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1 **Lithic technological and spatial analysis of the final Pleistocene at Border Cave, South Africa**

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22

23 **Abstract**

24 This contribution focuses on the recently excavated lithic assemblage from Border Cave Members 1 RGS, 3 BS,
25 2 WA and 2 BS. These members were attributed by Beaumont to the Howiesons Poort and post-Howiesons Poort
26 Industries of the southern African Middle Stone Age. Here we consider lithics as indicators of cultural behaviour,
27 site formation processes, and occupation intensity. As such, the assemblage is explored in depth through lithic
28 technology attribute analysis, particle size distribution, and spatial analysis. These lines of inquiry follow the new

29 allostratigraphic divisions proposed for the deposits by Stratford and colleagues. Results show that the lower
30 members share a degree of similarity in terms of flaking strategies and raw material selection, whereas the
31 upper members record a dissimilar set of features, with differentiation between them. The technological and
32 spatial analyses suggest the sporadic presence of different groups at the site, each characterized by distinct sets
33 of knapping techniques and methods but employing related knapping strategies and using similar raw materials.
34 The interpretation of these members as a palimpsest of sporadic occupation is supported by the low number of
35 archaeological finds by sediment volume. The evidence at hand does not support a Howiesons Poort attribution
36 for the lowest members. The data show that lithics from part of Member 2 WA and 2 BS are in accordance with
37 those of the recently defined Sibudan technocomplex.

38 *Keywords:* Lithic, technology, spatial distribution, particle size, Middle Stone Age

39

40

Dedicated to L. Gerardo Vega Toscano, *in memoriam*

41 **1. INTRODUCTION**

42 Border Cave has one of the longest archaeological stratigraphic sequences in southern Africa with a
43 record that covers Marine Isotopic Stages (MIS) 7 to 2. The stratigraphic, archaeological, and
44 chronometric analyses of Peter Beaumont (1978) and subsequent researchers have made it a
45 reference site on the African continent. Furthermore, this site has been instrumental in demonstrating
46 the ancient chronology of the Middle Stone Age (MSA) (Beaumont and Vogel, 1972), which at the time
47 was not clearly associated with the Pleistocene (Thackeray, 1992 and references therein). The
48 Beaumont (1978) excavations also showed for the first time the exceptional degree of organic
49 preservation in a southern African MSA context. Such remarkable plant preservation was later
50 documented at other southern African sites such as Klasies River (Deacon, 1993), Strathalan B
51 (Opperman and Heydenrych, 1990; Opperman, 1996) and Sibhudu (Wadley et al., 2011). The
52 remarkable plant preservation at Border Cave has recently been corroborated following
53 palaeobotanical investigations, which documented the oldest known evidence of grass bedding
54 construction and cooked starchy rhizomes (Wadley et al., 2020a, b; Sievers et al., 2022). Border Cave
55 has also been instrumental in defining a putative precocious stage of the Later Stone Age (Beaumont
56 and Vogel 1972, but see de la Peña 2015a and Bader et al., 2022). In addition, at this site several
57 human remains and a burial with an associated ornament was documented (Beaudet et al, this volume
58 and d'Errico and Backwell, 2016 for a synthesis of human remains at the site). All of these aspects have
59 made Border Cave a key site in the debate about *Homo sapiens* cultural behaviour in a specific biome
60 of southern Africa the Indian Ocean coastal belt, which was not particularly well known until very
61 recently (Will et al., 2014; Bader and Will, 2017).

62 In this work, an in-depth technological and spatial analysis of the lithic artefacts from Members 1 RGBS
63 to 2 BS (~74–44 ka) is presented. These members were attributed to MSA 2/Howiesons Poort (HP) and
64 MSA 3/post-Howiesons Poort industries in previous works (Beaumont et al., 1978; Grün and
65 Beaumont, 2001; Grün et al., 2003; Villa et al., 2012). The material described here was yielded from
66 the recent excavations by Backwell and colleagues (2018, this volume) that commenced in 2015.

67 **1.1. Stone tools, objectives, and summary of research questions**

68 Because lithic production at Border Cave informed the structure of this investigation, it is important
69 to state how the lithics were understood in this analysis. Stone tools can provide information on site
70 formation and cultural behaviour, hence our analysis focused on three main aspects of archaeological
71 enquiry, namely lithics as indicators of 1) cultural behaviour, 2) taphonomy, and 3) occupation
72 intensity.

73 1. Lithics as cultural behaviour indicators are elicited through an in-depth technological analysis
74 following the *chaîne opératoire* approach (see Karlin et al., 1991 and Tostevin, 2012). Stone tools
75 reflect applied technological sequences and subsequent use and abandonment. Thus, this
76 theoretical framework can provide insight into the selection of raw materials, manufacture, use,
77 re-sharpening, and discard of all examined technological objects.

