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THE NEANDERTAL BONE INDUSTRY AT CHAGYRSKAYA CAVE, ALTAI REGION, RUSSIA

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ABSTRACT

For a long time, the rich bone industries of the Upper Palaeolithic were opposed to the opportunistic Neandertal bone tools among which the bone retoucher was the most common type. The recent finding of a few shaped bone tools into Mousterian contexts has been taken as an emergence of a "modern behaviour". However, this outlook is based on biased corpuses. On one side, the large number of unshaped bone tools recently discovered in Upper Palaeolithic assemblages leads us to reconsider what a bone industry can be. On the other side, the increasing discoveries of bone tools in more ancient contexts indicates that this type of production is not strictly linked to *Homo sapiens*. Chagyrskaya cave, located in the Siberian Altai, brings us the opportunity to discuss this question. Dated around 50,000 years BP, the site yielded a local facies of Mousterian lithic industry associated to several Neandertal remains. A technological and functional analysis of the faunal remains reveal more than one thousand bone tools. Most are retouchers, but a significant part belongs to other morpho-functional categories: intermediate tools, retouched tools and tools with a smoothed end. Even though these tools were mainly manufactured by direct percussion, their number and the recurrence of their morphological and traceological features lead us to consider them as a true bone industry. Far from the *Homo sapiens* standards, this industry has its own coherence that needs now to be understood.

KEYWORDS: Middle palaeolithic; Neandertal; Bone tool; Technology; Siberia

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1. Introduction

In Western Europe, the arrival of anatomically modern human and the disappearance of the last Neandertals, around 40,000 years BP, marked the transition from the Middle to the Upper Palaeolithic. It resulted in significant changes in the archaeological material cultures. Besides a different way of organizing the lithic production, anatomically modern Human (*Homo sapiens*) brought with him a great diversity of production attesting new practices. Objects made from bone materials, with the manufacture of ornaments, statuettes, musical instruments and hunting weapons, played a special role. Functional and social specialization was clearly expressed through a thorough shaping resulting in types that are today intelligible to us. In contrast, the absence of bone shaped artefacts in the Middle Palaeolithic assemblages led to the idea that other hominines, including Neandertal, did not produce a bone industry and that this deficiency was probably due to a cognitive difference between species. Bone industry is seen by many authors as a trait of the "behavioural modernity" (Mellars, 1989; Klein, 1995; Bar-Yosef, 2002; D'Errico, 2003; Henshilwood and Marean, 2003; Zilhao, 2007).

At the beginning of the 20th century, Dr. Henri-Martin highlighted, in the Mousterian levels of La Quina site (Charentes, France), the systematic use of bone flakes for flint shaping (Henri-Martin, 1906). However, despite the frequency of these "*retouchoirs*" in the Middle Palaeolithic assemblages (for a synthesis of Western European bibliographic references, see Costamagno et al., 2018, for Eastern Europe see in particular Bonc-Osmolovskij, 1940; Gvozdover and Formozov, 1960; Selinskij, 1983; Filippov and Lûbin, 1994; Khlopachev, 2013), they are usually considered as the result of an opportunistic use of bone fragments. This feeling is based on the lack of standardization of the blanks, their collection from alimentary waste and their production by percussion, a technique which is considered as being unsuitable for shaping bone material. Bone retouchers are not fully considered as being tools because they would reflect a lesser degree of conceptualization than Upper Palaeolithic implements. On La Quina site, as well as in Pech-de-l'Azé and Abri Peryony (Dordogne, France), 4 fragments of burnisher made from ribs are said to be the first Neandertal specialized bone tools (Soressi et al., 2013; Tartar and Costamagno, 2016), because of their morphological unity and the possible shaping by abrasion of their active end. The authors see, in this apparent shape control, the emergence of a modern behaviour. However, the small number of pieces is interpreted as the result of a punctual use of bone and prevents from speaking of industry. It is only in the Chatelperronian layer of Arcy-sur-Cure (Yonne, France, D'Errico et al., 2004) and, to a lesser extent, in Uluzzian sites of Italy (D'Errico et al., 2012), that the quantity of objects made from hard animal materials, their diversity, their standardization and their shaping techniques generate a consensus about the status of the assemblages. Although associated with Neandertal remains, the likelihood that these bone industries are the work of modern Human, or the result of his influence, remains a disputed topic (Peresani, 2008; Roussel and Soressi, 2014). In every case, the assessment of Neandertals' bone tools is always done with reference to those of modern Human, with the background of a paralleling of their respective cognitive abilities. But the comparison of some Neandertal pieces with the archetypal production of *Homo sapiens* is based on biased corpuses.

New analytical criteria and a more systematic application of use wear analyses gradually reveal, in the Upper Palaeolithic, categories of bone artefacts that were absent from the typological inventories. The case is particularly evident with the Solutrean assemblages (Baumann, 2014). They are famous for

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their foliated lithic points for which manufacturing required a high degree of expertise, and for their ivory ornaments. However, in the same time, they also included a bone industry that remained undetected because of minimal shaping and of debitage processes based on percussion technique (Baumann and Maury, 2013; Baumann, 2014; Baumann and Hinguant, 2016). Different types of tools had not been distinguished from the faunal remains, such as pressure flakers, which were essential for shaping lithic laurel leaves points, shouldered points and willow-leave blades. Once brought to light, they appear as typical markers of the period. A similar observation on the abundance of unshaped bone artefacts produced by percussion was done in the early Upper Palaeolithic (Tartar, 2012). Therefore, the recognition of a bone industry cannot be based on the shaping degree only nor on particular shaping techniques such as abrasion or scraping.

The presence, in Denisova Cave, of the oldest ornaments found in Eurasia, coupled with non-Sapiens hominin remains, in a pattern quite similar to that of the Chatelperronian layer of Arcy-sur-Cure, but with little bone industry, has led us to undertake there the same research than in the Solutrean assemblages. The scenario for the Middle to Upper Palaeolithic transition appears to be more complex in Altai than in the Western end of the continent, genetically and culturally. Three different human lineages were present in or near the foothills: the Denisovians, the Neandertals and the Anatomically Modern Humans. Anthropological remains (Krause et al., 2010) and DNA found in the sediments (Slon et al., 2017b) of Denisova cave show inter-stratifications between Neandertal and Denisovian occupations and the occurrence of hybridization between the two species (Slon et al., 2018). The cultural remains suggest a gradual evolution of the local industry towards the Upper Palaeolithic with the emergence, from 50,000 BP, of various ornaments in different materials as well as bone needles and awls. The application of our analytical frame to several stratigraphic units of the cave revealed in each of them diverse bone tools mainly produced by percussion (Baumann et al., 2017; Kozlikin et al., 2020). However, in this context, it was difficult to assign them to one of the hominines who lived in the cave, or, more precisely speaking, to distinguish what belonged to each of them and with which specificity if any?

A hundred kilometres from there, in the contemporary layers of Chagyrskaya Cave, which only yielded remains of Neandertals (Derevianko et al., 2018; Viola et al., 2012), along with a Mousterian lithic assemblage (Derevianko et al., 2018; Kolobova et al., in press), the discovery of numerous bone tools could be one element of the answer.

2. Archaeological context

Chagyrskaya Cave (Krasnoshchekovsky district, Altai Region, Russia, Fig. 1, B) is located on the left bank of the Charysh River valley, in the foothills area of the north-western part of the Altai mountains (Fig. 1, A). While the karst formations of this region have been the subject of academic reports since the 18th century, the Palaeolithic site of Chagyrskaya was discovered only in 2007 and is still under excavation. Twenty- two meters above the river, the cavity is open to the North and consists in two chambers with an area of about 130m2. The surveys, conducted over a depth of 3.6 m, show the succession of at least 7 stratigraphic units. Layers 1 to 4 are Holocene age deposits, while layers 5 to 7 are dated to the end of MIS4 beginning of MIS3. The archaeological assemblages were mainly collected in layer 6, which can be subdivided into 4 sub-layers (6a, 6b, 6c1 and 6c2). The paleontological studies conducted on these assemblages tend to show that bones from sub-layer 6a is primarily the result of

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accumulation by carnivores (Derevianko et al., 2018).

The C14 dating made on bison bones give infinite dates that place layers 5 and 6 in a chronological range older than 49,000 ka BP. They were completed by series of optical dating of the sediments that place the anthropic occupations of layer 6 between 47,000 and 59,000 ka BP. Layer 7, much older, would mark the transition from MIS 9 to 8 (Derevianko et al., 2018).

The material found in the Pleistocene layers is very homogeneous. Pebbles were used as raw material for producing lithic assemblage (Zasurye jasper, porphyrite, fine-grain sandstone, and hornstone) collected in the river near the cave (Derevianko et al., 2015). The primary knapping focused on radial and orthogonal technology, aimed to flake production. Convergent and simple side scrapers as well as retouched points largely predominate in the assemblage. Technologically and typologically significant part of the tool kit are plano-convex and plano-convex alternate bifacial tools (Kolobova et al., 2019). The lithic assemblage from Chagyrskaya cave in frame of Siberian Altai is only similar to the assemblage from Okladnikova Cave; that both make up regional Sybiryachikha Middle Palaeolithic variant (Derevianko et al., 2013, 2018). The fauna includes nearly 37 mammalian taxa as well as fish, bird and amphibian. The large mammals of layer 5 are mainly represented by the genus capra and Ovis and seem to have been accumulated by carnivores, in particular by hyena (*C. Crocuta spelaea*) who used the cave as a den. In layer 6, bison (*Bison priscus*) bones, with traces of human consumption, are dominant, followed by yanghir (*Capra sibirica*), argali (*Ovis ammon*) and equids (including *Equus ovodovi*). The wolf (*Canis Lupus*), the fox (*Vulpes vulpes*), the hyena (*C. Crocuta spelaea*) and the mammoth (*Mammuthus primigenius*) are always present. The faunal spectrum, in combination with palynological analyses, refers to a rather arid and cold climate where the steppe dominated, but where forest patches including dark coniferous trees and Siberian pines, may have been persisting along the river (Vasiliev, 2013; Rudaya et al., 2017; Derevianko et al., 2018).

The numerous human remains, probably belonging to several adults and children, found almost exclusively in the horizons of layer 6, are attributed only to Neandertal (Viola et al., 2012; Mednikova, 2013; Derevianko et al., 2018, Fig. 1, C).

3. Material and method

Samples come from the sorting out of the whole faunal assemblages (about 200,000) from the 10 years excavation (campaigns 2008 to 2018), stored at the Institute of Archaeology and Ethnography (SB RAS) in Novosibirsk (Siberia, Russia). For the present study, a representative 780 pieces coming from the 1083 bone tool assemblage were selected. The collection was examined with the naked eye and then with a stereoscopic microscope (Nikon SMZ-1). Systematic photographic recording was performed with Canon EOS 1000D and 100D SLR cameras and a Canon EF-S 60 mm macro objective. We also carried out a preliminary micro-traceological examination of some samples through acetate casts by using an Olympus BHM metallographic microscope with LM PLan FL 5, 10x and 20X objective and DIC prisms. Photomicrographs were taken with a Canon 1100D SLR camera.

