but, apart from a set of commonly shared characteristics (*navettes*, phallic representations, *cupules* ornaments, grooved double-bevelled type B points), features a certain degree of variation within the single assemblages assigned to it. For example, a high percentage of projectile points from Garenne have a circular cross section (Chauvière & Rigaud, 2008; Chauvière et al., 2017; Houmard, 2003), which is rare at Roc-de-Marcamps (Allain et al., 1985, Fig. 26; 27; Pétillon, 2016, Fig. 4) and unknown at both Maszycka and Grappin (Malgarini, 2014, 264). Roc-de-Marcamps, in return, stands out for a series of sculpted human heads (Allain et al., 1985, Fig. 28), which otherwise are absent, except for one specimen reported from Laugerie-Basse (ibid., Fig. 19.2). At Maszycka, the often-stressed "originality of artistic concepts" in *navette*-bearing assemblages (Allain et al., 1985, 95) is reflected by unique decorations on many points and on the slotted rib. From a

typo-technological and stylistic point of view, the osseous assemblage of Maszycka does not provide any evidence for Epigravettian influence, but instead reveals strong connections to the contemporaneous western European early Middle Magdalenian.

Palethnography of Maszycka cave

Previously described activities of LUP humans at Maszycka comprise the production and maintenance of lithic and osseous tools; the preparation and consumption of hunted animals, predominantly reindeer, horse, and saiga; and the use of mineral pigments and the processing and deposition of human remains, whose number and age composition suggest that the site was repeatedly visited by a reproductive group of hunter-gatherers (Kozłowski et al., 1993, 2012, 2017; Orschiedt et al., 2017).

Based on the analysis of the osseous industry, it can be stated that the majority of tools were not produced on-site but imported, either as semi-finished or, predominantly, finished products. This observation, which was already noted by Kozłowski et al., (1993, 161), is in marked contrast to other Magdalenian sites, like Grappin (Malgarini, 2014), Isturitz (Pétillon, 2006), La Madelaine and Laugerie-Basse (Bräem, 2008), or Petersfels cave (Pfeifer, 2016), where complete on-site operation chains for the production of all present osseous tool types can be reconstructed from multiple raw material blocks, pre-forms, waste pieces, and finished objects.

The most numerous tool type at Maszycka are projectile points, which mirrors the high demand of those armatures, resulting from the way they were deployed (comp. Pétillon et al., 2011). With a minimal number of 33 individual pieces, the inventory is big enough to equip several hunters. There are only two antler raw material blocks, none of which bears traces of blank removal, and thus on-site production of blanks for projectile points can be ruled out. According to the few prepared blanks and the single pre-form, some projectile points were made on-site, but the majority were definitely brought in. Two kinds of point were used: average sized antler and ivory specimens as parts of delivered darts of various calibres, and a particularly big ivory point, which probably was tipping a thrusting lance. Single outliers of particularly large osseous projectile points are present in several Magdalenian assemblages from central Europe, for example Kesslerloch (CH), Petersfels (D), Kniegrotte (D) and Pekárna (CZ) (Pfeifer, 2021), and thus it seems that lances were a regular part of LUP hunting equipment, either as secondary weapons for dispatching wounded animals or primary weapons for hunting megaherbivores such like bovids and rhino, the bones of which were recovered at Maszycka. On the other end of the metric spectrum, some small but delicately made points might have been used by subadult hunters, whose presence is attested in the human remains. Multiple typical fractures account for the use of projectile points during hunting activities, but in contrast to many other sites, they were not rejuvenated. That at least some curation of hunting weapons took place is evidenced by the presence of a few lithic backed bladelets. The deposition of complete or easily repairable osseous projectile points at Maszycka, apparently close to each other in the entrance area (Kozłowski et al., 1993, 166), has parallels at other Magdalenian cave sites (e.g., Chauvière & Rigaud, 2009; Pfeifer, 2016; Stodiek, 1993, 169) and possibly means that caches of armatures were

created at repeatedly visited sites (comp. Fienup-Riordan, 2007, 137). Carnivore gnawing on two points shows that those were temporarily accessible. The deposition of a big perforated baton, likely a straightening tool, is possibly connected to that, since long and slender osseous points tend to warp quickly and have to be periodically realigned.

Concerning the few tools relating to rather 'domestic' activities, like *navettes*, smoothers, awls, wedges and needles, there is evidence that entire production sequences were carried out on site. The smaller one of the raw material blocks sectioned by a circular groove (Fig. 2: 1) has the right dimensions for *navette* manufacture, and there is also one *navette* pre-form (Fig. 13: 9). Large mammal ribs suited for smoothers are present in the faunal assemblage, and if the interpretation of the slotted rib proposed here is followed (Fig. 16), were used. The wedge (Fig. 14: 7) is made from a small transversal antler segment similar to the *navettes*, and in another case, a fractured projectile point was re-used in such a way (Fig. 7: 6). The needle blank suggests that bone needles were produced, too (Fig. 2: 5). Their absence in the osseous inventory is possibly owing to Ossowski's excavation technique as well as to unfavourable preservation conditions at the front area and in the backdirt.

The extraordinary richness of Maszycka in decorated osseous artefacts (40.4%), especially projectile points (63.6%), requires further discussion. Decorating hunting armatures is a widespread phenomenon among archaeological and historic hunter-gatherer societies. As means of symbolic communication, ornaments on projectiles can on the one hand serve to evoke supernatural powers in favour of the user, with an emphasis on hunting success (e.g. Bohr, 2014), and on the other hand function as signals of group membership (Lucas, 2021; Pfeifer, 2017). Based on ethnographic fieldwork among late twentieth century Kalahari San archers, Wiessner (1983) introduced the concept of "assertive style" to characterise "formal variation in material culture which is personally based and which carries information supporting individual identity, by separating persons from similar others as well as by giving personal translations of membership in various groups" (ibid., 258; 271). When implemented at Maszycka, that model says that apart from a common set of symbols, such as *cupules* and pointed ovates, which all *navette*-using groups certainly recognised and understood, and which set them apart from other contemporary traditions of the early Middle Magdalenian (Angevin, 2017; Gauvrit Roux, 2022; Sécher, 2020), the more unique motives served as signals of individuals within their own distinct group. Not only did the Magdalenian hunter-gatherers at Maszycka belong to the first humans who reappeared in the northern mid-latitudes of eastern central Europe after more than three millennia of likely hiatus (Lengyel et al., 2021; Maier et al., 2021; Nerudová & Neruda, 2015; Połtowicz-Bobak & Bobak, 2020), these people were also roaming on the eastern border of the territory occupied by bearers of that techno-complex, which may at the same time have been the western margin of the Epigravettian sphere (Kozłowski et al., 2017; Nerudová & Neruda, 2014; Połtowicz-Bobak, 2020; Wiśniewski et al., 2017), contacts to which are shown by the presence of Volhynian flint originating from outcrops some 300 km to the east (Kozłowski et al., 1993, 179; 2017, 197). Under such particular circumstances, both success in hunting as well as group cohesion were certainly particularly important and endorsed through intensified symbolic communication using a common set of

signs (comp. Fuentes et al., 2017; Kohler et al., 2004; Lucas, 2021). The deposited, perhaps buried, human remains at Maszycka may be interpreted accordingly as a territorial marker and social reference point for the small group.