78 2. With regard to lithics as taphonomic indicators, the particle size distribution of all the lithics (Schick,
79 1986; Bertran et al., 2012) (independently of their size) and the distribution of heating attributes
80 (Wadley et al., 2017) and residues were analysed. Stone Age-bearing cave and rock shelter sites
81 are complex sedimentary environments. The formation of deposits are influenced by a
82 combination of primary and secondary anthropogenic and natural processes (Farrand, 2001; Mallol
83 & Goldberg, 2017; Schiffer, 1983; Schick, 1986). Natural processes, including sedimentary
84 deposition, erosion, and post-depositional movement, can alter the spatial organization,
85 composition, and chronological signal of the archaeological record (Schick, 1986, 1987; Bertran et
86 al., 2012, 2019). To measure the potential loss of such information, assessment of post-
87 depositional disturbance need to be conducted. To do this, particle shape, size and density of lithics
88 are the main physical criteria used to assess the degree of disturbance in the archaeological
89 deposits analysed here.

90 3. Lithics as indicators of occupation intensity are explored by combining taphonomic data and spatial
91 analyses. Through spatial analysis of the vertical and horizontal distribution of the lithic artefacts
92 we identify areas of high and low density in order to extrapolate if they are correlated with
93 anthropic or taphonomic processes. The main aims of this analysis are to test whether lithics can
94 be used as proxies for site formation processes, as well as to identify areas of intense occupation

95 using the spatial information acquired from our recent excavations. This exercise complements the
96 in-depth stratigraphic facies and faunal analyses conducted by Stratford and colleagues (this
97 volume). The spatial distribution study aims to understand the nature of the relationship between
98 lithics from the different members and sub-member units examined here, and the synchronic and
99 diachronic relationships between the lithic remains. Understanding these relationships makes it
100 possible to interpret, on the one hand, the organization of the activities of the groups that occupied
101 the cave during short-term events and, on the other, the relationship between these relatively
102 short-term events and long-term events recorded in the stratigraphic sequence. This work is
103 conditioned both by the activities of human groups (frequency, intensity, duration, etc.) and by
104 non-anthropogenic site formation processes (origin, sedimentation rates, erosion, etc.). Therefore,
105 spatial analysis can inform us about cultural behaviour, the modality of occupation, site formation
106 processes, and the intricate interaction between them.

107 The specific objectives of this manuscript can be summarized in the following questions, associated
108 with the three main aspects related to lithics just mentioned.

109 Regarding cultural behaviour: What are the main technological strategies represented in the different
110 stratigraphic units? Can we group lithic assemblages according to members and sub-member units?
111 What are the technological continuities and/or discontinuities between contiguous members and sub-
112 member units? Do the previous cultural attributions (Beaumont, 1978; Beaumont et al., 1992; Grün
113 and Beaumont, 2001) correspond with the technological changes observed in the recently recovered
114 lithic assemblages? Do we observe a punctuated evolution or a gradual continuum in lithic technology
115 through time?

116 Regarding taphonomic indicators: What does particle size distribution tell us in comparison to
117 experimental knapping assemblages? What are the differences between members and sub-member
118 units regarding particle size? Is heating modification on lithic remains distributed evenly among the
119 members and sub-member units? Are macroscopic residues distributed evenly among the members
120 and sub-member units?