Three categories of features have been distinguished: taphonomic traces, technical traces from flaking and shaping, use-wear traces. With the help of the criteria outlined in the literature (see in particular Turner, 1983; Behrensmeyer, 1978; Villa and Mahieu, 1991; Lyman, 1994; Fisher, 1995; Behrensmeyer et al., 1986; Fernandez-Jalvo and Andrews, 2016) we looked for post-depositional organic

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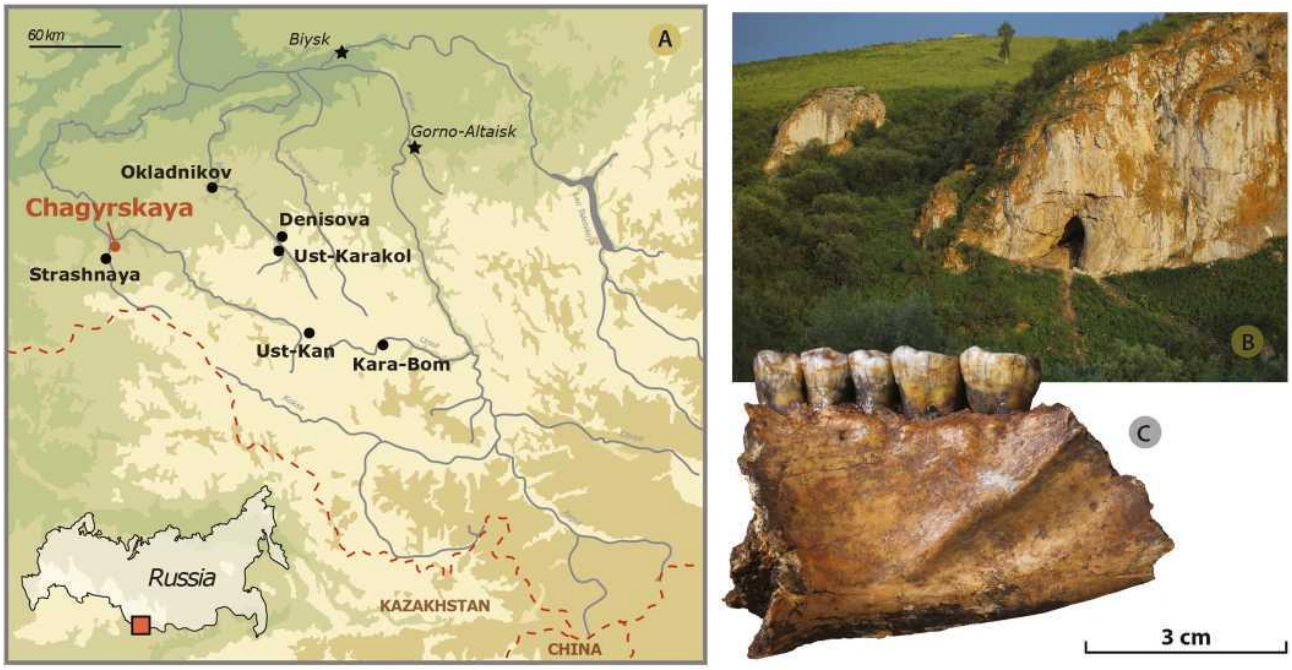
(microorganism, animals, plants) and inorganic (weathering, sedimentary compaction, run-off, etc.) modifications, resulting in dissolution, cracking, striations, erosion, disintegration, vermiculation, concretions. We paid a close attention to the origin of fragmentation, in particular for distinguishing anthropic fracturing from that produced by carnivores (Blumenshine and Selvaggio, 1991; Blumenshine, 1996; Villa and Bartram, 1996; Villa et al., 2004; Fourvel, 2012).

Figure 1. *Chagyrskaya cave. A - Geographical location (DAO M. Baumann); B - View of the cave entrance (photo S.I. Zelenkii); C - Neandertal Mandible (photo H. Plisson).*



The technological analysis of the anthropic fracturing relies on the presence of cortical flakes among the faunal remains and by percussion marks and notches from direct percussion on the bones. The morphology of the fracture facets with smooth surface, curved or V-shaped outline, oblique angle, evidence a percussion made on fresh bones (Blumenshine and Selvaggio, 1988; Brugal and Defleur, 1989; Villa and Mahieu, 1991; Outram, 2002; Pickering and Egeland, 2006; Galan et al., 2009). Both technological and use-wear traces observations were compared to archaeological and experimental published referentials (Semenov, 1957; 1964; Villa and d'Errico, 2001; Vincent, 1985, 1993; Ettos, 1985; Averbouh and Provenzano, 1999; Liolios, 1999; Maigrot, 2003; Rigaud, 2007; Tartar, 2009; Mozota, 2012; Baumann, 2014) and completed by ongoing experiments on unshaped and formal bone tools production and use. We carried out experimentations on bone retouchers, intermediate tools and retouched tools. We have also started an experimental program on hide working and other tasks that can macroscopically dull bone tools edges, in order to supplement common knowledge. The functional characteristics of the bone retouchers are already largely exposed in previous studies (e. g. Huston et al., 2018), while our results, concerning specific issues, will be delivered in a related article. The low referential available for the bone intermediate and retouched tools required significant investments. Here are partially exploited results obtained on these two categories over three years within a collective French-Russian program, including bone and lithic (flintknappers) specialists.

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4. Results

4.1. STATE OF PRESERVATION

Several types of modifications have been identified among the faunal remains. The most important are traces of consumption by carnivores, Wolf (*Canis lupus*) and Hyenas (*C. crocuta spelaea*), i.e. punctures and pits from teeth impacts, fractures scars/scooping out of matter, coring and furrowing from the friction of the teeth, smoothing from ingestion with a dimpled aspect or a shiny surface (Campas and Beauval, 2008; Fourvel, 2012). Bones fragments attacked by acid corrosion, which are strongly dulled and dimpled, are concentrated in layers 5 and 6a. Their rate decreases in layers 6b and 6c, while in the same layers cut marks frequency can reach 30%. Traces of vermiculation, less frequent, are found mainly on Holocene bones, except at the entrance of the cave where they also affect the pieces in layers 6a and 6b (Derevianko et al., 2018). The objects of the corpus under study can be regarded as relatively well preserved. However, their technological and traceological reading was partly limited by a desiccation of the material which induced a longitudinal fragmentation of the pieces, with post-depositional breaks affecting about 30% of the corpus, and more rarely a transverse disintegration, leading to a deformation of the volumes or a desquamation of the outer layers. Manganese oxide deposits are found on almost all pieces of the corpus but do not interfere with the reading of surfaces.

4.2. PROVENANCE OF THE BLANKS

The anatomical parts and taxa used for the bone toolkit are not diversified. These are mainly long bone diaphysis (83.2%) and flat bone (16.2%) of medium (16.1%) and large (82.9%) mammals. Among the long bones, the tibias, humerus and femurs of Bison (*Bison priscus*), and more rarely Equidae, have been preferred. Flat bone blanks are mainly ribs, which are more difficult to attribute to a taxon. The site also contains rare tool fragments on Mammoth ivory, a piece made from a long bone of Rhinoceros and one from a brow tine of a red-deer antler (*Cervus elaphus*).

On the site of Chagyrskaya, the single breaking technique identified is direct percussion. In an anthropic assemblage, the breaking of long bones is quasi invariably part of the food consumption process for marrow extraction. Therefore, the obtainment of bone blanks for technical purposes is generally seen as a recuperation of flakes among the butchering wastes (Tartar, 2012). In Chagyrskaya, the gathering of the blanks from the faunal remains is all the more conceivable as the site seems to have been used for the processing and consumption of bison carcasses. The bone material is very abundant. However, this collection was not necessarily opportunistic. In the Mousterian site of Les Pradelles, the repeated use of certain parts of the long bones led to the assumption that this could correspond to a selection of tool blanks at the time of butchering. The stock thus built up could have been consumed as and when required (Costamagno et al., 2018). At Chagyrskaya, the anatomical selection of the blanks supports this idea (Kolobova et al. this volume).

4.3. BONE TOOLS CHARACTERISATION

Four categories of artefacts were distinguished according to the particular pattern of their presumed traces of use and their resemblance with tools identified in Upper Palaeolithic sites and in some Middle Palaeolithic ones according to similar traceological and/or morphological criteria: retouchers

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(N = 680), intermediate tools (N = 37), retouched or damaged flakes (N = 49) and blunt pieces (N = 14, Table 1, Fig. 2). These categories are not defined with the same accuracy. For what concerns the retouchers, we know both their cinematic and the task in which they were involved. They are light soft hammers for retouching lithic cutting edges. In the case of intermediate tools, the particular arrangement of the damage, at both ends, refers to a same operating mode. The tools are hammered on one end for splitting or cutting a material with the opposite end. The present lack of comparative base on intermediate bone tools prevents from identifying here the tasks carried out or the worked materials, i. e. from subcategorising this group. The third category groups all the bone flakes with lateral edge modification from use or retouch, whatever the presumed technical cause (active edge deterioration, shaping, adaptation to handling, etc.).

The fourth one is also heterogeneous since it includes pieces having in common a blunt end which cannot be attributed to natural weathering, but which could proceed from shaping and various uses. One piece may belong to several categories. In most cases, the retouched and the intermediate tools have also evidence of use as retouchers, in a former step of the blank when the chronology is discernible. More than 80% of these tools were found in layers 6B and 6C, with a particular concentration in the 6C1 horizon (Table 1).

Table 1 *- Distribution of Chagyrskaya bone tools by level.*

Type	Layer									Total
	2	3	5	6A	6B	6C1	6C2	7	Ind.	
Bone retouchers	1	-	16	58	185	**281**	98	8	33	**680**
Rounded tips	-	-	-	2	4	4	3	1	-	**14**
Retouched tools	-	-	2	8	15	16	7	1	-	**49**
Intermediate tools	-	-	1	3	14	10	4	3	2	**37**
Total	**1**		**19**	**71**	**218**	**311**	**112**	**13**	**35**	**780**

4.4. RETOUCHERS

Retouchers are the most common bone tools found in Palaeolithic assemblages. They have been present since the Lower Palaeolithic (Roberts and Parfitt, 1999; Langlois, 2004; Smith, 2013; Jéquier et al., 2012; Kolfschoten et al., 2015; Moigne et al., 2016), they are particularly frequent in the Middle Palaeolithic (see, in particular, Mallye et al., 2012; Jéquier et al., 2012; Mozota, 2012; Blasco et al., 2013; Abrams et al., 2014; Daujeard et al., 2014; Rosell et al., 2015; Rougier et al., 2016; Doyon et al., 2018; Mateo-Lomba et al., 2019) and last all over the Upper Palaeolithic (Armand and Delagnes, 1998; Patou-Mathis, 2002; Castel et al., 2003; Castel and Madelaine, 2003; Rigaud, 2007; Tartar, 2009, 2012). The oldest mention of these tools dates back to 1874 in France, when Daleau reported "anvil bones" in the Grotte des Fées (Daleau, 1883 in Patou-Mathis and Schwab, 2002). At a time when definition of bone

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industry was based on typology, retouchers were among the few tools identified by their traces of use. The absence of a recognizable shape led directly to their functional study, as soon as they were discovered, through ethnological comparisons and experiments. At the beginning of the 20th century, Henri-Martin proposed, on the basis of the samples from La Quina site (Charente, France), two methods of use: as a "mallet" or as an "anvil", i.e. as a hammer, for retouching lithic artefacts, or as a cutting support (Henri-Martin, 1906). Further functional studies confirmed the first hypothesis (see, in particular, Bonc-Osmolovskij, 1940; Semenov, 1964; Feustel, 1973; Rigaud, 1977, 2007; Vincent, 1988; Chase, 1990; Bourguignon, 2001; Schwab, 2009; Mozota, 2012; Mallye et al., 2012), also suggesting that some specimens may also have been used as pressure retouchers (Selinskij, 1983; Plisson, 1988) or for bladelets knapping (Tartar, 2012). If the function of the pieces seems being confirmed, the category of bone retouchers still forms a poorly differentiated group, because of the diversity of the blanks, but also of the uniformity of the impacts traces which does not let a priori observe significant differences between the assemblages. Although samples from teeth, antler or ivory exist, the vast majority of the retouchers are diaphyseal splinters, probably from bone breaking for marrow extraction. The traces of use are in the form of repeated impacts, that are more or less linear and parallel to each other, concentrated in a small area of the cortical side of the bone. Going further in the comparisons of the assemblages recurs a homogenization of the descriptions and nomenclature (Patou-Mathis and Schwab, 2002; Mallye et al., 2012). as well as the understanding of the role of these bone tools in the lithic production systems and, more broadly, their implication in the activities done in the sites (Costamagno et al., 2018).