At Maszycka, a highly diverse spectrum of activities can be reconstructed. During repeated visits within a relatively short period of time, families consumed large animals, produced and curated a few hunting weapons and domestic tools, deposited many of them, used mineral pigments, and processed and laid down their dead. Against that background, the small cave site neither fits the criteria of a residential site/base camp sensu Binford (1980; comp. Kozłowski et al., 1993, 185, 196) nor of a dedicated hunting camp particularly well and hence shows the limitations of that classic dichotomic model for explaining the variability of Magdalenian settlement activities (Bosinski, 1975; Richter, 2018; Weniger, 1982). As Maszycka is to date a singular site, no further statements on its place within early Middle Magdalenian land use patterns in eastern central Europe can be made. It corresponds, however, quite well to the *camp-to-killsite* model by D. Leesch and W. Müller (Leesch et al., 2019, 122; Müller 2006), in which a successful hunting event by a small and highly mobile group of hunter-gatherers is regarded as the basis for all activities tangible in the archaeological record (Pasda & Weiß, 2020).

Maszycka Cave and the Recolonisation of Eastern Central Europe

In southern Poland, evidence of human occupation during the LGM is so patchy (Połtowicz-Bobak & Bobak, 2020) that even a total depopulation of that region between 24 and 19 ka cal. BP is argued for, owing to extremely unfavourable climatic and environmental conditions (Lengyel et al., 2021). Moravia and Lower Austria, on the other hand, provide a sound archaeological record for the first half of the LGM, but only sparse and ambiguous data for the second (Händel et al., 2020; Nerudová & Neruda, 2015; Nerudová et al., 2021; Škrdla et al., 2021). The northern mid-latitudes of eastern central Europe therefore lack reliable evidence of human occupation between 22 and 19 ka cal. BP (Maier et al., 2020, 2021). The only region continuously populated throughout the LGM was apparently the Carpathian Basin (Lengyel et al., 2021).

After the end of the LGM, the archaeological record resumes. Besides Maszycka cave, the open-air sites of Targowisko 10 (PL) and Brno-Štýřice III (CZ) produced series of AMS dates between 19–18 ka cal. BP and thus are partially contemporary with Maszycka (Nerudová & Neruda, 2014; Wilczyński, 2009). The age of the small assemblage from Velké Pavlovice (CZ), containing a cut-marked mammoth tusk fragment, is possibly 18–17 ka cal. BP according to a single AMS date with a large standard deviation (Svoboda et al., 2020). The archaeo-stratigraphic interpretation of these sites is not unambiguous (see Maier, 2015, 236 f. for a discussion), most researchers, however, assign them to the Epigravettian (Lengyel et al., 2021; Nerudová & Neruda, 2015; Wiśniewski et al., 2017). This implies that bearers of that techno-complex, perhaps originating from the Carpathian Basin (Lengyel et al., 2021, 23), penetrated into the northern mid-latitudes of eastern central Europe at about the same time when the Magdalenian crossed the Rhine into western central Europe (Pasda, 2017). This

view is in principal accordance with the bidirectional expansion model suggested by Kretschmer (2015, 122) and proposed by Maier (2015), which argues for a roughly simultaneous resettlement of central Europe by LUP populations from western and (south)eastern Europe. However, in this model, the early expansion phases into the western and eastern part of central Europe, respectively, were initially both linked to the Magdalenian (Maier, 2015, 240 f.). In a later work (Maier et al., 2020), we replaced this taxonomic unit by the more neutral concept of artefact associations to make supra-regional comparisons of assemblages more comprehensible, but the Maszycka inventory remains nevertheless equivalent to the Magdalenian *à navettes* (Maier et al., 2020, 411). If therefore Maszycka was a Magdalenian site with south-eastern roots, whose occupants adapted the concept of *navettes* by communication with the western *navette*-bearing groups (Maier, 2017a and b), it should otherwise be expected to display marked regional idiosyncrasies, especially as it dates to the very beginning of the recolonisation process, when interaction between the western and eastern populations had just resumed (Maier et al., 2020, 441).

According to the osseous industry, this is not the case. In contrast, striking, sometimes minute, similarities to western European *navette*-bearing assemblages as to overall type spectrum, technology and ornaments exist. The only particularity of Maszycka are type A projectile points (see above). However, since the morphologies of osseous projectiles in early Middle Magdalenian assemblages are generally quite diverse (Angevin, 2017; Chauvière, 2016; Guy Straus & González Morales, 2020; Malgarini, 2014; Pétillon, 2016), the type A points probably testify to the inherent variability of projectile design within small social units (cf. Eerkens & Lipo, 2005, 326 ff.; Wiessner, 1983).

The discontinuous archaeological record is another problem for the hypothesis of a regional development of the Magdalenian sensu lato in eastern central Europe. The present gap of three millennia between 22 and 19 ka cal. BP implies that contrary to western Europe (Ducasse et al., 2021; Kretschmer, 2015), there were no local traditions rooted in the LGM for the Magdalenian of Maszycka to emerge from.

Current evidence therefore suggests that the occupants of Maszycka originated from western Europe, which supports previous propositions (e.g. Allain et al., 1985; Kozłowski et al., 1993, 2012, 2017; Otte, 2012; Połtowicz-Bobak, 2013; Wiśniewski et al., 2017). Obviously, enough time was spent in eastern central Europe to make use of the local resource mammoth ivory and to bury a substantial fraction of their population. In addition to that, recurrent immigrations may of course have taken place. This might be indicated by the range of ^{14}C dates of 18.6–18 ka cal. BP.

Soon after the end of the LGM, by around 19 ka cal. BP, the northern mid-latitudes of central Europe had become principally habitable for hunter-gatherers (Maier et al., 2020). The large open-air site of Munzingen in the Upper Rhine Plain, which may even be slightly older, was by no means a remote outpost of newcomers but attests an already well-established Magdalenian population with good knowledge of the local resources (Pasda, 2017). Between 19 and 18 ka cal. BP, an oscillation of particularly dry climate facilitated the migration of saiga antelope, which is among the hunted fauna at Maszycka, from eastern to western Europe (Nadachowski et al., 2016). The eastbound expansion(s) of the Magdalenian *à navettes* probably followed that corridor through central Europe (Jöris, 2021), with one route leading through

the southern middle range mountain zone, as evidenced by an artefact made from *Plattensilex* from the Franconian Jura (Kozłowski et al., 1993, 2012, 2017). Several Magdalenian palimpsests, mainly cave sites, within this 'saiga corridor' furnished conspicuous osseous artefacts, which could also relate to the early Middle Magdalenian (Maier et al., 2020). One of them, Kniegrotte cave in eastern Germany, yielding among others a projectile point reminiscent of type A with sub-triangular cross section and *cupules* decoration, suggests another migration route along the northern margin of the middle range mountains (Pfeifer, 2020). A projectile point with carved longitudinal ledges from layer g/h of Pekárna cave (Maier et al., 2020, Fig. 6.18), strongly resembling a piece from Maszycka (Fig. 10: 15), makes it likely that the Moravian Karst, later a focal area of the Magdalenian in eastern central Europe (Valoch, 2001), was visited, too (cf. Nerudová et al., 2019).

