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Shell tools and productive strategies of hunter-gatherer groups: Some reflections from a use-wear analysis at the Balma del Gai site (Barcelona, Spain)

David Cuenca-Solana, Ignacio Clemente-Conte, L. Lloveras, P. García-Argüelles, J. Nadal

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Highlights:

- 1) Broaden the technological spectrum linked with the Epipalaeolithic hunter-gatherers.
- 2) Demonstrate a diversified use of the shells as adornments, food and tools also in archaeological contexts located some distance from the coastline
- 4) Correlation among the different technological elements that make up the hunter-gatherers' toolkits, through global analysis of the different types of elements that compose them.
- 5) From a methodological point of view, demonstration of the potential of use-wear methodology to reconstruct the productive strategies of human groups.

1 **Shell tools and productive strategies of hunter-gatherer groups: some reflections**
2 **from a use-wear analysis at the Balma del Gai site (Barcelona, Spain).**

3

4 David Cuenca-Solana

5 Instituto Internacional de Investigaciones Prehistóricas de Cantabria. (Universidad de Cantabria,
6 Gobierno de Cantabria, Grupo Santander). Universidad de Cantabria. Edificio Interfacultativo,
7 Avda. Los Castros s/n.º 39005. Santander, España.

8

9 Centre de Recherche en Archéologie, Archeosciences, Histoire (CReAAH), UMR-6566, Rennes
10 (Francia). cuencad@unican.es

11

12 Ignacio Clemente-Conte

13 Arqueología de las Dinámicas Sociales. CSIC- Institución Milá y Fontanals (IMF).
14 ignacio@imf.csic.es

15

16 Lluís Lloveras

17 SERP. Secció de Prehistòria i Arqueologia. Universitat de Barcelona.

18 lluisslloveras@ub.edu

19

20 Pilar García-Argüelles

21 SERP. Secció de Prehistòria i Arqueologia. Universitat de Barcelona.

22 garciaarguelles@ub.edu

23

24 Jordi Nadal

25 SERP. Secció de Prehistòria i Arqueologia. Universitat de Barcelona.

26 jordinadal@ub.edu

27

28 **Abstract**

29

30 Balma del Gai site is a small rock shelter situated in the municipality of Moià (Barcelona,
31 Spain) at an altitude of 760 metres above sea level and 50 km from the current coastline. The
32 levels of occupation in this context are dated between 13,442 cal BP and 9,552 cal BP, being
33 related to the so-denominated “Epimagdalenian” and “Microlaminar Sauveterroid” complexes.
34 The excavations have provided important mollusc samples, both terrestrial and marine, which
35 have been studied and considered alimentary and adornment resources. In this article, we
36 present the results of the use-wear analyses of the shell tools of *Mytilus galloprovincialis*
37 Lamarck, 1819 and *Glycymeris glycymeris* (Linnaeus, 1758). The results of these analyses and
38 their comparison with analytical experimentation demonstrate that some of these shells were

39 used as tools for developing diverse productive activities related to the processing of materials
40 of animal, mineral and vegetal origin. In this way, this research contributes to: 1) broaden the
41 technological spectrum registered in this context and in a wider sense for Epipalaeolithic hunter-
42 gatherers (beyond the traditional technological elements), 2) demonstrate a diversified use of the
43 shells as adornments, food and tools in the site; an aspect of great interest especially bearing in
44 mind the distance from the coast.

45

46 **Key words:** Shell tools, use-wear analysis, Epipalaeolithic, hunter-gatherers, Mediterranean
47 coast, perishable materials.

48

49 **Introduction**

50

51 The Balma del Gai site is situated in the municipality of Moià (Province of Barcelona,
52 Northeastern Iberia; 2° 08' 19" E; 41° 49' 00" N). It is a small rock shelter of 10 metres in length
53 and 5.5 metres in depth, some 760 metres above sea level and nowadays some 50 km from the
54 coastline (Fig. 1). The site is located in a high plateau landscape and it is set among some cliffs,
55 where a stream that shares its name with the rock shelter flows. The archaeological site was
56 discovered in the mid of 1970s by Joan Surroca and was excavated almost immediately during a
57 short period of two years. Later, programmed excavations were carried out until 2016 (Nadal et
58 al., 2017). The sedimentary thickness of the archaeological site is poorly developed and its
59 stratigraphy is simple: it is formed by three levels, the highest (superficial level), with
60 scrambled materials from previous phases and a palimpsest of protohistoric and historic
61 occupations up to the seventeenth century, level I, which is of interest in this study, concentrates
62 different phases of the Epipalaeolithic occupation, which will be commented on, and lastly level
63 II, which is an accumulation of gelifraets precedent from the alteration of the rock shelter wall
64 and which must have been formed in a very cold period at the end of the Pleistocene, and which
65 is archaeologically sterile (Bergadà, 1998).

66 Figure 1. a) Localization of Balma del Gai. b) Planimetry of the archaeological intervention at
67 the site. c) General view of the rock shelter. d) Diagram showing the stratigraphic development
68 established through the archaeological intervention at the site.

69

70 With respect to the level of our focus, level I, the occupations took place between the second
71 half of the XIV millennium and the end of the XI/beginning of the X millennium before present,
72 in calibrated dates (Table 1). During the Epipalaeolithic the existence of two clearly delimited
73 phases has been observed, one older, traditionally defined as the Microlaminar complex is
74 characterized by the presence of micropoints and backed bladelets, and a later one, the

75 Geometric complex (*facies* Filador) (García-Argüelles et al., 2013), in which the previous
76 elements were substituted by geometrical microliths –triangles and segments- obtained using the
77 microburin technique. After recent studies, it seems that this division was not so radical and in
78 fact the second period did not suppose a substitution of techno-elements but a minor
79 incorporation of the geometric component into the existing microlithism, so it would be better to
80 speak of two *facies* with no clear discontinuity: Epimagdalenian and Microlaminar Sauveterroid
81 (Román, 2012). This is totally corroborated at the Balma del Gai, where, during the last stage of
82 occupation (from -140 cm to the top of level 1, see figure 1: d), some geometrical microliths
83 were incorporated without there being changes in other aspects such as economic strategies or
84 the areas where raw materials were accessed (Nadal et al., 2017).

85 Table1. Datings obtained for the site and their chrono-cultural attribution according to lithic
86 typology. Calibrations of datings was done using the IntCal20 Northern Hemisphere curve
87 (Reimer et al., 2020)

