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BRIEF REPORT

Not so unusual Neanderthal bone tools: new examples from Abri Lartet, France

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Introduction

Status of Neanderthal bone tools

Debates on the cognitive and technological capacities of hominins often focus on the production of artifacts from organic materials (Klein 1989; Mellars and Stringer 1989; D'Errico et al. 1998; McBrearty and Brooks 2000; Henshilwood et al. 2001; Henshilwood and Marean 2003). Among Neanderthals, retouching of shells (Douka and Spinapolice 2012; Romagnoli et al. 2016; Villa et al. 2020) or the transformation of plant materials (Aranguren et al. 2018; Niekus et al. 2019; Hardy et al. 2020), especially for the manufacture of composite weapons and tools, is regarded as evidence of complex technology (Langley et al. 2008; Wragg Sykes 2015; Hoffecker 2018). When it comes to bone tools, however, opinions are mixed.

Retouchers, which occur frequently in Mousterian contexts (e.g., Semenov 1957, 1964; Schelinskii 1983; Mallye et al. 2012; Daujeard et al. 2014; Costamagno et al. 2018), can be considered expedient artifacts, referring to R. Lee Lyman's (1984) definition. They are non-standardized, collected from butchery remains, processed by percussion and discarded after a short period of use, although nuances are sometimes made regarding the selection degree of the bone fragments (e.g., Martellota et al. 2021). Debates arise over the few other bone tools reported in Mousterian contexts, which are sometimes called expedient (Romandini et al. 2014; Tartar and Costamagno 2016; Aranguren et al. 2019), sometimes formal (Gaudzinski 1999; Burke and D'Errico 2008; Soressi et al. 2013). In both cases, authors take Upper Paleolithic bone industries—that involve the production of standardized forms completed using scraping or abrasion—as a point of reference for characterizing earlier bone tool production. This has led to the view that the use of scraping and abrasion techniques, prior to the Upper Paleolithic, is a premise of "behavioral modernity" (Mellars 1989; Klein 2000; McBrearty and Brooks 2000; D'Errico 2003; D'Errico and Henshilwood 2007; d'Errico et al. 2020). In contrast, percussion is regarded as a technique borrowed from lithic technology, unsuitable for bone shaping unlike scraping and abrasion (e.g., Vincent 1985; Ono 2006; Burke and d'Errico 2008; Romandini et al. 2014; Rosell et al. 2015).

Four rib fragments with smoothed ends shaped by abrasion, found in a Mousterian context, have been reported as the first specialized tools in Europe through comparison with Upper Paleolithic "lissoirs" (Soressi et al. 2013). However, these tools, used for smoothing hide according to a micro-wear analysis, are minimally shaped given the selection of a skeletal part (ungulate rib fragments) whose morphology naturally lends itself to technical standardization. Other specimens of smooth-ended ribs have been

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a
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◀**Fig. 1** Bone tools with smoothed-end from Abri Lartet. (**a**) Flexion fracture with smoothing of the active part. (**b**) Sagittal section showing invasive smoothing on the cortical side and a facet at the front edge. (**c**) Specimen on a tibia of *Rangifer tarandus*. (**d**) Specimen on a medium-sized rib of an undetermined Ungulata. (**e**) Facet at the front edge. (**f**) Sagittal section showing the facet. (**g**) Specimen on a rib of *Equus ferus*. (**h**) Smoothing of the active part and striations from shaping (photos: M. Baumann, except a, h, H. Plisson)

reported in Middle Paleolithic assemblages spanning nearly 30,000 years (Henri-Martin 1907–1910; Patou-Mathis 1993; Gaudzinski 1999; Mozota Holgueras 2012; Oulad El Kaïd 2016; Stepanchuk et al. 2017; Villeneuve et al. 2019; Baumann et al. 2020; Supplementary information [SI] Fig. 1; SI Table 1). Some have a similar active end to the four samples from Pech de l'Aze and Abri Peyrony, other not, and blunting is not necessarily linked to hide processing (Arrighi et al. 2016). The functional diversity of such tools needs to be explored before drawing a parallel with the anatomically modern human (AMH) productions.

Here, we contribute to understanding this diversity by presenting a set of bone tools, including a series of smoothed-ended ribs, identified in the Mousterian levels of the Abri Lartet in Charente, France.