A weighty objection to the direct migration of Magdalenian hunter-gatherers from western Europe is that the scenario "that a small group of people separated from their group of origin and travelled 1300 km into an unknown and unpopulated area without leaving any signs of their presence until they arrived in the Polish Jura, where they disappeared shortly after" (Maier, 2017b, 96), is indeed difficult to convey. Three major points may nevertheless be raised in its support. First, the ethnohistorical record on North American Subarctic hunter-gatherers provides evidence of surprisingly high terrestrial mobility of small social units including all ages and genders covering several hundred kilometres in the summer season (Burch, 1991, 2013; Helm, 1993; Hill, 2013, 7 f.; Kendrick et al., 2005). Accordingly, it can be supposed that LUP groups could move comparatively quickly through the open Pleniglacial landscapes of central Europe, leaving few or no traces behind at their stops. In that regard, the Upper Magdalenian open-air site of Dreieich-Götzenhain (D, Federal State of Hesse) is of note, where the majority of lithic raw materials originate from an outcrop some 300 km to the south. In combination with the short-term occupation of the site, this is convincingly interpreted as a direct northbound migration of a small group (Terberger et al., 2013). Second, as pointed out above, the distribution pattern of sites relating to the Magdalenian *à navettes* might be less disrupted than previously thought, and instead small, but fairly diagnostic assemblages between eastern France and eastern Poland indicate stopovers in between. Third, the archaeological record preserved at Maszycka was possibly not the result of a single migration from the west, but accumulated during several occupations during the centuries when the 'saiga corridor' was active. In that view, the temporary disappearance of humans from eastern central Europe after 18 ka cal. BP, if it at all happened (cf. Jöris, 2021; Maier et al., 2020), did not mean a "local extinction" of the Magdalenian population, but rather a retraction of its range pulsation to western Europe.

Conclusions and Perspectives

Maszycka cave is a site clearly attributable to the central European Magdalenian (Maier, 2015), at which typical and elsewhere widely attested human activities circling around the processing of animals and the production and maintenance of

lithic and osseous tools are tangible (cf. Pasda & Weiß, 2020). Remarkable, but not unique, particularities are the numerous human remains and the high percentage of complete, decorated projectile points without any evidence of rejuvenation. Whether there is a causal relationship between these observations, e.g. in the sense of burial goods, has to remain purely hypothetical. A fresh look at the faunal assemblage would probably provide new information on taphonomy, taxa hunted, animal processing, and seasonality and thus allow further statements about the function of the site to be made. On archaeological grounds, it is proposed that the humans responsible of the material record migrated from western Europe. Depending on aDNA preservation, future palaeogenetic analyses on the human remains will likely be able to reveal the origin of the Maszycka inhabitants (cf. Fu et al., 2016; Posth et al., 2016).

Concerning the resettlement of eastern central Europe after the LGM, it can certainly be stated "that the process of recolonization was of complex nature in terms of cultural diversity" (Wiśniewski et al., 2017, 25). Around 19/18 ka cal. BP, the region apparently saw excursions by both the bearers of the Epigravettian and the Magdalenian, which may (Wiśniewski et al., 2017) or may not (Lengyel et al., 2021) have been simultaneous. Contacts of whatever nature of the Maszycka occupants to the Epigravettian sphere, notably in the eastern European Plain and not in the Carpathian Basin, are evidenced by the Volhynian flint artefacts, and it is also during the occupation of Maszycka when the phenomenon of headless anthropomorphic depictions emerges both in the western European Magdalenian and eastern European Epigravettian, which probably owes to direct communication via the 'saiga corridor' (Jöris, 2021). The search for possible interrelations between the Magdalenian and the Epigravettian therefore seems most promising in present-day Ukraine, Romania, Moldova, and western Russia (cf. Chabai et al., 2020; Demidenko, 2020; Gavrilov, 2021; Gulder, 1952; Łanczont et al., 2021; Noiret, 2009).

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s41982-022-00125-9.

Acknowledgements *This contribution is in memory of Prof. Dr Stefan Karol Kozłowski, excavator of Maszycka cave (1938–2022).* The author is grateful to Dr Jacek Górski, (Archaeological Museum Cracow) for his kind permission to study the objects from the Ossowski excavations as well as Prof. Dr Stefan Karol Kozłowski (†), Prof. Dr Karol Szymczak and Dr habil. Bartosz Kontny (University of Warsaw), and Dr Wojciech Brzeziński (State Archaeological Museum Warsaw) for their kind permission to study the objects from the excavations by S. K. Kozłowski. Prof. Dr Marta Połtowicz-Bobak (University of Rzeszów), Dr Agnieszka Dziedzic and Dr Damian Stefański (Archaeological Museum Cracow), Dr Michał Przeździecki (University of Warsaw), and Dr Witold Grużdź (State Archaeological Museum Warsaw) have to be thanked for their outstanding organisational support of this work. Dr Johann Tinnes (PreRec, Cologne) and Dr Romain Malgarini (ATER, Paris Nanterre) kindly provided me with their unpublished PhD theses. Special thanks go to Jun. Prof. Dr Andreas Maier (University of Cologne) for our fruitful and ongoing discussions on Late Upper Palaeolithic recolonisation scenarios. Prof. Dr Marta Połtowicz-Bobak, Prof. Dr Clemens Pasda (University of Jena) and Prof. Dr Thomas Terberger (University of Göttingen/Lower Saxony State Office for Cultural Heritage) owe many thanks for their comments on earlier drafts of the manuscript. Finally, the remarks by two anonymous reviewers are highly appreciated. The work was supported by the German Research Foundation (DFG), grant number 442218485.

Funding Open Access funding enabled and organized by Projekt DEAL.

Declarations

Competing Interests The author has no competing interests to declare that are relevant to the content of this article.

References

Adams, J. S., & Andrefsky Jr, W. (2019). Do projectile points get cold? An experimental approach examining composite and stone projectile technology. *North American Archaeologist*, *40*(3), 1–21. https://doi.org/10.1177/0197693119873165

Allain, J., Desbrosse, R., Kozłowski, J.-K., & Rigaud, A. (1985). Le Magdalénien à Navettes. *Gallia Préhist, 28*, 37–124.

Allen, H., & Akermann, K. (2015). Innovation and change in northern Australian Aboriginal spear technologies: The case for reed spears. *Archaeology in Oceania, 50*, 83–93. https://doi.org/10.1002/arco.5051

Angevin, R. (2017). Participation et résistances au modèle socioculturel magdalénien dans le Massif Central: aspects des constructions identitaires en marge des technocomplexes «Lussac-Angles» et «à navettes». In C. Bourdier, L. Chehmana, R. Malgarini, & M. Połtowicz-Bobak (Eds), L'Essor du Magdalénien. Aspects culturels, symboliques et techniques des faciès à navettes et à Lussac-Angles. Actes de la séance de la Société préhistorique française, Besançon 17.–19. octobre 2013 (pp. 249–260). Paris: SPF.

Averbouh, A. (2000). *Technologie de la matière osseuse travaillée et implications palethnologiques: l'exemple des chaînes d'exploitation du bois de cervidé chez les magdaléniens des Pyrénées*. PhD thesis, University of Paris 1 – Panthéon Sorbonne.

Binford, L. R. (1980). Willow smoke and dog's tails: Hunter-gatherer settlement systems and archaeological site formation. *American Antiquity, 45*(1), 4–20.

Bohr, R. (2014). *Gifts from the thunder beings: Indigenous archery and European firearms in the Northern Plains and Central Subarctic* (pp. 1670–1870). University of Nebraska Press.

