

1 **Morphometric and technological analysis of Acheulean Large Cutting Tools from**  
2 **Porzuna (Ciudad Real, Spain) and questions of African affinities**

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4 Adrián Arroyo<sup>1, 2\*</sup>, Tomos Proffitt<sup>3\*</sup>, Alastair Key<sup>4\*</sup>

5 <sup>1</sup> Institut Català de Paleoecologia Humana i Evolució Social (IPHES), Zona Educacional 4, Campus Sescelades  
6 URV (Edifici W3) 43007, Tarragona (Spain)

7 <sup>2</sup> Universitat Rovira i Virgili (URV), Àrea de Prehistòria, Avinguda de Catalunya 35, 43002 Tarragona, Spain

8 <sup>3</sup> Institute of Archaeology, University College London, 31–34 Gordon Square, London WC1H 0PY (UK)

9 <sup>4</sup> School of Anthropology and Conservation, University of Kent, Canterbury, Kent CT2 7NR (UK)

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11 \*Corresponding authors: adri.arroyourena@gmail.com (A. Arroyo); t.proffitt@ucl.ac.uk (T. Proffitt)  
12 A.J.M.Key@kent.ac.uk (A. Key)

13

14 **Abstract**

15 The Acheulean of central Spain is well known from a handful of sites. Rarely, however, are  
16 these assemblages subject to systematic technological and morphological analyses. Numerous  
17 years of surface collection within the Porzuna area (Ciudad Real) has yielded a substantial  
18 collection of Lower-Middle Palaeolithic lithic material (with over 8000 stone tools), now  
19 housed at the Museo Provincial of Ciudad Real. It has been suggested that the LCT technology  
20 of the Spanish Acheulean may have been directly influenced by ESA African technological  
21 traditions; however, others have suggested a European origin for the technology. Here we  
22 present a techno-typological and 3D morphometric analysis of the LCT's collected at Porzuna.  
23 We compare the Porzuna artefacts to other known local assemblages from Ciudad Real as well  
24 as Acheulean LCT's from north, east and South Africa, to investigate potential technological  
25 and morphological affinities. Results of our analysis show that despite sharing technological  
26 similarities, such as the use of large flakes as blanks, significant morphological differences  
27 exist between the African and Iberian LCTs.

28 **Keywords:** Large Flake Acheulean; Iberian Peninsula; handaxe; morphometric analysis; Early  
29 Stone Age

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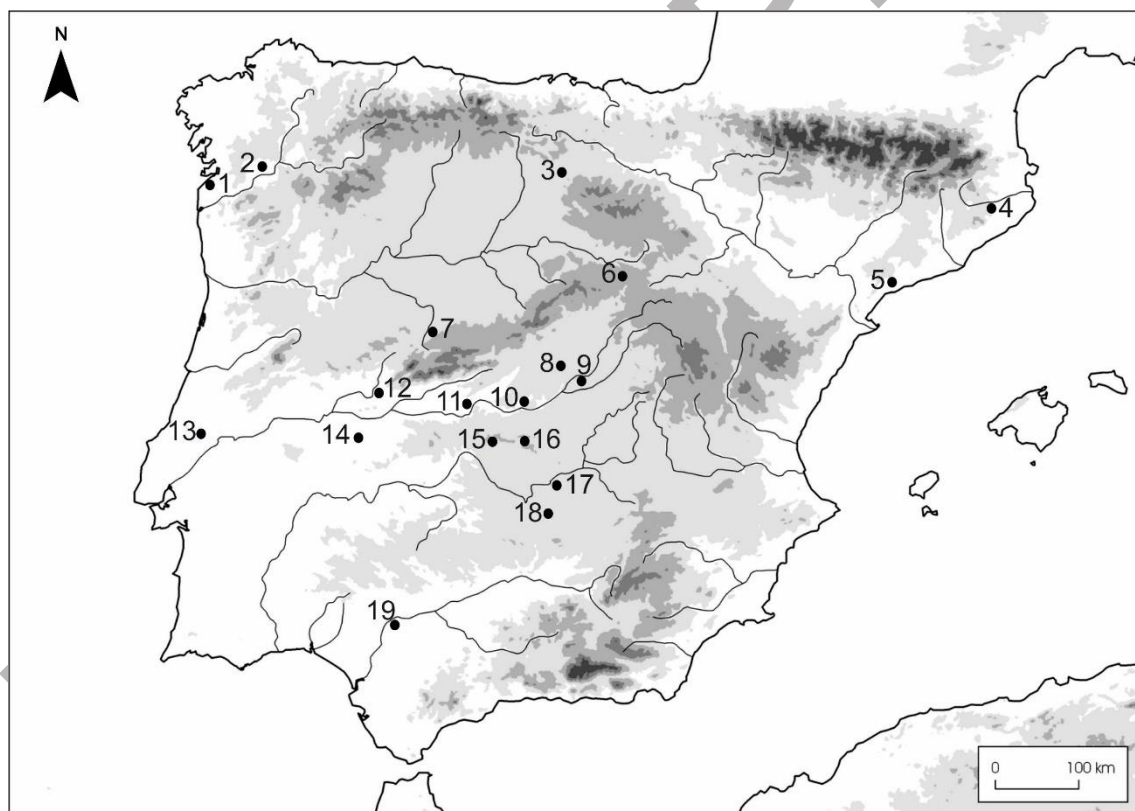
### 31 **1) Introduction**

32

33 The Acheulean emerged in East Africa in association with a new species, *Homo erectus*  
34 *s.l.*, and became the longest lasting human cultural tradition (~1.76-0.2 million-years-ago  
35 [Mya]). Characterised by the appearance of large flake technologies and bifacially flaked core  
36 tools (Isaac, 1969; de la Torre et al., 2008), collectively termed as large cutting tools (LCTs),  
37 the rapid diffusion of Acheulean technology between 1.76 and 1.7 Mya is evidenced at sites  
38 such as Kokiselei 4 at West Turkana (Kenya) (Lepre et al., 2011), KGA6-A1 at Konso  
39 (Ethiopia) (Beyene et al., 2013), FLK W at Olduvai Gorge (Tanzania) (Diez-Martín et al.,  
40 2015), and Gona (Quade et al, 2004; Semaw et al., 2018). Subsequently, Acheulean LCT's  
41 became widespread across Africa, Europe, the Levant and large swathes of Asia and Arabia  
42 (e.g. Isaac, 1977; de la Torre et al., 2008; Presnyakova et al., 2018; Mishra et al, 2010; Goren-  
43 Inbar and Saragusti, 1996; Zhang et al., 2010; Shipton et al., 2014; 2018).

44 The origin and dispersal of the Acheulean in Europe is an important and ongoing point  
45 of debate. This includes within the Iberian Peninsula, where the earliest evidence of hominin  
46 occupation comes from sites such as Barranco León and Fuente Nueva, dated to 1.4-1.2 Ma  
47 (Toro Moyano et al., 2011), and Sima del Elefante (Atapuerca) (Carbonell et al., 2008) dated  
48 to 1.2 Ma; although their lithic assemblages have been classified as Oldowan or Mode 1. The  
49 earliest Iberian Acheulean assemblages have been documented at Barranc de la Boella, dated  
50 to ca. 1 Ma (Valverdú et al., 2014), and Cueva Negra, dated to 0.9-0.78 Ma (Scott and Gibert,  
51 2009). Middle Pleistocene sites are, however, common on river terraces across the Iberian  
52 Peninsula. This includes the central Spanish area of Porzuna and Campo de Calatrava, where

53 several Acheulean sites have previously been identified along the Guadiana River and its  
54 tributaries (Santonja and Redondo, 1973; Santonja and Querol, 1976; Vallespí et al. 1979;  
55 1980; Alañón Flox 1980; 1982; Ciudad Serrano et al., 1983a; Ciudad Serrano, 1986). Other  
56 large river basins in the Iberian Peninsula with documented Acheulean sites include the Tagus  
57 and its tributaries (Santonja et al., 1978; Querol and Santonja, 1979; Santonja and Pérez-  
58 González, 2002; Rodríguez de Tembleque et al. 2004; Santonja and Villa, 2006), and the  
59 Guadalquivir river basin (Vallespí, 1992; Caro Gómez, 2000; Fernández Caro, 2008) (Figure  
60 1). The wide documentation of LCTs across the Iberian Peninsula has resulted in multiple  
61 analyses highlighting their importance to hominin populations in this region (Santonja and  
62 Villa, 1990; 2006; Arroyo and de la Torre, 2013; Méndez-Quintas et al, 2018).