88

89 Balma del Gai is remarkable for the good preservation of the organic material, and the faunal
90 remains. As for vertebrates, the most abundant species is rabbit-*Oryctolagus cuniculus*
91 (Linnaeus, 1758)-, with thousands of remains which were clearly introduced into the site by
92 anthropogenic action destined to food and use of skins (García-Argüelles et al., 2004; Lloveras
93 et al., 2011a; Rosado-Méndez et al., 2019). Other larger species are represented by ungulates,
94 among which, the most abundant are red deer -*Cervus elaphus* (Linnaeus, 1758)- followed by
95 small bovines -*Rupicapra rupicapra* (Linnaeus, 1758) and *Capra Pyrenaica* (Linnaeus, 1758)-,
96 and wild boar -*Sus scrofa* (Linnaeus, 1758)-, and by carnivores, with remains of Iberian lynx
97 *Lynx pardinus* (Temminck, 1827), wild cat -*Felis silvestris* (Schreber, 1777)- and fox -*Vulpes*
98 *vulpes* (Linnaeus, 1758)- (Volart et al., 2014; Nadal et al., 2017). Molluscs should have special
99 mention. At the site, in terms of anthropic contributions, large numbers of shells of continental
100 snails and some marine species have been recovered. The continental ones are represented
101 almost exclusively by a large accumulation of *Cepaea nemoralis* Linnaeus 1758. The
102 taphonomic studies and the parallel archaeological ones lead to the interpretation of this
103 accumulation as a result of collection for alimentary purposes (Estrada et al., 2009; Lloveras et
104 al., 2011b). Likewise, there are samples of marine origin, represented by scaphopods, bivalves
105 and gastropods. Although the remains are not very abundant, the distance of the site from the
106 coastline and the taxonomical variability of the assemblage, make them especially interesting.
107 Among these, *Antalis vulgaris* (da Costa, 1778), *Antalis dentalis* (Linnaeus, 1758), *Pecten*
108 *jacobaeus* (Linnaeus, 1758), *Mytilus galloprovincialis*, *Glycymeris nummaria*, *Glycymeris*
109 *glycymeris* (as well as elements of *Glycymeris* sp., which have not been specifically
110 determined), *Tritia neritea* (Linnaeus, 1758), *Trivia costulata* (Gmelin, 1791), *Tritia reticulata*

111 (Linnaeus, 1758) and *Columbella rustica* (Linnaeus, 1758) have been identified (Estrada et al.,
112 2010). Although most of the remains, especially the gastropods and scaphopods, can be
113 considered elements used as ornamentation, in some bivalves, no modifications have been
114 detected for that use, so they are considered suitable for use-wear analysis. The main goal of this
115 study focuses on the analysis and interpretation of these marine malacofaunal remains,
116 particularly on the shells that do not present modifications to be considered as personal
117 ornaments. Through detailed examination of use-wear traces we will show that at least some of
118 these shells were used with technological purposes. Furthermore, the use of these elements in a
119 hunter-gatherer's site located far from the current coastline is interpreted in a social-cultural
120 key.

121 **1. Material and methods**

122

123 While carrying out this research, all the marine bivalve fragments and complete shells collected
124 in the different interventions at the site were analyzed. Therefore, in this analysis we will ignore
125 the marine gastropods and scaphopods, collected with a purpose oriented to the manufacture of
126 elements for adornment, as is supported by the presence of several elements of this type at the
127 site (Estrada et al., 2010). The species nomenclature applied in this study was that proposed by
128 the World Register of Marine Species (WoRMS, <http://www.marinespecies.org/>).

129 The possibility of successfully carrying out an analysis of use-wear depends directly on the state
130 of preservation of the samples under study. In this sense, the shells analyzed presented an
131 adequate state of preservation, which has enabled their successful study. Only some of the
132 samples, especially the *Glycymeris glycymeris* shells, presented concretions that covered
133 important parts of their surface. Several of these were cleaned for 50 minutes using an Ulsonix
134 Proclean 2.0 ultrasonic cleaner using soap and water. This cleaning is oriented to remove these
135 concretions and did not produce any degradation of the surfaces of shells analyzed by use-wear
136 methodology.

137 On the whole, a total of 30 shells, 18 of *Glycymeris glycymeris* and 12 of *Mytilus*
138 *galloprovincialis*, were studied through use-wear analysis methodology (Semenov, 1964) (Table
139 2). That is, observing them macro and microscopically to document the alterations generated
140 through the use of these shells as tools and analysing them experimentally to verify or refute the
141 interpretation of these traces. To perform the analysis, a binocular Leica S8APO lens was used
142 to search for macro-polishing, abrasions, rounding and scars. Moreover, a Leica DM2500M
143 metallographic microscope was used to identify the micro-polishing and striations of use and to
144 determine, when possible, how (movement and/or action) and what material was processed with
145 these tools. For documentation of these use-wear traces a Leica MC190HD Camera was adapted

146 for both devices. In this way, the sample was studied using high and low magnifications
147 between 10X and 400X (Cuenca-Solana et al., 2017).

148 To interpret the use-wear traces, we used the results obtained from different analytical
149 experimental programmes carried out in the last years (Cuenca-Solana, 2010, 2013, 2015,
150 Cuenca-Solana et al, 2013, 2015, 2016a, 2016b). This analytical experimental program
151 comprising more than 150 experiments oriented to process mineral (ocher, shells or clay),
152 vegetable (wood and plant non wood) and animal (skin, leather and fish, among others) matters
153 using shell tools. Also, the aim of some of these experiments has been to understand and
154 describe the influence of different taphonomic processes in the preservation of shell surfaces.

155

156 Table 2. Shell taxa from Balma del Gai analyzed through use-wear methodology.

157

158 2. Results

159

160 The use-wear analysis of the 30 shells from the Balma del Gai site enabled the documentation
161 of the confirmed use of 8 of them and the probable use of another 2 specimens (Table 3).
162 Specifically, the fragment of *Glycymeris glycymeris* #525 and the fragments of *Mytilus*
163 *galloprovincialis* #1329, #234, #131, #47, #173, #114 and #416 were determined as a tool. A
164 probable use was shown for the fragment of *Glycymeris glycymeris* #82 as well as the fragment
165 of *Mytilus galloprovincialis* #C1. Furthermore, another 3 shells of *Glycymeris glycymeris*
166 (specimens #147, #160-165 and #174) also showed traces linked to their use. However, in these
167 cases the disposition and characteristics of traces, along with the presence in the 3 pieces of
168 perforations made in the umbo zone, seem to link these shells to probable use as personal
169 ornaments.

170 Table 3. Functional interpretation of the shell tools documented at La Balma del Gai site.

171

172 The level of development of the use-wear on two probable tools (#C1 and #82) has not enabled
173 us to link their use with any activity or a specific worked material. In both cases, we can only
174 indicate that they were probably used to process a medium-hard material with a transverse
175 action, in the case of piece #82, and interleaved transverse and longitudinal actions in the case
176 of piece #C1 (Table 3).

177 Nevertheless, it was possible to establish deeper interpretations about the functionality of the
178 other shell tools. We have documented the use of tools to process material of animal, vegetal
179 and mineral origin. As for the tools used to process material of animal origin, the use-wear
180 traces documented on the *Glycymeris glycymeris* #525 shell indicate its use to be linked with a
181 dry or semidry skin-processing activity. This functional interpretation is based on the

182 characteristics presented by the traces on the edge of the shell that has served as active zones.
183 Therefore, in this case, the use-wear traces are characterized by the presence of polishing with a
184 rough, not very greasy aspect, with a matt sheen. Small, short and irregular striations can be
185 observed on the inner face, mostly with an orientation perpendicular to the edge. The presence
186 of semicircular micro-holes that accentuate the roughness of the surface should also be
187 highlighted. Likewise, at microscopic level, some small ochre stains can be seen. In addition,
188 the distribution of the use-wear traces on the edge indicates that there is a significant chance that
189 this shell was fractured during its use.
190 Moreover, 4 fragments of *Mytilus galloprovincialis* present use-wear traces which enable us to
191 link their use to the processing of mineral material, although with some slight differences. The
192 fragments of *Mytilus galloprovincialis* #47 (Fig. 2) and #114 present a shiny and compact
193 micro-polishing with great development of very chaotic striations, oriented predominantly
194 transverse to the edge, and to a lesser extent also longitudinal and oblique. The characteristics of
195 the use-wear traces relate this piece to use oriented to scraping a mineral material, probably
196 ochre, through a principally transverse action.