Boroń, T. (2010). Le mobilier magdalénien en matières dures d'origine animale du site de Wilczyce 10 (district de Sandomierz, Pologne). *Bulletin de la Société préhistorique française, 107*, 507–520. https://doi.org/10.3406/bspf.2010.13948

Bosinski, G. (1975). Der Magdalenien-Fundplatz Gönnersdorf. In Römisch-Germanisches Zentralmuseum Mainz (Ed.), *Ausgrabungen in Deutschland. Vorgeschichte – Römerzeit* (pp. 42–63). RGZM Monogr. 1/1. Bonn: Rudolf Habelt

Bosinski, G. (2009). The hafting of backed bladelets in the Late Magdalenian. In J. M. Burdukiewicz, K. Cyrek, P. Dyczek, & K. Szymczak (Eds), *Understanding the past. Papers offered to Stefan K. Kozłowski* (pp. 55–58). University of Warsaw. Warsaw

Bräem, L. (2008). *Approche typo-technique des ensembles osseux de Laugerie-Basse et de La Madeleine. La production des équipements en bois de cervidé au Magdalénien moyen et récent en Périgord*. Ph.D. dissertation. Universitée de Provence, Aix-Marseille

Breuil, H. (1925). Notes sur le voyage Paléolithique en Europe Centrale. *L'anthropologie, 35*, 272–291.

Breuil, H. (1937). *Les subdivisions du Paléolithique supérieur et leur signification*. Lagny: Grevin et fils.

Burch, E. S., Jr. (1991). Herd following Reconsidered. *Current Anthropology, 32*(4), 439–445.

Burch, E. S. Jr. (2013). From skeptic to believer: The making of oral histories. In E. Hill (Ed.), *Inupiaq Ethnohistory – Selected essays by Ernest S. Burch Jr.* (pp. 1–16). University of Alaska Press. Fairbanks

Cattelain, P. (1997). Hunting during the Upper Palaeolithic. Spearthrower or bow, or both? In H. Knecht (Ed.), *Projectile Technology. Interdisciplinary contributions to archaeology* (pp. 213–240). New York: Plenum

Cattelain, P. (2017). Les propulseurs du Magdalénien moyen ancien et apparentés. In C. Bourdier, L. Chehmana, R. Malgarini, & M. Połtowicz-Bobak (Eds), *L'Essor du Magdalénien. Aspects culturels, symboliques et techniques des faciès à navettes et à Lussac-Angles. Actes de la séance de la Société préhistorique française, Besançon 17.–19. octobre 2013* (pp. 235–247). Paris: SPF

Chabai, V. P., Stupak, D. V., Veselsky, A. P., & Dudnyk, D. V. (2020). Barmaki Site in the context of Epigravettian of the Middle Dnieper Basin. *Archaeology and Early History of Ukraine, 37*(4), 107–125. https://doi.org/10.37445/adiu.2020.04.08 <Emphasis Type="Italic">in Ukrainian</Emphasis>

Chauvière, F.-X. (2016). Osseous projectile points in the Magdalenian: 'True' points versus pointed waste products. In M. C. Langley (Ed.), Osseous projectile weaponry: Towards an understanding of Pleistocene cultural variability (pp. 161–169). New York: Springer.

Chauvière, F.-X., & Rigaud, A. (2008). Le travail du bois de renne à La Garenne (Saint-Marcel, Indre, France): Entre conceptions préhistoriennes et techniques magdaléniennes ou comment séparer ébauches et déchets des pointes varies? *Bullet Préhistoire du Sud-Ouest, 16*, 173–183.

Chauvière, F.-X., & Rigaud, A. (2009). Oubliées ou stockées? Les ébauches de pointes de projectiles en bois de renne et leur gestion par les Magdaléniens de La Garenne (Indre, France). In S. Bonnardin, C. Hamon, M. Lauwers, & B. Quilliec (Eds), *Du matériel au spirituel. Réalités archéologiques et historiques des « dépôts » de la Préhistoire à nos jours. XXIXe rencontres internationales d'archéologie et d'histoire d'Antibes* (pp. 283–290). Antibes: Éditions APDCA

Chauvière, F.-X., Chehmana, L., Houmard, C., Pinçon, G., & Taylor, A. (2017). Les productions techniques à l'origine des faciès du Magdalénien moyen à navettes et Lussac-Angles: les industries osseuses et lithiques de la Garenne (Indre), du Roc-aux-Sorciers et de la Marche (Vienne). In C. Bourdier, L. Chehmana, R. Malgarini, & M. Połtowicz-Bobak (Eds), *L'Essor du Magdalénien. Aspects culturels, symboliques et techniques des faciès à navettes et à Lussac-Angles. Actes de la séance de la Société préhistorique française, Besançon 17.–19. octobre 2013* (pp. 57–71). Paris: SPF

Clark, J. G. D. (1953). The groove and splinter technique of working reindeer and red deer antler in Upper Palaeolithic and Early Mesolithic Europe. *Archiva De Prehistoria Levantina, 4*, 57–65.

Clarkson, C. (2016). Testing archaeological approaches to determining past projectile delivery systems using ethnographic and experimental data. In R. Iovita & K. Sano (Eds.), *Multidisciplinary approaches to the study of Stone Age weaponry* (pp. 189–202). Springer.

Coppe, J., Lepers, C., Clarenne, V., Delaunois, E., Pirlot, M., & Rots, V. (2019). Ballistic study tackles kinetic energy values of Palaeolithic weaponry. *Archaeometry, 61*, 933–956. https://doi.org/10.1111/arcm.12452

Demidenko, Y. E. (2020). Magdalenian in Eastern Europe: Is it really there? *Anthropologie (Brno), 58*(2–3), 227–249. https://doi.org/10.26720/anthro.20.06.11.1

Ducasse, S., Chauvière, F.-X., & Pétillon, J.-M. (2021). Breaking bad? Discarding the solutrean norms: Chronology, evolution and geographical extent of the badegoulian phenomenon in Western Europe. *Quaternary International, 581–582*, 61–83. https://doi.org/10.1016/j.quaint.2020.10.063

Eerkens, J. W., & Lipo, C. P. (2005). Cultural transmission, copying errors, and the generation of variation in material culture and the archaeological record. *Journal of Anthropological Archaeology, 24*, 316–334.

Feustel, R. (1980). *Magdalénienstation Teufelsbrücke I - Archäologischer Teil*. Weimar: Museum für Ur- und Frühgeschichte Thüringens.

Fienup-Riordan, A. (2007). *Yuungnaqpiallerput – the way we genuinely live*. Seattle/London: Masterworks of Yup'ik science and survival. University of Washington Press.

Frison, G. C. (1989). Experimental use of Clovis weaponry and tools on African elephants. *American Antiquity, 54*, 766–784.