Archaeological context

The Abri Lartet, an elevated chamber located in the west part of the Grotte de Montgaudier (Charente, France; SI Fig. 2a), was excavated by Louis Duport between 1966 and 1986 (Debénath and Duport 1987). The main archaeological deposits come from level 2 (SI 1; SI Fig. 2c–d) and contain a lithic assemblage dominated by Levallois materiel consistent with a "Ferrassie" facies (SI 2). The level 2 faunal assemblage is abundant, highly fragmented, and dominated by long bone shaft fragments. It appears to be mostly anthropogenic. Cut-marked specimens are common, and the carnivore impact is limited. We taxonomically identified 697 of 2276 specimens from level 2-unit C4. Of this sample, 96.4% was attributed to *Rangifer tarandus*. Other ungulates present are *Equus ferus*, *Bos/Bison*, *Cervus elaphus*, and an undetermined Caprinae. Only one remain was attributed to a carnivore (*Vulpes* sp.). The dominance of *Rangifer tarandus* suggests the accumulation of deposits during a relatively cool climatic episode (Ready and Morin 2019).

Materials and methods

The tools discussed here belong to the Duport collection held at the Museum of Angoulême (Charente, France). They were discovered during a study of the Abri Lartet faunal remains whose aim was to establish the extent of carnivore activity relative to human activity. We inspected 50% of the layer 2 large faunal assemblage, focusing on the qualitative assessment of skeletal representation patterns, evidence of carnivore damage, and indicators of anthropogenic activity such as cut marks as well as evidence of tool use and manufacturing (Ready and Morin 2019).

Along with several bone retouchers, we identified six bone tools belonging to other functional categories. As bone retouchers have already been the subject of numerous studies (e.g., Hutson et al. 2018; Patou-Mathis 2002), we carried out the technological and functional analysis on the other tool categories. In 1971, Debénath and Duport published a small number of "worked and used bones" from the Abri Lartet deposits (Debénath and Duport 1971; SI 3; SI Fig. 3). The re-examination of these items provided two additional tools.

The eight specimens (SI Fig. 4) were examined with the naked eye and then with a Nikon SMZ-1 stereoscopic microscope. Photography was conducted using a Canon EOS 1000D camera with a Canon EF-S 60 mm f/2.8 Macro USM objective and with a Wild M420 Makroskop with 5.8×–35× apochromatic zoom, supplemented by a Canon EOS 1100D camera. Sequences of Makroskop shots with the progressive shift of focus were compiled with Helicon Focus software. For a subset of artifacts, an examination was performed using µCT (SI 4; SI Table 2). Volume reconstruction and visualization of µCT sections were performed using Avizo v. 7.1 software (Thermo Fisher Scientific, Waltham; SI Files 1–6). Our identification of the manufacture and use-wear traces is based on a comparison with published archaeological, experimental, and ethnographic references as well as with the results of our own experiments (SI 5; SI Fig. 5).