63  
64 **Figure 1.** Location of a selection of Middle Pleistocene Acheulean sites from the Iberian  
65 Peninsula. Legend: 1. Budiño; 2. Porto Maior; 3. Galería (Atapuerca); 4. Puig d’Esclats;  
66 5. La Cansaladeta; 6. Torralba and Ambrona; 7. La Maya; 8. San Isidro; 9. Áridos; 10.  
67 Pinedo; 11. Puente Pino; 12. El Sartalejo; 13. Gruta da Aroeira; 14. Santa Ana; 15  
68 Porzuna; 16. El Sotillo; 17. Albalá; 18. El Chiquero; 19. Las Jarillas.

69           The earliest hominin migrations into Iberia, and in turn the appearance of the  
70 Acheulean, could have occurred through two routes. Individuals could either have colonised  
71 the peninsular from a North Africa route across the Strait of Gibraltar or spread through  
72 Western Europe. To date, both remain viable as potential dispersal routes of Acheulean  
73 technology into Iberia. Archaeological and faunal evidence has led O'Regan (2008) and  
74 Martínez and Garriga (2016), for example, to favour repeated episodes of Acheulean hominin  
75 population dispersals from Western European and the Levant into Iberia. Alternatively, Sharon  
76 (2011) has suggested a North African dispersal, based on the use of large flakes for biface  
77 manufacture, the high number of cleavers in assemblages, and the use of raw materials beside  
78 flint. To date, however, few studies have set out to formally test the hypothesised north African-  
79 Iberian dispersal routes as evidenced through lithic artefacts. Indeed, in a similar vein to  
80 hominin dispersal studies in other regions, there is a need for detailed typo-technological and  
81 morphometric comparisons of artefacts from both 'origin' and 'destination' localities (Goren-  
82 Inbar and Saragusti, 1996; Lycett and von Cramon-Taubedel, 2008; Lycett, 2009; Fleagle et  
83 al., 2010; Shipton and Petraglia, 2011; Wang et al., 2012).

84           Here, we present a technological and 3D shape analysis of a new Acheulean LCT  
85 assemblage collected from the Porzuna area of Ciudad Real, Spain. Our aim is to conduct a  
86 comparison of LCTs from this location with six other known Acheulean assemblages from  
87 Campo de Calatrava (El Sotillo and El Chiquero, Spain), north Africa (STIC and Cunette),  
88 East Africa (HK, Olduvai Gorge) and South Africa (Elandsfontein). We assess techno-  
89 typological and 3D morphometric traits from Porzuna alongside these Spanish and African  
90 assemblages, contextualizing the Porzuna artefacts among other Central Spanish sites, while  
91 also contributing to our understanding of potential south-western dispersal routes into Europe  
92 by Middle Pleistocene hominins.

93

94        **2) Materials and Methods**

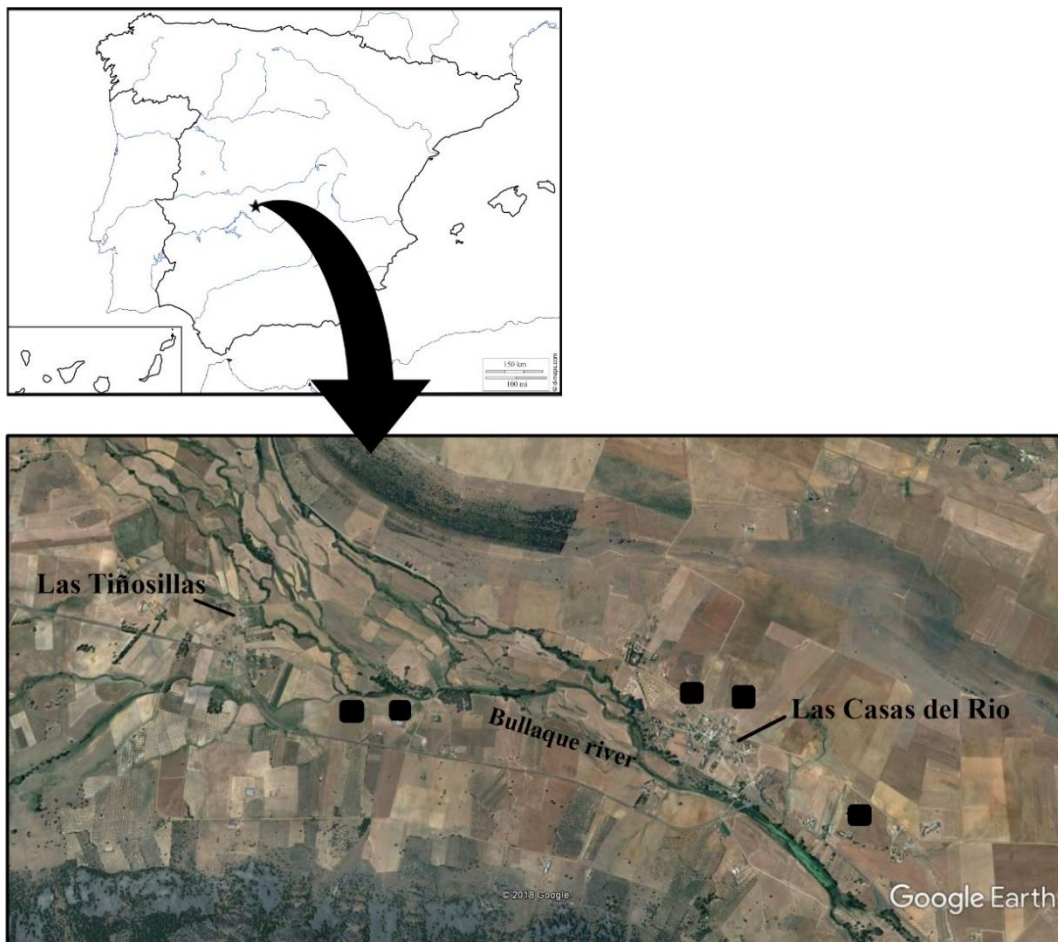
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96        **2.1 Materials**

97        *The archaeological locality of Porzuna*

98        Porzuna lies in the north-west of Ciudad Real province (Spain), close to the foothills of  
99        the Montes de Toledo (in the north) and the volcanic area of Campo de Calatrava (to the south).

100       Porzuna valley is crossed by the Bullaque River and filled with alluvial fan deposits. Multiple  
101       open-air artefact localities occur on its +5m river terrace. Our recent visits to the area confirmed  
102       the availability of high densities of raw material (mainly quartzite) and artefacts (Figure 2).



103

104        **Figure 2.** Location of Porzuna and general view of the area. Black squares refer to the points  
105        where lithics were collected (according to Vallespí et al., 1985).

106 The Porzuna assemblage currently contains over 8000 artefacts (including cores,  
 107 débitage, retouched pieces and LCTs [bifaces, cleavers, picks and large flakes]) recovered by  
 108 various prospectors from the 1950s onwards. First reported by Vallespí and colleagues (1979  
 109 and 1985), the assemblage was initially considered a mixture of Acheulean and Mousterian of  
 110 Acheulean Tradition (MTA) artefacts, with very high densities of bifaces (>400), cleavers  
 111 (>300) and picks (>130). Such occurrences were rarely documented outside of Africa at that  
 112 time. Despite the lack of radiometric dates, Ciudad Serrano (1988) estimated the site to be  
 113 included within the last glaciation (Würm I; ca 115 Kya). In a wider regional context, additional  
 114 studies of the Guadiana and Jabalón rivers documented the presence of the Acheulean  
 115 assemblages in +10/13 m and +8 m terraces (Santonja, 1996; Santonja, Pérez González, 2002,  
 116 2010), while the only radiometric chronology available to date was obtained from a +13/16 m  
 117 terrace in the Guadiana river dated to 153.867 BP (López et al., 2005).

118 The lithic collection presented in this paper belongs to a previously unreported Porzuna  
 119 assemblage deposited at the ‘Museo Provincial of Ciudad Real’ in 2015. Collected by a local  
 120 prospector and subsequently donated, it consists of 216 artefacts separated into two localities:  
 121 Las Casas del Rio (n= 58, 27%) and the larger assemblage of Las Tinosillas (n= 157, 73%)  
 122 (Table 1). Within this assemblage there is a clear bias towards larger artefacts (cores and LCTs)  
 123 compared to débitage which is underrepresented in the analysed assemblage. Due to this  
 124 inherent bias we decided to focus our analysis exclusively on the LCTs (n= 130).

