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1 Title

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3 The Neandertal bone industry at Chagyrskaya cave, Altai Region, Russia

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53 Abstract:

54

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

70

71 Key words: Middle Palaeolithic, Neandertal, Bone tool, Technology, Siberia.

72

73 1. Introduction

74

75 In Western Europe, the arrival of anatomically modern human and the disappearance of the last
76 Neandertals, around 40,000 years BP, marked the transition from the Middle to the Upper Palaeolithic.
77 It resulted in significant changes in the archaeological material cultures. Besides a different way of
78 organizing the lithic production, anatomically modern Human (*Homo sapiens*) brought with him a great
79 diversity of production attesting new practices. Objects made from bone materials, with the manufacture
80 of ornaments, statuettes, musical instruments and hunting weapons, played a special role. Functional
81 and social specialization was clearly expressed through a thorough shaping resulting in types that are
82 today intelligible to us. In contrast, the absence of bone shaped artefacts in the Middle Palaeolithic
83 assemblages led to the idea that other hominines, including Neandertal, did not produce a bone industry
84 and that this deficiency was probably due to a cognitive difference between species. Bone industry is
85 seen by many authors as a trait of the "behavioural modernity" (Mellars, 1989; Klein, 1995; Bar-Yosef,
86 2002; D’Errico, 2003; Henshilwood and Marean, 2003; Zilhão, 2007).

87

88 At the beginning of the 20th century, Dr. Henri-Martin highlighted, in the Mousterian levels of the Quina
89 site (Charentes, France), the systematic use of bone flakes for flint shaping (Henri-Martin, 1906).
90 However, despite the frequency of these "*retouchoirs*" in the Middle Palaeolithic assemblages (for a
91 synthesis of Western European bibliographic references, see Costamagno et al., 2018, for Eastern
92 Europe see in particular Bonch-Omoloskyi, 1940; Gvozdover and Formozov, 1960; Fillippov and Lûbin
93 1994; Klopachev, 2013), they are usually considered as the result of an opportunistic use of bone
94 fragments. This feeling is based on the lack of standardization of the blanks, their collection from
95 alimentary waste and their production by percussion, a technique which is considered as being
96 unsuitable for shaping bone material. Bone retouchers are not fully considered as being tools because
97 they would reflect a lesser degree of conceptualization than Upper Palaeolithic implements. On La
98 Quina site, as well as in Pech-de-l’Azé and Abri Peryony (Dordogne, France), 4 fragments of burnisher
99 made from ribs are said to be the first Neandertal specialized bone tools (Soressi et al., 2013; Tartar and
100 Costamagno, 2016), because of their morphological unity and the possible shaping by abrasion of their
101 active end. The authors see, in this apparent shape control, the emergence of a modern behaviour.
102 However, the small number of pieces is interpreted as the result of a punctual use of bone and prevents
103 from speaking of industry. It is only in the Chatelperronian layer of Arcy-sur-Cure (Yonne, France,

104 D'Errico et al., 2004) and, to a lesser extent, in Uluzzian sites of Italy (D'Errico et al., 2012), that the
105 quantity of objects made from hard animal materials, their diversity, their standardization and their
106 shaping techniques generate a consensus about the status of the assemblages. Although associated with
107 Neandertal remains, the likelihood that these bone industries are the work of modern Human, or the
108 result of his influence, remains a disputed topic (Peresani, 2008; Roussel and Soressi, 2014). In every
109 case, the assessment of Neandertals' bone tools is always done with reference to those of modern Human,
110 with the background of a paralleling of their respective cognitive abilities. But the comparison of some
111 Neandertal pieces with the archetypal production of *Homo sapiens* is based on biased corpuses.

112
113 New analytical criteria and a more systematic application of use wear analyses gradually reveal, in the
114 Upper Palaeolithic, categories of bone artefacts that were absent from the typological inventories. The
115 case is particularly evident with the Solutrean assemblages (Baumann, 2014). They are famous for their
116 foliated lithic points for which manufacturing required a high degree of expertise, and for their ivory
117 ornaments. However, in the same time, they also included a bone industry that remained undetected
118 because of minimal shaping and of debitage processes based on percussion technique (Baumann and
119 Maury, 2013; Baumann, 2014; Baumann and Hinguant, 2016). Different types of tools had not been
120 distinguished from the faunal remains, such as pressure flakers, which were essential for shaping lithic
121 laurel leaves points, shouldered points and willow-leave blades. Once brought to light, they appear as
122 typical markers of the period. A similar observation on the abundance of unshaped bone artefacts
123 produced by percussion was done in the early Upper Palaeolithic (Tartar, 2012). Therefore, the
124 recognition of a bone industry cannot be based on the shaping degree only nor on particular shaping
125 techniques such as abrasion or scraping.

126
127 The presence, in Denisova Cave, of the oldest ornaments found in Eurasia, coupled with non-Sapiens
128 hominin remains, in a pattern quite similar to that of the Chatelperronian layer of Arcy-sur-Cure, but
129 with little bone industry, has led us to undertake there the same research than in the Solutrean
130 assemblages. The scenario for the Middle to Upper Palaeolithic transition appears to be more complex
131 in Altai than in the Western end of the continent, genetically and culturally. Three different human
132 lineages were present in or near the foothills: the Denisovians, the Neandertals and the Anatomically
133 Modern Humans. Anthropological remains (Krause et al., 2010) and DNA found in the sediments (Slon
134 et al., 2017) of Denisova cave show inter-stratifications between Neandertal and Denisovian occupations
135 and the occurrence of hybridization between the two species (Slon et al., 2018). The cultural remains
136 suggest a gradual evolution of the local industry towards the Upper Palaeolithic with the emergence,
137 from 50,000 BP, of various ornaments in different materials as well as bone needles and awls. The
138 application of our analytical frame to several stratigraphic units of the cave revealed in each of them
139 diverse bone tools mainly produced by percussion (Baumann et al., 2017; Kozlikin et al., 2020).
140 However, in this context, it was difficult to assign them to one of the hominines who lived in the cave,
141 or, more precisely speaking, to distinguish what belonged to each of them and with which specificity if
142 any?

143
144 A hundred kilometres from there, in the contemporary layers of Chagyrskaya Cave, which only yielded
145 remains of Neandertals (Derevianko et al., 2018; Viola et al., 2012), along with a Mousterian lithic
146 assemblage (Derevianko et al., 2018; Kolobova et al., in press), the discovery of numerous bone tools
147 could be one element of the answer.

148 149 2. Archaeological context

150
151 Chagyrskaya Cave (Krasnoshchekovsky district, Altai Region, Russia, fig. 1, B) is located on the left
152 bank of the Charysh River valley, in the foothills area of the north-western part of the Altai mountains
153 (fig. 1, A). While the karst formations of this region have been the subject of academic reports since the
154 18th century, the Palaeolithic site of Chagyrskaya was discovered only in 2007 and is still under

155 excavation. Twenty-two meters above the river, the cavity is open to the North and consists in two
156 chambers with an area of about 130m². The surveys, conducted over a depth of 3.6 m, show the
157 succession of at least 7 stratigraphic units. Layers 1 to 4 are Holocene age deposits, while layers 5 to 7
158 are dated to the end of MIS4 beginning of MIS3. The archaeological assemblages were mainly collected
159 in layer 6, which can be subdivided into 4 sub-layers (6a, 6b, 6c1 and 6c2). The paleontological studies
160 conducted on these assemblages tend to show that bones from sub-layer 6a is primarily the result of
161 accumulation by carnivores (Derevianko et al., 2018).

162
163 The C14 dating made on bison bones give infinite dates that place layers 5 and 6 in a chronological
164 range older than 49,000 ka BP. They were completed by series of optical dating of the sediments that
165 place the anthropic occupations of layer 6 between 47,000 and 59,000 ka BP. Layer 7, much older,
166 would mark the transition from MIS 9 to 8 (Derevianko et al., 2018).

167
168 The material found in the Pleistocene layers is very homogeneous. Pebbles were used as raw material
169 for producing lithic assemblage (Zasurye jasper, porphyrite, fine-grain sandstone, and hornstone)
170 collected in the river near the cave (Derevianko et al., 2015). The primary knapping focused on radial
171 and orthogonal technology, aimed to flake production. Convergent and simple side scrapers as well as
172 retouched points largely predominate in the assemblage. Technologically and typologically significant
173 part of the tool kit are plano-convex and plano-convex alternate bifacial tools (Kolobova et al., 2019).
174 The lithic assemblage from Chagyrskaya cave in frame of Siberian Altai is only similar to the
175 assemblage from Okladnikova Cave; that both make up regional Sybiryachikha Middle Palaeolithic
176 variant (Derevianko et al. 2013, 2018). The fauna includes nearly 37 mammalian taxa as well as fish,
177 bird and amphibian. The large mammals of layer 5 are mainly represented by the genus capra and Ovis
178 and seem to have been accumulated by carnivores, in particular by hyena (*C. Crocuta spelaea*) who used
179 the cave as a den. In layer 6, bison (*Bison priscus*) bones, with traces of human consumption, are
180 dominant, followed by yanghir (*Capra sibirica*), argali (*Ovis ammon*) and equids (including *Equus*
181 *ovodovi*). The wolf (*Canis Lupus*), the fox (*Vulpes vulpes*), the hyena (*C. Crocuta spelaea*) and the
182 mammoth (*Mammuthus primigenius*) are always present. The faunal spectrum, in combination with
183 palynological analyses, refers to a rather arid and cold climate where the steppe dominated, but where
184 forest patches including dark coniferous trees and Siberian pines, may have been persisting along the
185 river (Vasiliev, 2013; Rudaya et al., 2017; Derevianko et al., 2018).

186
187 The numerous human remains, probably belonging to several adults and children, found almost
188 exclusively in the horizons of layer 6, are attributed only to Neandertal (Viola et al., 2012; Mednikova,
189 2013; Derevianko et al, 2018; fig. 1, C).