Fuentes, O., Lenoir, M., Martinez, M., & Welté, A.-C. (2017). Les représentations humaines et leurs enjeux. Regards croisés entre le Roc-aux-Sorciers (Angles-sur-l'Anglin, Vienne) et le Roc-de-Marcamps (Prignac-de-Marcamps, Gironde). In C. Bourdier, L. Chehmana, R. Malgarini, & M. Połtowicz-Bobak (Eds), *L'Essor du Magdalénien. Aspects culturels, symboliques et techniques des faciès à navettes et à Lussac-Angles. Actes de la séance de la Société préhistorique française, Besançon 17.–19. octobre 2013* (pp. 119–135). Paris: SPF

Fu, Q., Posth, C., Hajdinjak, M., Petr, M., Mallick, S., Fernandes, D., Furtwangler, A., Haak, W., Meyer, M., Mittnik, A., Nickel, B., Peltzer, A., Rohland, N., Slon, V., Talamo, S., Lazaridis, I., Lipson, M., Mathieson, I., Schiffels, S., … Reich, D. (2016). The genetic history of Ice Age Europe. *Nature, 534*, 200–205. https://doi.org/10.1038/nature17993

Gaudzinski, S., Turner, E., Anzidei, E. P., Àlvarez-Fernández, E., Arroyo-Cabrales, J., Cinq-Mars, J., Dobosi, V. T., Hannus, A., Johnson, E., Münzel, S. C., Scheer, A., & Villa, P. (2005). The use of Proboscidean remains in every-day Palaeolithic life. *Quaternary International, 126–128*, 179–194. https://doi.org/10.1016/j.quatint.2004.04.022

Gauvrit Roux, E. (2022). Socio-economic dynamics of Magdalenian hunter-gatherers: Functional perspective. *PLoS ONE, 17/10*, e0274819. https://doi.org/10.1371/journal.pone.0274819

Gauvrit Roux, E., Cattin, M. I., Yahemdi, I., & Beyries, S. (2020). Reconstructing Magdalenian hunting equipment through experimentation and functional analysis of backed bladelets. *Quaternary International, 554*, 107–127. https://doi.org/10.1016/j.quaint.2020.06.038

Gavrilov, K. N. (2021). The epigravettian of central Russian plain. *Quaternary International, 587–588*, 326–343. https://doi.org/10.1016/j.quaint.2020.10.016

Ginter, B., Poltowicz, M., Pawlikowski, M., Skiba, S., Trabska, J., Wacnik, A., Winiarska-Kabacinska, M., & Wojtal, P. (2005). Dzierżysław 35 – Ein neuer Fundplatz des Magdalénien in Oberschlesien. *Archäol. Korresp., 35*, 431–446.

Gulder, A. (1952). Die Paläolithstation von Kamegg im Kamptal. *N.-Ö Arch Austriaca, 10*, 16–27.

Guy Straus, L. & González Morales, R. (2020). The Magdalenian sequence of El Mirón Cave(Ramales de la Victoria, Cantabria) in the context of Northern Spain and the broader Franco-Cantabrian Region. In M. Langlais, & L. G. Straus (Eds), *Corrélations chrono-stratigraphiques et interactions culturelles au cours du Magdalénien entre l'Espagne cantabrique et le Sud-Ouest de la France… et au-delà. Session XVII-2 du XVIIIe Congrès de l'UISPP, Paris, 6 juin 2018. Actes de la séance de la Société Préhistorique Francaise* (pp. 185–204). Paris: SPF.

Händel, M., Simon, U., Maier, A., Brandl, M., Groza-Săcaciu, S. M., Timar-Gabor, A., & Einwögerer, T. (2020). Kammern-Grubgraben revisited – First results from renewed investigations at a well-known LGM site in east Austria. *Quaternary International, 587–588*, 137–157. https://doi.org/10.1016/j.quaint.2020.06.012

Hare, P. G., Greer, S., Gotthardt, R., Farnell, R., Bowyer, V., Schweger, C., & Strand, D. (2004). Ethnographic and Archaeological Investigations of Alpine Ice Patches in Southwest Yukon, Canada. *Arctic, 57*, 260–272.

Hare, P. G., Thomas, C. G., Topper, T. N., & Gotthardt, R. M. (2012). The archaeology of Yukon ice patches: New artifacts, observations, and insights. *Arctic*, 65. *Suppl., 1*, 118–135.

Helwig, K., Poulin, J., Monahan, V., & Thomas, C. (2021). Ancient throwing dart reveals first archaeological evidence of castoreum. *Science and Reports, 37*, 102949. https://doi.org/10.1016/j.jasrep.2021.102949

Helm, J. (1993). "Always with them either a feast or a famine": Living off the land with Chipewyan Indians, 1791–1792. *Arctic Anthr., 30*, 46–60.

Hill, E. (Ed.). (2013). *Iñupiaq Ethnohistory: Selected Essays by Ernest S. Burch. Jr*. University of Alaska Press.

Höck, C. (2000). Das Magdalénien der Kniegrotte. Ein Höhlenfundplatz bei Döbritz, Saale-Orla-Kreis. Theiss: Stuttgart

Houmard, C. (2003). Réflexions sur les têtes de projectiles rainurées d'après l'étude du site de La Garenne (Indre). *Préhistoires Méditerranéennes, 12*, 1–14.

Housley, R. A., Gamble, C. S., Street, M., & Pettitt, P. B. (1997). Radiocarbon evidence for the Lateglacial human recolonisation of northern Europe. *Proceedings of the Prehistoric Society, 63*, 25–54.

Jöris, O. (2021). The Late Magdalenian of Gönnersdorf and its headless anthropomorphic depictions. On social coherence and the Late Upper Palaeolithic colonization of Central Europe. In S. Gaudzinski-Windheuser, & O. Jöris (Eds), *The beef behind all possible pasts. The Tandem-Festschrift in honour of Elaine Turner and Martin Street* (pp. 325–368). Monogr. RGZM 157. Mayence: RGZM. https://doi.org/10.11588/propylaeum.868.c11323

Kahlke, R.-D. (2015). The maximum geographic extension of Late Pleistocene Mammuthus primigenius (Proboscidea, Mammalia) and its limiting factors. *Quaternary International, 379*, 147–154. https://doi.org/10.1016/j.quaint.2015.03.023

Kendrick, A., Lyver, P. O. B., Łutsel K'e Dene First Nation. (2005). Denesǫline (Chipewyan) knowledge of barren-ground caribou (Rangifer tarandus groenlandicus) movements. *Arctic, 58*(2), 175–191.

Kohler, T. A., VanBuskirk, S., & Ruscavage-Barz, S. (2004). Vessels and villages: Evidence for conformist transmission in early village aggregations on the Pajarito Plateau New Mexico. *Journal of Anthropological Archaeology, 23*, 100–118.

Kostrzewski, J. (1928). Polen. In M. Ebert (Ed.), *Reallexikon der Vorgeschichte* (Vol. 10, pp. 177–200)

Kozłowski, J. K. (1963). *Stanowisko przemysłu Magdaleńskiego w jaskini Maszyckiej*. Materiały Archeologiczne 4 (pp. 5–52). Cracow Archaeological Museum. Cracow

Kozłowski, S. K., Sachse-Kozłowska, E., Marshak, A., Madeyska, T., Kierdorf, H., Lasota-Moskalewska, A., Jakubowski, G., Winiaska-Kabacińska, M., Kapica, Z., & Wierciński, A. (1993). Maszycka Cave, a Magdalenian site in southern Poland. *Jahrbuch des Römisch-Germanischen Zentralmuseums Mainz, 40*(1), 115–252.