	Las Casas del Rio		Las Tinosillas	
	N	%	N	%
Natural base	0	0.0	2	1.3
Retouched piece	1	1.7	0	0.0
Flake	5	8.6	7	4.4
Flake fragment	0	0.0	1	0.6
Large cutting tool	21	36.2	109	69.0
Core	31	53.4	39	24.7
<b>Total</b>	<b>58</b>	<b>100</b>	<b>158</b>	<b>100</b>

125



126 **Table 1.** Breakdown of categories with all pieces included in the new assemblage accessed.

127

128 *Comparative archaeological assemblages*

129 Handaxes included in the 3D shape analysis were selected from sites in central Spain,  
130 and north, east and South Africa.

131 The Spanish assemblages include El Sotillo and El Chiquero; both are housed at the  
132 Museo Provincial of Ciudad Real (Spain). The lithic assemblage from El Sotillo, located ~20  
133 km to the east of Porzuna, is formed of 115 bifaces, cleavers, knives and large flakes collected  
134 during the 1980's (see: Serrano et al., 1983; Arroyo and de la Torre, 2013). Located in a  
135 Pleistocene alluvial fan deposit in the Bullaque river valley (Portero et al., 1988), recent  
136 excavations at this locality have increased the assemblage size and will soon shed light on the  
137 absolute chronology of the assemblage. El Chiquero, located ~60 km south of Porzuna, is  
138 formed by a small group of surface collected handaxes ( $n = 8$ ) from the left side of the Jabalón  
139 river valley. In this site, since the initial collection of surface material, no additional works  
140 were undertaken.

141 North African artefacts were selected from various localities from Sidi Abderrahman.  
142 Main sites include STIC, Cunnette and Grotte des Ours. Based on previous studies of these  
143 collections, STIC contains 'cruder' handaxes than Cunnette with a predominance of quartzite  
144 cobbles as blanks. Comparative analysis of human remains found in nearby localities support  
145 an estimated chronology between 0.6-0.4 Ma (Marshall et al., 2002).

146 From Olduvai, handaxes were selected from the Hopwood's Korongo (HK) site.  
147 Located on the north side of the gorge, this site was excavated during the 1931 expedition  
148 (Leakey and Roe, 1994). Despite uncertainties about its stratigraphic position, test trenches  
149 excavated in 1969 determined that HK is located in upper Bed IV or even the Masek Bed, and

150 therefore has a chronology of < 0.6 Ma (Leakey and Roe, 1994). At HK, the majority of the  
151 handaxes are made of coarse grain quartzite and flake as blank (Marshall et al., 2002).

152 Finally, we selected bifaces from the South African site of Elandsfontein 8634 with an  
153 estimate age base of faunal remains between 0.7-0.6 Ma (Marshall et al., 2002). The  
154 assemblage is predominantly formed of bifaces, but also contains low frequencies of cleavers.  
155 Raw materials include silcrete, Table Mountain sandstones, and quartz (Marshall et al., 2002).

156

## 157 **2.2 Methods**

158 All artefacts were initially technologically classified as Large Cutting Tools (LCTs), as  
159 proposed by Isaac (1977). Tools were subsequently classified into different categories (biface,  
160 uniface, cleaver, pick, knife, LCT blank, undifferentiated LCT) following definitions by  
161 Kleindienst (1962) and Isaac (1977). We used the term undifferentiated LCT to refer those  
162 large flake tools that cannot be included within the other categories. A technological analysis  
163 was performed for each tool, considering attributes such as raw material, type of blank,  
164 presence of cortex, number of *façonnage* removals, and point shape (i.e. McNabb et al., 2004;  
165 de la Torre and Mora, 2018). All artefacts had basic morphometric data taken from them using  
166 digital callipers, In each case the maximum dimension was taken.

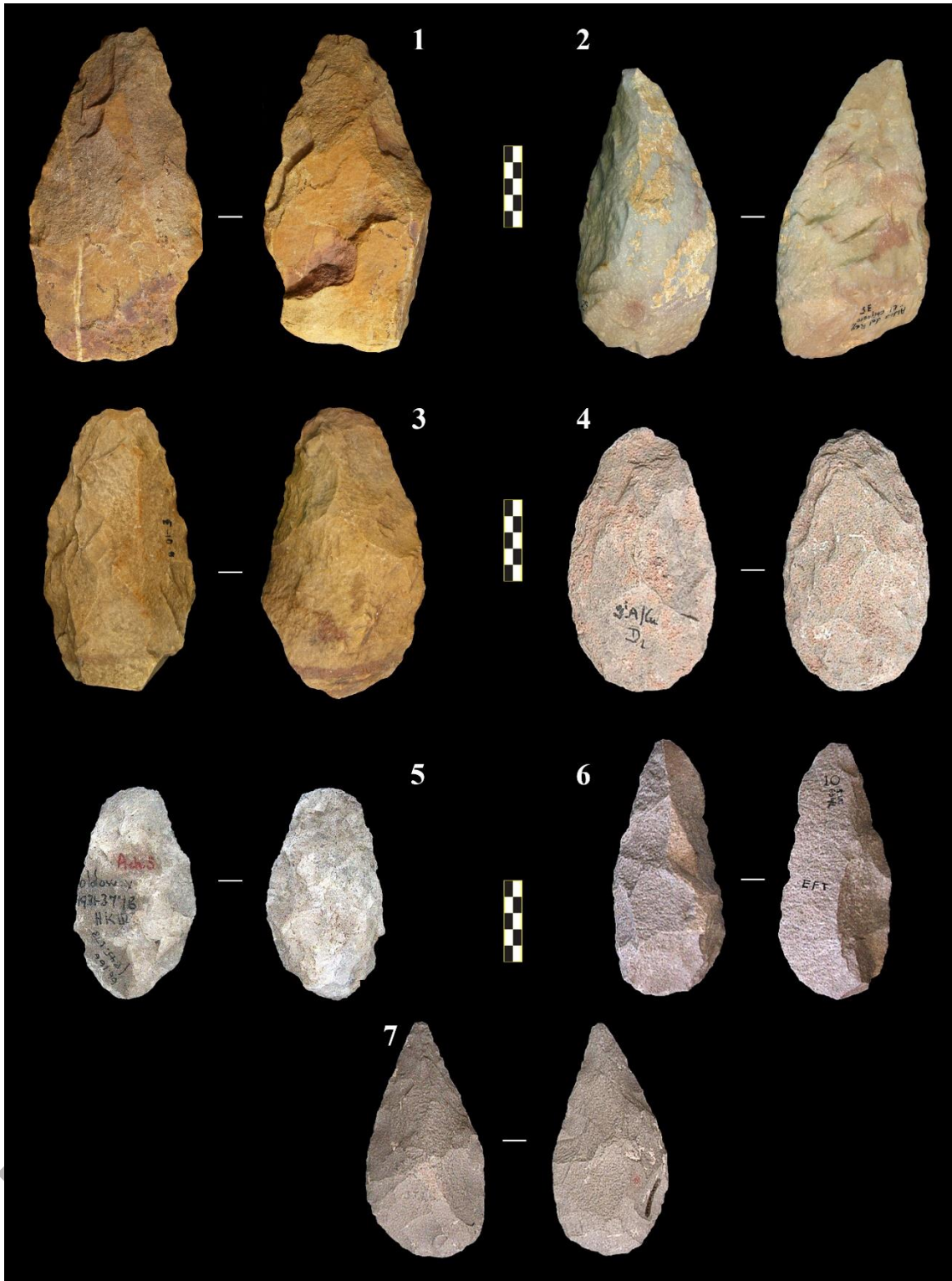
167 Both parametric and non-parametric statistical tests were conducted depended on the  
168 type (categorical vs numerical) and distribution of data under study. A combination of Chi-  
169 square (Cramers V) (for categorical data) and Kruskal-Wallis and Mann Whitney U (for  
170 numerical data) tests were used to test for intra assemblage variation. The significant threshold  
171 was assessed at a 0.05 significance level, and post hoc analyses were employed where  
172 appropriate. Adjusted residuals were calculated for Chi-Square tests, with a value of 2.0 and -  
173 2.0 being taken to assess significant at a 0.05 confidence level. Pair-wise comparisons were  
174 undertaken for both Kruskal-Wallis and Mann-Whitney U tests. All statistical tests were  
175 computed using a combination of Microsoft Excel, SPSS and PAST (Hammer et al., 2001).