A preliminary study carried out on 8 Chagyrskaya retouchers, from layers 6C1 and 6B (campaign 2012; Derevianko et al., 2018, p. 231-236), showed that they are long bone diaphysis fragments, having one to two impact areas, in different degrees of use. They probably have to be related to the thinning steps of the bifaces, whose removal has the characteristic stigmas of a soft percussion (ibid). Following this preliminary report, we undertook a systematic search for retouchers in the faunal remains. More than a thousand samples were found. This large quantity of tools, resulting from a well-defined chrono-cultural context, allows statistical analyses to be carried out, as initiated through a geometric-morphometric shape analysis, with the aim to highlight trends in the general morphology of the pieces and to detect possible processes of blank shaping. In this context, a random selection of 100 retouchers have been the subject of complete zooarchaeological, taphonomic and technological analyses (for a precise description see Kolobova et al. this volume). The results obtained on this first corpus can be partly transposed to the pieces included in this article.

While weathering is common on the assemblage, the advanced stages (3, 4 & 5; Behrensmeyer, 1978) are present only in 6 cases. The same number of remains were altered by carnivore activities (furrowing, punctures and pits). Root etchings are absent. Consequently, 87% of the remains present more than 50% of their cortical unmodified, allowing a direct observation of superficial marks. The blanks were mostly obtained from large ungulate remains (97%). 43 retouchers were identified at the specific level and were attributed to Bison (NISP = 32), Horse (NISP = 9), Capra sp. (NISP = 1) and Rhinoceros (NISP = 1). There is a strong bias in the skeletal part representation since 92% of the blanks were produced on long bones shaft: (Tibia NISP = 28; Humerus, NISP = 20; Femur, NISP = 11 Radio-ulna, NISP = 3; Metapodial, NISP = 3; Unidentified Long Bone, NISP = 27). Rib (NISP = 5), Scapula (NISP = 1) and a transversal process of a bison lumbar were also used. Among the 680 retouchers inventoried, it is also worth noting the occasional use of antler and ivory. Layer 6B gave a deer antler retoucher. It is an adult deer antler frontal tine broken by flexion at its base and used on its widest face. The three fragments of ivory retoucher are small, desquamated lamellae, whose contours and lower face are affected by recent breaks.

The upper surface with the use marks is also altered by a taphonomic dulling. It is therefore difficult to approximate the original size of the pieces. Ivory retouchers have also been reported in the Micoquian layer of the Kulna cave (layer 7) (Czech Republic; Neruda and LazniCkova-Galetova,2018). There, both complete samples are relatively large (L. = 12,53-5,7 cm and W. = 4,42-5,28 cm), which corresponds to the largest Chagyrskaya's bone specimens (see below), but thin (T. = 0.17-0,47 cm), close to the thickness values of the Chagyrskaya's ivory specimens (T. = 0,2-0.3 cm). Then, we can hypothesize that the ivory retouchers at Chagyrskaya were probably originally larger but not necessarily thicker, i.e. originally made from ivory lamellae and not from tusk segments. Either way, the introduction of ivory in the site could be anthropic. A few fragments of ivory and two long bones from adult mammoth, fractured fresh and without traces of consumption by carnivores, were found in the same layer (6B).

At least 28% of the retouchers are complete or sub-complete, that is to say, free of clear post-depositional or recent breaks, while 30% of the corpus is affected by at least one post-depositional break (transverse and/or longitudinal) and 14% is in a fragmentary state (multiple post- depositional and recent breaks). The remaining 27% appear to have been affected by a secondary fracturing, generally transversal, probably from use. For the complete samples, the lengths range from 4.4 cm to 13.3 cm (average 8.2 cm), the widths from 1.2 cm to 5.7 cm (average 3.2 cm) with compact bone tissue thicknesses between 0.3 cm and 1.3 cm (average 0.8 cm). There is no particular dimensional template. Neither the width/thickness ratio in the entire corpus shows a particular concentration of the dimensions (Fig. 3). Although long bison bones have been preferentially selected from the faunal remains, there is no visible size standardization.

More than half of the retouchers show scraping traces (Fig. 4, B). These traces are systematically covered by the impacts from use and cover the same area on the cortical face. The striations from scraping are oblique relatively to the main axis of the blank, are not numerous nor regular but well-marked. They do not therefore correspond to a phase of cleaning the periosteum or regularizing the bone surface, but rather to an action aimed at creating relief, probably for a better grip of the lithic edge on the bone. The configuration of the impact marks corresponds to what is classically observed on such tools (Fig. 4, C). These are linear impacts, more rarely "V" shaped or triangular, always transversal to the main axis of the bone flake (Fig. 4, A and E). The different forms of impacts can be found in the same active surface and are often combined with negatives of small chips removal (Fig. 4, D). The loss of matter does not depend only on the blow but also on the previous impacts that facilitate and/or limit its development. According to Mallye et al., (2012), the detachment of matter occurs when the bone is dry. The active areas are generally unique (located near one end of the blank) and not very dense. They would result from a single operation and a rather occasional use of the tool. This trend and the very large number of retouchers identified can be explained by the nature of the tasks carried out in Chagyrskaya. In situ butchery activities provide both an abundant quantity of bone (large stock of potential blanks that could likely become retouchers if needed) and at the same time require the frequent shaping and maintenance of lithic cutting edges for carcass processing, that can range from a few retouches to the complete shaping of the edge.

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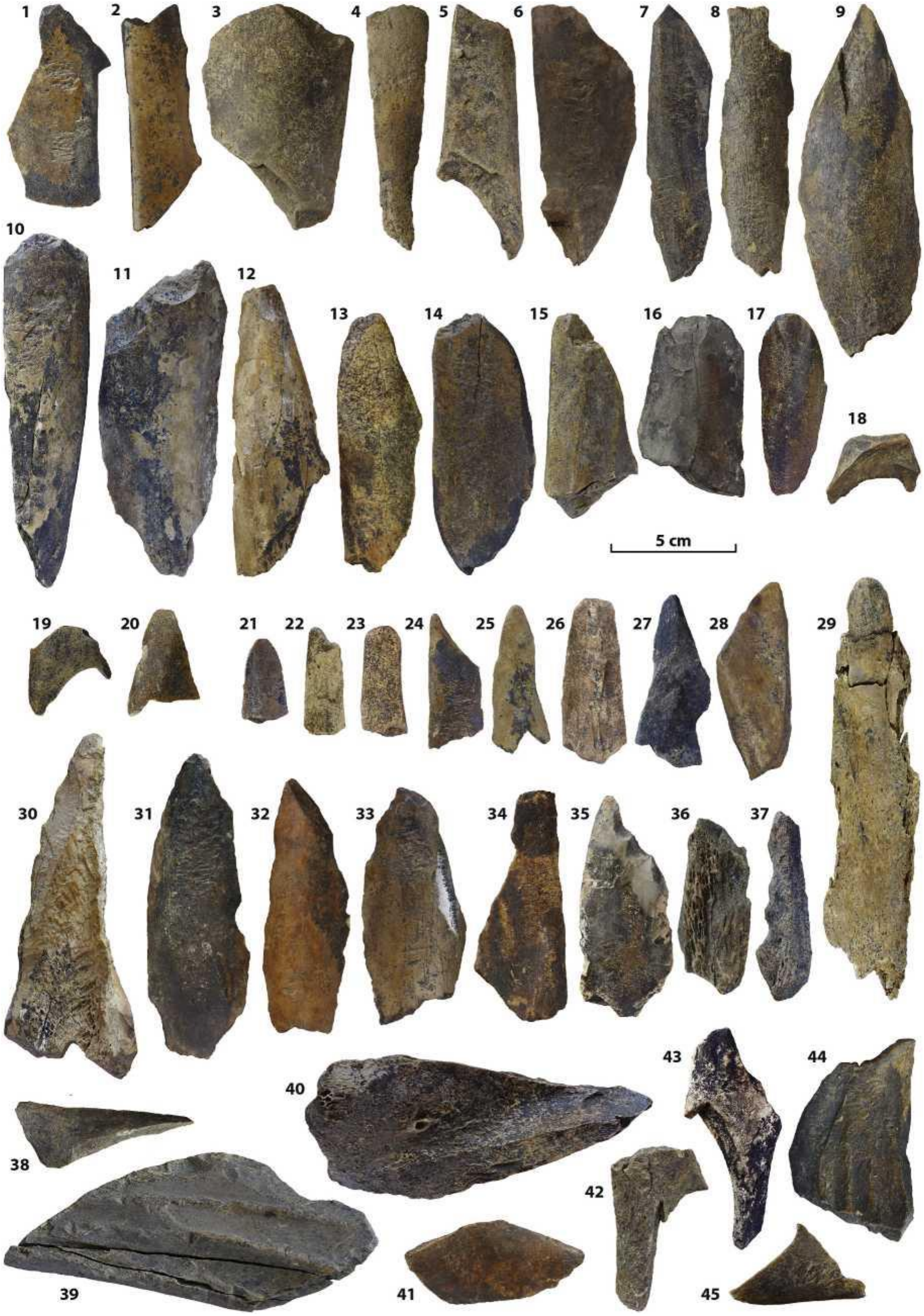
Figure 2. *Part of the bone industry found in Chagyrskaya, 2008-2018 excavations, 1 to 9, 19, 20, 38 and 45 - Retouchers, 10 to 18 and 42 - Intermediate tools; 21 to 29 - rounded tips; 30 to 37, 39, 41, 43 and 44 - Retouched tools (photos M. Baumann).*



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Several intermediate tools (N = 14), pieces with retouched edge tools (N = 34) and pieces with blunt tip (N = 5) have traces of use as retoucher. When it is possible to establish a chronology of the different phases of use, the impact areas of the retouchers appear to be cut by the end crushing of the intermediate tools, the retouch of the edges or the blunting of the tips. These retouchers no longer have their original morphology and dimension.

4.5. INTERMEDIATE TOOLS (N = 34)

The category of intermediate tools regroups pieces whose damages, at both ends, reflect the same operating mode. The tools are hammered on one end for splitting or cutting the worked material with the opposite end. In the Western Upper Palaeolithic, intermediate tools made from antler are better known than those made from bone. For now, the oldest occurrences were found in the early Aurignacian. They can be made with an expedient shaped half-antler beam of reindeer, such as in the Gravettian culture, or directly from a complete beam, such as in the Solutrean. They can also be made from sticks which are fully shaped and sometimes decorated, like in the Magdalenian (e. g. Deffarges et al., 1974; Camps-Fabrer et al., 1998; Legrand, 2000; Goutas, 2004; Braem, 2008; Tartar, 2009; Baumann, 2014; Malgarini, 2014; Lefebvre and Pétillon, 2018). For most authors, the choice of antler for this type of tool is directly related to the properties of the material. Having more collagen than bone, antler is more resistant to bending and longitudinal compressive stresses, i.e. more resistant to shocks (O'Connor, 1987; McGregor and Currey, 1983; Rajaram, 1986; Albrecht, 1977). The intermediate tool use wear characteristics have been established on this raw material. The hammered end is identified by the presence of an impacted surface where the bone fibres are compacted (Fig. 5, A). Hammering can also lead to the formation of a crushing flange around the edge of the impact surface (deformation of bone fibres, Rigaud, 1984) or to the removal of more or less invasive chips (rupture of bone fibres). The traces of use at the other end vary depending on the processed material. On the active part, frequently bevelled, compactions and removals (Fig. 5, B) are sometimes combined with striations of variable lengths that start from the front line or from the use wear polish (Provenzano, 1998). Surface analysis, experimental reconstructions and ethnographic comparisons have provided various functional hypotheses. Bevelled tools could be used for skin processing (Stordeur, 1980). They are also suitable for wood and antler working, splitting wedge, barker, chisel, etc. (Semenov, 1964; Rigaud, 1984; Camps-Fabrer et al., 1998; Provenzano, 1998).

Recently, more than a hundred of intermediate tools made from bones were found in several Early Aurignacian assemblages, such as Castanet, Gatzarria, Brassampouy, Isturitz, Tuto de Camalhot or Labeko Koba (Letourneux, 2005; Tartar, 2009, 2012).