197 Fig. 2. Fragment of *Mytilus galloprovincialis* #47 (above) and detail of the use-wear traces
198 (below) interpreted as generated by scraping of a block of ochre at 100X. Scale 3cm.

199
200 Pieces #1329 and #416 (Fig.3) present a less shiny polishing than fragments #47 and #114, with
201 a lesser degree of striations and on the contrary a greater presence of micro-holes developed on
202 the inner face of the shell that has functioned as the driving face during its use. In this case, this
203 piece could be related to the processing of a mineral material, but probably in contact with skin.
204 Thus, we consider that these 2 working tools could have been used to spread ochre on a skin
205 during the leather tanning process.

206 Fig. 3. Fragment of *Mytilus galloprovincialis* #416 (above) and detail of the use-wear traces
207 (below) interpreted as generated by for spread ochre on a skin at 200X. Scale 3cm.

208
209 Moreover, it was possible to reassemble 2 of the pieces analyzed, as both were part of the same
210 shell before fracture. These were the fragments of *Mytilus galloprovincialis* #234 and #131
211 (Fig. 4), which present in their respective active zones, localized on the edge of the shell, use-
212 wear traces linked to an activity oriented to processing vegetal origin material. Specifically,
213 both pieces present quite penetrating polishing, rough, slightly shiny and closed, with some
214 more compact zones. Furthermore, multidirectional and irregular striations have been
215 documented on these pieces, always with a dark bottom. Taking into account all these
216 characteristics of the use-wear traces, these fragments would have been used, before fracture of

217 the shell, to extracting or stretching vegetable fibres, through scraping, in predominantly
218 transverse actions, maybe on a hard surface like a stone, which would have generated roughness
219 and more compact micro-polishing in specific areas of these tools.

220 Fig. 4. Fragment of *Mytilus galloprovincialis* #131(above) and detail of the use-wear traces
221 (below) interpreted as generated by for scraping, stretching and/or extracting fibres through
222 transverse actions at 100X. Scale 3cm.

223

224

225 Finally, another fragment of *Mytilus galloprovincialis* also showed evidence of use oriented to
226 processing a material of vegetable origin, although with distinct characteristics. It is piece #173
227 (Fig. 5), which presents, in its active zone, compact micro-polishing, with a remarkable
228 presence of multi-striated zones principally oriented transverse to the edge, in which the
229 external face of the shell was used. At the macroscopic level, there is an accentuated rounding
230 of these edges, with deep striations and scars. Evaluating these characteristics, based on the
231 experimental work carried out (Cuenca-Solana, 2013), we consider that this shell fragment of
232 *Mytilus galloprovincialis* would have been used to smoothen and/or polish hard wood.

233 Fig. 5. Fragment of *Mytilus galloprovincialis* #173 (below) and detail of the use-wear traces
234 (above) interpreted as generated by for smoothening and/or polishing hard wood, at 100 and
235 200X.

236

237 3. Discussion

238

239 The results obtained after use-wear analysis of the malacological collection of Balma del Gai
240 provided information to establish a more complete interpretation on the productive activities of
241 the human groups who occupied this context during the Epipalaeolithic. One of the first aspects
242 to be highlighted is that 30% of the marine bivalves found in the site were used as tools. In this
243 way, 10 of the 30 remains of marine malacofauna analyzed present use-wear traces that enabled
244 their use to be confirmed. In relation to this aspect, the presence of several shells collected *post*
245 *mortem*, especially *Glycymeris glycymeris*, can be highlighted. This seems to indicate that this
246 small set of marine shells was collected on the coast, located at some 50 Km from the rock
247 shelter, and transported to the Balma del Gai exclusively oriented to their use as raw material
248 for shell tools. This use of these marine resources as a raw material, also documented in other
249 contexts of hunter-gatherers previously analyzed (Cuenca-Solana, 2013, 2015, 2016a, 2016b),
250 implies planning relate in relation to the overall management of toolkits. All raw materials
251 processed using shell tools in La Balma del Gai had already been previously identified in
252 contexts located in the Iberian Peninsula. Thus, in this previous research it has been possible

253 recognize the use of these tools to processing mineral (ocher) (Cuenca-Solana et al, 2013;
254 2016a, 2016b), vegetable (wood and plant non-wood) (Cuenca -Solana et al., 2013, 2016b) and
255 animal materials (skin and leather) (Cuenca-Solana, 2013; Cuenca-Solana et al., 2013, 2015).
256 Moreover, the use of shell tools is documented at Balma del Gai in all the phases of occupation,
257 from XIV to X millennium before the present. This continuity with respect to the management
258 of these tools was maintained even with the progressive increase in lithic carving and
259 principally with the use of geometric microliths from the end of the XI millennium,
260 approximately. The constancy in the use of shell tools along all the archaeological sequence in
261 the site is one more evidence that supports the previously mentioned clear continuity in
262 subsistence and technology along the two Epipalaeolithic facies, the Epimagdalenian and the
263 Microlaminar Sauveterroid,. (Nadal et al., 2017).
264 With respect to the functional interpretation of these tools, the comparison with the results
265 obtained from different analytical experimental programmes carried out (Cuenca-Solana, 2010,
266 2013, 2015, Cuenca-Solana et al, 2013, 2015, 2016a, 2016b) enables the confirmation of their
267 use to effect different productive activities oriented to processing materials of animal, plant and
268 mineral origin (Fig. 6). In this sense, the data obtained through analysis of other evidence found,
269 especially fauna and anthracological remains, are also very coherent with this interpretation.
270 Thus, the presence of *Buxus sempervirens* in different periods of occupation of the site (Allué et
271 al., 2007), as well as the documentation of more than 15000 remains of *Oryctolagus cuniculus*,
272 many of them with cut traces directly linked to obtaining skin (Rosado-Méndez et al., 2019),
273 enable the relation of the use of these tools to some of the productive activities in this context.
274 Likewise, the result of our analysis indicates that the exploitation of at least a part of the more
275 than 270 remains of ochre found at la Balma del Gai (Estrada et al., 2011) could have been done
276 with shell tools.

277 Fig. 6. Shell tools from the experimental analytical program used to establish the functional
278 interpretation at La Balma del Gai. a) Detail of the use-wear traces generated on *Mytilus*
279 *galloprovincialis* shell use to spread ochre on skin at 200X. b) Use-wear traces on *Patella* sp.
280 shell generated by extracting and stretching fibres of *Juncus* sp. at 100X. c) Use-wear traces
281 generated on *Mytilus galloprovincialis* shell used to smoothen wood of *Buxus sempervirens* at
282 100X. d) Use-wear traces generated on *Mytilus galloprovincialis* shell used to scrape a block of
283 ochre to obtain powder at 100X.