176 **3D Shape Analysis**

177 To facilitate shape comparisons between Porzuna, other Iberian, and African LCT  
178 assemblages, 3D morphometric data were collected from seven Acheulean handaxe  
179 assemblages. This included Porzuna (n = 57), El Sotillo (n = 34), El Chiquero (n = 8), STIC (n  
180 = 40), Cunnette (n = 40), Olduvai Gorge (n = 40), and Elandsfontein (n = 40) (Figure 3). The  
181 selection of African assemblages was chiefly based on matching their chronology and the  
182 estimated dates of the central Spanish sites.

Pre Print Proof



183

184 **Figure 3.** Examples of handaxes from Porzuna (1), El Chiquero (2), El Sotillo (3), Cunnette  
 185 (4), HK (Olduvai Gorge, 5), Elandsfontein (6) and STIC (7).

186 The three Spanish sites (Porzuna, El Sotillo, and El Chiquero) had morphometric data  
 187 collected from plan-view and side-view digital photos taken by the authors. Corresponding

188 STIC, Cunnette, Olduvai and Elandsfontein digital photos were downloaded from the freely  
189 available Biface Database (Marshall et al., 2002). The number of artefacts included in the  
190 Porzuna assemblage represents the total number of handaxes present in the assemblage  
191 deposited at the museum in 2015 ( $n = 57$ ). The El Sotillo samples represent 29.6% of the LCT  
192 assemblage (following counts by Arroyo and Torre, 2013), while we used the whole  
193 assemblage of El Chiquero available. The Biface Database holds substantial numbers of  
194 handaxes from the other four assemblages. We chose a random selection of 40 from each to  
195 include as a representative sub-sample. In each instance plan-view and side view photos were  
196 chosen as the side displaying the most flake scars above  $0.5 \text{ cm}^2$  in maximum dimension  
197 (Lycett et al. 2006). Each handaxe was scaled in mm using the scale-bar present in each image.

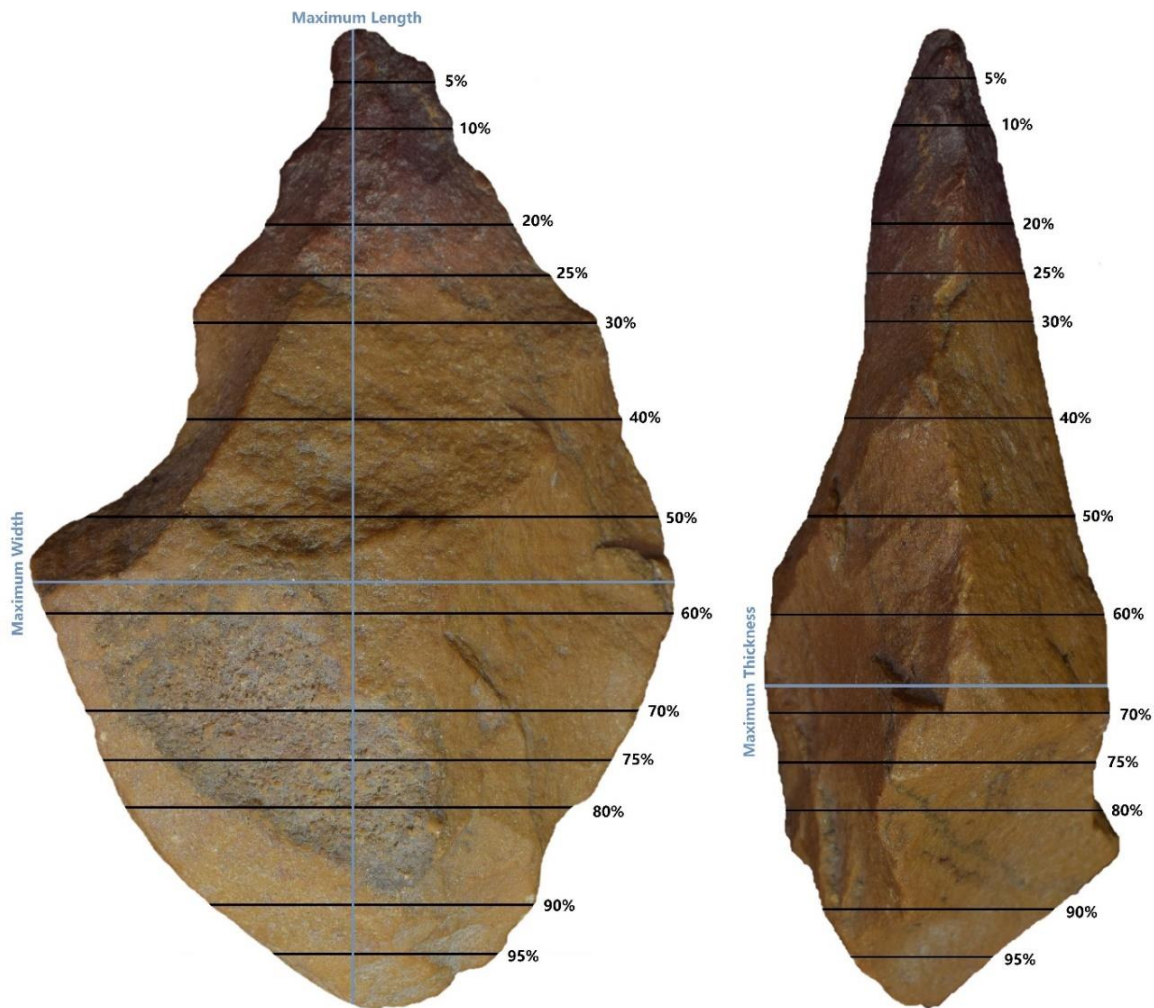
198         Within the variation of the LCTs categories existing within the Acheulean assemblages  
199 (i.e. picks, cleavers, etc) we selected only handaxes as they tend to display technological  
200 characteristics that facilitate their inclusion in morphometric analysis, allowing also to assess  
201 potential variations on the shape of the same type of artefact between populations.

202         Here, we use a 3D Cartesian co-ordinate shape analysis system outlined in detail  
203 elsewhere (Costa, 2010; Eren et al., 2014; Schillinger et al., 2015; Key and Lycett, 2017). Once  
204 each handaxe image was orientated by means of its line of maximum symmetry following  
205 Lycett et al. (2006), 29 metric variables were recorded in mm using the free image analysis  
206 software ImageJ (Figure 4). Variables recorded included the maximum length, width, and  
207 thickness of each tool. A further 26 metric variables were recorded from each tool; 13 plan-  
208 view width, and 13 side-view thickness, measurements. These additional variables were  
209 recorded at specific percentage points along the length of each artefact (Figure 4).

210         These 29 metric variables were size-adjusted using the geometric mean method, which  
211 has been shown to appropriately remove isometric size (scaling) differences between  
212 specimens, while retaining shape information (Jungers et al., 1995; Lycett et al., 2006).

213 Geometric mean can be calculated as  $\sqrt[n]{a_1 \times a_2 \times a_3 \times \dots \times a_n}$  where a series of variables ( $a_n$ )  
214 are computed as the nth root of their product. This was undertaken individually for the 29  
215 metrics recorded from each handaxe, in turn producing 29 size-adjusted metrics describing  
216 shape for each tool. Principal component analysis (PCA) was used to examine shape variability  
217 among the 260 handaxes examined across all seven Acheulean assemblages. The size adjusted  
218 data from all tools were entered a PCA such that the major patterns of shape variation between  
219 artefacts could be examined in a hierarchical fashion. The PCA was performed using PAST v.3.14  
220 (Hammer et al., 2001).

221



222

223 **Figure 4.** The 29 metric variables recorded form each artefact. The tool in this image has  
224 already be orientated by means of its maximum symmetry.