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Figure 3. *Distribution of the cross-section modules (ratio width/thickness) of the retouchers, Chagyrskaya cave, 2008-2018 excavations.*

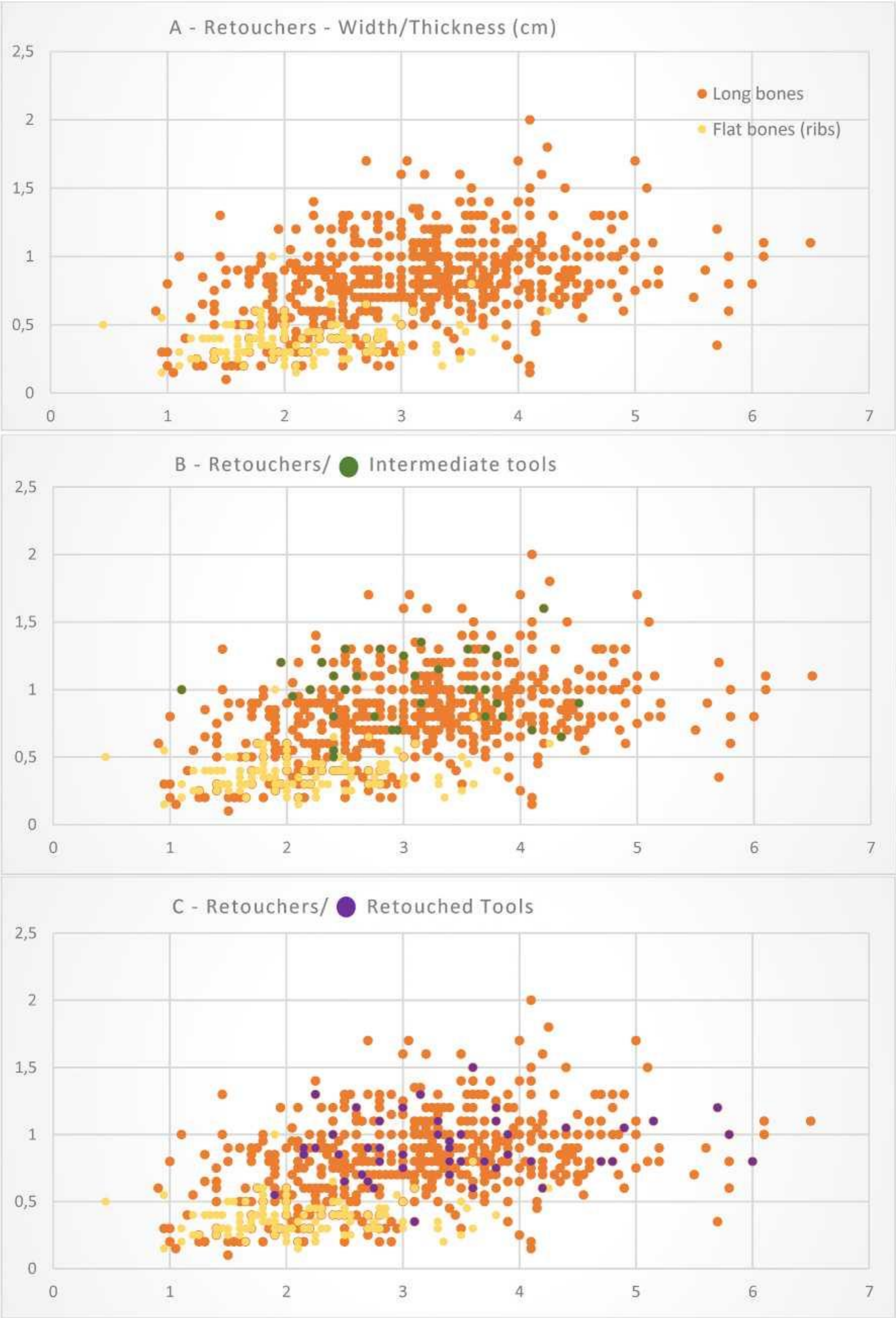

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Figure 4. *Retouchers, Chagyrskaya cave, 2008-2018 excavations; A - Retoucher with light impact marks, B - Scraping traces, C - Common orientation of the impact marks, D - Retoucher with hard impact marks (photos M. Baumann).*

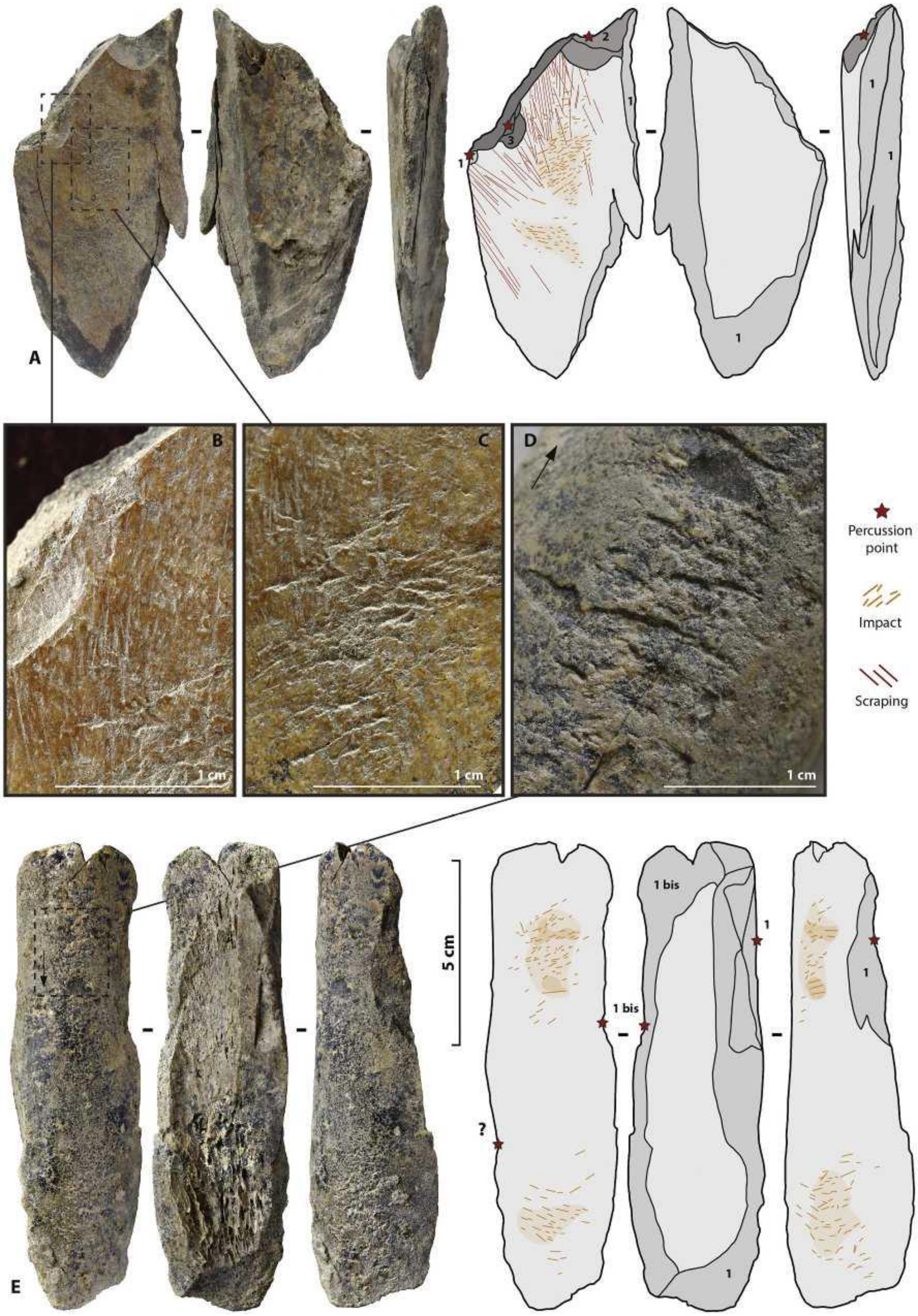

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Figure 5. *Archaeological and experimental referentials for the intermediate tools; A - Use-wear traces on the striking surface from an antler sample, Upper Palaeolithic, Malaya Siya site (Russia), B - Use-wear traces on the active part, from an antler sample, Upper Palaeolithic, Malaya Siya site (Russia), C - Experimental intermediate toll used for woodworking (Pinus Sylvestris; photos H. Plisson), D - Size reduction resulting from this task (photo M. Baumann).*