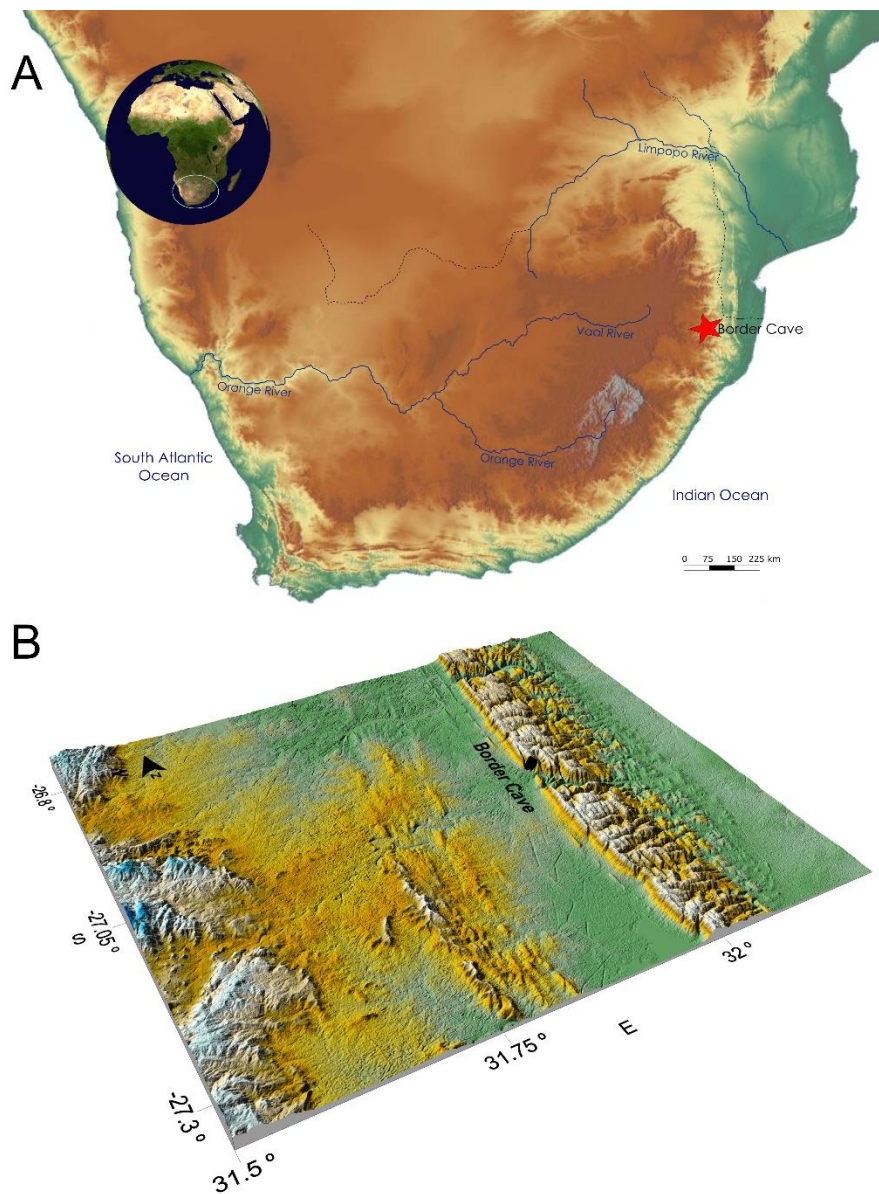
121 Regarding spatial analysis: How does the spatial distribution of lithics correspond with the member
122 and sub-member unit divisions? More specifically, is there a correspondence between vertical
123 distribution of the assemblages and the stratigraphic divisions? Are artefacts distributed randomly
124 with respect to vertical and horizontal dimensions, or is it possible to distinguish concentrations?

125 The lithic variability recorded should be related to other lines of enquiry recently undertaken at the
126 site, including the study of plant and faunal remains, taphonomy and stratigraphy (Sievers et al., 2022;

127 Stratford et al., 2022). A similar methodological proposal was implemented by de la Peña and Wadley
128 (2017) for an analogous assemblage at Sibhudu Cave.

129 **1.2. Border Cave site location**

130 Border Cave is situated in northern KwaZulu-Natal 82 km West of the Indian Ocean (27°1'19"S,
131 31°59'24"E). Named because of its proximity to the border with Eswatini (formerly Swaziland), the site
132 is located in the Lebombo Mountains at the top of a steep cliff at an altitude of 600 masl (Figure 1).
133 The rock shelter is approximately 50 m wide, 35 m deep and with a West facing opening, overlooking
134 the Eswatini lowveld. The cave formed in the Lower Jurassic felsic extrusive rocks of the Jozini
135 Formation, Lebombo Group, approximately 182.1 ± 2.9 mya (Riley et al., 2004).