225 Shape differences between artefact assemblages were statistically examined using PC1  
226 and PC2, which represent 43% and 24% of the observed variation (respectively). PC1 is most  
227 heavily loaded (i.e. influenced) by maximum length and the width measurements recorded at  
228 50-80% of handaxe length. PC2 is principally loaded by maximum length measurements and  
229 width in the base of the tool (75-95% of handaxe length). Kruskal-Wallis tests were used to  
230 identify whether significant differences in median PC1 and PC2 values existed within four sets  
231 of artefact assemblages. The Porzuna artefacts were independently compared to the two  
232 Spanish (El Chiquero and El Sotillo), two Moroccan (STIC, Cunnette), and Olduvai and  
233 Elandsfontein Acheulean sites. Additionally, the four African sites were compared  
234 independently of the Porzuna material. Post-hoc Mann-Whitney U tests were used to identify  
235 the nature and direction of any significant differences. Significance was assumed in-line with  
236 the Bonferroni Correction in all instances.

237

### 238 **3) Results**

#### 239 **3.1 Technological characteristics of the Porzuna assemblage**

240 The studied assemblage is dominated by bifaces (n = 57, 43.8%) and unifaces (n = 25,  
241 19.2%), however, picks (n = 17, 19.2%), knives (n = 12, 9.2%), and cleavers (n = 11, 8.5%)  
242 are also represented, along with a small number of unmodified LCT blanks (n = 4, 3.1%) and  
243 four (3.1%) examples which cannot be assigned a typical typological classification (Figure 5).  
244 All were made on fine grain local quartzite; the same raw material as the rest of the Porzuna  
245 Assemblage.

246 Large flakes predominate within the assemblage (n = 63, 48.5%), however, cobbles  
247 have also been extensively used (n = 49, 37.7%). Split cobbles (n = 4, 3.1%) and tabular blocks  
248 (n = 2, 1.5%) contribute only a small proportion of the blank types. There is a significant  
249 difference in blank type between LCT categories, as indicated by a Chi-Square (Cramers V)



250 test ( $X^2 = 0.317, p = 0.001$ ). Adjusted residuals show that this difference is derived from an  
251 over representation of indeterminate blanks for bifaces, flake blanks for LCT blanks, cleavers,  
252 and knives, and cobbles blanks for picks.

253 Most LCT's fall between 100-160 mm in length with an average of 144.6 mm, however,  
254 some range in excess of 200 mm. On average LCT's are relatively thick (mean = 51.3 mm) and  
255 heavy, with a mean weight of 677.7 g and ranging from 100.4 g to 1919.3 g. A Mann-Whitney  
256 U test shows a significant difference in dimensions between LCT categories; however, a pair-  
257 wise comparison shows that this difference is due to a general heterogeneity in LCT length and  
258 weight between groups with no category being significantly longer, shorter or heavier. Knives,  
259 however, are significantly wider than bifaces, cleavers and picks, while picks are significantly  
260 thicker than cleavers and bifaces.

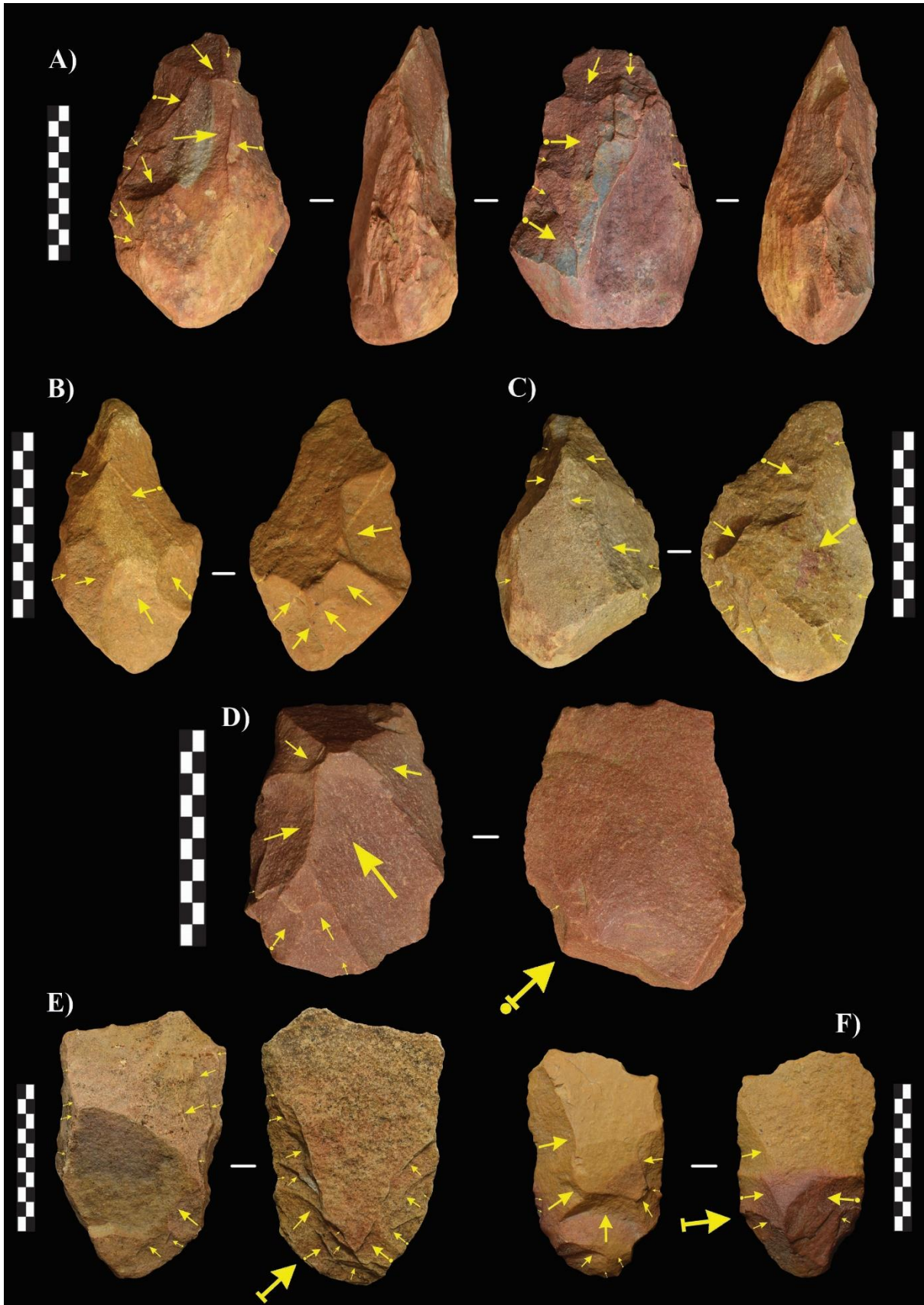
261 Ninety-six (73.8%) of the LCT's possess <50% dorsal cortex coverage, with this  
262 proportion increasing once examples with no remaining cortex are included (n = 107, 82.3%).  
263 There is a significant difference in cortex coverage between all LCT categories (Cramer's V  
264 ( $X^2 = 0.297, p = 0.028$ )) and blank types (Cramers V ( $X^2 = 0.375, p = 0.019$ )), with knives  
265 being significantly non-cortical, cobble blanks possessing significantly >50% cortex, and  
266 indeterminate blanks possess an over-representation of 0% cortex coverage.

267 The majority of the worked LCT's have been bifacially flaked (n = 99, 77.3%), with  
268 only 22.7% (n = 29) exhibiting unifacial *façonnage*. Most LCTs possess a convergent pointed  
269 tip (n = 102, 78.5%), however, convergent square, oblique and generalised tips are also present  
270 within the assemblage (n = 14, 10.8%), with an equal number of divergent tips (n = 14, 10.8%).  
271 Convex (n = 52, 40%), straight (n = 48, 36.9%) and pointed (n = 30, 23.1%) bases are all  
272 represented within the assemblage.

273

274





275

276 **Figure 5.** Examples of handaxes (A-C), LCT (D), and cleavers (E-F) from the analysed  
 277 assemblage of Porzuna.

278 Of the LCTs produced on flakes, side struck flakes were primarily used as blanks (n =  
279 35, 55.6%), however, end struck flakes are also present (n = 16, 25.4%). In a minority of cases,  
280 it is impossible to identify the flake type due to the degree of secondary shaping. The majority  
281 (n = 52, 82.6%) of flakes used as blanks retain evidence of the platform used to detach from  
282 the core; for half of these, an attempt to thin the platform and bulb is evident. This thinning is  
283 primarily through invasive direct flake removals using the dorsal surface of the flake as a  
284 platform.