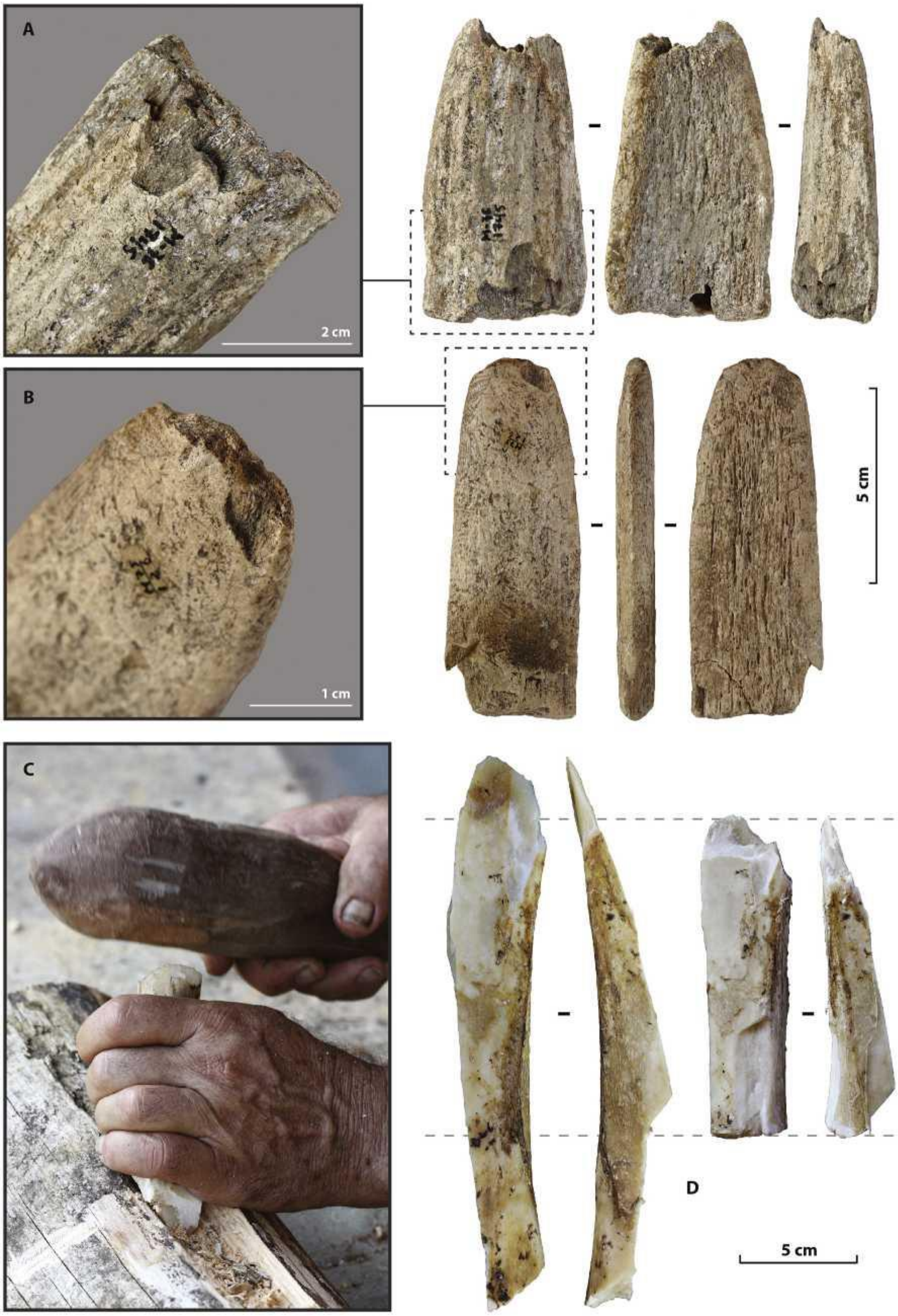

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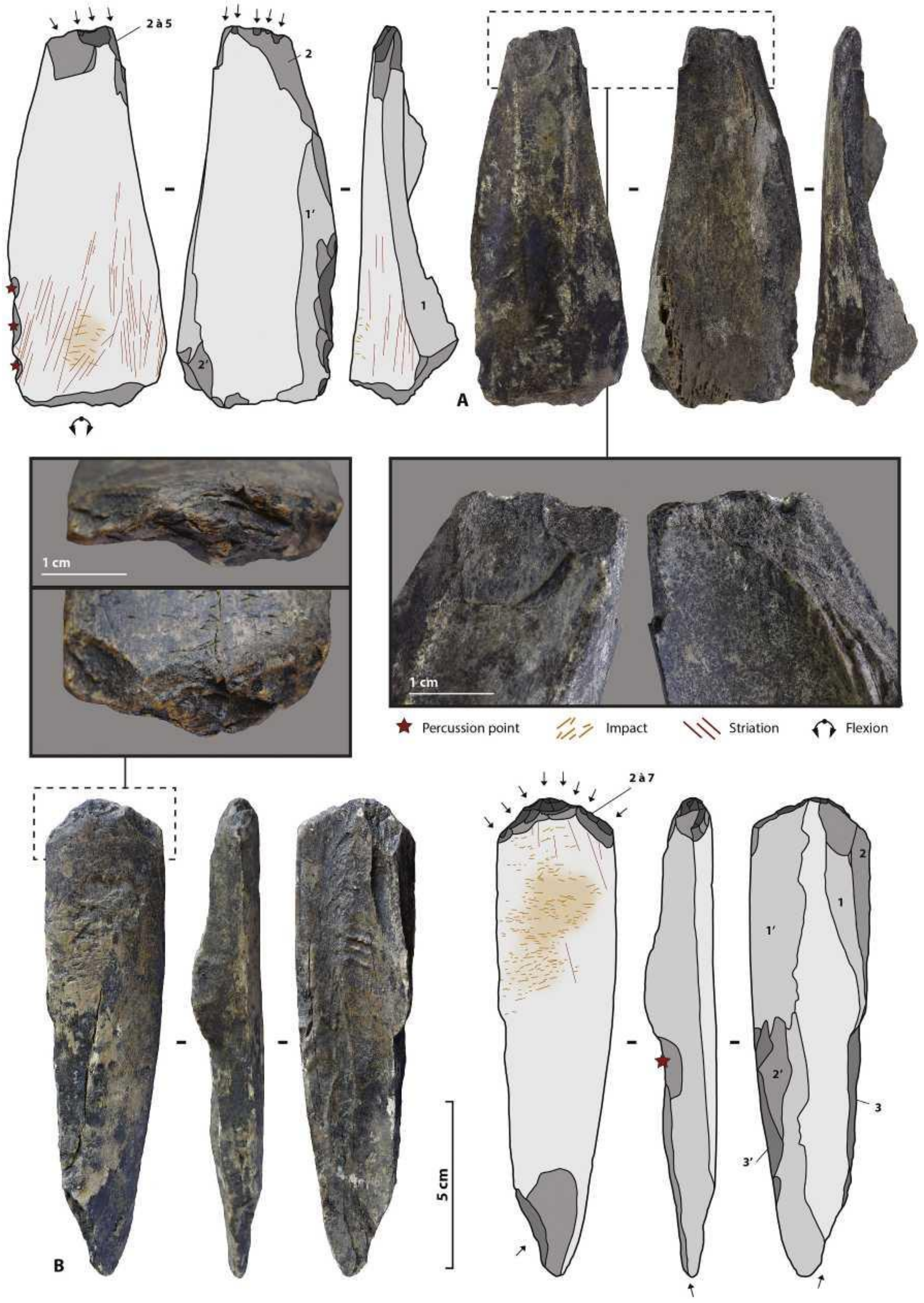
Figure 6. *Intermediate tools made from bone, Chagyrskaya cave, 2008-2018 excavations; A - Intermediate tool with straight and asymmetrical active end, B - Intermediate tool with convex and symmetrical active end (photos M. Baumann).*



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This is the largest known inventory yet, however, intermediate bone tools could be identified in other chronocultural assemblages with a targeted search for this type of piece in faunal remains, as seen in the Solutrean (Baumann et al., 2016). In addition, intermediate bone tools do not appear to be specific to the Upper Palaeolithic. Several samples may as well be present in the Lower Palaeolithic assemblage of Schoningen (Jequier et al., 2012). They also have been mentioned in late Mousterian sites, such as Gatzarria (Basque country, France, Tartar, 2012), Axlor (Bizkaia, Spain, Mozota, 2012), and Karabi Tamchin (Crimea, Ukraine, Burke and d'Errico, 2008). The traces of use are of the same nature than on antler, but the more mineralized bone tissue is more prone to fractures and to removals of splinters, particularly from the proximal part. Compactions and polishes are mentioned on Aurignacian specimens and on the sample from Karabi Tamchin. In all cases, it is the overlapping of several generations of removals on the same (longitudinal) axis that made possible to diagnose the use as intermediate tool.

All the pieces of our corpus are made from shaft fragments of large mammal long bones (bison/horse size). With an average width of 3 cm and an average thickness of 1 cm, they are among the largest bone tools of the site. Their dimensions correspond to the upper values of the retouchers (Fig. 3, B) but with a smaller dispersion of widths. Thus, intermediate tools are more elongated. Complete or sub-complete pieces have an average length of 11.3 cm, the longest specimen, proximally fractured, being 14 cm long. The distal ends (active part in contact with the worked material) are very often formed by the natural bevel at the intersection of the cortical face and of the fracture plane. In the case where the removals completely obliterate the initial shape of the active part, the latter is too slightly bevelled, sometimes symmetrically (more or less equivalent removals on both sides; Fig. 6, B), but most often with a pronounced asymmetry (the removals are preferably on the upper surface, Fig. 6, A). The morphology of this active edge varies according to the specimens, but it is possible to distinguish two types of ends: straight (cf. Fig. 6, B) and convex (cf. Fig. 6, A). An interrelationship seems to be emerging between large distal extremities and invasive removals, and between narrow extremities and less marked removals, probably due to the difference in resistance of the initial active edge. The identification of the proximal part is based on the presence of an impacted surface and/or of particularly large removals. In most of the cases, the percussion surface is absent. Nevertheless, the proximal ends then have transverse fractures in flexion, indicating a violent and sudden rupture of the bone fibres (in a fresh state; cf. Fig. 6, A). Two groups of fractures are distinct. The first includes transversal bending fractures. They are mainly located in the mesial part (based on the average length of the entire samples). The second group includes oblique and more or less curved fractures, which are then close to the distal end. In at least one case, the tool was reused after fracturing. All these fractures could result from accidental breaks during use. This is an additional indication of use as an intermediate tool that is subject to high compressive stresses. When the proximal parts are preserved, there are two cases: either the end is wide and relatively flat, with small chipping, or the end is narrow and pointed (cf. Fig. 6, B). This particular morphology is due to the presence of invasive oblique lateral fractures on both sides of the percussion surface. These remaining percussion areas are in alignment with the distal active zone. Two pieces of the corpus are chips detached from a percussion surface, with negatives of previous removals on their dorsal face.

Edge scars, although of very variable morphology, are the only use wear common to all the pieces. Compaction of the matter is frequent on the distal ends but more difficult to detect on the proximal

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ends, which are thicker and less subject to deformation. Analyses of the bone microstructure are being carried out on these pieces for assessing our interpretation and propose definite diagnostic criteria for the recognition of this type of action. Blunts are only present on the distal ends. They can affect the edges of the removal negatives or more rarely form an invasive area on the lower face of the tool. The latter is then without removal negatives. In addition to the type of activity performed with the tool and the material worked on, the development of wear, and more particularly the loss of material, must also be linked to the duration of use of the tool. In our experiments, the use of an unshaped diaphysis flake as an intermediary followed three steps. During the first step, the raw blank often presents fragile zones (thin edge thickness, inadequate angles, etc.) that will quickly deteriorate (Fig. 5, D), probably because the blank morphologies were not well adapted to the task. When the edge becomes stable, starts a second phase of alteration. The bone tissue no longer breaks but absorbs shocks. It then records deformations. The tool may then gradually deteriorate and lose the minimal qualities required for its efficiency. A third step could also be considered if we take into account that some invasive removals may be not from use but from rejuvenation. Retouch of bone blanks by direct percussion is not uncommon on the site (see the following paragraph). Finally, we have detected, on the archaeological samples, some isolated striations extending from the active front. The morphological diversity of the distal parts, as well as the variability of the removals and of the combination of traces, probably result from the diversity of tasks performed with these tools. Experiments are underway to create a larger referential framework taking into account the diversity of raw materials available in the site's environment during the prehistoric occupations.

4.6. RETOUCHED TOOLS

The oldest examples of retouched bone tools would be from Olduvai Gorge sites in East Africa, found in horizons dated between 1.8 and 1 Ma with the first industries of the Acheulean tradition. While the reality of the bone tools described by M. Leakey (1971), then partially confirmed by P. Shipman (Shipman and Phillips-Conroy,1977), is still under discussion, the recent reassessment of the collections by L. Backwell and F. d'Ettos (1985) confirms the presence of used artefacts but underlines the difficulty to differentiate them from the rest of the bone assemblage on the base of traceological criteria (Backwell and d'Errico, 2004). The « bifaces » (handaxes) made on diaphysis of large mammals, found in Italian (Castel di Guido, Fontana Ranuccio, Polledrara, Malagrotta, Casal de' Pazzi), German (Bilzingsleben) or Hungarian (Vertesszolos), are more widely accepted. Although in the sites the specimens are not numerous, the analogies of form and retouch between lithic and bone bifaces let little doubt about the bone ones (see in particular Zutovski and Barkai, 2016). Retouched bone tools have also been documented throughout the Middle Palaeolithic in very different environmental and anthropic contexts. In the Middle Stone Age of South Africa, in the site of Blombos (d'Errico and Henshilwood, 2007) or in Siberia, in the last mousteroid assemblages of Denisova cave (Kozlikin et al., 2020), a few pieces are present within a relatively rich and diversified bone industry. In the Mousterian assemblages of Western Europe, such as in Spain, on the sites of Gran Dolina, Bolomor (Rosell et al., 2015) and Axlor (Mozota, 2012), in France, on the sites of Vaufrey (Vincent, 1993), Combe-Grenal and La Ferrassie (Tartar and Costamagno, 2016), or again in Italy, on the site of Fumane (Romandini et al., 2014a), the few retouched pieces mentioned are found in assemblages where the only other identified bone tools are retouchers.

In the absence of an explicit shaping of the tool, uncertainty remains about the anthropic and

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intentional nature of the retouch. First, because other processes such as bone breaking for marrow procurement (see Pickering and Egeland, 2006) or bone consumption by carnivores (see Blumenshine and Selvaggio, 1991), can lead to the formation of removals that mimic retouch on bone edges. Secondly, because percussion is often considered as a technique that is not adapted to the shaping of bone materials. « L'artisan de ces périodes [Paléolithique moyen] n'a pas reconnu la nature spécifique de l'os [...] et a applique au support osseux des techniques empruntées au façonnage de la pierre; celles-ci parfaitement adaptées à la rigidité et à la cohesion du matériau lithique, sont plus ou moins inadéquates pour le travail d'une telle substance/The craftsman of these periods [Middle Palaeolithic] did not recognize the specific nature of bone [...] and applied to the bone blanks techniques borrowed from the shaping of stone; these techniques, perfectly adapted to the rigidity and cohesion of the lithic material, are more or less inadequate for the work of such a substance. » (Vincent, 1985, p.23). The idea of a transfer of techniques will also be proposed to explain the use of scraping at the beginning of Upper Palaeolithic, the techniques being, borrowed from wood working (Liolios, 2003). A causal link is implicitly established between the development of bone industries in the upper Palaeolithic and the systematic shaping by scraping or abrasion. Thus, for the previous periods, the absence or rarity of bone tools is ascribed to the absence of appropriate techniques for their shaping. The presupposition is often reinforced by the difficulty of experimentally mastering percussion on bone and antler (Allain et al., 1974; Liolios, 1999; Backwell and d'Errico, 2004; Tartar, 2009; Romandini et al., 2014).