190
191 Figure 1

192 193 3. Material and method

194
195 Samples come from the sorting out of the whole faunal assemblages (about 200,000) from the 10 years
196 excavation (campaigns 2008 to 2018), stored at the Institute of Archaeology and Ethnography (SB RAS)
197 in Novosibirsk (Siberia, Russia). For the present study, a representative 780 pieces coming from the
198 1083 bone tool assemblage were selected. The collection was examined with the naked eye and then
199 with a stereoscopic microscope (Nikon SMZ-1). Systematic photographic recording was performed with
200 Canon EOS 1000D and 100D SLR cameras and a Canon EF-S 60 mm macro objective. We also carried
201 out a preliminary micro-traceological examination of some samples through acetate casts by using an
202 Olympus BHM metallographic microscope with LM PLan FL 5, 10 and 20X objective and DIC prisms.
203 Photomicrographs were taken with a Canon 1100D SLR camera.

204

205 Three categories of features have been distinguished: taphonomic traces, technical traces from flaking
206 and shaping, use-wear traces. With the help of the criteria outlined in the literature (see in particular
207 Turner, 1983; Behrensmeyer, 1978; Villa and Mahieu, 1991; Lyman, 1994; Fisher, 1995; Behrensmeyer
208 et al., 1986; Fernández-Jalvo and Andrews, 2016) we looked for post-depositional organic
209 (microorganism, animals, plants) and inorganic (weathering, sedimentary compaction, run-off, etc.)
210 modifications, resulting in dissolution, cracking, striations, erosion, disintegration, vermiculation,
211 concretions. We paid a close attention to the origin of fragmentation, in particular for distinguishing
212 anthropic fracturing from that produced by carnivores (Blumenshine and Selvaggio, 1991;
213 Blumenshine, 1996; Villa and Bartram, 1996; Villa et al., 2004; Fourvel, 2012).

214
215 The technological analysis of the anthropic fracturing relies on the presence of cortical flakes among the
216 faunal remains and by percussion marks and notches from direct percussion on the bones. The
217 morphology of the fracture facets with smooth surface, curved or V-shaped outline, oblique angle,
218 evidence a percussion made on fresh bones (Blumenshine and Selvaggio, 1988; Brugal and Defleur,
219 1989; Villa and Mahieu, 1991; Outram, 2002; Pickering and Egeland, 2006; Galán et al., 2009). Both
220 technological and use-wear traces observations were compared to archaeological and experimental
221 published referentials (Semenov, 1957, 1964; Villa and D'Errico, 2001; Vincent, 1985, 1993; ETTOS,
222 1985; Averbough and Provenzano, 1999; Liolios, 1999; Maigrot, 2003; Rigaud, 2007; Tartar, 2009;
223 Mozota, 2012; Baumann, 2014) and completed by ongoing experiments on unshaped and formal bone
224 tools production and use. We carried out experimentations on bone retouchers, intermediate tools and
225 retouched tools. We have also started an experimental program on hide working and other tasks that can
226 macroscopically dull bone tools edges, in order to supplement common knowledge. The functional
227 characteristics of the bone retouchers are already largely exposed in previous studies (e. g. Huston et
228 al., 2018), while our results, concerning specific issues, will be delivered in a related article. The low
229 referential available for the bone intermediate and retouched tools required significant investments. Here
230 are partially exploited results obtained on these two categories over three years within a collective
231 French-Russian program, including bone and lithic (flintknappers) specialists.

232 233 4. Results

234 235 4.1 State of preservation

236
237 Several types of modifications have been identified among the faunal remains. The most important are
238 traces of consumption by carnivores, Wolf (*Canis lupus*) and Hyenas (*C. crocuta spelaea*), i. e. punctures
239 and pits from teeth impacts, fractures scars/scooping out of matter, coring and furrowing from the
240 friction of the teeth, smoothing from ingestion with a dimpled aspect or a shiny surface (Campas and
241 Beauval, 2008; Fourvel, 2012). Bones fragments attacked by acid corrosion, which are strongly dulled
242 and dimpled, are concentrated in layers 5 and 6a. Their rate decreases in layers 6b and 6c, while in the
243 same layers cut marks frequency can reach 30%. Traces of vermiculation, less frequent, are found
244 mainly on Holocene bones, except at the entrance of the cave where they also affect the pieces in layers
245 6a and 6b (Derevianko et al., 2018). The objects of the corpus under study can be regarded as relatively
246 well preserved. However, their technological and traceological reading was partly limited by a
247 desiccation of the material which induced a longitudinal fragmentation of the pieces, with post-
248 depositional breaks affecting about 30% of the corpus, and more rarely a transverse disintegration,
249 leading to a deformation of the volumes or a desquamation of the outer layers. Manganese oxide deposits
250 are found on almost all pieces of the corpus but do not interfere with the reading of surfaces.

251 252 4.2. Provenance of the blanks

253
254 The anatomical parts and taxa used for the bone toolkit are not diversified. These are mainly long bone
255 diaphysis (83.2%) and flat bone (16.2%) of medium (16.1%) and large (82.9%) mammals. Among the

256 long bones, the tibias, humerus and femurs of Bison (*Bison priscus*), and more rarely Equidae, have
257 been preferred. Flat bone blanks are mainly ribs, which are more difficult to attribute to a taxon. The
258 site also contains rare tool fragments on Mammoth ivory, a piece made from a long bone of Rhinoceros
259 and one from a brow tine of a red-deer antler (*Cervus elaphus*).

260
261 On the site of Chagyrskaya, the single breaking technique identified is direct percussion. In an anthropic
262 assemblage, the breaking of long bones is quasi invariably part of the food consumption process for
263 marrow extraction. Therefore, the obtainment of bone blanks for technical purposes is generally seen as
264 a recuperation of flakes among the butchering wastes (Tartar, 2012). In Chagyrskaya, the gathering of
265 the blanks from the faunal remains is all the more conceivable as the site seems to have been used for
266 the processing and consumption of bison carcasses. The bone material is very abundant. However, this
267 collection was not necessarily opportunistic. In the Mousterian site of Les Pradelles, the repeated use of
268 certain parts of the long bones led to the assumption that this could correspond to a selection of tool
269 blanks at the time of butchering. The stock thus built up could have been consumed as and when required
270 (Costamagno et al., 2018). At Chagyrskaya, the anatomical selection of the blanks supports this idea
271 (Kolobova et al., this volume).

272 273 4.3. Bone tools characterisation

274
275 Four categories of artefacts were distinguished according to the particular pattern of their presumed
276 traces of use and their resemblance with tools identified in Upper Palaeolithic sites and in some Middle
277 Palaeolithic ones according to similar traceological and/or morphological criteria: retouchers (N = 680),
278 intermediate tools (N = 37), retouched or damaged flakes (N = 49) and blunt pieces (N = 14, table 1, fig.
279 2). These categories are not defined with the same accuracy. For what concerns the retouchers, we know
280 both their cinematic and the task in which they were involved. They are light soft hammers for
281 retouching lithic cutting edges. In the case of intermediate tools, the particular arrangement of the
282 damage, at both ends, refers to a same operating mode. The tools are hammered on one end for splitting
283 or cutting a material with the opposite end. The present lack of comparative base on intermediate bone
284 tools prevents from identifying here the tasks carried out or the worked materials, i. e. from
285 subcategorising this group. The third category groups all the bone flakes with lateral edge modification
286 from use or retouch, whatever the presumed technical cause (active edge deterioration, shaping,
287 adaptation to handling, etc.). The fourth one is also heterogeneous since it includes pieces having in
288 common a blunt end which cannot be attributed to natural weathering, but which could proceed from
289 shaping and various uses. One piece may belong to several categories. In most cases, the retouched and
290 the intermediate tools have also evidence of use as retouchers, in a former step of the blank when the
291 chronology is discernible. More than 80% of these tools were found in layers 6B and 6C, with a
292 particular concentration in the 6C1 horizon (table 1).

293
294 Tab. 1

295
296 Figure 2

297 298 4.4 Retouchers

299
300 Retouchers are the most common bone tools found in Palaeolithic assemblages. They have been present
301 since the Lower Palaeolithic (Roberts and Parfitt, 1999; Langlois, 2004; Smith, 2013; Julien et al., 2015;
302 Kolfshoten et al., 2015; Moigne et al., 2015), they are particularly frequent in the Middle Palaeolithic
303 (see, in particular, Mallye et al., 2012; Jequier et al., 2012; Mozota, 2012; Blasco et al., 2013; Abrams
304 et al., 2014; Deaujard et al., 2014; Rosell et al., 2015; Rougier et al., 2016; Doyon et al., 2018; Mateo-
305 Lomba et al., 2019) and last all over the Upper Palaeolithic (Armand and Delagnes, 1998; Patou-Mathis,

306 2002; Castel et al., 2003; Castel and Madelaine, 2003; Rigaud, 2007; Tartar, 2009, 2012). The oldest
307 mention of these tools dates back to 1874 in France, when Daleau reported "anvil bones" in the Grotte
308 des Fées (Daleau, 1883 in Patou-Mathis and Schwab, 2002). At a time when definition of bone industry
309 was based on typology, retouchers were among the few tools identified by their traces of use. The
310 absence of a recognizable shape led directly to their functional study, as soon as they were discovered,
311 through ethnological comparisons and experiments. At the beginning of the 20th century, Henri-Martin
312 proposed, on the basis of the samples from the Quina site (Charente, France), two methods of use: as a
313 "mallet" or as an "anvil", i. e. as a hammer, for retouching lithic artefacts, or as a cutting support (Henri-
314 Martin, 1906). Further functional studies confirmed the first hypothesis (see, in particular, Bonch-
315 Osmolovskiy, 1940; Semenov, 1964; Feustel, 1973; Rigaud, 1977, 2007; Vincent, 1988; Chase, 1990;
316 Bourginon, 2001; Schwab, 2009; Mozota, 2012; Mallye et al., 2012), also suggesting that some
317 specimens may also have been used as pressure retouchers (Šchelinskii, 1983; Plisson, 1988) or for
318 bladelets knapping (Tartar, 2012). If the function of the pieces seems being confirmed, the category of
319 bone retouchers still forms a poorly differentiated group, because of the diversity of the blanks, but also
320 of the uniformity of the impacts traces which does not let a priori observe significant differences between
321 the assemblages. Although samples from teeth, antler or ivory exist, the vast majority of the retouchers
322 are diaphyseal splinters, probably from bone breaking for marrow extraction. The traces of use are in
323 the form of repeated impacts, that are more or less linear and parallel to each other, concentrated in a
324 small area of the cortical side of the bone. Going further in the comparisons of the assemblages recurs a
325 homogenization of the descriptions and nomenclature (Patou-Mathis et al., 2002; Mallye et al., 2012).
326 as well as the understanding of the role of these bone tools in the lithic production systems and, more
327 broadly, their implication in the activities done in the sites (Costamagno et al., 2018).