Kozłowski, S. K., Połtowicz-Bobak, M., Bobak, D., & Terberger, T. (2012). New information from Maszycka cave and the late glacial recolonization of central Europe. *Quaternary International, 272–273*, 288–296. https://doi.org/10.1016/j.quaint.2012.02.052

Kozłowski, S. K., Terberger, T., Bobak, D., Orschiedt, & J., Połtowicz-Bobak, M. (2017). Eastern borders of the Magdalenian "á navettes". Maszycka cave in Lesser Poland (Southern Poland). In C. Bourdier, L. Chehmana, R. Malgarini, & M. Połtowicz-Bobak (Eds.), *L'Essor du Magdalénien. Aspects culturels, symboliques et techniques des faciès à navettes et à Lussac-Angles. Actes de la séance de la Société préhistorique française, Besançon 17.–19. octobre 2013* (pp. pp. 187–205). Paris: SPF

Kretschmer, I. (2015). *Demographische Untersuchungen zu Bevölkerungsdichten, Mobilität und Landnutzungsmustern im späten Jungpaläolithikum*. KSPA 6. Rahden/Westf: Marie Leidorf

Łanczont, M., Połtowicz-Bobak, M., Bobak, D., Mroczek, P., Nowak, A., Komar, M., & Standzikowski, K. (2021). On the edge of eastern and western culture zones in the early Late Pleistocene. Święte 9 – A new epigravettian site in the south-east of Poland. *Quaternary International, 587–588*, 172–188. https://doi.org/10.1016/j.quaint.2020.08.028

Langlais, M. (2020). Des segments chronoculturels au modèle archéo-stratigraphique du Magdalénien dans le Sud-Ouest français (21 000-16 000 cal. BP). In M. Langlais, & L. G. Straus (Eds), *Corrélations chrono-stratigraphiques et interactions culturelles au cours du Magdalénien entre l'Espagne cantabrique et le Sud-Ouest de la France… et au-delà. Session XVII-2 du XVIIIe Congrès de l'UISPP, Paris, 6 juin 2018. Actes de la séance de la Société Préhistorique Francaise* (pp. 109–137). Paris: SPF.

Langlais M., Pétillon, J. M., & Sécher, A. (2017). Les débuts du Magdalénien moyen dans le Sud-Ouest français. Témoignages croisés des équipements lithiques et osseux. In C. Bourdier, L. Chehmana, R. Malgarini, & M. Połtowicz-Bobak (Eds), *L'Essor du Magdalénien. Aspects culturels, symboliques et techniques des faciès à navettes et à Lussac-Angles. Actes de la séance de la Société préhistorique française, Besançon 17.–19. octobre 2013* (pp. 209–234). Paris: SPF.

Langley, M. C. (2015). Investigating maintenance and discard behaviours for osseous projectile points: A Middle to Late Magdalenian (c. 19000–14000 cal. BP) example. *Journal of Anthropological Archaeology, 40*, 340–360. https://doi.org/10.1016/j.jaa.2015.10.001

Langley, M. C., Pétillon, J.-M., & Christensen, M. (2016). Diversity and evolution of osseous hunting equipment during the Magdalenian (21,000–14,000 cal BP). In M. C. Langley (Ed.), *Osseous projectile weaponry: Towards an understanding of Pleistocene cultural variability* (pp. 143–158). Springer.

Leesch, D., Bullinger, J., & Müller, W. (2019). Vivre en Suisse il y a 15000 ans. *Le Magdalénien*. Basel: Arch. Suisse.

Lefebvre, A., Marín-Arroyo, A. B., Álvarez-Fernández, E., De la Rasilla Vives, M., Duarte Matías, E., Cuetoe, M., Tapiaf, J., Berganza, E., & Pétillon, J.-M. (2021). Interconnected Magdalenian societies as revealed by the circulation of whale bone artefacts in the Pyreneo-Cantabrian region. *Quaternary Science Reviews, 251*, 106692. https://doi.org/10.1016/j.quascirev.2020.106692

Lengyel, G., Bárány, A., Béres, S., Cserpák, F., Gasparik, M., Major, I., Molnár, M., Nadachowski, A., Nemergut, A., Svoboda, J., Verpoorte, A., Wojtal, P., & Wilczyński, J. (2021). The Epigravettian chronology and the human population of eastern Central Europe during MIS2. *Quaternary Science Reviews, 271*, 107187. https://doi.org/10.1016/j.quascirev.2021.107187

Lucas, C., 2021. Some weapons to take away: The spread of decorated projectile points across Magdalenian societies. In L. Mevel, M.-J. Weber, & A. Maier (Eds), *En Mouvement / On the Move / In Bewegung. Mobility of people, objects and ideas during the European Upper Palaeolithic. Actes de la séance commune de la Société préhistorique française et la Hugo Obermaier-Gesellschaft à Strasbourg (16 - 17 mai 2019)* (pp.149–171). Séances de la Société préhistorique française 17. Paris: SPF