285 Cobbles (n = 23, 40.4%) and flakes (n = 22, 38.6%) are the preferred blanks for biface  
286 (handaxe) production. Bifaces show a varying degree of secondary *façonnage*, with just over  
287 half possessing between 1-10 flake removals (n = 30, 52.7%) associated with shaping, whilst  
288 47.3% (n = 27) are more heavily worked, with between 11-20 removals. 89.5% (n = 51) of  
289 them possess a pointed tip.

290 Three *chaîne opératoires* have been identified during the manufacture of handaxes. One  
291 consists of blanks (mainly cobbles) with the medial-distal part bifacially shaped, while the  
292 proximal area of the blank is untouched and remains cortical (e.g. Figure 5A). The second group  
293 of artefacts include large flakes with minimum *façonnage* work to obtain a pointed shape (e.g.  
294 Figure 5b). Finally, there is a group of tools in which the natural morphology of the blank is  
295 used, leaving one of the surfaces unmodified and shaping the opposed ones using either a  
296 unifacial or centripetal exploitation.

297 Flakes (n= 10, 90.9%) are the preferred blank for cleaver production, with only a single  
298 example in which the flake blank could not be confirmed. Most of the secondary working on  
299 cleavers is associated with the removal of the bulb of percussion, the thinning of the original  
300 flake platform as well as the shaping of the base of the tool (Figure 5E). It is also interesting to  
301 highlight the identification of some cleavers with potential use wear traces represented by a  
302 series of scars located on their distal edge (*tranchant*), similar to the traces described in

303 experimental studies (Claud et al., 2015) and cleavers from the Ethiopian site of Mieso (de la  
304 Torre et al., 2014).

305 Many of the picks in the Porzuna assemblage are produced on complete cobbles (n =  
306 12, 70.6%) or split cobbles (n = 2, 11.8%), with a single example of a flake blank being used  
307 (5.9%). In general, picks were not subjected to substantial secondary working, with an average  
308 of 5.8 *façonnage* extractions each. The trihedral pick shape is often due to a steep intersection  
309 of two large removals on the dorsal surface, associated with the core preparation prior to the  
310 removal of the LCT blank.

311 On the manufacture of knives, flake blanks were used exclusively (n = 12). Both, large  
312 end struck (n = 4, 33.3%) and side struck (n = 8, 66.7%) flakes were used, with side struck  
313 flakes being more prevalent. The majority of knives possess between 0 – 50% dorsal cortex (n  
314 = 11, 91.6%), and are bifacially worked (n = 11, 78.6%) possessing an average of 9 *façonnage*  
315 removals being and relatively minimally shaped, possessing between 1-10 removals (n = 8,  
316 66.6%).

317 Finally, unifaces show a similar blank selection to bifaces, in that both complete cobbles  
318 (n = 12, 48%) and flakes (n = 11, 44%) predominate; both end struck (n = 4) and side struck (n  
319 = 4) flakes were used in equal measure, whilst there are also single examples of split cobbles  
320 and tabular blocks being used as blanks. All unifaces possess pointed tips, with a small number  
321 having been shaped through the detachment of 1 (n = 3, 12%) or 2 (n = 3, 12%) notches towards  
322 the tip. The unifaces are minimally shaped, with the majority possessing fewer than 11  
323 removals (n= 19, 76%), with only a small number exhibiting greater secondary reduction (n =  
324 6, 24%).

### 325 **3.2 Shape differences**

326 Figure 6 plots PC1 against PC2 for all handaxe assemblages, separated according to the  
327 four Kruskal-Wallis tests. These principal component plots illustrate handaxe shape differences

328 and overlap between assemblages. The three Spanish assemblages display a substantial amount  
 329 of correspondence in their forms, with the variation observed in Porzuna subsuming all but  
 330 eight of the other bifaces (Figure 6a). Kruskal-Wallis tests between the Spanish assemblages,  
 331 for both PC1 and PC2, reveal significant differences in median PC score values (Table 2 and  
 332 Table 3). Mann-Whitney U tests reveal mean rank shape values to be significantly different  
 333 between the three assemblages in all instances, other than Porzuna and El Sotillo for PC2  
 334 (weighted by maximum tool length and base width).  
 335

Assemblage Set (PC1)	Kruskal-Wallis ( <i>p</i> )
Porzuna, El Chiquero, El Sotillo	.0001
Porzuna, STIC, Cunnette	<.0001
Porzuna, Olduvai, Elandsfontein	<.0001
STIC, Cunnette, Olduvai, Elandsfontein	<.0001

336  
 337 **Table 2.** Kruskal-Wallis tests of median differences for PC1 between the four sets of  
 338 Acheulean handaxe assemblages.  
 339

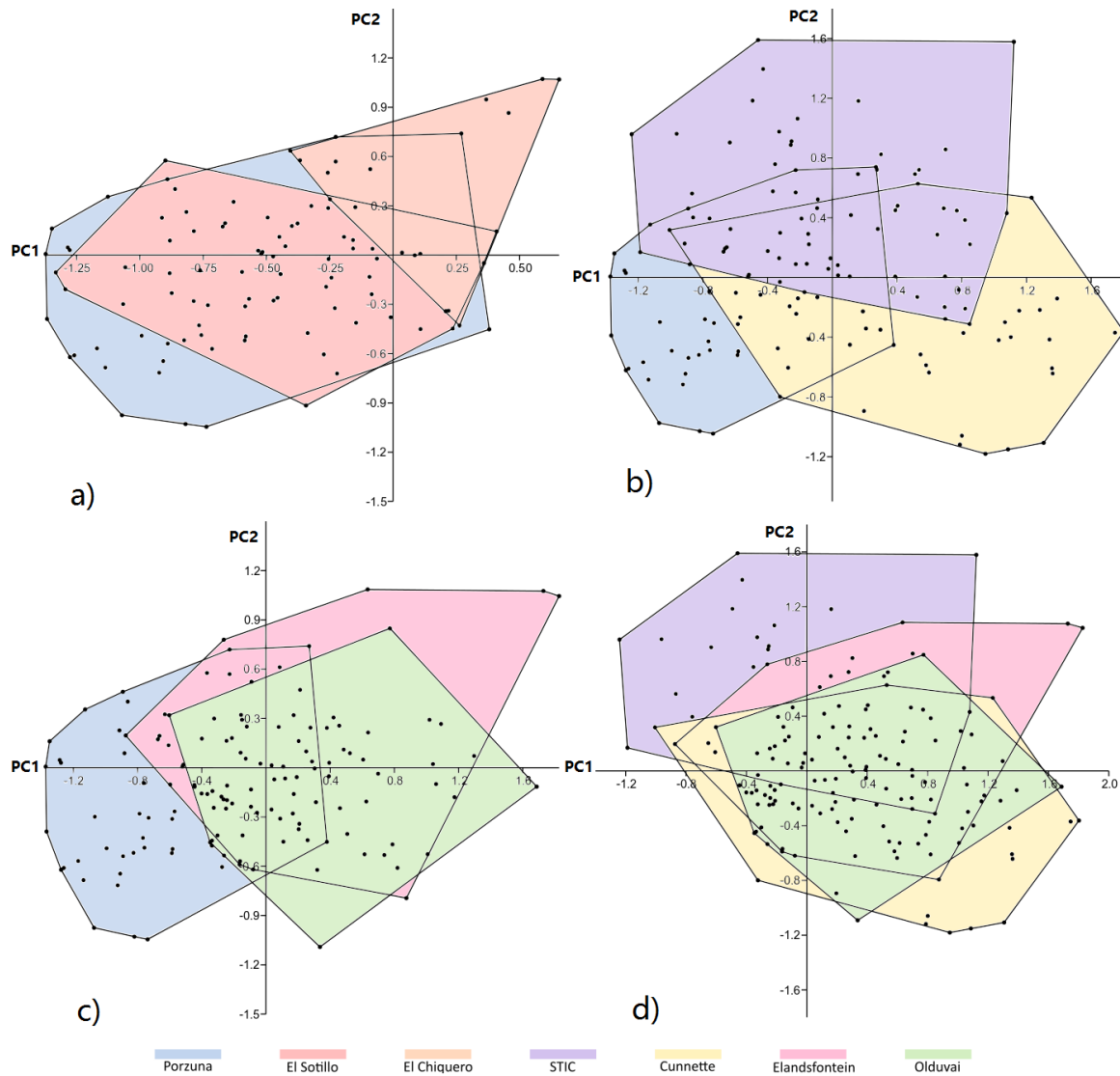
Assemblage Set (PC2)	Kruskal-Wallis ( <i>p</i> )
Porzuna, El Chiquero, El Sotillo	.0012
Porzuna, STIC, Cunnette	<.0001
Porzuna, Olduvai, Elandsfontein	.0716
STIC, Cunnette, Olduvai, Elandsfontein	<.0001