328
329 A preliminary study carried out on 8 Chagyrskaya retouchers, from layers 6C1 and 6B (campaign 2012;
330 Derevianko et al., 2018, p. 231-236), showed that they are long bone diaphysis fragments, having one
331 to two impact areas, in different degrees of use. They probably have to be related to the thinning steps
332 of the bifaces, whose removal has the characteristic stigmas of a soft percussion (ibid). Following this
333 preliminary report, we undertook a systematic search for retouchers in the faunal remains. More than a
334 thousand samples were found. This large quantity of tools, resulting from a well-defined chrono-cultural
335 context, allows statistical analyses to be carried out, as initiated through a geometric-morphometric
336 shape analysis, with the aim to highlight trends in the general morphology of the pieces and to detect
337 possible processes of blank shaping. In this context, a random selection of 100 retouchers have been the
338 subject of complete zooarchaeological, taphonomic and technological analyses (for a precise description
339 see Kolobova et al., this volume). The results obtained on this first corpus can be partly transposed to
340 the pieces included in this article.

341
342 While weathering is common on the assemblage, the advanced stages (3, 4 & 5; Behrensmeyer, 1978)
343 are present only in 6 cases. The same number of remains were altered by carnivore activities (furrowing,
344 punctures and pits). Root etchings are absent. Consequently, 87% of the remains present more than 50%
345 of their cortical unmodified, allowing a direct observation of superficial marks. The blanks were mostly
346 obtained from large ungulate remains (97%). 43 retouchers were identified at the specific level and were
347 attributed to Bison (NISP=32), Horse (NISP=9), Capra sp. (NISP=1) and Rhinoceros (NISP=1). There
348 is a strong bias in the skeletal part representation since 92% of the blanks were produced on long bones
349 shaft: (Tibia NISP=28; Humerus, NISP=20; Femur, NISP=11 Radio-ulna, NISP = 3; Metapodial, NISP
350 = 3; Unidentified Long Bone, NISP= 27). Rib (NISP=5), Scapula (NISP=1) and a transversal process
351 of a bison lumbar were also used. Among the 680 retouchers inventoried, it is also worth noting the
352 occasional use of antler and ivory. Layer 6B gave a deer antler retoucher. It is an adult deer antler frontal
353 tine broken by flexion at its base and used on its widest face. The three fragments of ivory retoucher are

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

365
366 At least 28% of the retouchers are complete or sub-complete, that is to say, free of clear post-depositional
367 or recent breaks, while 30% of the corpus is affected by at least one post-depositional break (transverse
368 and/or longitudinal) and 14% is in a fragmentary state (multiple post-depositional and recent breaks).
369 The remaining 27% appear to have been affected by a secondary fracturing, generally transversal,
370 probably from use. For the complete samples, the lengths range from 4.4 cm to 13.3 cm (average 8.2
371 cm), the widths from 1.2 cm to 5.7 cm (average 3.2 cm) with compact bone tissue thicknesses between
372 0.3 cm and 1.3 cm (average 0.8 cm). There is no particular dimensional template. Neither the
373 width/thickness ratio in the entire corpus shows a particular concentration of the dimensions (fig. 3).
374 Although long bison bones have been preferentially selected from the faunal remains, there is no visible
375 size standardization.

376
377 More than half of the retouchers show scraping traces (fig. 4, B). These traces are systematically covered
378 by the impacts from use and cover the same area on the cortical face. The striations from scraping are
379 oblique relatively to the main axis of the blank, are not numerous nor regular but well-marked. They do
380 not therefore correspond to a phase of cleaning the periosteum or regularizing the bone surface, but
381 rather to an action aimed at creating relief, probably for a better grip of the lithic edge on the bone. The
382 configuration of the impact marks corresponds to what is classically observed on such tools (fig. 4, C).
383 These are linear impacts, more rarely "V" shaped or triangular, always transversal to the main axis of
384 the bone flake (fig. 4, A and E). The different forms of impacts can be found in the same active surface
385 and are often combined with negatives of small chips removal (fig. 4, D). The loss of matter does not
386 depend only on the blow but also on the previous impacts that facilitate and/or limit its development.
387 According to Mallye et al. 2012, the detachment of matter occurs when the bone is dry. The active areas
388 are generally unique (located near one end of the blank) and not very dense. They would result from a
389 single operation and a rather occasional use of the tool. This trend and the very large number of
390 retouchers identified can be explained by the nature of the tasks carried out in Chagyrskaya. In situ
391 butchery activities provide both an abundant quantity of bone (large stock of potential blanks that could
392 likely become retouchers if needed) and at the same time require the frequent shaping and maintenance
393 of lithic cutting edges for carcass processing, that can range from a few retouches to the complete
394 shaping of the edge.

395
396 Figure 3

397
398 Several intermediate tools (N = 14), pieces with retouched edge tools (N = 34) and pieces with blunt tip
399 (N = 5) have traces of use as retoucher. When it is possible to establish a chronology of the different
400 phases of use, the impact areas of the retouchers appear to be cut by the end crushing of the intermediate

401 tools, the retouch of the edges or the blunting of the tips. These retouchers no longer have their original
402 morphology and dimension.

403

404 Figure 4

405

406 4.5 Intermediate tools (N= 34)

407

408 The category of intermediate tools regroups pieces whose damages, at both ends, reflect the same
409 operating mode. The tools are hammered on one end for splitting or cutting the worked material with
410 the opposite end. In the Western Upper Palaeolithic, intermediate tools made from antler are better
411 known than those made from bone. For now, the oldest occurrences were found in the early Aurignacian.
412 They can be made with an expedient shaped half-antler beam of reindeer, such as in the Gravettian
413 culture, or directly from a complete beam, such as in the Solutrean. They can also be made from sticks
414 which are fully shaped and sometimes decorated, like in the Magdalenian (e. g. Deffarges et al., 1974;
415 Camps-Fabrer et al., 1998; Legrand 2000; Goutas, 2004; Braëm, 2008; Tartar, 2009; Baumann, 2014;
416 Malgarini, 2014; Lefebvre and Pétilion, 2018). For most authors, the choice of antler for this type of
417 tool is directly related to the properties of the material. Having more collagen than bone, antler is more
418 resistant to bending and longitudinal compressive stresses, i.e. more resistant to shocks (O'Connor,
419 1987; Mc Gregor, 1985; Rajaram, 1986; Albrecht, 1977). The intermediate tool use wear characteristics
420 have been established on this raw material. The hammered end is identified by the presence of an
421 impacted surface where the bone fibres are compacted (fig. 5, A). Hammering can also lead to the
422 formation of a crushing flange around the edge of the impact surface (deformation of bone fibres,
423 Rigaud, 1984) or to the removal of more or less invasive chips (rupture of bone fibres). The traces of
424 use at the other end vary depending on the processed material. On the active part, frequently bevelled,
425 compactations and removals (fig. 5, B) are sometimes combined with striations of variable lengths that
426 start from the front line or from the use wear polish (Provenzano, 1998). Surface analysis, experimental
427 reconstructions and ethnographic comparisons have provided various functional hypotheses. Bevelled
428 tools could be used for skin processing (Stordeur, 1980). They are also suitable for wood and antler
429 working, splitting wedge, barker, chisel, etc. (Semenov, 1964; Rigaud, 1984; Camps-Fabrer et. al, 1998;
430 Provenzano, 1998).

431

432 Figure 5

433

434 Recently, more than a hundred of intermediate tools made from bones were found in several Early
435 Aurignacian assemblages, such as Castanet, Gatzarria, Brassampouy, Isturitz, Tuto de Camalhot or
436 Labeko Koba (Letourneux, 2005; Tartar, 2009, 2012). This is the largest known inventory yet, however,
437 intermediate bone tools could be identified in other chronocultural assemblages with a targeted search
438 for this type of piece in faunal remains, as seen in the Solutrean (Baumann et al., 2016). In addition,
439 intermediate bone tools do not appear to be specific to the Upper Palaeolithic. Several samples may as
440 well be present in the Lower Palaeolithic assemblage of Schöningen (Julien et al., 2015). They also have
441 been mentioned in late Mousterian sites, such as Gatzarria (Basque country, France, Tartar, 2012), Axlor
442 (Bizkaia, Spain, Mozota, 2012), and Karabi Tamchin (Crimea, Ukraine, Burke and d'Errico, 2008). The
443 traces of use are of the same nature than on antler, but the more mineralized bone tissue is more prone
444 to fractures and to removals of splinters, particularly from the proximal part. Compactations and polishes
445 are mentioned on Aurignacian specimens and on the sample from Karabi Tamchin. In all cases, it is the
446 overlapping of several generations of removals on the same (longitudinal) axis that made possible to
447 diagnose the use as intermediate tool.