284
285 Anyway, taking into account the results of our study and their relation to other evidence found,
286 fauna and anthracological remains, it seems that the shells of the Balma del Gai could have been
287 used to carry out actions oriented to the manufacture and production of elements linked to the
288 management and exploitation of skin, especially with the high quantitative presence of

289 *Oryctolagus cuniculus*. This link would have developed directly and indirectly through carrying
290 out different productive activities. Thus, only the shell of *Glycymeris glycymeris* #525 could
291 have been used directly to process skin. The low percentage of shell tools oriented to carry out
292 this activity is explained from the preliminary results obtained in the use-wear study of lithic
293 tools, that seem to indicate that the processing of skin was carried out principally through the
294 use of these elements. (Mangado et al., 2006). These studies were mainly conducted on
295 endscrapers and showed clear evidences that these tools were used for the processing of dry
296 skins, specifically 75% of the identified use-wear marks indicated this activity (García-
297 Argüelles et al., 2004). Moreover, the use of the fragments of *Mytilus galloprovincialis* #47
298 (Fig. 2) and #114 would have been oriented to obtaining ochre powder by scraping blocks of
299 this mineral. Likewise, from the comparison of the results obtained in the experimental
300 programme developed (Cuenca-Solana, 2013, Cuenca-Solana et al., 2013, 2016a, 2016b), we
301 can interpret that the fragments of *Mytilus galloprovincialis* #1329 and #416 (Fig.3) could have
302 been used to extend this ochre over the skins, during the leather tanning process. In this sense,
303 other researchers have previously demonstrated the variety of techniques and materials used to
304 carry out the leather tanning process (Beyries, 2008) both in ethnographic and archaeological
305 contexts. The use of ochre as an additive to carry out this activity through the use of lithic tools
306 has been documented through use-wear analysis in different archaeological contexts (Gijn,
307 1989; Ríos Garaizar et al., 2002, among others). The benefit of this use is based on the
308 antiseptic characteristics of ochre, which contributes to better preservation of skin (Audouin and
309 Plisson, 1982). From the viewpoint of use-wear analysis, the use of this additive to scrape skin
310 is characterized, due to its abrasive character, by greater development of the micro-polish and
311 rounding, and above all, greater presence of micro-holes on the surface of the tools used for this
312 activity (Clemente, 1997; González Urquijo and Ibáñez Estévez, 1994; Vaughan, 1985).
313 Furthermore, the fragments of *Mytilus galloprovincialis* #234 and #131 (Fig. 4), used to extract
314 and stretch vegetable fibres, and the piece #173 (Fig. 5), linked to the smoothening or polishing
315 of hard wood, maybe could have been oriented to manufacturing infrastructures, such as string
316 and wooden frames, necessary to stretch and tan skin. The importance of these tools resides in
317 the possibility of demonstrating the use of perishable elements, such as vegetable fibres and
318 wood, which are therefore only identifiable indirectly in this context.
319 On the other hand, the presence of seashells in inland sites that are not interpreted as decorative
320 elements, because they do not present modifications for this purpose (*Glycymeris*) or because
321 their use as a support for the manufacture of personal ornaments has never been detected, could
322 be related to the relationship of these inland sites and synchronous occupations hitherto little
323 known on the Mediterranean coast of the Iberian Peninsula. In fact, new discoveries as well as
324 the revision of old excavated sites are showing that the Mediterranean hunter-gatherer
325 settlements are more numerous than previously thought (Román et al., 2020). In addition, other

326 investigations have highlighted that the number of marine malacofaunistic specimens recovered
327 in Epipaleolithic and Mesolithic sites from NE Iberia decrease in quantity and diversity as we
328 move away from the seacoast. Lloveras et al. (2019) showed how the diversity keeps wide up to
329 distances between 30 and 50 km from the current coast line. However, from these distances, the
330 taxonomic diversity is reduced to a few species, mainly small gastropods and scaphopods, used
331 exclusively with ornamental purposes. These data is consistent with the idea that hunter-
332 gatherers that had direct contact with the seashore (e.g. during some months along the year, in
333 seasonal camps) displayed more diversity and quantity of shells in their inland seasonal camps
334 compared to the groups that only acceded to these items from interchange with other groups. In
335 this sense, Balma del Gai behaves as those sites displaying great diversity of molluscs, as might
336 be expected. The fact of finding shells that do not have an exclusive ornamental, but a
337 technological purpose would reinforce the hypothesis that these groups did not obtain the
338 marine shells indirectly by exchanges but directly in the coast, probably in seasonal coastal
339 settlements situated in their annual range area. In Balma del Gai, we only have clear evidence of
340 occupations corresponding to late summer or autumn, as evidenced by the growth stage of some
341 of the red deer antlers recovered and the presence of charred blackthorn endocarps (Estrada et
342 al., 2011). Besides, the great amounts of *Cepaea nemoralis* shells accumulated in the site,
343 considered as result of gathering for human consumption also reinforce this idea, as the land
344 snails would be active only in wet and cool seasons. In these coast sites, the molluscs also had a
345 nutritional function. In the seasons that those communities moved to the inland sites, they would
346 transport with them not only ornamental objects but also unmodified or scarcely transformed
347 pieces, collected already dead from the coast or as by-products of food, for their technological
348 use in the inland sites. In this sense, the identification of shell tools from inland sites is not
349 unusual during the Palaeolithic and Mesolithic periods, since many of the shell tools used by
350 hunter-gatherers groups are located at distances between 20 and 40 km from the coastline
351 (Cuenca-Solana et al., 2015). In addition, from a taxonomic perspective the results obtained in
352 La Balma del Gai show a preference for the use of two species of shells (*Mytilus*
353 *galloprovincialis* and *Glycymeris glycymeris*) exploited more or less frequently during the
354 Palaeolithic and the Mesolithic in the Mediterranean coast (Román et al., 2020). Furthermore,
355 the documentation of shell tools of both species previously in other archaeological contexts
356 (Courtin & Vigié, 1987; Gutiérrez Zugasti et al, 2011, Clemente & Cuenca-Solana, 2011,
357 Manca, 2016, among others), and also the development of different experimental protocols
358 (Tumung et al., 2015; Cuenca-Solana, 2013) show that shells of both taxa have a very suitable
359 morphology and hardness for their potential technological use.

360 From the results obtained in this research and other studies previously carried out (Cuenca-
361 Solana, 2013; 2015; Cuenca-Solana et al., 2013, 2016a, 2016b, among others) we can establish
362 some reflections about the role of shell tools for the development of the productive strategies of

363 hunter-gatherer groups: a) Shell tools should be considered as part of the toolkits potentially
364 used by hunter-gatherer groups. In this sense, in recent years there has been an increasing body
365 of evidence of technological use of these marine resources that justifies this approach (Barton &
366 White, 1993, Schmidt et al., 2001, Cristiani et al., 2005, Choi and Driwantoro, 2007, Jones and
367 Keegan, 2001, Szabó et al., 2007; Szabó, 2008; Szabó and Koppel, 2015, Lammers, 2008,
368 Mansur & Clemente-Conte, 2009, Douka, 2011, Douka & Spinapolice, 2012, Cuenca-Solana,
369 2013, 2015, Cuenca-Solana et al., 2013, 2016a, 2016b, Romagnoli et al., 2015, Tumung et al.,
370 2015, among others). Furthermore, this interpretation is also supported by numerous and varied
371 ethnographic information, an aspect that we have previously shown (Cuenca-Solana et al.,
372 2011). b) From a methodological perspective, in addition to studying this evidence typologically
373 and technologically, it must also be assessed from a functional viewpoint through use-wear
374 analysis. The potential of this methodology lies in its ability to establish an interpretation of
375 tools that is linked with the role played within the survival strategies of human groups. In
376 addition, as the results obtained in the Balma del Gai have shown, from the application of this
377 methodology, it is possible to recognize the presence of perishable materials, usually
378 unperceived in the archaeological record, although probably fundamental for the development
379 of numerous and varied activities carried out by the hunter-gatherer groups. c) The correlation
380 among the different technological elements that make up the hunter-gatherers' toolkits, through
381 global analysis of the different types of elements that compose them, is the only way to develop
382 an objective scientific approach to the tool management carried out by these groups, and
383 therefore to increase our knowledge about technological and economic aspects linked to their
384 ways of life.