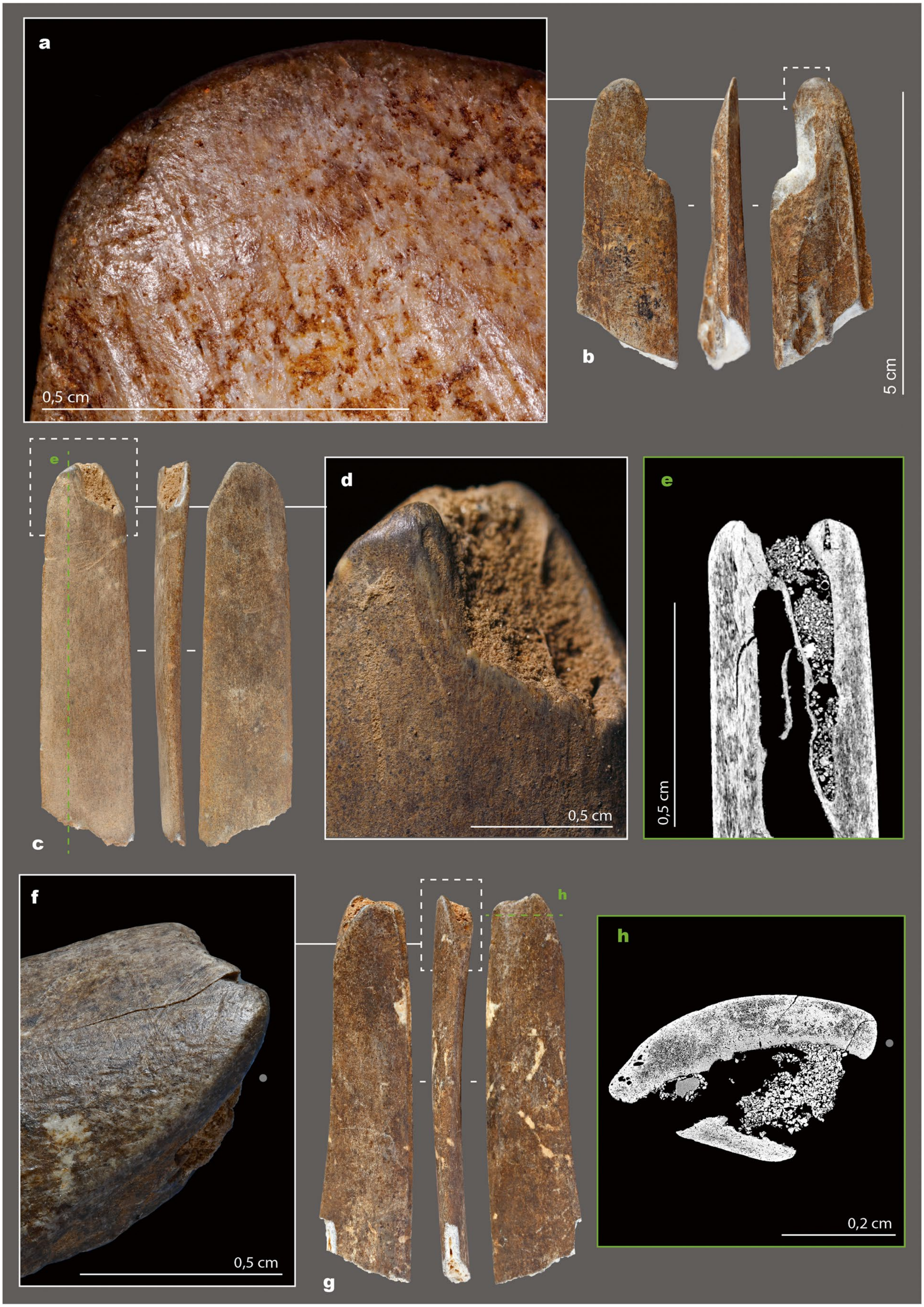
Due to the lack of precise spatial information on the tools and the presence of a small number of Upper Paleolithic tools in the collection (SI 6), direct AMS dating was undertaken to confirm their Middle Paleolithic attribution.

Samples of the unused ends of six of the Lartet bone tools were sent for AMS radiocarbon dating at the University of Oxford Radiocarbon Accelerator Unit. Details of the dating procedure can be found in Bronk Ramsey et al. (2004), Bronk Ramsey (2009), and Brock et al. (2010). Dates were calibrated using the OxCal computer program v. 4.4.2 using the IntCal20 dataset (Reimer et al. 2020). Due to the small size of some of the samples and low collagen yields, none of the specimens was ultrafiltered. The dates provided are therefore likely to be underestimated, and for this reason, should all be treated as minimum ages.

Results

Technological and macro-use wear analysis

Six of the specimens are tools with smoothed ends on *Rangifer tarandus* long bones ($n = 2$) and ribs of medium-sized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◀**Fig. 2** Bone tools with smoothed-end from Abri Lartet. (**a**) Smoothed scar, striations, and crack on the medullar side of the beveled active end. (**b**) Specimen on a metatarsal of a *Rangifer tarandus*. (**c**) Specimen on a medium-sized rib of an undetermined Ungulata. (**d**) Smoothing with slight and regular striations. (**e**) Sagittal section showing smoothing on the inner and outer surfaces of the fractured end. (**f**) Facet on the lateral edge of the active end. (**g**) Specimen on a medium-sized rib of an undetermined Ungulata. (**h**) Transverse section of the lateral facet (photo: M. Baumann, except a, d, H. Plisson)

ungulates, possibly *Rangifer tarandus* ($n=3$) and *Equus ferus* ($n=1$).