448

449 All the pieces of our corpus are made from shaft fragments of large mammals long bones (bison/horse
450 size). With an average width of 3 cm and an average thickness of 1 cm, they are among the largest bone
451 tools of the site. Their dimensions correspond to the upper values of the retouchers (fig. 3, B) but with
452 a smaller dispersion of widths. Thus, intermediate tools are more elongated. Complete or sub-complete

453 pieces have an average length of 11.3 cm, the longest specimen, proximally fractured, being 14 cm long.
454 The distal ends (active part in contact with the worked material) are very often formed by the natural
455 bevel at the intersection of the cortical face and of the fracture plane. In the case where the removals
456 completely obliterate the initial shape of the active part, the latter is too slightly bevelled, sometimes
457 symmetrically (more or less equivalent removals on both sides ; fig. 6, B), but most often with a
458 pronounced asymmetry (the removals are preferably on the upper surface, fig. 6, A). The morphology
459 of this active edge varies according to the specimens, but it is possible to distinguish two types of ends:
460 straight (cf. fig. 6, B) and convex (cf. fig. 6, A). An interrelationship seems to be emerging between
461 large distal extremities and invasive removals, and between narrow extremities and less marked
462 removals, probably due to the difference in resistance of the initial active edge. The identification of the
463 proximal part is based on the presence of an impacted surface and/or of particularly large removals. In
464 most of the cases, the percussion surface is absent. Nevertheless, the proximal ends then have transverse
465 fractures in flexion, indicating a violent and sudden rupture of the bone fibres (in a fresh state; cf. fig. 6,
466 A). Two groups of fractures are distinct. The first includes transversal bending fractures. They are
467 mainly located in the mesial part (based on the average length of the entire samples). The second group
468 includes oblique and more or less curved fractures, which are then close to the distal end. In at least one
469 case, the tool was reused after fracturing. All these fractures could result from accidental breaks during
470 use. This is an additional indication of use as an intermediate tool that is subject to high compressive
471 stresses. When the proximal parts are preserved, there are two cases: either the end is wide and relatively
472 flat, with small chipping, or the end is narrow and pointed (cf. fig. 6, B). This particular morphology is
473 due to the presence of invasive oblique lateral fractures on both sides of the percussion surface. These
474 remaining percussion areas are in alignment with the distal active zone. Two pieces of the corpus are
475 chips detached from a percussion surface, with negatives of previous removals on their dorsal face.

476
477 Edge scars, although of very variable morphology, are the only use wear common to all the pieces.
478 Compaction of the matter is frequent on the distal ends but more difficult to detect on the proximal ends,
479 which are thicker and less subject to deformation. Analyses of the bone microstructure are being carried
480 out on these pieces for assessing our interpretation and propose definite diagnostic criteria for the
481 recognition of this type of action. Blunts are only present on the distal ends. They can affect the edges
482 of the removal negatives or more rarely form an invasive area on the lower face of the tool. The latter is
483 then without removal negatives. In addition to the type of activity performed with the tool and the
484 material worked on, the development of wear, and more particularly the loss of material, must also be
485 linked to the duration of use of the tool. In our experiments, the use of an unshaped diaphysis flake as
486 an intermediary followed three steps. During the first step, the raw blank often presents fragile zones
487 (thin edge thickness, inadequate angles, etc.) that will quickly deteriorate (fig. 5, D), probably because
488 the blank morphologies were not well adapted to the task. When the edge becomes stable, starts a second
489 phase of alteration. The bone tissue no longer breaks but absorbs shocks. It then records deformations.
490 The tool may then gradually deteriorate and lose the minimal qualities required for its efficiency. A third
491 step could also be considered if we take into account that some invasive removals may be not from use
492 but from rejuvenation. Retouch of bone blanks by direct percussion is not uncommon on the site (see
493 the following paragraph). Finally, we have detected, on the archaeological samples, some isolated
494 striations extending from the active front. The morphological diversity of the distal parts, as well as the
495 variability of the removals and of the combination of traces, probably result from the diversity of tasks
496 performed with these tools. Experiments are underway to create a larger referential framework taking
497 into account the diversity of raw materials available in the site's environment during the prehistoric
498 occupations.

499
500 Figure 6

501
502 4.6 Retouched tools

503

504 The oldest examples of retouched bone tools would be from Olduvai Gorge sites in East Africa, found
505 in horizons dated between 1.8 and 1 Ma with the first industries of the Acheulean tradition. While the
506 reality of the bone tools described by M. Leakey (1971), then partially confirmed by P. Shipman
507 (Shipman and Phillips-Conroy, 1977), is still under discussion, the recent reassessment of the collections
508 by L. Backwell and F. d'Errico (2004) confirms the presence of used artefacts but underlines the
509 difficulty to differentiate them from the rest of the bone assemblage on the base of traceological criteria
510 (Backwell and d'Errico, 2004). The « bifaces » (handaxes) made on diaphysis of large mammals, found
511 in Italian (Castel di Guido, Fontana Ranuccio, Polledrara, Malagrotta, Casal de' Pazzi), German
512 (Bilzingsleben) or Hungarian (Vértesszőlös), are more widely accepted. Although in the sites the
513 specimens are not numerous, the analogies of form and retouch between lithic and bone bifaces let little
514 doubt about the bone ones (see in particular Zutovski and Barkai, 2016). Retouched bone tools have also
515 been documented throughout the Middle Palaeolithic in very different environmental and anthropic
516 contexts. In the Middle Stone Age of South Africa, in the site of Blombos (d'Errico and Henshilwood,
517 2007) or in Siberia, in the last mousteroid assemblages of Denisova cave (Kozlikin et al., 2020), a few
518 pieces are present within a relatively rich and diversified bone industry. In the Mousterian assemblages
519 of Western Europe, such as in Spain, on the sites of Gran Dolina, Bolomor (Rosell et al., 2015) and
520 Axlor (Mozota, 2012), in France, on the sites of Vaufrey (Vincent, 1993), Combe-Grenal and La
521 Ferrassie (Tartar and Costamagno, 2016), or again in Italy, on the site of Fumane (Romandini et al.,
522 2014), the few retouched pieces mentioned are found in assemblages where the only other identified
523 bone tools are retouchers.

524
525 In the absence of an explicit shaping of the tool, uncertainty remains about the anthropic and intentional
526 nature of the retouch. First, because other processes such as bone breaking for marrow procurement (see
527 Pickering and Egeland, 2006) or bone consumption by carnivores (see Blumenshine and Selvaggio,
528 1991), can lead to the formation of removals that mimic retouch on bone edges. Secondly, because
529 percussion is often considered as a technique that is not adapted to the shaping of bone materials.
530 « L'artisan de ces périodes [Paléolithique moyen] n'a pas reconnu la nature spécifique de l'os [...] et a
531 appliqué au support osseux des techniques empruntées au façonnage de la pierre ; celles-ci parfaitement
532 adaptées à la rigidité et à la cohésion du matériau lithique, sont plus ou moins inadéquates pour le travail
533 d'une telle substance / The craftsman of these periods [Middle Palaeolithic] did not recognize the
534 specific nature of bone [...] and applied to the bone blanks techniques borrowed from the shaping of
535 stone ; these techniques, perfectly adapted to the rigidity and cohesion of the lithic material, are more or
536 less inadequate for the work of such a substance. » (Vincent, 1985, p.23). The idea of a transfer of
537 techniques will also be proposed to explain the use of scraping at the beginning of Upper Palaeolithic,
538 the techniques being, borrowed from wood working (Liolios, 2002). A causal link is implicitly
539 established between the development of bone industries in the upper Palaeolithic and the systematic
540 shaping by scraping or abrasion. Thus, for the previous periods, the absence or rarity of bone tools is
541 ascribed to the absence of appropriate techniques for their shaping. The presupposition is often
542 reinforced by the difficulty of experimentally mastering percussion on bone and antler (Alain et al.,
543 1974; Liolios 1999; Backwell and d'Errico, 2004; Tartar, 2009; Romandini et al., 2014a).

544
545 In theory, however, the intrinsic characteristics of bone are suitable for such action. One third of the
546 fresh bone consists of an organic matter made of a fundamental substance and of collagen fibres that
547 give the material elastic and plastic properties. It can absorb energy by reversible deformation, fix
548 residual permanent deformation, or break if the applied force exceeds its resistance. The oriented
549 collagen fibrils give the bone a lamellar structure, making it stronger in the longitudinal axis than in the
550 perpendicular one. But at the same time, two thirds of the bone are made of a mineral component,
551 hydroxyapatite microcrystals, oriented in the same direction as collagen fibres. In the Mohs rock
552 hardness scale, apatite is between calcite and quartz. In each lamella, the orientation of the
553 collagen/microcrystal fibres is more or less perpendicular to that of the adjacent lamella, structuring the
554 material into a solid and relatively homogeneous grid (McGregor, 1985; Barone, 1986; Vincent, 1984;

555 Maigrot, 1997). Bone therefore shares characteristics with hard materials of conchoidal fracture. Its
556 percussion leads to the formation of a percussion cone below the contact point, sometimes with lancets
557 and undulations (Ficher, 1995; Crabtree, 1972; Morlan, 1980; Villa and Bartram, 1996). However, it is
558 to be expected that the pattern of marks on the bone will differ from the ones seen on flint, as we observe
559 differences between obsidian and grainy quartz.

560
561 In practice, the assessment of a material's knapping suitability has to be based on experimental tests
562 (Inizan et al., 1995). We therefore conducted a series of bone blank retouching tests according to the
563 following methodological protocol: the experimental pieces were made on bone blanks from tibias,
564 humerus, femurs, radius and metapods of adult cows aged 1 to 8 years (7 individuals), adult deer (2
565 individuals) and an adult equine. Several groups were made according to the relative freshness of the
566 bones, mainly determined by the presence of fat, colour and degree of weathering. Our fresh bones
567 (stage 0, cf. Behrensmeyer, 1978) are those obtained in butchery after slaughter of the animals, the driest
568 bones (stage 5, cf. Behrensmeyer, 1978) are those of an equine animal recovered after several years'
569 exposure to the open air (dry and cold environment). All the debitage was carried out in direct
570 percussion with a hard hammer (pebbles from 1 to 1,5 kg) on anvil (fig. 7, A). In each group, we have
571 selected the blanks with the most favourable edge angles for knapping. The blanks were then retouched
572 in direct percussion (fig. 7, B and C), by an experienced knapper (S. M.), with different types of
573 hammers: soft organic (wood, antler), soft mineral (fine sandstone, limestone, schist) and hard mineral
574 (quartzite). The objective of the retouch was to install a cutting edge, or to rectify the line of a natural
575 cutting edge formed by the fracture. Depending on the configuration of the blank, the retouch was
576 therefore unifacial or bifacial. The number of removals varied from one specimen to another.

577
578 Figure 7

579
580 According to our tests, we can say that bone responds favourably to knapping, under some conditions.
581 All types of hammer can be used for retouching bone. However, they do not allow the same type of
582 retouch. Hard mineral hammers tend to produce abrupt removals (short, deepening the matter). The soft
583 hammers give a flatter and more invasive retouch of scaly morphology (fig. 7, D). The state of the
584 matter, on the other hand, plays an important role in the control of the removals. Unlike lithic materials,
585 bone evolves over time. After the animal's death, it gradually and in a non-homogeneous way loses its
586 organic mass through internal cell death mechanisms and external exchange with the environment. The
587 propagation of the shock wave depends on the homogeneity of the material. In a heterogeneous material,
588 the morphology and extent of retouches is more difficult to control. To a certain extent, a completely
589 dry bone, therefore homogeneous again, recovers its knapping qualities. In all cases, bone knapping
590 responds to physical laws that should allow regularities to be observed. While not all the marks from
591 intentional knapping are defined, not always readable and are sometimes ambiguous, the pattern of
592 removals on the bone blank remains, in our opinion, a key element for the identification of the pieces.