385

386 **4. Conclusions**

387

388 From the results obtained in this research and their comparison with other data obtained from
389 the different studies carried out at La Balma del Gai, faunal and anthracological studies and use-
390 wear analysis of lithic tools, we can establish a general interpretation of a part of the productive
391 activities carried out by the hunter-gatherer groups that occupied this site between the second
392 half of the XIV millennium and the end of the X before the present. In this way, the results of
393 the set of studies done fit with a seasonal occupation, principally centred on the summer-autumn
394 and with the exploitation of a wide range of resources with clear predominance of hunting
395 activity oriented to the capture of rabbits to use both their skin and meat. In this context, the
396 shell tools had an important role within the set of technological elements employed to carry out
397 these subsistence activities. They were especially linked to the treatment of perishable materials
398 (vegetable fibres and wood) and carrying out actions oriented to obtaining and processing
399 elements that were related to the most intense activities in this context, which was obtaining and

400 preparing skin. In this sense, the shell tools use could be oriented to some specific moments of
401 the "chaîne opératoire" while most of the skinning process was performed with lithic tools,
402 specifically endscrapers. From another perspective, the use of shell tools at La Balma del Gai
403 fits with the general pattern demonstrated by hunter-gatherer groups, since the Palaeolithic, with
404 respect to the use of this type of technological elements (Cuenca Solana, 2013, 2015, 2016a,
405 2016b): that is, carrying out short-duration actions within productive processes for which the
406 use of very specialized technology is not necessary. This use could have been oriented to saving
407 and protecting the correct functionality of the lithic and bone tools.

408 The development of this analysis of use-wear traces enables the demonstration of the potential
409 of this methodology to reconstruct the productive strategies of human groups. Finally, the
410 results obtained also constitute a good sample of the diversified potential use of shells as food,
411 adornment or as tools, an aspect of great interest when reconsidering the true role played by
412 malacological resources within the productive strategies of hunter-gatherer groups.

413 Finally, the identification of unmodified but used (presenting use-wear traces) shells in the site
414 reinforces the idea that Balma del Gai was an inland seasonal occupation of hunter-gatherer
415 populations with a catchment territory that at some time in the year also included coastal
416 settlements where people had access to this type of materials. Future archaeological data would
417 allow us to corroborate or not this hypothesis.