340  
 341 **Table 3.** Kruskal-Wallis tests of median differences for PC2 between the four sets of  
 342 Acheulean handaxe assemblages.  
 343

344 Figure 6b details the shape-space variation observed between Porzuna and the two  
 345 Moroccan Acheulean sites (STIC and Cunnette). Differences in shape clearly exist between the  
 346 three assemblages, with Porzuna displaying lower PC1 and PC2 values than the other two sites,  
 347 while STIC has some of the highest PC2 values and Cunnette has the highest PC1 values.  
 348 Kruskal-Wallis tests for PC1 and PC2, again, revealed significant median differences between

349 the sites. In all but one instance Mann-Whitney U tests revealed the mean ranks of PC1 and  
 350 PC2 to be significantly different between assemblages (Table 4 and Table 5). Porzuna and  
 351 Cunnette, however, display similarly ranked PC2 values (Table 5).

352



353

354 **Figure 6.** PC1 plotted against PC2 for the four primary intra-site comparisons of handaxe 3D  
 355 shape. Figure ‘a’ depicts the shape space of the three Spanish sites, ‘b’ compares  
 356 Porzuna and the two Moroccan sites, ‘c’ likewise compares Porzuna with Olduvai and  
 357 Elandsfontein, while ‘d’ illustrates the four African sites.

358

359

Mann-Whitney U (PC1)			
	Porzuna	El Chiquero	
El Chiquero	.0003		
El Sotillo	.0112	.0067	
	Porzuna	STIC	
STIC	<.0001		
Cunnette	<.0001	<.0001	
	Porzuna	Olduvai	
Olduvai	<.0001		
Elandsfontein	<.0001	.4273	
	STIC	Cunnette	Olduvai
Cunnette	<.0001		
Olduvai	.1134	<.0001	
Elandsfontein	.0364	.0031	.4273

360

361 **Table 4.** Mann-Whitney U tests of mean rank for PC1 between the four sets of Acheulean  
 362 handaxe assemblages.

363

Mann-Whitney U (PC2)			
	Porzuna	El Chiquero	
El Chiquero	.0005		
El Sotillo	.3801	.0009	
	Porzuna	STIC	
STIC	<.0001		
Cunnette	.1847	<.0001	
	Porzuna	Olduvai	
Olduvai	.8199		
Elandsfontein	.0404	.0497	
	STIC	Cunnette	Olduvai
Cunnette	<.0001		
Olduvai	<.0001	.0952	
Elandsfontein	<.0001	.0019	.0497

364

365 **Table 5.** Mann-Whitney U tests of mean rank for PC2 between the four sets of Acheulean  
 366 handaxe assemblages.

367



368           There is some shared shape space between Porzuna handaxes and those from Olduvai  
369 Gorge and Elandsfontein, although there are also clear differences, with the two African  
370 assemblages displaying higher PC1 values. Olduvai and Elandsfontein share similar shape  
371 spaces. As with the Moroccan assemblage significant differences in median values were  
372 identified between Porzuna, Olduvai and Elandsfontein via a Kruskal-Wallis test. Although  
373 this was only for PC1 (Table 2). Mann-Whitney U tests identified significant differences in PC1  
374 mean ranks between Porzuna and the two African assemblages, but not between Olduvai Gorge  
375 and Elandsfontein. No PC2 tests returned significant differences.

376           The final plot, Figure 6d, details shape differences between the four African handaxe  
377 assemblages. Greater overlap between the assemblages is illustrated here, relative to the two  
378 African comparisons that include Porzuna. STIC appears to have a number of artefacts with a  
379 combination of low PC1 and high PC2 values, which the other sites do not display; but this  
380 only represents a third of the assemblage. Kruskal-Wallis tests for both PC1 and PC2 revealed  
381 significant median differences between the sites. As with above, Mann-Whitney U tests did not  
382 identify significant differences between Olduvai and Elandsfontein. This was similarly the case  
383 between STIC and Olduvai/Elandsfontein for PC1, and Cunnette and Olduvai for PC2 (Table  
384 5). The other tests returned significant shape differences.

#### 386           **4) Discussion**

##### 387           **4.1 Integrating Porzuna within the Acheulean at the Iberian Peninsula**

388           Our analyses demonstrate this previously unreported assemblage of Acheulean  
389 artefacts from Porzuna to have similar metrics and technological characteristics to the rest of  
390 the collection hitherto studied (Vallespí et al 1979; 1985; Serrano Ciudad, 1985; Cabrera,  
391 1986). Together, Porzuna can now be considered to contain one of the largest accumulations  
392 of Acheulean LCTs in the Iberian Peninsula, with over a thousand documented tools. Nearby,

393 at El Sotillo, there is also a large assemblage of LCTs predominantly formed of large flakes  
394 (Ciudad Serrano, 1983b; Arroyo and Torre, 2013). Within this assemblage, indeterminate  
395 LCTs, cleavers and knives show low degree of shaping of the ventral faces, and flake blanks  
396 tend to be dominated by side-strike flakes as documented also at Porzuna. At El Chiquero,  
397 despite of the low frequency of handaxes deposited at the museum ( $n = 8$ ), six are produced on  
398 flake blanks. These handaxes tend to be smaller (mean length of 152.5 mm [SD = 24.2 mm],  
399 and mean weigh of 424.1 g [SD 124.7 g]), with a higher degree of shaping and symmetry than  
400 the Porzuna ones. Thus, at a local scale seems to be technological similarities within the  
401 Acheulean assemblages in which there was a common use of large flakes during the Middle  
402 Pleistocene. Given this wider pattern we would suggest that other Acheulean localities in  
403 Campo de Calatrava (Santonja and Querol, 1976; Vallespí et al., 1980) yet to be reviewed may  
404 share similar technological traits.

405 Despite some shape central tendency differences between the three Spanish  
406 assemblages, the PCA plots reveal near complete overlap in their shape space. Moreover,  
407 relative to the African assemblages, the Spanish LCTs cluster closely. Thus, we are confident  
408 in assigning some uniformity in shape between the Porzuna, El Sotillo and El Chiquero  
409 assemblages. Arguably, therefore, there was transmission of stone tool related cultural  
410 information between populations enough to maintain a consistent Late Acheulean LCT shape  
411 in this region. Alternatively, limited cultural transmission distance may have been present  
412 between the hominins responsible for producing these three assemblages, in turn explaining  
413 their limited shape differences (Lycett et al., 2016). As far as is represented through the three  
414 assemblages analysed here, however, there is a unified expression of the Acheulean LCT  
415 culture in central Iberia during the Late Acheulean. This conclusion is supported by the  
416 technological analyses described above. Additional studies that include a greater number of  
417 Iberian sites may provide further evidence in support of this tentative conclusion.

418 Beyond Porzuna and Campo de Calatrava, other Spanish sites such as El Sartalejo  
419 (Cáceres) similarly display LCTs produced from large cobbles with a low degree of *façonnage*  
420 (Santonja 1986; Moloney, 1992). Moreover, sites including Gruta da Aroeira (Daura et al.,  
421 2018) and Santa Ana (Ollé et al., 2014), together with Galería (Atapuerca) (Garcia-Medrano et  
422 al., 2014), are known to display LCTs made on large flakes. Porzuna is, then, not alone in either  
423 respect. The later sites, Gruta da Aroeira and Atapuerca, display the only evidence in the Iberian  
424 Peninsula of an association between Acheulean technology and *H. heidelbergensis* remains. In  
425 addition, in the NW of Spain recent excavations at Portomaior (Galicia) have unearthed an  
426 LCT assemblage dated to 293-205 Kya dominated by handaxes and a low frequency of cleavers  
427 and picks (Méndez-Quintas et al., 2006; 2018), showing that LCTs have a wider distribution  
428 across the Iberian Peninsula.