593
594 At least 49 retouched tools are identified at Chagyrskaya. Like the intermediate tools, they were made
595 on large ungulates remains (bison/horse size). The pieces have an average length of 8.6 cm. The
596 retouched tools are shorter than the intermediate tools. The average length of the retouchers is
597 equivalent, however the largest specimens are significantly longer (up to 21.5 cm) than the retouched
598 ones (up to 13.8 cm). The width-thickness ratios of the retouched tools cover the high part of those of
599 the retouchers, but only on the highest widths (fig. 3, C). In other words, blanks used for the retouched
600 tools are among the thickest, the widest and the shortest of the collection (except the disparate category
601 of the artefacts with rounded tip).

602
603 When the retouches are not cut by a fracture, they cover from one-third to three-quarters of the blank
604 periphery. They are preferably located on one side, extend to one end and sometimes extend to the

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

618
619 Nearly 70% of the retouched tools were also retouchers. When the chronology can be established, the
620 retouch appears always posterior to impacts. In 20% of cases, axial removals could result from use as
621 intermediate tool, but in the current state of our research, it is difficult here to differentiate between
622 removals from shaping and removals from use, moreover when both types are likely to be on the same
623 edge. On at least two specimens, a notch seems to have been made near or in continuity with the
624 retouched edge (cf. fig. 8, n°1). Lastly, a retouched piece with a flat blunted end is very similar to a
625 pressure tool (see below). Retouched specimens are a good illustration of multiple sequential uses of the
626 bone blanks on the site, what means to consider the management of these blanks over time and reinforces
627 the idea of a stock of the most suitable samples (the largest ones?) as proposed in the Mousterian site of
628 Les Pradelles (Costamagno et al., 2018).

629
630 Figure 8

631 632 4.7 Rounded tips

633
634 This fourth category in our inventory is not surprising since bone awls and borers are frequent tools in
635 Pre and Protohistoric assemblages. Even in recent periods, the natural morphology of particular bones
636 was used without significant shaping, such as herbivorous ulna (Camps-Fabrer, 1990, fiche 5), which
637 can make difficult the identification of this kind of tools among the faunal remains. Since we are dealing
638 here with bone artefacts from pre-sapiens, i.e. mainly if not only produced by percussion, the main
639 concerns are the criteria for establishing their consistency. As for the categories of the retouchers and of
640 the intermediate tools, the main distinguishing feature here is a common type of use wear, not necessarily
641 from a same task, localized on the same specific part of the artefact. The main difference is that natural
642 agents can hardly mimic end crushing or tiny surface impacts whereas edge rounding is the most
643 frequent bone alteration induced by various post depositional processes.

644
645 As any archaeological discipline, use wear analysis is based on actualist frames of reference (Plisson,
646 1991), which take into account the taphonomical parameters. Through the regularities observed in the
647 causal relationship between effectors and effects, reading rules are proposed for deciphering features
648 resulting from shaping, use, curation and alteration. The main criteria for differentiating edge rounding
649 from use and edge rounding from natural agents are the extension, the localization, the orientation, the
650 transition with the contiguous surface and the coupled features. Natural erosion or dissolution resulting
651 in smoothing of the edges and surfaces is generally covering most part of the objects, if not all, while
652 the use wear is restricted to the active edges or surfaces. Rounding resulting from hafting or handling

653 can be more extended but it is always related to a particular part of the tool of suitable morphology,
654 while friction from transport (bag, sleeve, etc.) is superficial and does not touch the concavities. The
655 efficiency of tools relies on the control of the motion and working angle of the active edge, which
656 induces the regularity of the use wear, its localization and its cinematic features, such as the striations.
657 What distinguishes use striations is that they are not strictly parallel, due to very slight variations in
658 handling during the repetitive action, and that part of them become more or less smoothed in course of
659 the process. Conversely, post depositional striations are crisscrossed with a random distribution all over
660 the surface, scratching the underneath gloss. The rounding's profile of the active edge (in cross section)
661 depends on the motion and on the physical properties of the smoothing worked material, which can be
662 organic or mineral, dry, fresh or wet, compact or grainy, from soft to very hard (e.g. flint pressure),
663 while the maximal extend of this rounding is fixed by the minimal acuteness necessary for getting the
664 expected effect on the worked matter (e.g. Semenov, 1964; Plisson, 1985; Peletier et Plisson, 1986;
665 Plisson 2007). For example, the hide deflesher and the hide softener have in common to operate on
666 fresh/semi wet flexible hide, which gives a gradual transition of both rounding with the adjacent faces,
667 but the former will never reach the same extension than the latter. When the raw hide is dry, the macro
668 wear from scraping is faceted.

669
670 According to the criteria set out, we have retrieved from the faunal remains 14 tools with more or less
671 visible smoothing of their tip. One of them (fig. 9, A) is comparable to the *first specialized bone tool*
672 *made by Neandertals in Europe* pointed out by Soressi & al. (2013) in Mousterian sites of South-
673 Western France. It is a long fragment of rib of large ungulate (L = 16,3 cm, l. = 3,55 cm, Th. = 0,45 cm),
674 with a blunt regular convex distal end (fig. 9, B). From this end has been removed, on 1 cm, the internal
675 hemi-side of the rib in order to free a single blade of compact bone. The symmetrical shape of the tip
676 cannot have been obtained nor by breakage nor by use: the acute denticulation from breaking would not
677 have been suitable for working a dulling material till getting such a regular convexity. Before use, the
678 end was previously rectified by abrasion, which is experimentally in such case the most appropriate and
679 simple shaping technique. The areas of slightly intersect striations on the external face confirm the
680 deduction. While slightly smaller and with both hemi-sides, the closest sample in the inventory of
681 Soressi & al is the *lissoir* AP-7839 from Abri Peyrony, not because it is the most complete, but because
682 of its semi-circle active end. Their 3 other samples have an ogival end, like the Upper Palaeolithic
683 examples used in the demonstration (op. cit. fig. 4). There is also in Chagyrskaya assemblage a similar
684 type of blunted tool, with convex converging edges. This one (fig. 9, C) is not made from a rib but from
685 an elongated fragment of diaphysis. Such as the previous one, it has been shaped by abrasion but with a
686 harder abrader, resulting in 2 domed facets whose ridges are erased by the use-wear of the tip (fig. 9, D
687 and E). A short fragment of rib (fig. 9, F), from a bigger mammal, has a macro-rounding of a same
688 convex outline than the one of the first tool, without a clear limit between the use-wear and the adjacent
689 surfaces but with a larger front (fig.9, G). There are some longitudinal striations on its lateral edge,
690 resulting probably from shaping (fig. 9, H). Another remain (fig. 9, L), made from a fragment of a large
691 ungulate long bone shaft, has a heavy blunting but with a straight shape, evidence of compaction, deep
692 striations and incrustation negatives (fig. 9, K). Its lateral edge is carefully retouched.

693
694 Figure 9

695
696 A second subcategory includes fragments of shafts, but with a narrower tip looking more like borers.
697 However, according to the profile of its apical rounding, which does not overlap with the lateral ridges,
698 one (fig. 9, J) does not look as resulting from a rotating motion; two transverse grooves slightly
699 smoothed bar its tip (fig. 9, I). The other one (fig. 10, A) has a more complex history. Its blank was, in
700 a previous step, used as a retoucher before the modification of the natural trihedral formed by an oblique

701 fracture (fig. 10, B). The reason for abrading a natural acute point is unclear but the rounded beak results
702 from a mineral abrasion, which is not due to the sediments nor, on the main length, to the work of a soft
703 stone. There has also a deep striation on its tip (fig. 10, C).

704

705 A third subcategory consists of artefacts with more discreet and diversified tip rounding. Among them,
706 one must consider a sample (fig. 10, D), which has the same outline than the one shown fig. 9, C, but
707 without evidence of shaping. Its whole surface is shiny, a bite dull, such has a weathered artefact.
708 However, a closer look at its tip reveals a tiny but typical slightly convex blunting from use on two
709 secant axes: cutting the tip itself (fig. 10, E) and along its adjacent left edge (fig. 10, F). At a microscopic
710 scale are visible transverse short striations such as on the front of flint scrapers used on dry hide (fig.
711 10, G). A naturally ogival diaphysis fragment (fig. 10, H), with a discrete dissymmetric rounding of its
712 naturally ogival end fracture (fig. 10, I), most likely belongs to the same functional group. Four micro
713 borers are also worth mentioning, which have in common to be naturally acute splinters, but with two
714 distinct types of tip smoothing: a micro abrasion (fig. 10, J), or a very soft dulling of the tip crushing,
715 (fig. 10, L). The other samples are less explicit, like a knife or a chisel, on the active edge of which is a
716 tiny dulling as the secondary feature of a use-wear from a cutting or a slicing action.