The tool from a tibia fragment (Fig. 1c) was flaked by direct percussion. Its active part is located on an oblique bending fracture from which most of the sharp denticulations have been removed by abrasion, giving the edge a convex contour (SI Fig. 8C1–C4). Smoothing is more invasive on the cortical side, and a convex wear facet is also present at the front edge (Fig. 1b). The convex profile blunting with plane break to the adjacent faces and slight overlapping faceting effect (SI File 1) suggests an axial motion on a flexible, slightly abrasive material, with variations in tool handling. The closest analogy we have experimentally for such morphology of edge rounding is the dehairing of semidry skin (SI Fig. 7j), but here the striations are scarcely perceptible (perhaps due to post-depositional alteration). As far as its drawing is precise enough, the lost sample (SI Fig. 3b) may have been used in the same way.

The active part of the second specimen is a bevel with an ogival front (Fig. 2b). The double axial symmetry and regularity of the latter (SI File 2; SI Fig. 8C5–C8) suggest shaping by abrasion since all forms are slightly convex, with gently rounded protrusions, without flat faceting or the clusters of strictly parallel striations that are the hallmark of scraping (Peltier and Plisson 1986). The smoothing of the piece is more extensive on the medullary side and associated with a partially smoothed scar and isolated striations more or less perpendicular to the cutting edge (Fig. 2a). This combination of features has been previously described for the active parts of wedges or chisels used to work woody materials (Campana 1989; Sidéra 1993; Camps-Fabrer 1998; Tartar 2009; Maigrot et al. 2013; Stewart 2013). There is no vegetal luster. However, such polish, which results from a micro-coating of silica (Stordeur and Anderson-Gerfaud 1985), is soluble in a basic PH context (Plisson and Mauger 1988).

The tools on the ribs are segments complete in cross-section. Their active parts are on oblique bending fractures that reveal trabecular tissue. In two cases, microtomographic imaging shows internal cracks that were likely caused by the bending of the piece (SI Fig. 9C5; SI Fig. 10C3). The edges of the fractured ends are rounded. However, the distribution and extent of smoothing and associated traces vary from piece to piece.

On the *Equus ferus* rib (Fig. 1g), the sagittal sections are asymmetrical (SI Fig. 9C1–C4): the junction between the dorsal side and the fractured edge is regularly convex, while the junction with the ventral side is flatter (SI File 3). This rounding is compatible with use as a skin smoother (SI Fig. 7e–f); however, a coat of modern varnish over adhering sediment leaves the hypothesis open. The dorsal and ventral sides are marked with deep striations, perpendicular to the edge and crossing slightly (Fig. 1h). Such striations are characteristic of abrasion shaping with a coarse grit abrader (SI Fig. 7a).

Slight and regular striations are visible on the ventral side of the first medium-sized ungulate rib (Fig. 2c–d). Smoothing is present on the inner and outer surfaces of the fractured end (Fig. 2e; SI Fig. 9C5–C6; SI File 4), suggesting penetrating contact in a slightly abrasive material. For now, the closest comparison is with a digging stick from Swartkrans (Backwell and d'Errico 2001).

On the second medium-sized ungulate rib (Fig. 2g), extensive and regular smoothing on the lateral edge (Fig. 2f, h) results from intentional shaping. At the apical end, the smoothing is less pronounced and did not completely remove the irregularities of the bending fracture (SI Fig. 10C1–C3; SI File 5). Thus, here, the smoothing is probably the result of use rather than shaping. On the ventral side, a few deep oblique striations extending from the fractured edge may be the result of wear from use. The short transverse striations on the dorsal side are more difficult to interpret but are probably anthropogenic.

The third medium-sized ungulate rib (Fig. 1d) smoothing occurs on the upper part of the fractured end, the tip of which has been reduced by abrasion on a flat surface, creating a 3×2 mm facet (Fig. 1e–f; SI Fig. 10C5–C7; SI File 6). Tools with a blunt trihedral tip are present in the Mousterian bone industry of the Chagyrskaya Cave (Russia) but with a more convex facet (Baumann et al. 2020).

Among the smooth-ended tools, four specimens show small areas with impact scars, two of which were prepared by scraping, indicating that they were also briefly used in retouching flint edges (SI Fig. 11).