429 In sum, archaeological sites such as Galería (Atapuerca), Porzuna, Santa Ana, El  
430 Sartalejo or Portomaior confirm that within a time span between 500-150 ka, across the  
431 Peninsula, an Acheulean culture existed in which there was a manufacture of large flakes  
432 coexisting with the manufacture of handaxes made from cobbles, something that is uncommon  
433 beyond the Pyrenees where large flakes within the Acheulean assemblages are rare (Sharon,  
434 2011). All these sites share common characteristics, being mainly located on river terraces  
435 (with the exception of Galería (Atapuerca) and Santa Ana) and the primary raw material used  
436 to obtain large flakes being quartzite. In fact, as pointed by Santonja and Villa (2006), the  
437 presence of cleavers and large flakes is determined by the raw material as happened in the  
438 Iberian Peninsula where there is an abundance of large quartzite cobbles and blocks (but see  
439 Sharon, 2008). The concentration of Iberian Acheulean sites along river basins and their  
440 tributaries could be related to a high degree of mobility in hominin populations and the  
441 important of the fluvial networks (Santisteban and Schulte, 2007).

#### 442 **4.2 Determining African affinities in the Iberian Acheulean**

443 Our second aim was to understand the nature of any overlap between Porzuna and Late  
444 Acheulean LCT artefacts from Africa, to better understand potential dispersal routes into Iberia  
445 from modern-day Morocco (Alimen, 1975). Technologically, Porzuna contains a large number  
446 of LCTs produced on large flakes, and as highlighted by Sharon (2010), the LFA displays wide  
447 chronological and spatial distributions in the Old World. Nonetheless, within France and other  
448 Western European countries the presence of this techno-complex is less dominant, with cobble  
449 blanks dominating relative to large flakes. Previously, the frequent presence of large flake  
450 LCTs in Iberia, but not other areas of Western Europe, has been used to support hypothesised  
451 hominin migration routes across the Strait of Gibraltar (Freeman, 1975; Santonja and Villa,  
452 2006), as well as a North African origin of the Iberian Acheulean (Sharon, 2011).

453 Geological and faunal data confirms that North Africa and the Iberian Peninsula were  
454 never connected during the Pleistocene (O'Regan, 2008; Croitor, 2018), but the Strait could  
455 have been narrowed and more accessible during glacial periods (Straus, 2001). It is our view  
456 that the common presence of LCTs made on large flakes in Iberia cannot alone confirm  
457 frequent or sustained hominin migration from North Africa, nor an African origin for the  
458 Iberian Acheulean. Certainly, technological convergence appears as an alternative possibility.  
459 Equally, however, the technological similarities observed between Iberia (including Porzuna)  
460 and African Acheulean industries does suggest the potential of hominin dispersals and  
461 highlights the need to formally test the hypothesis through other means.

462 Here, we have taken a small step toward addressing the question of an African origin  
463 for the Iberian Acheulean by comparing the shape of handaxes from these two locations.  
464 Handaxes have potential to be highly variable in their shape (Wynn and Tierson, 1990; Lycett  
465 and Gowlett, 2008; Petraglia and Shipton, 2008), with differences in mean tendencies between  
466 assemblages often attributed to the influence of cultural evolutionary mechanisms (Lycett et  
467 al., 2016), among other factors. Low shape homogeneity between Acheulean LCT assemblages

468 would in turn suggest the presence of substantive cultural transmission distances (and therefore  
469 limited contact) between populations. Our results indicated significant shape differences  
470 between Porzuna and all African assemblages when described using PC1 (significant PC2  
471 differences were site-specific). Tests between the four African sites also revealed some  
472 significant differences for both PC1 and PC2, but generally these locations displayed greater  
473 similarity in shape with each other, than they did with Porzuna (Figure 6). We would contend,  
474 then, that as far as our results can demonstrate, the Porzuna material does not display a strong  
475 association with the African LCT assemblages examined here. Thus, there is no new evidence  
476 to support a proposed south-west dispersal route for Acheulean hominins into Europe. Reduced  
477 shape differences between the four African sites (Figure 6d), of which some display  
478 substantially greater geographic distances between them relative to Porzuna and the Moroccan  
479 sites, underlines the likely lack of cultural information flowing across the Gibraltar Strait.  
480 Insofar as our analyses demonstrate, the presence of large flakes on both sides of the Gibraltar  
481 Strait therefore appears to be the common point between these African and Iberian  
482 assemblages.

483 This does not rule out possible early dispersals into Iberia from North Africa, nor does  
484 it indicate there to be no dispersals during the Late Acheulean; rather, it suggests that if there  
485 were dispersals, they would have been limited enough to prevent the occurrence of a single,  
486 shared LCT cultural expression. As far as the origin and diffusion of LCT culture into Western  
487 Europe is concerned, our results do not provide support in favour of either a Western or Eastern  
488 route. Instead, they highlight the inherent difficulties of a Western water-bridging diffusion of  
489 hominin populations and culture during the Late Acheulean; a difficulty which also likely  
490 existed during earlier periods (O'Regan, 2008).

491 Technologically the Porzuna material is similar to the late Acheulean site of El Sotillo.  
492 Our shape analyses further indicate similarities between Porzuna and El Sotillo, as well as El

493 Chiquero (all sites from the same region). An estimated age for the Porzuna material of between  
494 400 and 200 Kya would not, therefore, be unreasonable. As discussed above, the shape  
495 distinctions observed between Porzuna and the African assemblages do not necessarily reflect  
496 deviation in age, but more likely represent a lack of contact and cultural exchange. The  
497 substantive Porzuna assemblage can tentatively be assigned to be of Late Acheulean origin,  
498 however, further dating of in situ sediments is needed to confirm this chronology.

499 By their very nature, Palaeolithic artefact shape analyses are limited by the sites  
500 sampled and the number of lithics examined. Here, we have taken a limited view of the  
501 Acheulean insofar as only seven sites have been considered. The inclusion of a greater number  
502 or alternative selection of Iberian and African sites could, certainly, alter our conclusions.  
503 Moreover, the inclusion of Levantine or Eastern European assemblages would provide a useful  
504 comparative sample and allow a hypothesised Eastern dispersal route for LCT technology to  
505 be tested. Nonetheless, our results are clear that the differences observed between Porzuna and  
506 Africa are generally greater than those observed between the four African sites. It is also true  
507 that the assemblages compared here have potential to not only be geographically disparate, but  
508 separated by tens, if not hundreds, of thousands of years.

509

## 510 **5) Conclusions**

511 Despite consisting of over 8000 artefacts, the Acheulean stone tool assemblage of  
512 Porzuna has received limited attention in the literature. Here, we have undertaken techno-  
513 typological and 3D morphometric analyses of the LCT material from Porzuna. Our aims were  
514 twofold. First, we wanted to contextualise Porzuna alongside other previously described  
515 Central Iberian material, to better understand any variation in LCT material, and the strength  
516 of any single Late Acheulean stone-tool culture in this region. Secondly, we investigated the



517 hypothesised South-West European out-of-Africa dispersal route across the Gibraltar Strait  
518 by comparing Porzuna with multiple African Late Acheulean LCT assemblages.

519 Comparisons between Porzuna and two other nearby assemblages reveal a regional  
520 representation of LCT culture in Central Spain during the late Acheulean; as represented  
521 through their shape and technological character. Similarities between Porzuna and the African  
522 materials are limited to common *chaîne opératoires* and technological classifications (on both  
523 cases, large flakes are used as blanks to manufacture LCTs), but significant shape differences  
524 and distinct central tendencies are observed between most assemblages, suggesting distinction  
525 handaxe ‘end-goals’ between these geographically diverse populations. Together, results  
526 highlight the commonality of Late Acheulean LCT production techniques across the Old  
527 World, and the strength of some regional stone tool cultural representations but provide no new  
528 evidence in support of a South-West dispersal route for hominins into Europe.

529 Porzuna represents a substantial collection of Acheulean artefacts that until now were  
530 ‘hidden’ from Palaeolithic literature. Given finite resources and the infrequent identification of  
531 new Lower Palaeolithic sites in Europe, we would argue that similar assemblages could, and  
532 indeed should, be better utilised for research purposes. Certainly, and as demonstrated here,  
533 collections such as Porzuna have considerable potential to shed light on the behaviour of  
534 European Middle Pleistocene hominins.

535

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546

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