717

718 On the basis of experimental replicas, the samples of South-Western France are functionally interpreted
719 as hide burnishers (Soressi et al., 2013), which is consistent with the general pattern of traces described
720 and agreed by many authors for similar tools of later Palaeolithic and Mesolithic. If burnishing still
721 today belongs to the final steps of traditional skin dressing, for making it "not only prettier but tougher
722 and more impermeable" (Semenov, 1964, p. 178) it involves rubbing-pounding machines for complete
723 skins, while different types of bone and wooden hand tools are still used by craftsmen and hobbyists for
724 small objects and surfaces. However, the only morphological modern equivalent, such as the one shown
725 in fig. 4F (Soressi et al. 2013), is a bone folder for bookbinders, which means a finishing tool for
726 meticulous craft. For the same task are also used spatulas with polished stone (agate) tips. "Lissoirs" as
727 the Palaeolithic ones are not reported in ethnographical tool-kits, nor in the handbooks of Indian tanning,
728 at the difference of bone fleshers, either because they were made differently (e.g. eskimo soapstone
729 burnishers), or because their use in the female sphere was not observable by male ethnographers.
730 According to C.L. Steinhauer, museum inspector for the Danish Ethnographic Museum, mentioned by
731 E. Lartet (1861), the Sami people in the XIXth Century were still using burnishers made from reindeer
732 antlers for flattening felled seam. This is in accordance with the techniques learnt a century later by the
733 French ethnologist Bernadette Robbe from Ammassalimiit women, the life of whom she shared during
734 several stays up to a full year (personal communication). Three "lissoirs" of Chagyrskaya, one shaped
735 (cf. fig. 9, C), two unshaped (cf. fig. 10, D and H), by their size, the morphology of their active end and
736 their use wear, fit well with the evoked leather dressmaking technique. The functional status of the long
737 sample made from a rib, with a convex front end (cf. fig. 9, A) is less clear. The alteration of its surface
738 is too pronounced for clearly distinguishing between the shaping and the use wear of its front.
739 Nonetheless the general morphology of the rounding is compatible with a long scraping of a soft organic
740 material, on a rather vertical position like a stretching stick. The narrowness of its active part is however
741 more in accordance with a clothing or maintenance task than with the final step of hide tanning. Despite
742 a less specific use wear, the 4 tiny borers (cf. fig. 10, K) could complete the leather tool-kit.

743

744 The two other heavily blunted samples do not belong to the same functional set. The one shown in fig.
745 9F looks like the same type of tool than fig. 9C, however there is no evidence of soft organic material
746 rubbing. All the visible features on the front suggest contact only with a mineral matter, from shaping
747 and possibly from use. Its top is compacted with some deep transversal scratches. As for fig. 9L, there
748 is no doubt about it, since its front is flat and compacted. Nor pseudo-borers fig. 10A and fig. 9J, whose

749 blanks bear marks of previous use, have a blunt tip imputable to hide working. They may be raw from
750 (re)shaping. However fig. 10A has the same features as fig. 9F: compacted appearance of the tip with
751 large scratch (photo). The closest comparisons for fig. 9L are the Solutrean pressure flakers.

752

753 Figure 10

754

755 5. Discussion and conclusion

756

757 The initial aim of the study was, on the basis of the Southern Western Solutrean experience (Baumann,
758 2014), to search for the existence of a substantial bone industry before the Upper Palaeolithic, i.e. before
759 AMH expansion in northern territories of Eurasia. Altai region is a convenient context for such
760 investigation, both because of a good preservation of the bone material, due to the low temperature of
761 sediments in cave sites, and to the discovery, in the Middle - Upper Palaeolithic transitional layers of
762 Denisova cave, of the oldest known symbolic bone artefacts along with some "formal" bone tools, in a
763 background of other hominines than AMH. Several categories of ad hoc bone tools, made from shaft
764 blanks, unshaped or rectified by percussion, were brought to light (Kozlikin et al., in 2020) in this cave.
765 However, the complex stratigraphy and evidence for interstratified seasonal occupants, with Denisovan-
766 Neandertal interbreeding, does not allow to ascertain who were the authors of such industry combining
767 formal and unformal bone artefacts. The cultural and biological unicity of the Middle Palaeolithic layers
768 of Chagyrskaya cave offered a more accurate context for enlarging the investigation, since bone
769 retouchers were already known in this assemblage attributed to the Eastern Micoquian tradition
770 (Derevianko et al., 2018; Kolobova et al., 2016). Former studies, in some Middle Palaeolithic sites in
771 France, Spain, Italia, or Crimea, suggested that bone retouchers could be associated with other forms of
772 bone tools, starting with the ones discovered by Dr. Henri Martin (Henri-Martin,1907).

773

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

783

784 The shaping techniques for bone working inherent to the new types of tools introduced at the beginning
785 of Upper Palaeolithic were requested by their functional design. What is relevant there is the
786 complexification of weaponry, not the scraping or the abrading of organic matters which are performed
787 since the lowest Palaeolithic (e.g. Keeley and Toth, 1981; d'Errico and Backwell, 2003).

788

789 Standardization and symbolic value are recurrently taken as indicator of the behavioural modernity
790 (detailed list of traits in Henshilwood and Marean, 2003), the later requesting the former. In the case of
791 bone artefacts, this has induced a mix-up between the raw material, the shaping techniques and the social
792 function. The implicit reference to what a bone industry should be results from a specific social
793 organization of AMH hunters-gatherers of Eurasia in a climatic and environmental context which
794 disappeared at the end of Pleistocene. Afterward, most of the Holocene hunters-gatherers had a much
795 simpler and monotonous use of bone materials than Gravettian or Magdalenian, and the same can be
796 underlined about rock art. Such implicit reference is so deeply rooted that even in a critical review of

797 the models used for characterizing modern behaviour, which points out that many of them are too much
798 empirically derived from and context-specific to the European Upper Palaeolithic record, the absence
799 of earlier bone industry is regarded as real : "(...) *it seems unlikely that these hominids did not recognize*
800 *the potential utility of bone as a raw material A more likely explanation is that they frequently chose not*
801 *to use bone, and our focus should be on why"* (Henshilwood and Marean, 2003, p. 633).

802
803 The inventory of Chagyrskaya provides another perspective: a bone industry, in which the shaping
804 process is done by percussion and requires abrasion only for some active edges. That seems to be have
805 been enough for getting efficient active parts. The diversity of functional types and the physical
806 complementarity with lithic implements, in length, resistance to impact, elasticity, dullness (which goes
807 hand in hand with a rapid convex shaping by abrasion, unlike lithic) or availability, prevents from
808 speaking of casual tools. The long diaphysis blanks for intermediate tools have not equivalent in the
809 lithic industry of Chagyrskaya. The active edges of leather dressing tools are similar to samples from
810 Late Palaeolithic context, where they have no knapped lithic substitute, while the bone retouchers are
811 involved in on site lithic tool maintenance and probably shaping.

812
813 Bone, as a tool material, is better known for its resistance to stress and impact and for its relative
814 elasticity than for its sharpness. Its appropriateness for making regular, smooth edges is acknowledged
815 since long, particularly in different steps of hide processing and leather dressing. Consequently, before
816 starting experimental programs of manufacturing and use of Chagyrskaya implements, with bones from
817 adult wild deer and domestic cow, we thought that bone edges from flaking were not as sharp and
818 resistant as flint ones. We a priori considered them as a kind of ersatz. Their efficiency in wood working
819 rapidly invalidated our presuppositions. We have to extend the empirical approach to butchering itself.

820
821 Hide processing by Neandertal was already evidenced in Russia by stone tools since the beginning of
822 modern traceology (Semenov, 1964). The recent identification of Mousterian bone burnishers, from
823 French sites (Soressi et al., 2013), shows that hide processing was, at least at the end of Middle
824 Palaeolithic, a quite sophisticated process as was possibly dressing if we consider the smaller tools from
825 Chagyrskaya and elsewhere the use of feathers (Romandini et al., 2014b) and pigments (Soressi and
826 d'Errico, 2007) .

827
828 Chagyrskaya bone tools are the result of a non-complex and efficient technology. They are not so
829 different from the Mousterian lithic ones which were produced, used and discarded in situ. Sophisticated
830 knapping and/or shaping was specific to the category of itinerant stone artefacts, which, by their
831 polyvalence, could meet different needs, some of them being alternatively core or tool (Boëda et al.,
832 1990; Geneste, 1991; Slimak, 2008). Around Chagyrskaya, the good lithic material was rare. It has been
833 dedicated to bifacial and deeply shaped artefacts, a part of which having been taken away. The first
834 evidence of the use of bone material in mobile items did not occur before the early Upper Palaeolithic
835 (Floss, 2015; Krivoschapkin et al., 2018; Fedorchenko et al., this volume, Belusova et al. in press) with
836 the spear points and ornaments which were also the first ones to require an in depth shaping and the
837 overcoming of the anatomical aspect of the blanks. Criteria are missing for identifying the geographical
838 provenience of bones from common mammals in which artefacts were made. However, the design of
839 bone tools in Chagyrskaya suggest that these were for immediate local use, except, may be, two small
840 burnishers polished by long handling. There is evidence of bone blanks recycling, but not of the
841 polymorphous structure that characterizes Mousterian itinerant technical objects. No element of
842 composite weapon has been found so far in the Eurasian Middle Palaeolithic, except in a late and specific
843 Mousterian facies of the Rhone Valley, called Neronian (Metz, 2017), which is not attributed to
844 Neandertal (Slimak et al., 2019), while several samples of excellent javelin are known (Thieme, 1997;

845 Schoch et al., 2015), made of wood only. Mousterian people didn't manufacture bone points, because
846 they were simply not arming their spears. It is probably not the under-use of grinding which prevented
847 them to make sustainable bone tools but the insufficient need for this shaping technique which
848 maintained it marginal. Flint and mechanically similar stones were, by their structure and volume, more
849 suitable than bone for the control by percussion of an evolutive structure, and consequently for "storing"
850 different solutions in a same object. Grinding and scraping are relevant for shaping and maintaining a
851 stable structure, i.d. monofunctional tools that leads to the interdependency of a greater number of
852 distinct elements inside the technical system. The shift from flexibility to specialization is the one from
853 the Middle to the Upper Palaeolithic, which did not occur only at a technical level. Adding symbolic
854 features to utilitarian artefacts, or shaping specific items for an exclusive or a dominant symbolic
855 purpose, was not a Mousterian concern. We can wonder whether one of the key differences between
856 Middle and Upper Palaeolithic does not lie in the total absence of social interference in tool design. This
857 is what G. Simondon (1958) called the technically pure object, that is, one that lacks any sign function,
858 which in his view and that of other authors (e. g. Lemonnier, 1991) never can be with *Homo sapiens*,
859 for whom even the most elementary action makes sense.

860
861 Meaningless objects resulting from flexible production schemes that prioritize output versatility are not
862 the best candidates for typologists seeking standardization, who were already confused (e.g. Dibble,
863 1987), by the lack of clear categories inside the Mousterian lithic industry. The fact that the raw material,
864 for bones *stricto sensu*, results from butchering didn't help either. This explains that the part of bone in
865 Mousterian technology has been underestimated. We assume that the abundance and diversity of bone
866 tools in Chagyrskaya is not a local singularity since some types of our inventory have already been
867 mentioned in another Mousterian contexts. Our present objective is to go further in their functional
868 identification by widening our experimental references and using analytical techniques that objectify
869 the relevant criteria.