The two last tools (SI Fig. 12a, d) can be classified as awls (Camps-Fabrer 1966; Camps-Fabrer et al. 1990; Gates St-Pierre 2007; Legrand and Sidéra 2007; Legrand 2017). The first is a vestigial *Equus ferus* metapodial—a naturally pointed bone—whose distal tip was broken by bending, renewed by scraping, and smoothed by use on soft material (SI Fig. 12b). The second awl is fashioned from a *Rangifer tarandus* metapodial splinter, taking advantage of the thickness and straightness of the posterior lateral ridges of the bone. The conical, regular shape of the tip, as well as a group of striations on one side, are suggestive of intentional scraping (SI Fig. 12c).

Dating the bone tool assemblage

Figure 3 shows the calibrated radiocarbon dates for the six tools sent for radiocarbon dating (tools depicted in SI Fig. 4.1 and 4.3–7). SI Tables 3 and 4 provide additional details on the radiocarbon samples. Higham et al. (2014) estimate an end boundary for the latest European Mousterian in the range of 41,030–39,260 cal BP. The dates of three of the Lartet bone tools have 95.4% probability distributions excluding (i.e., older than) 42,000 cal BP, while the two samples for which a substantial portion of the probability distribution is less than 40,000 cal BP (i.e., OxA-40377 and OxA-39508) have been noted by the laboratory as likely minimum ages.

In terms of a more general assessment of the age of the Lartet level 2 deposits, the assemblage is strongly dominated by *Rangifer tarandus* with a "Ferrassie" facies lithic industry associated with a Quina type of retouch (Debénath and Duport 1987). In the Poitou–Charentes region, this pattern is most consistent with an occupation dating to the end of marine isotope stage (MIS) 5 or early MIS 4 (Morin et al., 2014). Although the age of the Lartet deposits requires further clarification, there is no evidence of early Upper Paleolithic occupations in the level 2 assemblage and the few Upper Paleolithic artifacts that have been identified are of Magdalenian age (SI 6), an episode inconsistent with the AMS dates reported in SI Table 3. For these reasons, the bone tools presented here can be confidently attributed to the Middle Paleolithic.

Discussion and conclusions

The objects described have a common general structure: the shaping of a smooth apical active end on an elongated bone blank obtained either by percussion or by the selection of an anatomical part with suitable morphology. The morphological diversity of active ends (pointed or beveled, axial or bent, thin or thick, wide or narrow) and smoothing (light or pronounced, angled or transverse, with or without facet) suggests that these tools were used in different ways. In total, taking into account one lost piece from the Lartet collection and the two awls, we have 5 tools that are compatible with skin working, rather in the confectioning phase than in the primary processing, a narrow chisel that would correspond better to the working of a wooden material, a possible digging stick, and two end-shaped tools whose function is not identified.

The abundant Neanderthal bone industry recently discovered at Chagyrskaya Cave (Russia)—dating to 60,000 BP—provides an example of a larger tool assemblage with significant functional diversity. It includes a majority of axial tools, shaped mainly by percussion, occasionally by abrasion and/or scraping (Baumann et al. 2020; SI Fig. 13). These tools fit well with the definition of expedient tools (Lyman 1984), but their modes of use (e.g., chisel, softener) have no equivalents in the lithic industry. This indicates that Neanderthals knew how to take advantage of specific properties of bone matter (e.g., impact resistance, length, adjustable sharpness, availability) and how to transform it, whatever the technique used, to obtain efficient tools, as also argued by Soressi et al. (2013). A few smooth-ended tools dating around 350,000 BP at the sites of Schöningen (Germany; Julien et al. 2015) and Castel di Guido (Italy; Villa et al. 2021) suggest that bone