In theory, however, the intrinsic characteristics of bone are suitable for such action. One third of the fresh bone consists of an organic matter made of a fundamental substance and of collagen fibres that give the material elastic and plastic properties. It can absorb energy by reversible deformation, fix residual permanent deformation, or break if the applied force exceeds its resistance. The oriented collagen fibers give the bone a lamellar structure, making it stronger in the longitudinal axis than in the perpendicular one. But at the same time, two thirds of the bone are made of a mineral component, hydroxyapatite microcrystals, oriented in the same direction as collagen fibres. In the Mohs rock hardness scale, apatite is between calcite and quartz. In each lamella, the orientation of the collagen/microcrystal fibres is more or less perpendicular to that of the adjacent lamella, structuring the material into a solid and relatively homogeneous grid (McGregor and Currey, 1983; Barone, 1986; Vincent, 1984; Maigrot, 1997). Bone therefore shares characteristics with hard materials of conchoidal fracture. Its percussion leads to the formation of a percussion cone below the contact point, sometimes with lancets and undulations (Fisher, 1995; Crabtree, 1972; Morlan, 1980; Villa and Bartram, 1996). However, it is to be expected that the pattern of marks on the bone will differ from the ones seen on flint, as we observe differences between obsidian and grainy quartz.

In practice, the assessment of a material's knapping suitability has to be based on experimental tests (Inizan et al., 1995). We therefore conducted a series of bone blank retouching tests according to the following methodological protocol: the experimental pieces were made on bone blanks from tibias, humerus, femurs, radius and metapods of adult cows aged 1-8 years (7 individuals), adult deer (2 individuals) and an adult equine. Several groups were made according to the relative freshness of the bones, mainly determined by the presence of fat, colour and degree of weathering. Our fresh bones (stage 0, cf. Behrensmeyer, 1978) are those obtained in butchery after slaughter of the animals, the driest bones (stage 5, cf. Behrensmeyer, 1978) are those of an equine animal recovered after several years' exposure to the open air (dry and cold environment). All the debitages were carried out in direct

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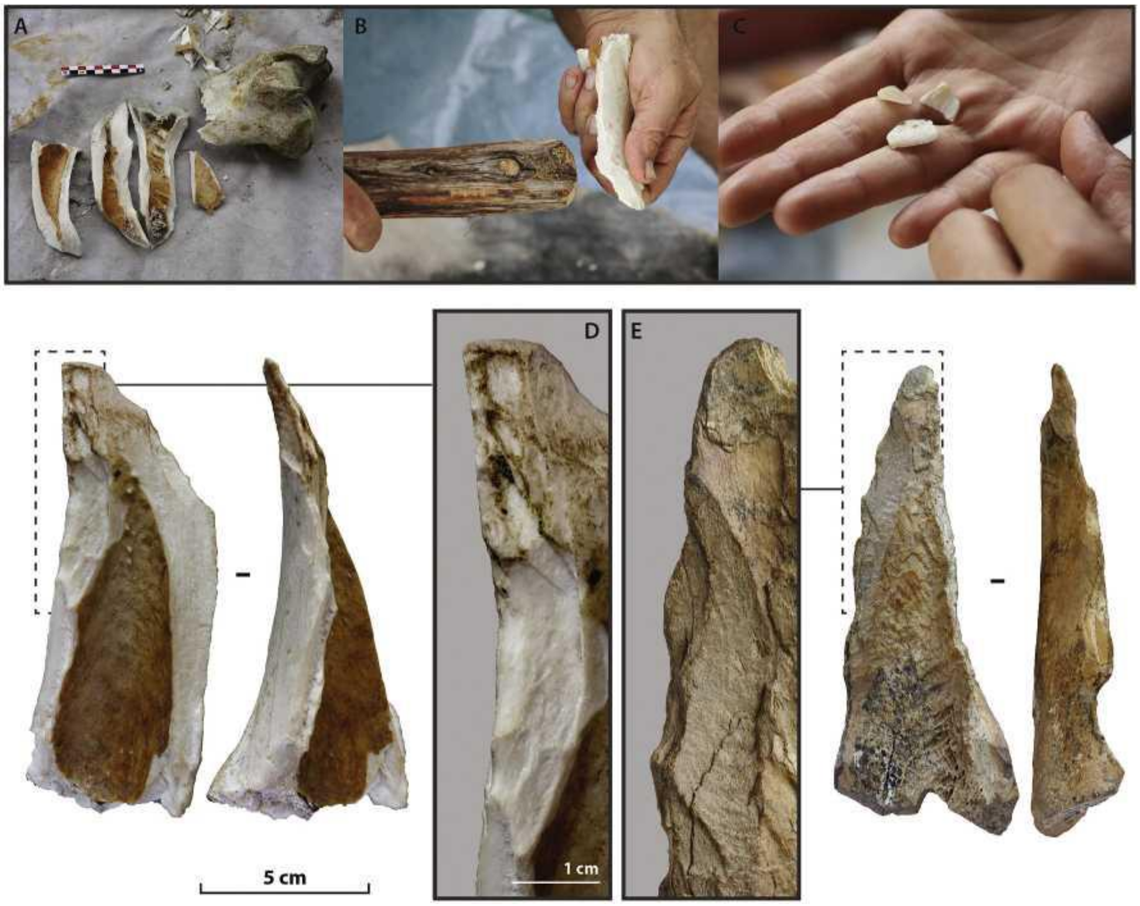
percussion with a hard hammer (pebbles from 1 to 1,5 kg) on anvil (Fig. 7, A). In each group, we have selected the blanks with the most favourable edge angles for knapping. The blanks were then retouched in direct percussion (Fig. 7B and C), by an experienced knapper (S. M.), with different types of hammers: soft organic (wood, antler), soft mineral (fine sandstone, limestone, schist) and hard mineral (quartzite). The objective of the retouch was to install a cutting edge, or to rectify the line of a natural cutting edge formed by the fracture. Depending on the configuration of the blank, the retouch was therefore unifacial or bifacial. The number of removals varied from one specimen to another.

Figure 7. *Experiments on bone knapping and archaeological comparisons, A - Debitage by direct percussion on anvil, B - Shaping by direct percussion with a soft hammer (wood), C - Small removals obtained by soft percussion (photos H. Plisson), D - Experimental sample, E - Corresponding archaeological sample (photos M. Baumann).*



According to our tests, we can say that bone responds favourably to knapping, under some conditions. All types of hammer can be used for retouching bone. However, they do not allow the same type of retouch. Hard mineral hammers tend to produce abrupt removals (short, deepening the matter). The soft hammers give a flatter and more invasive retouch of scaly morphology (Fig. 7, D). The state of the matter, on the other hand, plays an important role in the control of the removals. Unlike lithic materials, bone evolves over time. After the animal's death, it gradually and in a non-homogeneous way loses its organic mass through internal cell death mechanisms and external exchange with the environment. The propagation of the shock wave depends on the homogeneity of the material. In a

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heterogeneous material, the morphology and extent of retouches is more difficult to control. To a certain extent, a completely dry bone, therefore homogeneous again, recovers its knapping qualities. In all cases, bone knapping responds to physical laws that should allow regularities to be observed. While not all the marks from intentional knapping are defined, not always readable and are sometimes ambiguous, the pattern of removals on the bone blank remains, in our opinion, a key element for the identification of the pieces.

At least 49 retouched tools are identified at Chagyrskaya. Like the intermediate tools, they were made on large ungulates remains (bison/ horse size). The pieces have an average length of 8.6 cm. The retouched tools are shorter than the intermediate tools. The average length of the retouchers is equivalent, however the largest specimens are significantly longer (up to 21.5 cm) than the retouched ones (up to 13.8 cm). The width-thickness ratios of the retouched tools cover the high part of those of the retouchers, but only on the highest widths (Fig. 3, C). In other words, blanks used for the retouched tools are among the thickest, the widest and the shortest of the collection (except the disparate category of the artefacts with rounded tip).

When the retouches are not cut by a fracture, they cover from one- third to three-quarters of the blank periphery. They are preferably located on one side, extend to one end and sometimes extend to the opposite side. They form a slightly convex line on the mesio-distal part of the tool (Fig. 8, n° 1 et 4). They are almost always bifacial, but with a noticeable difference between the upper and lower faces. On the medullar side, the retouches are rather invasive, flat and scalariformous (Fig. 8, n° 3). On the cortical side, they are less numerous and more likely to be discontinuous. They are also shorter and steeper, except when they are at the distal end where they become flatter and more extensive. The morphological difference between the retouches on the upper and lower faces could be partly imputed to the structure of the raw material. The cortical surface, which is naturally convex, provides a less favourable angle, or at least does not allow flat retouch. Conversely, at the distal end, in the main axis of the blank, the curvature disappears and the propagation of the shock wave is facilitated by the longitudinal orientation of the bone fibres. Overall, overlapping is frequent and it is possible to count up to 4 generations of removals (Fig. 8, n^2 et 3). Dulling and edge damage of several pieces (cf. Fig. 8, n° 3) suggest their use as knives (it should be noted that at least one unretouched blank has the same type of wear on one edge). This leads us to consider that the retouches may be intended to shape or rejuvenate cutting edges.

Nearly 70% of the retouched tools were also retouchers. When the chronology can be established, the retouch appears always posterior to impacts. In 20% of cases, axial removals could result from use as intermediate tool, but in the current state of our research, it is difficult here to differentiate between removals from shaping and removals from use, moreover when both types are likely to be on the same edge. On at least two specimens, a notch seems to have been made near or in continuity with the retouched edge (cf. Fig. 8, n° 1). Lastly, a retouched piece with a flat blunted end is very similar to a pressure tool (see below). Retouched specimens are a good illustration of multiple sequential uses of the bone blanks on the site, what means to consider the management of these blanks over time and reinforces the idea of a stock of the most suitable samples (the largest ones?) as proposed in the Mousterian site of Les Pradelles (Costamagno et al., 2018).

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4.7. ROUNDED TIPS

This fourth category in our inventory is not surprising since bone awls and borers are frequent tools in Pre and Protohistoric assemblages. Even in recent periods, the natural morphology of particular bones was used without significant shaping, such as herbivorous ulna (Camps-Fabrer, 1990, fiche 5), which can make difficult the identification of this kind of tools among the faunal remains. Since we are dealing here with bone artefacts from pre-sapiens, i.e. mainly if not only produced by percussion, the main concerns are the criteria for establishing their consistency. As for the categories of the retouchers and of the intermediate tools, the main distinguishing feature here is a common type of use wear, not necessarily from a same task, localized on the same specific part of the artefact. The main difference is that natural agents can hardly mimic end crushing or tiny surface impacts whereas edge rounding is the most frequent bone alteration induced by various post depositional processes.

As any archaeological discipline, use wear analysis is based on actualist frames of reference (Plisson, 1991), which take into account the taphonomical parameters. Through the regularities observed in the causal relationship between effectors and effects, reading rules are proposed for deciphering features resulting from shaping, use, curation and alteration. The main criteria for differentiating edge rounding from use and edge rounding from natural agents are the extension, the localization, the orientation, the transition with the contiguous surface and the coupled features. Natural erosion or dissolution resulting in smoothing of the edges and surfaces is generally covering most part of the objects, if not all, while the use wear is restricted to the active edges or surfaces. Rounding resulting from hafting or handling can be more extended but it is always related to a particular part of the tool of suitable morphology, while friction from transport (bag, sleeve, etc.) is superficial and does not touch the concavities. The efficiency of tools relies on the control of the motion and working angle of the active edge, which induces the regularity of the use wear, its localization and its cinematic features, such as the striations. What distinguishes use striations is that they are not strictly parallel, due to very slight variations in handling during the repetitive action, and that part of them become more or less smoothed in course of the process. Conversely, post depositional striations are crisscrossed with a random distribution all over the surface, scratching the underneath gloss. The rounding's profile of the active edge (in cross section) depends on the motion and on the physical properties of the smoothing worked material, which can be organic or mineral, dry, fresh or wet, compact or grainy, from soft to very hard (e.g. flint pressure), while the maximal extend of this rounding is fixed by the minimal acuteness necessary for getting the expected effect on the worked matter (e.g. Semenov, 1964; Plisson and Thesis, 1985; Peletier et Plisson, 1986; Plisson, 2007). For example, the hide deflesher and the hide softener have in common to operate on fresh/semi wet flexible hide, which gives a gradual transition of both rounding with the adjacent faces, but the former will never reach the same extension than the latter. When the raw hide is dry, the macro wear from scraping is faceted.