870
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878 Archaeology and ethnography (SB RAS).

879
880
881 Figures

882
883 Figure 1: Chagyrskaya cave. A - Geographical location (DAO M. Baumann); B - View of the cave
884 entrance (photo S.I. Zelenkii); C - Neandertal Mandible (photo H. Plisson).

885
886 Figure 2: Part of the bone industry found in Chagyrskaya, 2008-2018 excavations, 1 to 9, 19, 20, 38 and
887 45 – Retouchers, 10 to 18 and 42 – Intermediate tools; 21 to 29 – rounded tips; 30 to 37, 39, 41, 43 and
888 44 – Retouched tools (photos M. Baumann).

889
890 Figure 3: Distribution of the cross-section modules (ratio width/thickness) of the retouchers,
891 Chagyrskaya cave, 2008 – 2018 excavations.

892

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

896
897 Figure 5: Archaeological and experimental referentials for the intermediate tools ; A – Use-wear traces
898 on the striking surface from an antler sample, Upper Palaeolithic, Malaya Siya site (Russia), B – Use-
899 wear traces on the active part, from an antler sample, Upper Palaeolithic, Malaya Siya site (Russia), C
900 – Experimental intermediate toll used for woodworking (*Pinus Sylvestris*; photos H. Plisson), D – Size
901 reduction resulting from this task (photo M. Baumann).

902
903 Figure 6: Intermediate tools made from bone, Chagyrskaya cave, 2008-2018 excavations; A –
904 Intermediate tool with straight and asymmetrical active end, B – Intermediate tool with convex and
905 symmetrical active end (photos M. Baumann).

906
907 Figure 7: Experiments on bone knapping and archaeological comparisons, A – Debitage by direct
908 percussion on anvil, B – Shaping by direct percussion with a soft hammer (wood), C – Small removals
909 obtained by soft percussion (photos H. Plisson), D – Experimental sample, E – Corresponding
910 archaeological sample (photos M. Baumann).

911
912 Figure 8: Retouched tools, Chagyrskaya cave, 2008-2018 excavations, 1 - Complete tool with mesio-
913 distal and bifacial retouches covering one-third of the blank periphery and with a mesial notch, 2 et 3 –
914 Mesial fragments with a bifacial retouched edge, 4 – Mesio-distal fragment similar to the complete one
915 (n°1), but less retouched, A and D – Differences between the retouches on the upper and the lower side,
916 B and C – Multi-generations of invasive retouches on the lower side (photos M. Baumann)

917
918 Figure 9: Rounded tips, Chagyrskaya cave, 2008-2018 excavations, A, F and I – Samples made from
919 ribs, C and L – Samples made from diaphysis, B – Blunt and regular distal end, D and E – Distal end
920 with domed facets, G – Distal end with large front, H – Striations on the lateral edge, J – Distal end with
921 transverse grooves, K – Large front with evidences of compaction, striation and incrustation negatives
922 (photos H. Plisson)

923
924 Figure 10: Rounded tips, Chagyrskaya cave, 2008-2018 excavations, A – Reuse of a retoucher made
925 from rib, B – Distal end formed by an oblique fracture, C – Distal end with a deep striation, D – Spatulate
926 sample, E – Blunting on the distal end, F – Blunting on the lateral edge, G – Transverse striations on the
927 lateral edge (photomicrography by the intermediary of an acetate cast, made possible by the excellent
928 preservation of the bone tissue), H and K, Samples made from diaphysis, I- Distal end with a
929 dissymmetric rounding, J – Borer with micro-abrasion, L – Dulling of the tip crushing, (photos H.
930 Plisson).

931
932 Table capture

933
934 Tab. 1: Distribution of Chagyrskaya bone tools by level

935
936 Bibliography

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1485 Tabl. 1

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

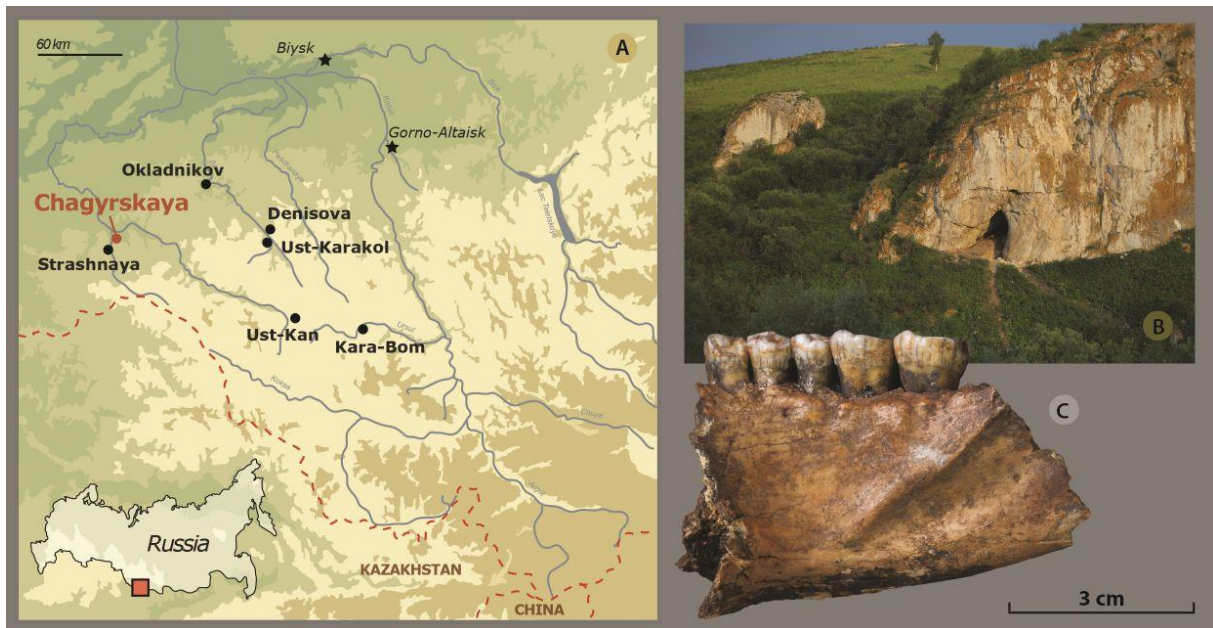
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1490 Figure 1



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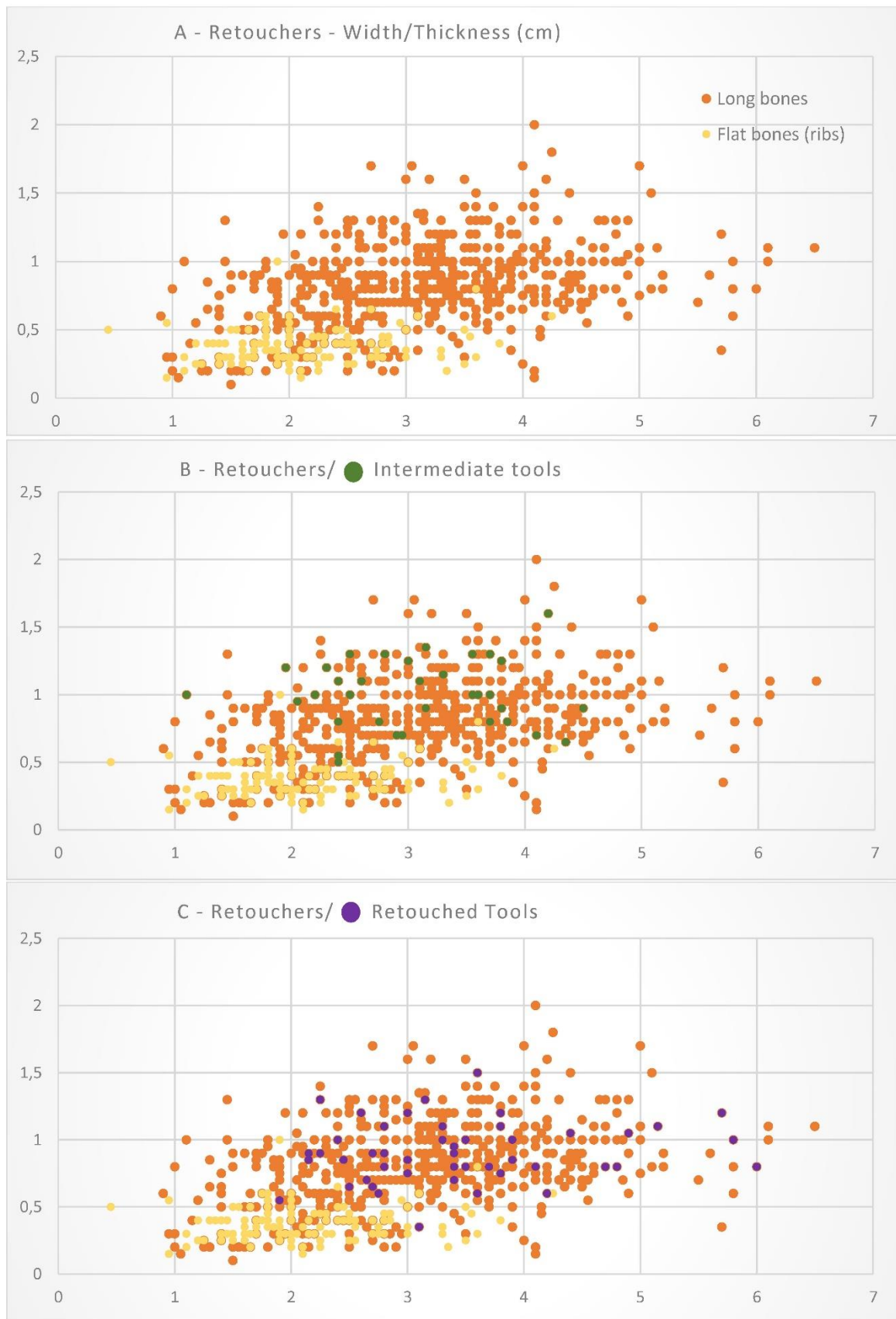
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1494 Figure 2