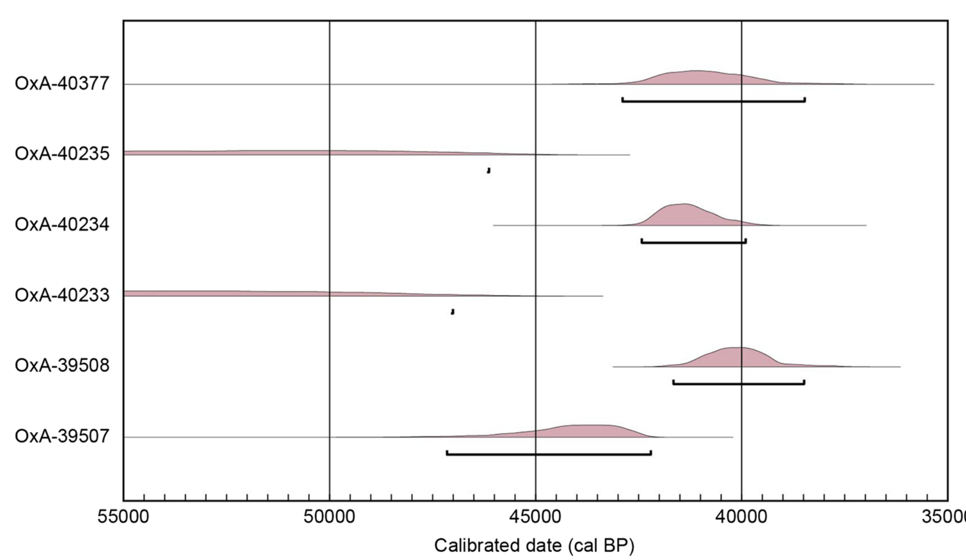

Fig. 3 Calibrated radiocarbon dates of Lartet bone tools (see SI Table 3 and SOM Table S3 for information on samples). Due to the small size of some of the samples and low collagen yields, none of the specimens was ultrafiltered (CAD: OxCal)

properties were probably already being exploited since the end of the Lower Paleolithic.

Abrasion is the simplest technique for removing sharp serrations that could accidentally pierce or tear a flexible material. Like scraping, used for thousands of years for woodworking (e.g., Thieme 1997; Claud et al. 2013; Gao et al. 2021), abrasion is not an innovation of the late Middle Paleolithic, as it seems to have been already used in the Lower Paleolithic to shape the active ends of bone tools (Backwell and d'Errico 2005). At the beginning of the Upper Paleolithic, scraping and abrasion became widely used techniques in the manufacture of new types of bone objects whose final functional form could not be achieved by percussion. However, at the same time, percussion was still involved in the production of blanks, some of which were used with minimal further shaping. This less visible facet of technical systems has only recently been documented (Tartar 2012; Baumann 2014; Christensen and Goutas 2018). The increasing evidence for the use of scraping and abrasion in the Middle Paleolithic and the persistence of percussion techniques in the Upper Paleolithic blurs some of the technological contrasts that have been emphasized between these periods and demonstrates that such techniques in themselves cannot be used to make cognitive distinctions between Neanderthals and anatomically modern humans.

The point here is not to erase differences between periods or human lineages, but rather to approach them from a view of material culture that goes beyond overlapping notions of "simple" vs. "complex", "expedient" vs. "formal", or "non-standardized" vs. "standardized", which, when it comes to bone, may be confused with tool-making techniques. Notable bone objects involving full shaping by scraping and abrasion that are absent from Middle Paleolithic assemblages are projectile points, ornaments, and figurines. These artifact categories represent the major rupture of the beginning of the Upper Paleolithic in hunting, social, and symbolic terms. The thinning and rounding of rib ends or other bone blanks is not in itself a cognitive issue.

The bone tools from the Abri Lartet, combined with other recent or more ancient discoveries, suggest a functional diversity in Neanderthal bone tool use that has yet to be more documented. Similar discrete bone tools are likely present in faunal assemblages from many Middle Paleolithic sites and their uncovering will shed new light on Neanderthal behaviors.

Supplementary Information The online version contains supplementary material available at https://doi.org/10.1007/s12520-022-01674-4.

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Author contribution ER and EM analyzed the faunal remains from Abri Lartet. MB and HP conducted the technological and traceological analysis, and NV and HC conducted the microtomographic imaging. ER prepared Fig. 3; MB and HP prepared Figs. 1–2, SI Figs. 1–13, and SI Files 1–6. MB processed microtomographic views, and HP made the optical photos of the macroscopic details. SM, MB, and HP conducted bone processing experiments. KK provided information on the Chagyrskaya material. All authors contributed to writing the main manuscript and reviewed the manuscript.

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Declarations

Conflict of interest The authors declare no competing interests.

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