418

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420

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431

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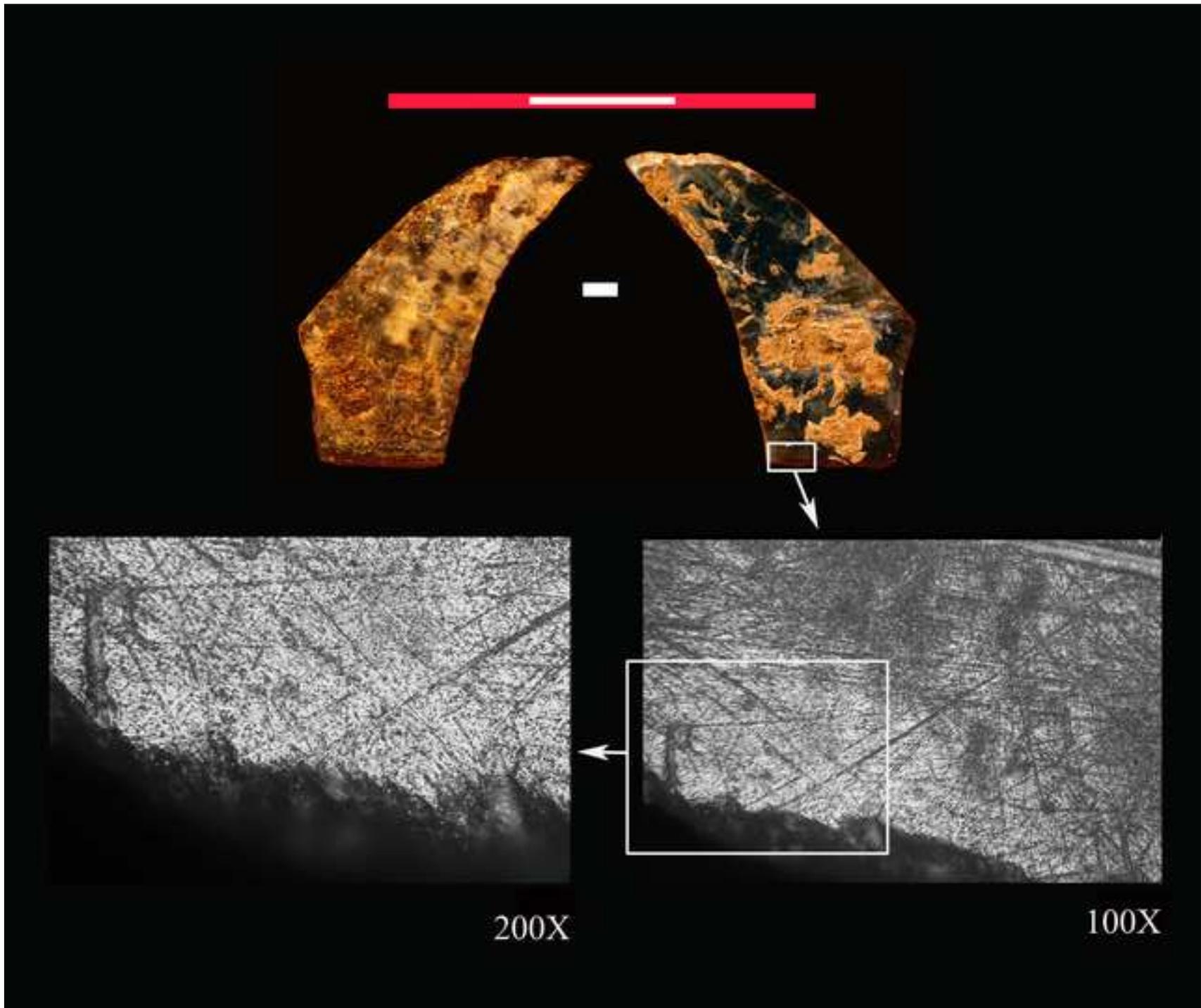
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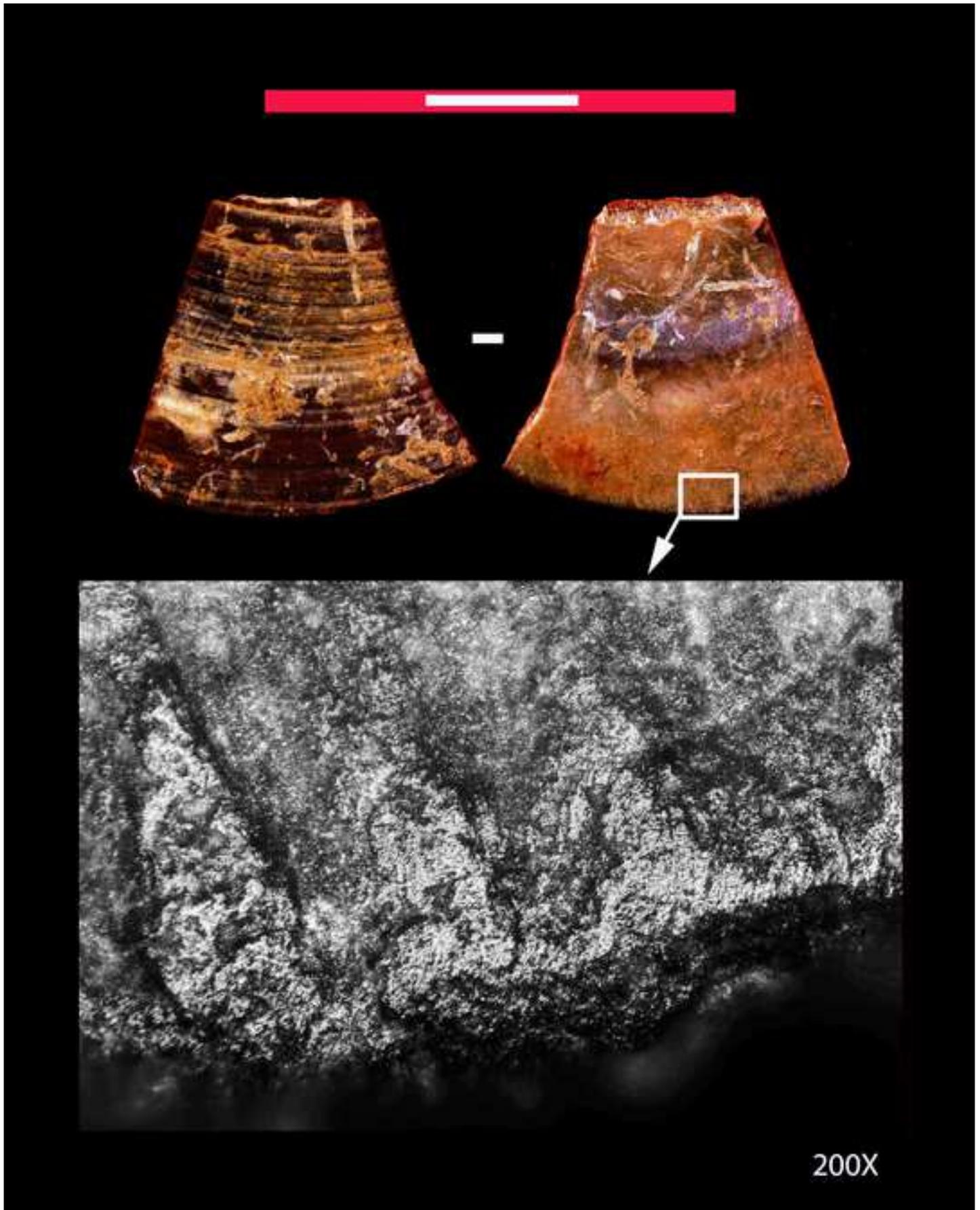