According to the criteria set out, we have retrieved from the faunal remains 14 tools with more or less visible smoothing of their tip. One of them (Fig. 9, A) is comparable to the *first specialized bone tool made by Neandertals in Europe* pointed out by Soressi & al. (2013) in Mousterian sites of South-Western France. It is a long fragment of rib of large ungulate (L = 16,3 cm, l. = 3,55 cm, Th. = 0,45 cm), with a blunt regular convex distal end (Fig. 9, B). From this end has been removed, on 1 cm, the internal hemi-side of the rib in order to free a single blade of compact bone. The symmetrical shape of the tip cannot have been obtained nor by breakage nor by use: the acute denticulation from breaking would not have been suitable for working a dulling material till getting such a regular convexity.

Figure 8. *Retouched tools, Chagyrskaya cave, 2008-2018 excavations, 1 - Complete tool with mesio-distal and bifacial retouches covering one-third of the blank periphery and with a mesial notch, 2 et 3 - Mesial fragments with a bifacial retouched edge, 4 - Mesio-distal fragment similar to the complete one (n 1), but less retouched, A and D - Differences between the retouches on the upper and the lower side, B and C - Multi-generations of invasive retouches on the lower side (photos M. Baumann).*

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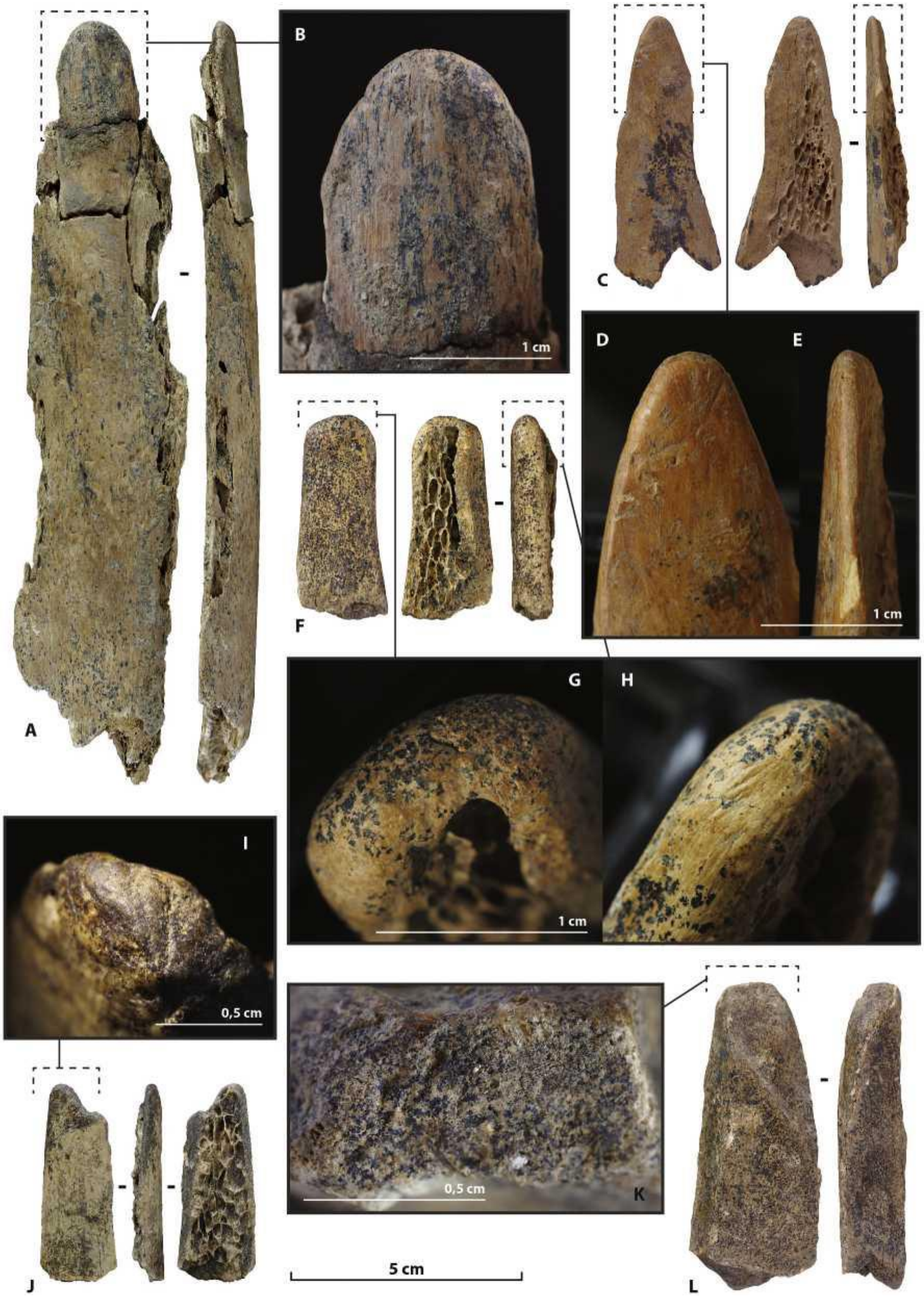
Figure 9. *Rounded tips, Chagyrskaya cave, 2008-2018 excavations, A, F and I - Samples made from ribs, C and L - Samples made from diaphysis, B - Blunt and regular distal end, D and E — Distal end with domed facets, G - Distal end with large front, H - Striations on the lateral edge, J - Distal end with transverse grooves, K - Large front with evidences of compaction, striation and incrustation negatives (photos H. Plisson).*



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Before use, the end was previously rectified by abrasion, which is experimentally in such case the most appropriate and simple shaping technique. The areas of slightly intersect striations on the external face confirm the deduction. While slightly smaller and with both hemi-sides, the closest sample in the inventory of Soressi & al is the *lissoir* AP-7839 from Abri Peyrony, not because it is the most complete, but because of its semi-circle active end. Their 3 other samples have an ogival end, like the Upper Palaeolithic examples used in the demonstration (op. cit. Fig. 4). There is also in Chagyrskaya assemblage a similar type of blunted tool, with convex converging edges. This one (Fig. 9, C) is not made from a rib but from an elongated fragment of diaphysis. Such as the previous one, it has been shaped by abrasion but with a harder abrader, resulting in 2 domed facets whose ridges are erased by the use-wear of the tip (Fig. 9D and E). A short fragment of rib (Fig. 9, F), from a bigger mammal, has a macro-rounding of a same convex outline than the one of the first tool, without a clear limit between the use-wear and the adjacent surfaces but with a larger front (Fig. 9, G). There are some longitudinal striations on its lateral edge, resulting probably from shaping (Fig. 9, H). Another remain (Fig. 9, L), made from a fragment of a large ungulate long bone shaft, has a heavy blunting but with a straight shape, evidence of compaction, deep striations and incrustation negatives (Fig. 9, K). Its lateral edge is carefully retouched.

A second subcategory includes fragments of shafts, but with a narrower tip looking more like borers. However, according to the profile of its apical rounding, which does not overlap with the lateral ridges, one (Fig. 9, J) does not look as resulting from a rotating motion; two transverse grooves slightly smoothed bar its tip (Fig. 9, I). The other one (Fig. 10, A) has a more complex history. Its blank was, in a previous step, used as a retoucher before the modification of the natural trihedral formed by an oblique fracture (Fig. 10, B). The reason for abrading a natural acute point is unclear but the rounded beak results from a mineral abrasion, which is not due to the sediments nor, on the main length, to the work of a soft stone. There has also a deep striation on its tip (Fig. 10, C).

A third subcategory consists of artefacts with more discreet and diversified tip rounding. Among them, one must consider a sample (Fig. 10, D), which has the same outline than the one shown Fig. 9, C, but without evidence of shaping. Its whole surface is shiny, a bite dull, such has a weathered artefact. However, a closer look at its tip reveals a tiny but typical slightly convex blunting from use on two secant axes: cutting the tip itself (Fig. 10, E) and along its adjacent left edge (Fig. 10, F). At a microscopic scale are visible transverse short striations such as on the front of flint scrapers used on dry hide (Fig. 10, G). A naturally ogival diaphysis fragment (Fig. 10, H), with a discrete dissymmetric rounding of its naturally ogival end fracture (Fig. 10, I), most likely belongs to the same functional group. Four micro borers are also worth mentioning, which have in common to be naturally acute splinters, but with two distinct types of tip smoothing: a micro abrasion (Fig. 10, J), or a very soft dulling of the tip crushing, (Fig. 10, L). The other samples are less explicit, like a knife or a chisel, on the active edge of which is a tiny dulling as the secondary feature of a use-wear from a cutting or a slicing action.

On the basis of experimental replicas, the samples of South-Western France are functionally interpreted as hide burnishers (Soressi et al., 2013), which is consistent with the general pattern of traces described and agreed by many authors for similar tools of later Palaeolithic and Mesolithic. If burnishing still today belongs to the final steps of traditional skin dressing, for making it "not only prettier but tougher and more impermeable" (Semenov, 1964, p. 178) it involves rubbing-pounding

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machines for complete skins, while different types or bone and wooden hand tools are still used by craftsmen and hobbyists for small objects and surfaces. However, the only morphological modern equivalent, such as the one shown in Fig. 4F (Soressi et al., 2013), is a bone folder for bookbinders, which means a finishing tool for meticulous craft. For the same task are also used spatulas with polished stone (aga te) tips. "Lissoirs" as the Palaeolithic ones are not reported in ethnographical tool-kits, nor in the handbooks of Indian tanning, at the difference of bone fleshers, either because they were made differently (e.g. eskimo soapstone burnishers), or because their use in the female sphere was not observable by male ethnographers. According to C.L. Steinhauer, museum inspector for the Danish Ethnographic Museum, mentioned by E. Lartet (1861), the Sami people in the XIXth Century were still using burnishers made from reindeer antlers for flattening felled seam. This is in accordance with the techniques learnt a century later by the French ethnologist Bernadette Robbe from Ammassalimiit women, the life of whom she shared during several stays up to a full year (personal communication). Three "lissoirs" of Chagyrskaya, one shaped (cf. Fig. 9, C), two unshaped (cf. Fig. 10, D and H), by their size, the morphology of their active end and their use wear, fit well with the evoked leather dressmaking technique. The functional status of the long sample made from a rib, with a convex front end (cf. Fig. 9, A) is less clear. The alteration of its surface is too pronounced for clearly distinguishing between the shaping and the use wear of its front. Nonetheless the general morphology of the rounding is compatible with a long scraping of a soft organic material, on a rather vertical position like a stretching stick. The narrowness of its active part is however more in accordance with a clothing or maintenance task than with the final step of hide tanning. Despite a less specific use wear, the 4 tiny borers (cf. Fig. 10, K) could complete the leather toolkit.

The two other heavily blunted samples do not belong to the same functional set. The one shown in Fig. 9F looks like the same type of tool than Fig. 9C, however there is no evidence of soft organic material rubbing. All the visible features on the front suggest contact only with a mineral matter, from shaping and possibly from use. Its top is compacted with some deep transversal scratches. As for Fig. 9L, there is no doubt about it, since its front is flat and compacted. Nor pseudo-borers Figs. 10A and 9J, whose blanks bear marks of previous use, have a blunt tip imputable to hide working. They may be raw from (re)shaping. However, Fig. 10A has the same features as Fig. 9F: compacted appearance of the tip with large scratch (photo). The closest comparisons for Fig. 9L are the Solutrean pressure flakers.