Maier, A. (2015). *The Central European Magdalenian. Regional diversity and internal variability*. Springer.
Maier, A. (2017a). Expansion or communication? The phenomenon of the Magdalenian à navettes from a Central European point of view. In C. Bourdier, L. Chehmana, R. Malgarini, & M. Połtowicz-Bobak (Eds.), *L'Essor du Magdalénien. Aspects culturels, symboliques et techniques des faciès à navettes et à Lussac-Angles. Actes de la séance de la Société préhistorique française, Besançon 17.–19. octobre 2013* (pp. 175–186). Paris: SPF
Maier, A. (2017). Population and settlement dynamics from the Gravettian to the Magdalenian. *Mitteilungen Gesellschaft Für Urgeschichte, 26*, 83–101.
Maier, A., Liebermann, C., & Pfeifer, S. J. (2020). Beyond the Alps and Tatra mountains – The 20–14 ka repopulation of the northern mid-latitudes as inferred from palimpsests deciphered with keys from western and central Europe. *Journal of Paleolithic Archaeology, 3*, 398–452. https://doi.org/10.1007/s41982-019-00045-1
Maier, A., Stojakowits, P., Mayr, C., Pfeifer, S., Preusser, F., Zolitschka, B., Anghelinu, M., Bobak, D., Duprat-Oualid, F., Einwögerer, T., Hambach, U., Händel, M., Kaminská, M., Kämpf, L., Łanczont, M., Lehmkuhl, F., Ludwig, P., Magyari, E., Mroczek, P., … Veres, D. (2021). Cultural evolution and environmental change in Central Europe between 40 and 15 ka. *Quaternary International, 581–582*, 225–240. https://doi.org/10.1016/j.quaint.2020.09.049
Malgarini, R. (2014). *Les gisements magdaléniens dans le Jura et les Alpes du nord et leurs industries osseuses*. Unpublished PhD-Thesis.
Malgarini, R., Mevel, L., Béreiziat, G., Bodu, P., Cupillard, C., Debout, G., & Carquigny, N. (2017). Les faciès du Magdalénien moyen dans l'Est de la France. Confrontation et discussion des industries osseuses et lithiques. In C. Bourdier, L. Chehmana, R. Malgarini, & M. Połtowicz-Bobak (Eds), *L'Essor du Magdalénien. Aspects culturels, symboliques et techniques des faciès à navettes et à Lussac-Angles. Actes de la séance de la Société préhistorique française, Besançon 17.–19. octobre 2013* (pp. 139–156). Paris: SPF.
Milks, A. (2020). A review of ethnographic use of wooden spears and implications for Pleistocene hominin hunting. *Open Quaternary, 6*(12), 1–20. https://doi.org/10.5334/oq.85
Müller, W. (2006). „Camp to food" or „food to camp"? Jagd und Rhythmus der Ortswechsel im Magdalénien am Beispiel von Champréveyres und Monruz (Neuchâtel, Schweiz). In Hugo Obermaier-Gesellschaft für Erforschung des Eiszeitalters und der Steinzeit e.V. (Ed.), *48th. Annual Meeting in Cologne, April 18–22, 2006* (p. 27). Erlangen: Hugo Obermaier Society
Müller, W., Pasda, C., Pfeifer, S., J., & Schüler, T. (2018/2019). Magdalénien und Spätpaläolithikum im Bärenkeller bei Garsitz (Stadt Königsee, Landkreis Saalfeld-Rudolstadt). *Neue Ausgrabungen und Funde in Thüringen*, 10, 7–18
Nadachowski, A., Lipecki, G., Ratajczak, U., Stefaniak, K., & Wojtal, P. (2016). Dispersal events of the saiga antelope (*Saiga tatarica*) in Central Europe in response to the climatic fluctuations in MIS 2 and the early part of MIS 1. *Quaternary International, 420*, 357–362.
Nerudová, Z., & Neruda, P. (2014). Štýžice III (koněvova st. or vídeňská st.) – An epigravettian site in Brno (Czech Republic). *Interdisciplinaria Archaeologica Natural Sciences in Archaeology, 5*, 7–18.
Nerudová, Z., & Neruda, P. (2015). Moravia between Gravettian and Magdalenian. In S. Sazelova, M. Novak, & A. Mizerova (Eds.), *Forgotten times and spaces: New perspectives in paleoanthropological, paleoethnological and archeological Studies* (pp. 378–394). Masaryk University.
Nerudová, Z., Hromadová, B., Neruda, P., & Zelenka, F. (2019). One ring to interpret. Bone ring-type adornment from the Epigravettian site Bratčice (Moravia, Czech Republic). *Quartär, 66*, 187–200.
Nerudová, Z., Neruda, P., & Hamrozi, P. (2021). Statistical and geographical modelling of Moravian (Czech Republic) Late Upper Palaeolithic occupation. *Quaternary International, 581–582*, 175–189. https://doi.org/10.1016/j.quaint.2020.07.003
Nikolskiy, P., & Pitulko, V. (2013). Evidence from the Yana Palaeolithic site, Arctic Siberia, yields clues to the riddle of mammoth hunting. *J. Arch. Sci., 40*, 4189–4197. https://doi.org/10.1016/j.jas.2013.05.020
Noiret, P. (2009). *Le Paléolithique supérieur de Moldavie*. Liège: Editions ERAUL.
Orschiedt, J., Schüler, T., Połtowicz-Bobak, M., Bobak, D., Kozłowski, S. K., & Terberger, T. (2017). Human remains from Maszycka cave (woj. Małopolskie / PL): The treatment of human bodies in the Magdalenian. *Archäol Korresp, 47*, 423–439.
Ossowski, G. (1885). *Jaskinie okolic Ojcowa pod wzgle˛dem paeontologicznym 11. Pamietnik Akademii Umiejętności w Krakowie.* Wydział Matematyczno-Przyrodniczy. Cracow

Otte, M. (2012). Appearance, expansion and dilution of the Magdalenian civilization. *Quaternary International, 272–273*, 354–361. https://doi.org/10.1016/j.quaint.2012.02.056

Pasda, C. (2017). Munzingen. A Magdalenian site in the southern upper Rhine plain (Germany). In C. Bourdier, L. Chehmana, R. Malgarini, & M. Połtowicz-Bobak (Eds), *L'Essor du Magdalénien. Aspects culturels, symboliques et techniques des faciès à navettes et à Lussac-Angles. Actes de la séance de la Société préhistorique française, Besançon 17.–19. octobre 2013* (pp. 157–173). Paris: SPF

Pasda, C., & Pfeifer, S. J. (2019). Tier und Mensch, Klima und Landschaft im Weichselspätglazial und Frühholozän Mitteldeutschlands. *Archäologisches Korrespondenzblatt, 49*, 465–478.

Pasda, C., & Weiß, M. (2020). Zur Funktion Von Magdalénienstationen. *Quartär, 67*, 45–84.

Pétillon, J.-M. (2006). *Des Magdaléniens en armes. Technologie des armatures de projectile en bois de cervidé du Magdalénien supérieur de la grotte d'Isturitz (Pyrénées-Atlantiques)*. Artefacts 10. Teignes: CEDARC

Pétillon, J.-M. (2016). Technological evolution of hunting implements among Pleistocene hunter-gatherers: Osseous projectile points in the middle and upper Magdalenian (19–14 ka cal BP). *Quaternary International, 414*, 108–134. https://doi.org/10.1016/j.quaint.2015.08.063

Pétillon, J.-M., Bignon, O., Bodu, P., Cattelain, P., Debout, G., Langlais, M., Laroulandie, V., Plisson, H., & Valentin, B. (2011). Hard core and cutting edge: Experimental manufacture and use of Magdalenian composite projectile tips. *Journal of Archaeological Science, 38*, 1266–1283. https://doi.org/10.1016/j.jas.2011.01.002

Pétillon, J.-M., Plisson, H., & Cattelain, P. (2016). Thirty years of experimental research on the breakage patterns of Stone Age osseous points. Overview, methodological problems and current perspectives. In R. Iovita, & K. Sano (Eds), *Multidisciplinary approaches to the study of Stone Age weaponry* (pp. 47–63). Dordrecht: Springer

Pettigrew, D. B. (2015). *The ballistics of archaic North American atlatls and darts*. Master's thesis, University of Arkansas. http://scholarworks.uark.edu/etd/1169. Accessed 10 Oct 2022

Pfeifer, S. J. (2012). Projectiles for kids. New evidence of child and youth versions of Magdalenian osseous points from the Teufelsbrücke cave site (Thuringia, Germany). *Ethnographisch-Archäologische Zeitschrift, 56*, 243–254.

Pfeifer, S. J. (2016). *Die Geweihfunde der magdalénienzeitlichen Station Petersfels. Eine archäologisch-taphonomische Studie*. Forschungen u. Berichte Archäologie Baden-Württemberg 3. Wiesbaden: Dr. Ludwig Reichert

Pfeifer, S. J. (2017). Ornamented osseous projectile points from the Balcarka and Pekárna caves: Evidence of direct interrelations between two Magdalenian sites in the Moravian Karst (Czech Republic). *Archäologisches Korrespondenzblatt, 47*, 141–152.

Pfeifer, S. J. (2019). Organische Projektile in Magdalénienstationen der Schweiz. Beitrag einer Artefaktgattung zur zeitlichen Gliederung der archäostratigrafischen Einheit. *Archäol. Korresp., 49*, 305–319.