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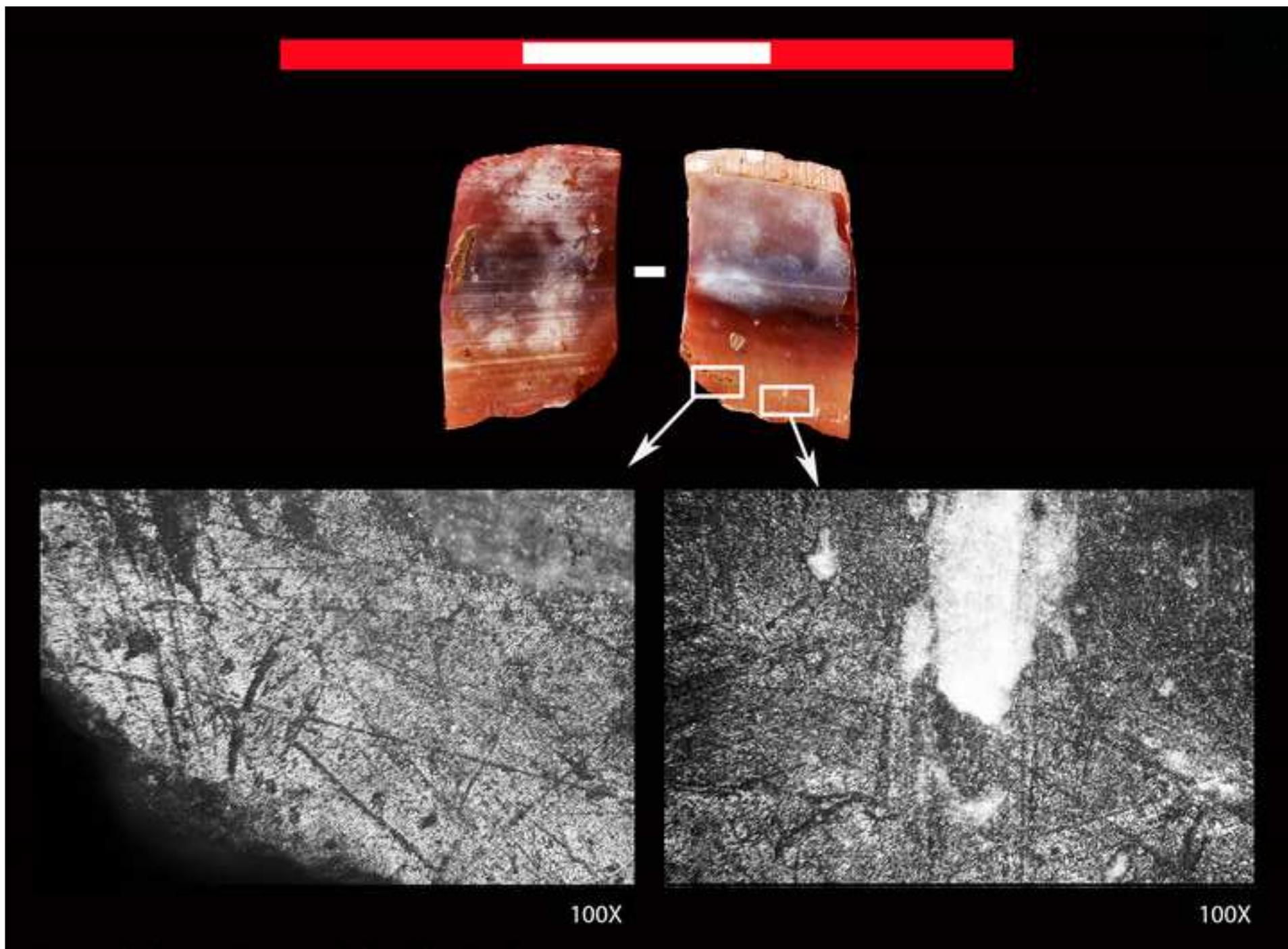
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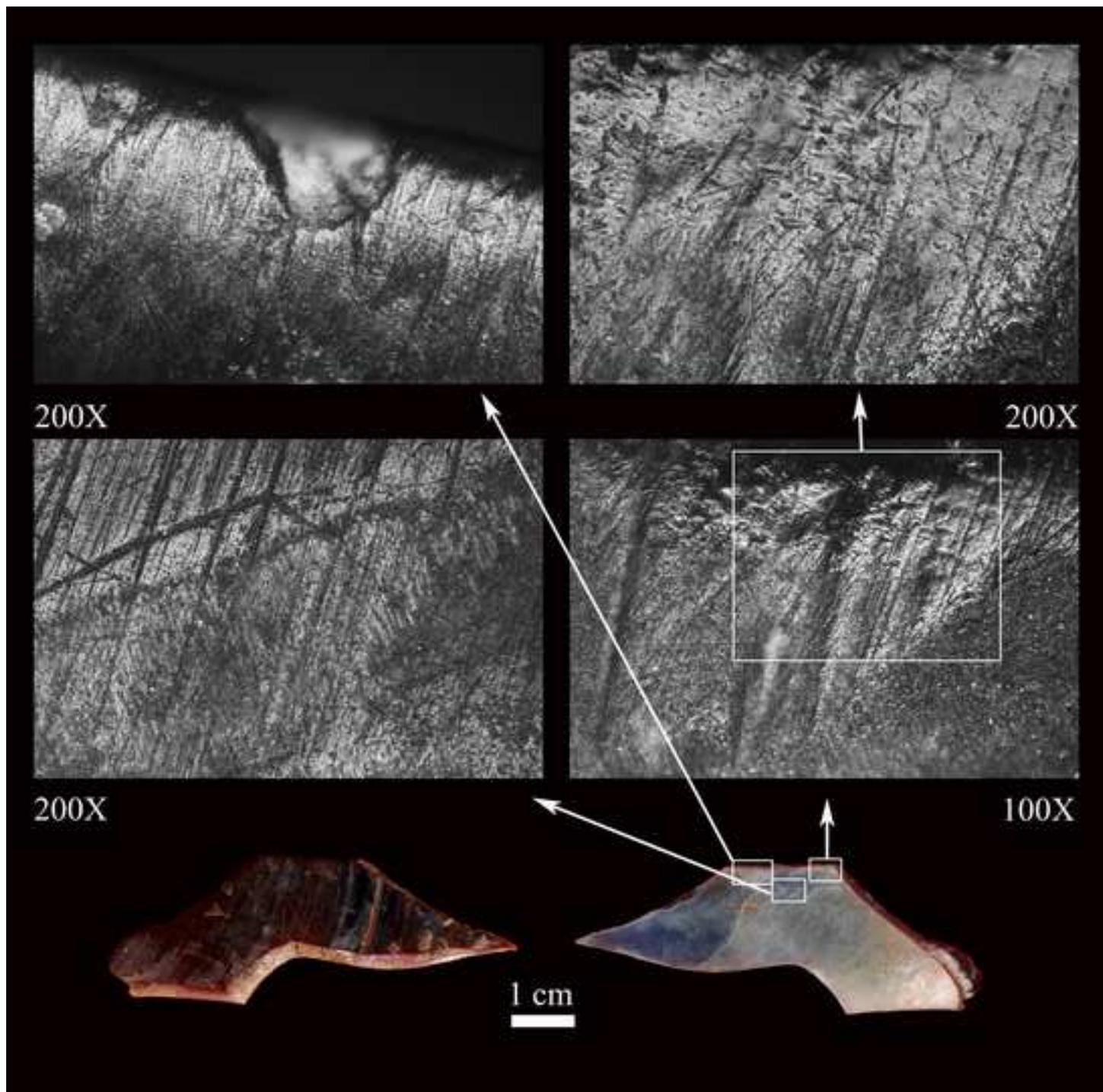
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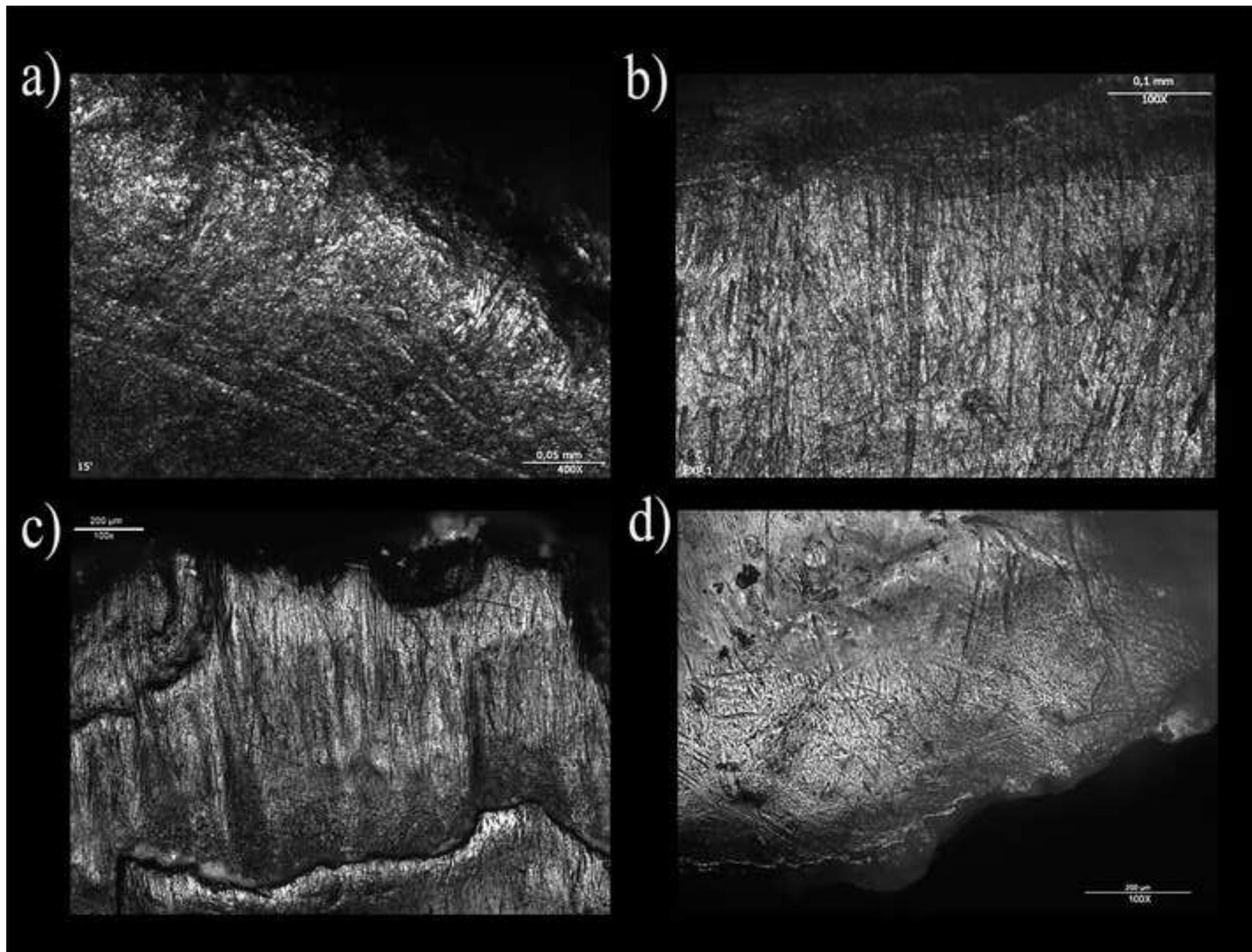
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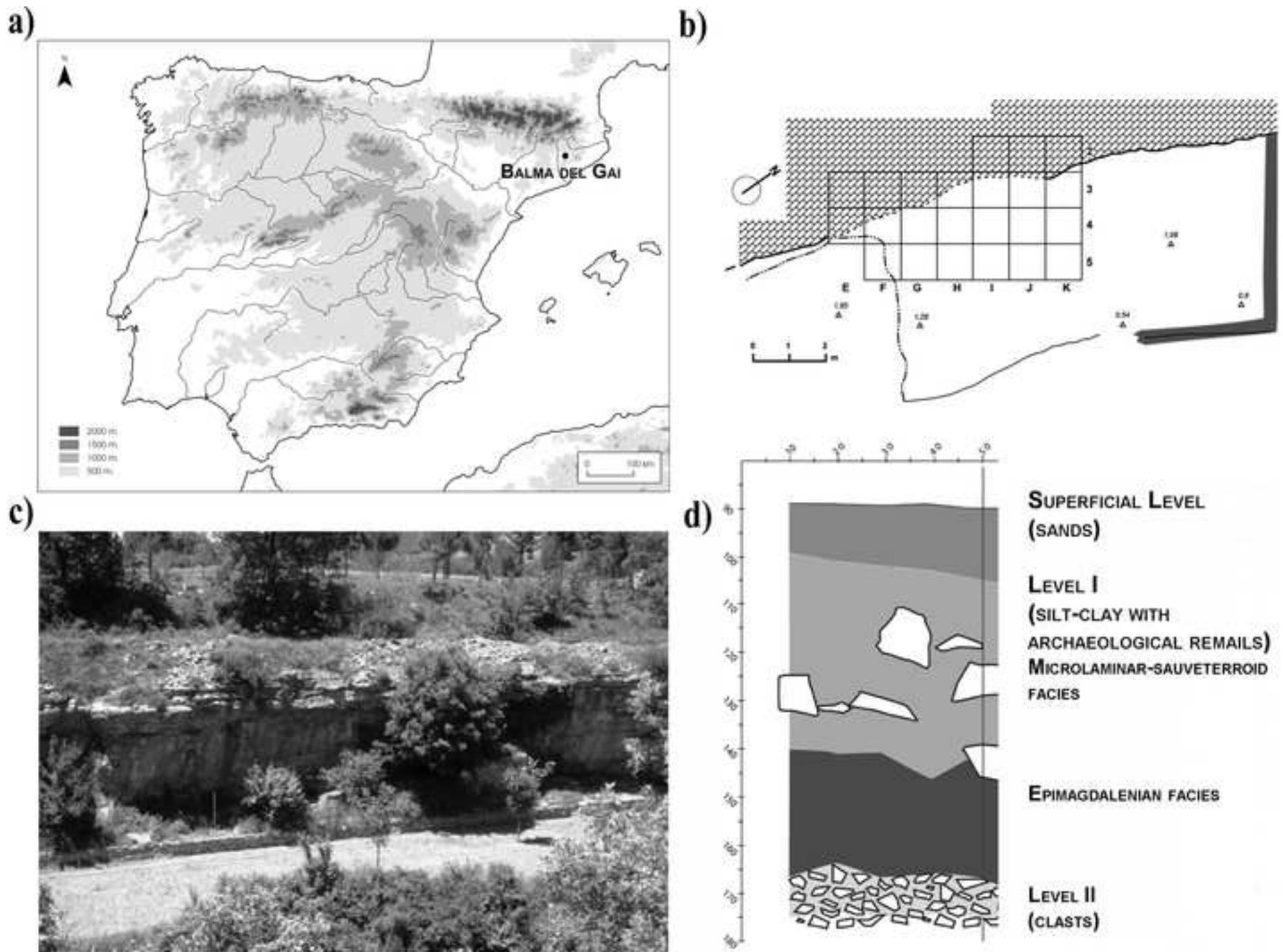