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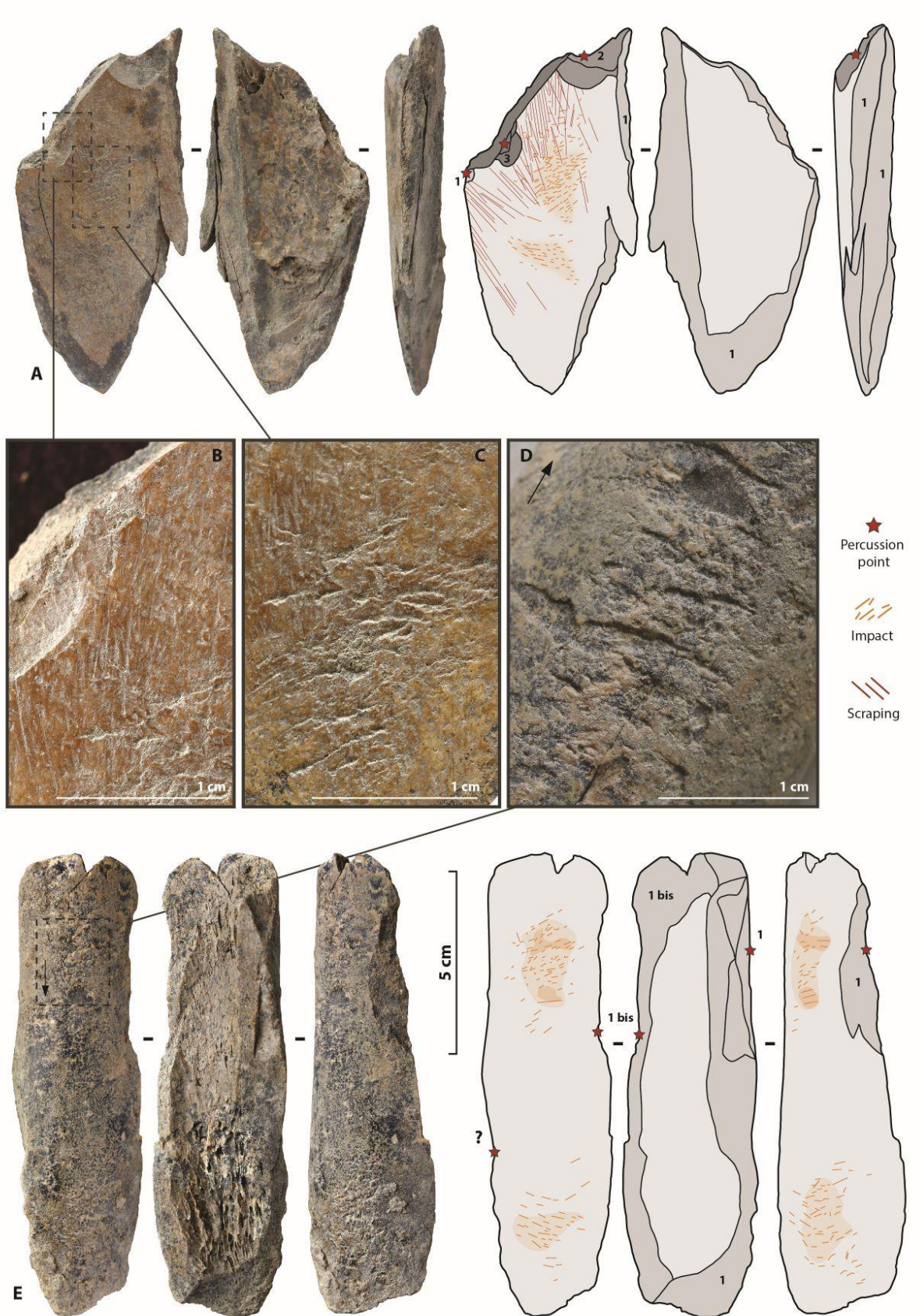
1497 Figure 3
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Figure 4



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Figure 5



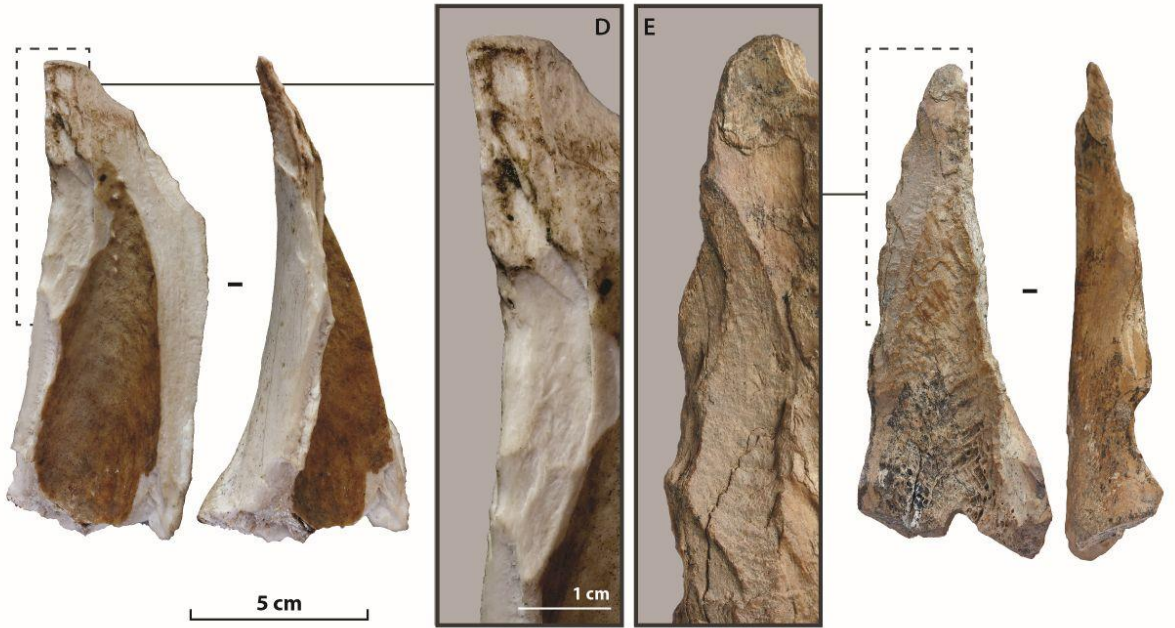
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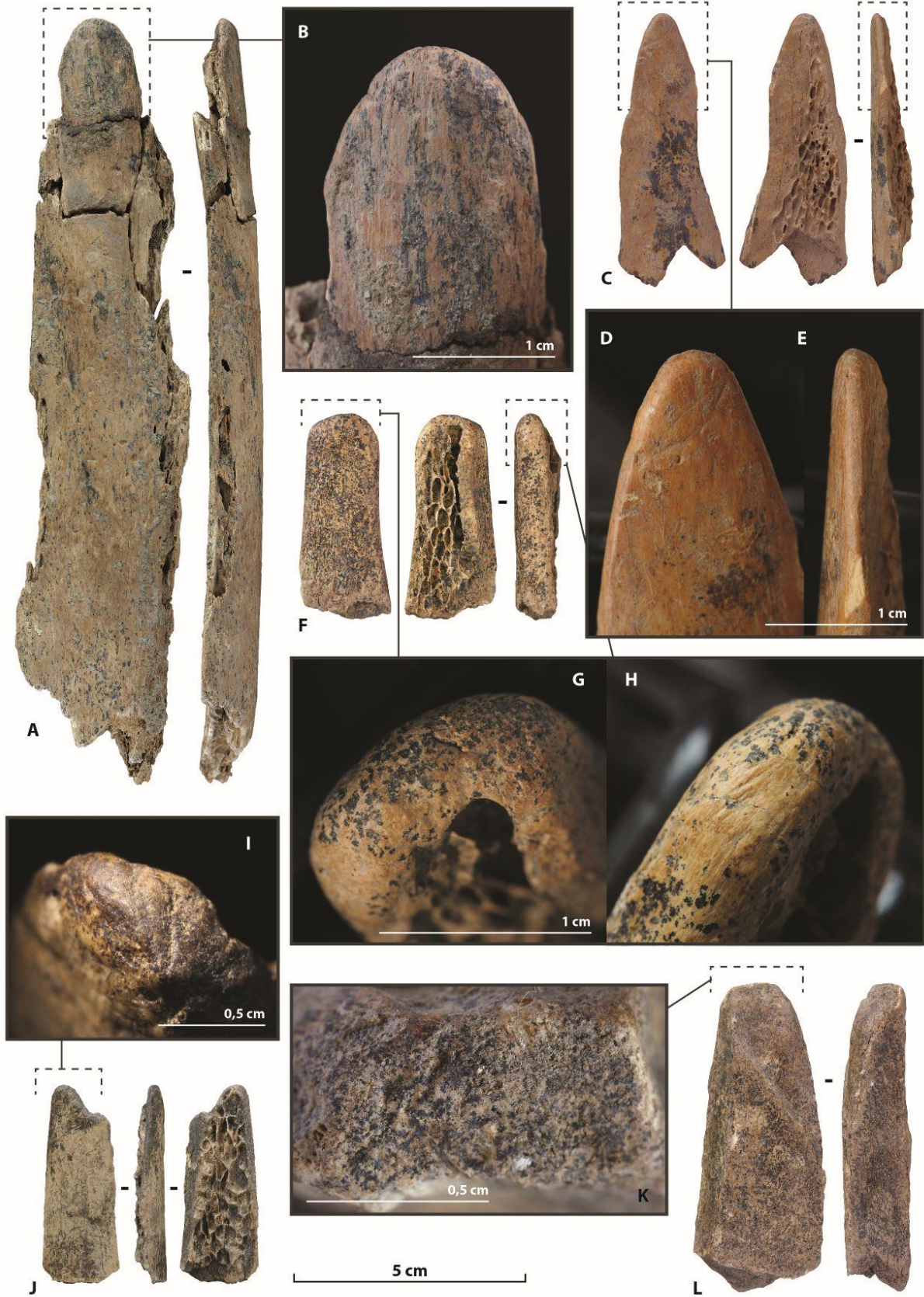
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