Pfeifer, S. J. (2020). Next stop: Kniegrotte? On the possibility of a Magdalenian à navettes in Eastern Germany. *Anthropologie (Brno), 58*(2–3), 199–214. https://doi.org/10.26720/anthro.20.03.26.1

Pfeifer, S. J., 2021. OsseoPro: a catalogue of osseous projectiles of the Central European Late Upper Palaeolithic (23–14 ka calBP). Digitale Bibliothek Thüringen. https://doi.org/10.22032/dbt.50428

Pfeifer, S. J., Hartramph, W. L., Kahlke, R.-D., & Müller, F. A. (2019). Proboscidean ivory was the most suitable osseous raw material for Late Pleistocene big game projectiles. *Scientific Report*. https://doi.org/10.1038/s41598-019-38779-1

Połtowicz-Bobak, M. (2013). *Wschodnia prowincja magdalenienu (Eastern Province of Magdalenian)*. Rzeszów: Wydawnictwo Uniwersytetu Rzeszowskiego (in Polish, with English summary)

Połtowicz-Bobak, M. (2020). Eastern border of the Magdalenian Culture – An area of settlement or resource gathering? *Anthropologie (Brno), 58*(2–3), 215–226. https://doi.org/10.26720/anthro.20.03.20.1

Połtowicz-Bobak, M., & Bobak, D. (2020). Human settlement in Polish territory during the Last Glacial Maximum (ca 24,000–19,000 cal. BP): the calm before a new deal. *Acta Geographica Lodziensia, 110*, 21–31. https://doi.org/10.26485/AGL/2020/110/2

Posth, C., Renaud, G., Mittnik, A., Drucker, D. G., Rougier, H., Cupillard, C., Valentin, F., Thevenet, C., Furtwängler, A., Wißing, C., Francken, M., Malina, M., Bolus, M., Lari, M., Gigli, E., Capecchi, G., Crevecoeur, I., Beauval, C., Flas, D., … Krause, J. (2016). Pleistocene mitochondrial genomes suggest a single major dispersal of non-Africans and a Late Glacial population turnover in Europe. *Current Biology, 26*, 827–833. https://doi.org/10.1016/j.cub.2016.01.037

Reynolds, N. (2020). Threading the weft, testing the warp: Population concepts and the European Upper Paleolithic chronocultural framework. In H. S. Groucutt, (Ed.), *Culture history and convergent*

evolution. Can we detect populations in prehistory? (pp. 187–212). Cham: Springer. https://doi.org/10.1007/978-3-030-46126-3_10

Richter, J. (2018). *Altsteinzeit – Der Weg der frühen Menschen von Afrika bis in die Mitte Europas*. Kohlhammer.

Sécher, A. (2020). What's up with the Early Middle Magdalenian in South-West of France (19.5–17.5 cal ky BP). New data from lithic technology and paleogeographic studies. *Anthropologie (Brno), 58*(2–3), 139–166. https://doi.org/10.26720/anthro.20.03.26.1

Sécher, A., & Caux, S. (2017). Technologie lithique et circulation des matières premières au Magdalénien moyen ancien. L'exemple de Moulin-Neuf (Saint-Quentin-de-Baron, Gironde). *Bulletin de la Societe Prehistorique Francaise, 114/2*, 295–314.

Škrdla, P., Vlach, M., Nejman, L., Bartík, J., Demidenko, Y. E., & Rychtaříková, T. (2021). Settlement strategies in Eastern Central Europe during the maximum extent of the last glacial ice sheet. *Quaternary International, 581–582*, 164–174. https://doi.org/10.1016/j.quaint.2020.09.047

Stodiek, U. (1993). *Zur Technologie der jungpaläolithischen Speerschleuder. Eine Studie auf der Basis archäologischer, ethnologischer und experimenteller Erkenntnisse*. Archaeologica Venatoria. Tübingen

Svoboda, J. (1976). Zur Problematik der magdalénienzeitlichen Kunst Mitteleuropas. *Anthropologie (brno), 14*(3), 163–193.

Svoboda, J., Boriová, S., Lengyel, G., Pokorný, P., Prokeš, L., Přichystal, A., Pryor, A., Sázelová, S., & Wilczyński, J. (2020). Last glacial maximum landscape and epigravettian horse hunting strategy in central Europe: The case of Stránská skála IV. *Přehled Výzkumů, 61*(1), 59–70.

Terberger, T. (2013). Le Dernier Maximum glaciaire entre le Rhin et le Danube, un réexamen critique. In P. Bodu, L. Chehmana, L. Klaric, L. Mevel, S. Soriano, & N. Teyssandier (Eds.), *Le Paléolithique supérieur ancien de l'Europe du Nord-Ouest. Réflexions et synthèses à partir d'un projet collectif de recherche sur le Centre et le Sud du Bassin parisien. Actes du colloque (Sens, 15–18 avril 2009)* (pp. 415–443). Paris: Société préhistorique française

Terberger, T., Floss, H., Heinzelmann, P., Kotula, A., & Serangeli, J. (2013). Down the Rhine river ca. 16,000 years ago: New evidence from the site Dreieich-Götzenhain, Hesse. In A. Pastoors, & B. Auffermann (Eds), *Pleistocene foragers: Their culture and environment. Festschrift in honour of Gerd-Christian Weniger for his sixtieth birthday* (pp. 101–116). Mettmann: Neanderthal Museum

Tinnes, J. (1995). *Die Geweih-, Elfenbein- und Knochenartefakte der Magdalénienfundplätze Gönnersdorf und Andernach*. Unpublished PhD thesis, Cologne University

Valoch, K. (2001). Das Magdalénien in Mähren – 130 Jahre Forschung. *Jahrb. RGZM, 48*, 103–159.

Weniger, G.-C. (1982). *Wildbeuter und ihre Umwelt.* Arch. Venatoria 5. Archaeologica Venatoria. Tübingen

Wiessner, P. (1983). Style and social information in Kalahari San projectile points. *American Antiquity, 48*, 253–276.

Wilczyński, J. (2009). Targowisko – a new Late Glacial site in southern Poland. *Eurasian Prehistory, 6*, 95–118.

Wild, M. (2020). *Coping with risk through seasonal behavioural strategies. Technological analysis of selected Late Upper Palaeolithic antler assemblages from northern Germany, southern Scandinavia and the Paris Basin.* Unters. u. Mat. Steinzeit Schleswig-Holstein u. Ostseeraum 12. Neumünster: Wachholtz

Wild, M., Fischer Mortensen, M., Andreasen, N. H., Borup, P., Casati, C., Eriksen, B. V., Frost, L., Gregersen, K., Henriksen, M. B., Kanstrup, M., Olsen, J., Pedersen, K. B., Petersen, P. V., Ramskov, C., Sørensen, L., Sorensen, M., & Wahlin, S. (2020). Palaeolithic bone and antler artefacts from Lateglacial and Early Holocene Denmark: Technology and dating. *Quartär, 67*, 105–180. https://doi.org/10.7485/QU67_5

Wiśniewski, A., Połtowicz-Bobak, M., Bobak, D., Jary, Z., & Moska, P. (2017). The Epigravettian and the Magdalenian in Poland: New chronological data and an old problem. *Geochronometria, 44*, 16–29. https://doi.org/10.1515/geochr-2015-0052

Wolf, S. (2015). *Schmuckstücke. Die Elfenbeinverarbeitung im Schwäbischen Aurignacien*. Kerns.

Wood, J., & Fitzhugh, B. (2018). Wound ballistics: The prey specific implications of penetrating trauma injuries from osseous, flaked stone, and composite inset microblade projectiles during the Pleistocene/Holocene transition, Alaska U.S.A. *Journal of archaeological science, 91*, 114–117. https://doi.org/10.1016/j.jas.2017.10.006