5. DISCUSSION AND CONCLUSION

The initial aim of the study was, on the basis of the Southern Western Solutrean experience (Baumann, 2014), to search for the existence of a substantial bone industry before the Upper Palaeolithic, i.e. before AMH expansion in northern territories of Eurasia. Altai region is a convenient context for such investigation, both because of a good preservation of the bone material, due to the low temperature of sediments in cave sites, and to the discovery, in the Middle - Upper Palaeolithic transitional layers of Denisova cave, of the oldest known symbolic bone artefacts along with some "formal" bone tools, in a background of other hominines than AMH. Several categories of ad hoc bone tools, made from shaft blanks, unshaped or rectified by percussion, were brought to light (Kozlikin et al. in 2020) in this cave. However, the complex stratigraphy and evidence for interstratified seasonal occupants, with Denisovan-Neandertal interbreeding, does not allow to ascertain who were the authors of such

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industry combining formal and unformal bone artefacts. The cultural and biological unicity of the Middle Palaeolithic layers of Chagyrskaya cave offered a more accurate context for enlarging the investigation, since bone retouchers were already known in this assemblage attributed to the Eastern Micoquian tradition (Derevianko et al., 2018; Kolobova et al., 2016). Former studies, in some Middle Palaeolithic sites in France, Spain, Italia, or Crimea, suggested that bone retouchers could be associated with other forms of bone tools, starting with the ones discovered by Dr. Henri Martin (Henri-Martin, 1907).

Neither these retouchers, nor the other type of bone tools described since then were seen as elements of a real industry, in the sense given to the lithic one, because of their shaping technique considered by scholars as inappropriate for working bone materials, by contrast with the production at the end of the Upper Palaeolithic, rich of a great diversity of ornamented objects involving a thorough carving. Such presumed inadequacy is often interpreted as the evidence of a technical cognitive deficiency: Neandertal and other hominines would not have been able to understand the specificity of hard organic matters. It sounds strange when considering the great skill put in shaping flint tools, which, in some Mousterian traditions, is at the level of the best achievements of Late Palaeolithic, not to say about the complexity of knapping concepts.

The shaping techniques for bone working inherent to the new types of tools introduced at the beginning of Upper Palaeolithic were requested by their functional design. What is relevant there is the complexification of weaponry, not the scraping or the abrading of organic matters which are performed since the lowest Palaeolithic (e.g. Keeley and Toth, 1981; d'Ettos, 1985).

Standardization and symbolic value are recurrently taken as indicator of the behavioural modernity (detailed list of traits in Henshilwood and Marean, 2003), the later requesting the former. In the case of bone artefacts, this has induced a mix-up between the raw material, the shaping techniques and the social function. The implicit reference to what a bone industry should be results from a specific social organization of AMH hunters-gatherers of Eurasia in a climatic and environmental context which disappeared at the end of Pleistocene. Afterward, most of the Holocene hunters-gatherers had a much simpler and monotonous use of bone materials than Gravettian or Magdalenian, and the same can be underlined about rock art. Such implicit reference is so deeply rooted that even in a critical review of the models used for characterizing modern behaviour, which points out that many of them are too much empirically derived from and context-specific to the European Upper Palaeolithic record, the absence of earlier bone industry is regarded as real: "(...) *it seems unlikely that these hominids did not recognize the potential utility of bone as a raw material A more likely explanation is that they frequently chose not to use bone, and our focus should be on why*" (Henshilwood and Marean, 2003, p. 633).

The inventory of Chagyrskaya provides another perspective: a bone industry, in which the shaping process is done by percussion and requires abrasion only for some actives edges. That seems to have been enough for getting efficient active parts. The diversity of functional types and the physical complementarity with lithic implements, in length, resistance to impact, elasticity, dullness (which goes hand in hand with a rapid convex shaping by abrasion, unlike lithic) or availability, prevents from speaking of casual tools. The long diaphysis blanks for intermediate tools have not equivalent in the lithic industry of Chagyrskaya. The active edges of leather dressing tools are similar to samples from Late Palaeolithic context, where they have no knapped lithic substitute, while the bone retouchers are

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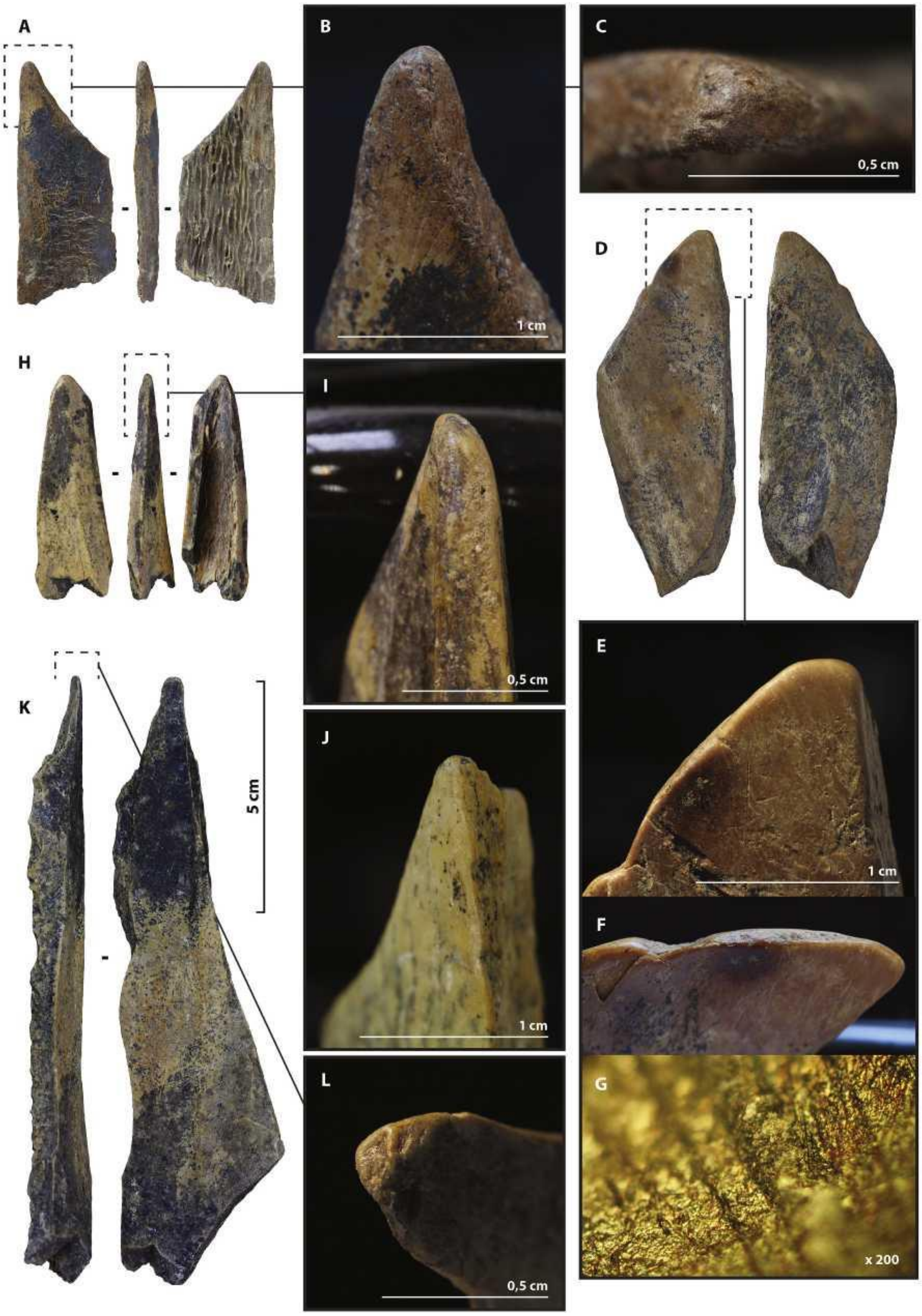
involved in on site lithic tool maintenance and probably shaping.

Figure 10. *Rounded tips, Chagyrskaya cave, 2008-2018 excavations, A - Reuse of a retoucher made from rib, B - Distal end formed by an oblique fracture, C - Distal end with a deep striation, D - Spatulate sample, E — Blunting on the distal end, F - Blunting on the lateral edge, G - Transverse striations on the lateral edge (photomicrography by the intermediary of an acetate cast, made possible by the excellent preservation of the bone tissue), H and K, Samples made from diaphysis, I- Distal end with a dissymmetric rounding, J - Borer with micro-abrasion, L - Dulling of the tip crushing, (photos H. Plisson).*



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Bone, as a tool material, is better known for its resistance to stress and impact and for its relative elasticity than for its sharpness. Its appropriateness for making regular, smooth edges is acknowledged since long, particularly in different steps of hide processing and leather dressing. Consequently, before starting experimental programs of manufacturing and use of Chagyrskaya implements, with bones from adult wild deer and domestic cow, we thought that bone edges from flaking were not as sharp and resistant as flint ones. We a priori considered them as a kind of ersatz. Their efficiency in wood working rapidly invalidated our presuppositions. We have to extend the empirical approach to butchering itself.

Hide processing by Neandertal was already evidenced in Russia by stone tools since the beginning of modern traceology (Semenov, 1964). The recent identification of Mousterian bone burnishers, from French sites (Soressi et al., 2013), shows that hide processing was, at least at the end of Middle Palaeolithic, a quite sophisticated process as was possibly dressing if we consider the smaller tools from Chagyrskaya and elsewhere the use of feathers (Romandini et al., 2014) and pigments (Soressi and d'Errico, 2007).

Chagyrskaya bone tools are the result of a non-complex and efficient technology. They are not so different from the Mousterian lithic ones which were produced, used and discarded in situ. Sophisticated knapping and/or shaping was specific to the category of itinerant stone artefacts, which, by their polyvalence, could meet different needs, some of them being alternatively core or tool (Boeda et al., 1990; Geneste, 1991; Slimak, 2008). Around Chagyrskaya, the good lithic material was rare. It has been dedicated to bifacial and deeply shaped artefacts, a part of which having been taken away. The first evidence of the use of bone material in mobile items did not occur before the early Upper Palaeolithic (Floss, 2015; Krivoshapkin et al., 2018; Fedorchenko et al. this volume, Belusova et al. in press) with the spear points and ornaments which were also the first ones to require an in depth shaping and the overcoming of the anatomical aspect of the blanks. Criteria are missing for identifying the geographical provenience of bones from common mammals in which artefacts were made. However, the design of bone tools in Chagyrskaya suggest that these were for immediate local use, except, may be, two small burnishers polished by long handling. There is evidence of bone blanks recycling, but not of the polymorphous structure that characterizes Mousterian itinerant technical objects. No element of composite weapon has been found so far in the Eurasian Middle Palaeolithic, except in a late and specific Mousterian facies of the Rhone Valley, called Neronian (Metz, 2017), which is not attributed to Neandertal (Slimak et al., 2019), while several samples of excellent javelin are known (Thieme, 1997; Schoch et al., 2015), made of wood only. Mousterian people didn't manufacture bone points, because they were simply not arming their spears. It is probably not the under-use of grinding which prevented them to make sustainable bone tools but the insufficient need for this shaping technique which maintained it marginal. Flint and mechanically similar stones were, by their structure and volume, more suitable than bone for the control by percussion of an evolutive structure, and consequently for "storing" different solutions in a same object. Grinding and scraping are relevant for shaping and maintaining a stable structure, i.d. monofunctional tools that leads to the interdependency of a greater number of distinct elements inside the technical system. The shift from flexibility to specialization is the one from the Middle to the Upper Palaeolithic, which did not occur only at a technical level. Adding symbolic features to utilitarian artefacts, or shaping specific items for an exclusive or a dominant symbolic purpose, was not a Mousterian concern. We can wonder whether one of the key differences between Middle and Upper Palaeolithic does not lie in the total absence of social interference in tool design. This is what G. Simondon (1958) called the technically pure object, that is, one that lacks any sign function, which in his view and that of other authors (e. g. Lemonnier, 1991) never can be with *Homo sapiens*, for whom even the most elementary action makes sense.

Meaningless objects resulting from flexible production schemes that prioritize output versatility are not the best candidates for typologists seeking standardization, who were already confused (e.g. Dibble, 1987), by the lack of clear categories inside the Mousterian lithic industry. The fact that the raw material, for bones stricto sensu, results from butchering didn't help either. This explains that the part of bone in Mousterian technology has been underestimated. We assume that the abundance and diversity of bone tools in Chagyrskaya is not a local singularity since some types of our inventory have already been mentioned in another Mousterian contexts. Our present objective is to go further in their functional identification by widening our experimental references and using analytical techniques that objectify the relevant criteria.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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