Facies	Lab ref.	radiocarbon dates	Cal BP (2-sigma)
<i>Epimagdalenian</i>	OxA-29608	11,440 ± 50 BP	13,442-13,180
	Gif-10029	11,170 ± 160 BP	13,340-12,759
	Mc-2140	11,050 ± 160 BP	13,240-12,731
<i>Transition</i>	Gif-95617	10,260 ± 90 BP	12,476-11,648
	OxA-27437	10,200 ± 45 BP	12,002-11,651
<i>Microlaminar</i>	Mc-2141	10,030 ± 160 BP	12,440-11,177
<i>Sauveterroid</i>	Mc-1418	9,840 ± 400 BP	12,616-10,290
	Gif-10028	8,930 ± 140 BP	10,368-9,552

Species	Level	Square	Sample id.	
<i>Glycymeris glycymeris</i>	I	F.4.3	1048	
	I	K3	530	
	I	F4.3	525	
	I	J3-Q2	639	
	I	H4 (2)	376	
	I	I4	147	
	I	J4	1177	
	I	I3	160-165	
	I	G3	174	
	I	E4	278	
	SUP/I	H3	23	
	I	I3	400	
	SUP/I	K4	82	
	I	H3	1823	
	?	H35	S/N	
	I	J3	1273	
	I	H3	1761	
	I	E4	130	
	<i>Mytilus galloprovincialis</i>	I	K3	872
			H32	c1
I		F43	804	
I		H3	1329	
I		E4	234	
I		E4	131	
SUP		I4	47	
SUP		F.4.2	173	
SUP		H5	114	
I		F4.3	416	
I		I3-Q2	217	
SUP		G4	35	

Species	Level	Square	Sample id	Use-wear result
<i>Glycymeris glycymeris</i>	I	F4.3	525	Use
<i>Glycymeris glycymeris</i>	I	I4	147	Personal ornaments?
<i>Glycymeris glycymeris</i>	I	I3	160-165	Personal ornaments?
<i>Glycymeris glycymeris</i>	I	G3	174	Personal ornaments?
<i>Glycymeris glycymeris</i>	SUP/I	K4	82	Probable use
<i>Mytilus galloprovincialis</i>		H32	C1	Probable use
<i>Mytilus galloprovincialis</i>	I	H3	1329	Use
<i>Mytilus galloprovincialis</i>	I	E4	234	Use
<i>Mytilus galloprovincialis</i>	I	E4	131	Use
<i>Mytilus galloprovincialis</i>	SUP	I4	47	Use
<i>Mytilus galloprovincialis</i>	SUP	F.4.2	173	Use
<i>Mytilus galloprovincialis</i>	SUP	H5	114	Use
<i>Mytilus galloprovincialis</i>	I	F4.3	416	Use

Action

Transversal scraping
Suspension/Transport?
Suspension/Transport?
Suspension/Transport?
Transversal scraping
Transversal and longitudinal action
Transversal and longitudinal action
Transversal scraping
Transversal scraping
Transversal scraping
Transversal scraping
Transversal scraping
Transversal and longitudinal action

Processed matter

Dry/semidry skin

Medium-hard material
Medium-hard material
Mineral (Ocher) + skin
Vegetal
Vegetal
Mineral (Ocher)
Hard wood
Mineral (Ocher)
Mineral (Ocher) + skin

Functional interpretation

Cleaning the skin during the tanning process

Indeterminate

Indeterminate

Extend ochre on skin

Extracting/stretching fibres

Extracting/stretching fibres

Ocher powder obtention

Polishing/smoothen hard wood sticks

Ocher powder obtention

Extend ochre on skin

Author statement;

David Cuenca-Solana; Conceptualization, Methodology, Formal análisis, Validation, Investigation, Writing - Original Draft, Writing - Review & Editing, Supervision, Data Curation, Funding acquisition.

Ignacio Clemente-Conte; Methodology, Formal análisis, Resources.

Lluís Lloveras; Investigation, Writing - Original Draft, Writing - Review & Editing, Supervision, Data Curation, Funding acquisition.

Pilar García-Argüelles; Investigation, Funding acquisition, Data Curation.

Jordi Nadal; Investigation, Writing - Original Draft, Writing - Review & Editing, Supervision, Funding acquisition, Project administration, Data Curation.