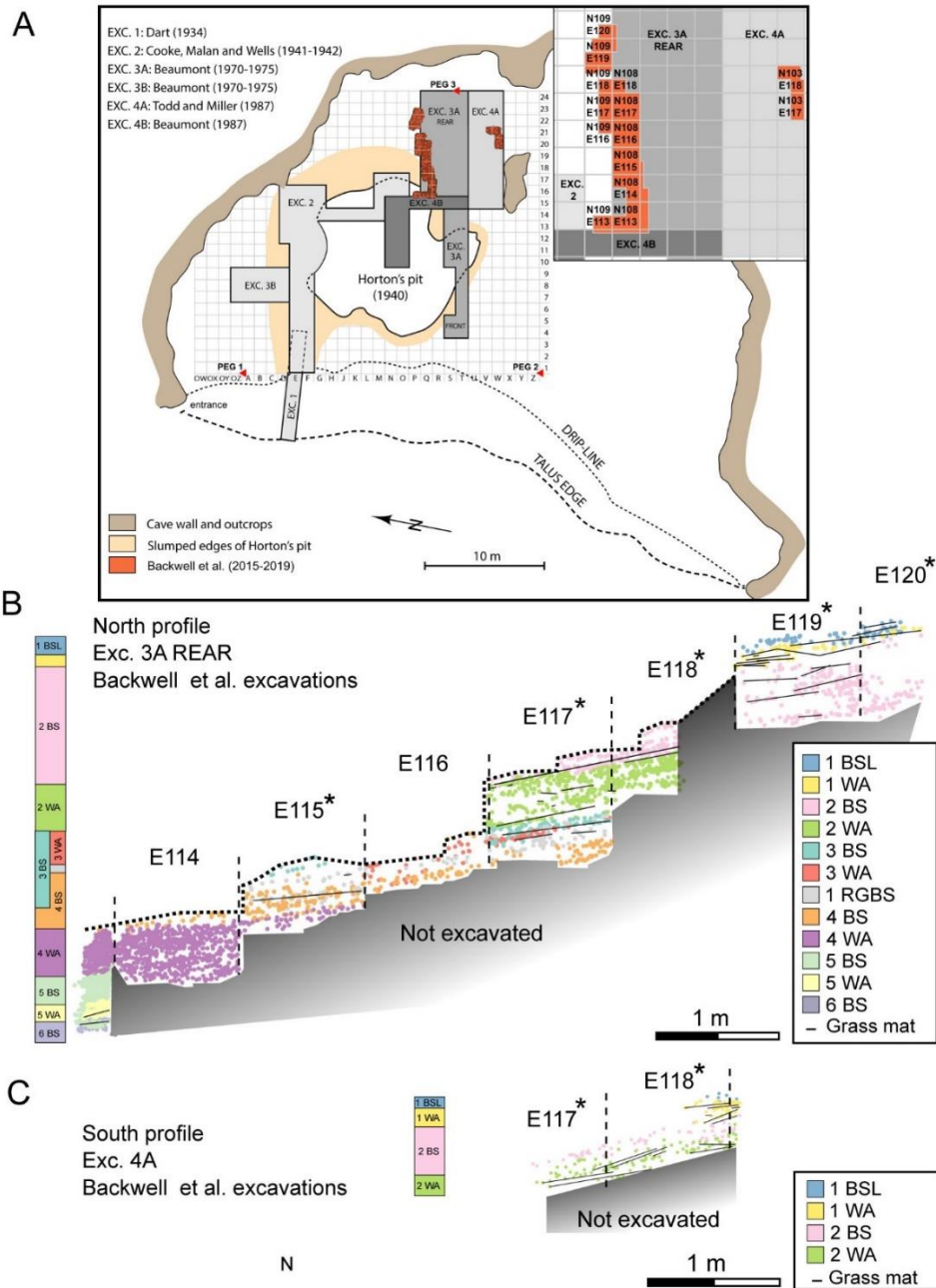


137 **Figure 1. A. Location of Border Cave in southern Africa (map courtesy of A. Val). B. Digital model of**
138 **the terrain at Border Cave in the Lebombo Mountains in South Africa (F. Colino), with the cave**
139 **overlooking the Eswatini lowveld.**

140

141 **1.3. Previous excavations**

142 Raymond Dart initiated excavations at the site in 1934. He dug a narrow trench at the entrance to the
143 shelter (Figure 2, EXC. 1), but unfortunately never published his findings, and the material has since
144 been misplaced. In 1940 a massive pit was dug in the centre of the cave deposit by W. E. Horton,
145 apparently to extract bat guano. He uncovered archaeological and human remains, including an adult
146 partial cranial vault (BC1), the shafts of two femora and tibiae that have since been lost, and a partial
147 adult mandible (BC2) (Cooke et al., 1945; de Villiers, 1973; Beaumont, 1978). A second excavation
148 campaign was conducted by Cooke, Malan, and Wells in 1941 and 1942 (Figure 2, EXC. 2), and led to
149 the noteworthy discovery of an infant burial (BC3) associated with a *Conus* shell (Cooke et al., 1945;
150 d'Errico and Backwell, 2016) that came from Member 1 RGSB. From 1970 to 1975 extensive excavation
151 of the site was conducted by Peter Beaumont, who exposed a 4 m-deep sedimentary sequence of
152 alternating brown sand (BS) and white ash (WA) deposits (Beaumont, 1978; Butzer et al., 1978) (Figure
153 2, EXC 3A). The deposits contained MSA lithic assemblages that he initially ascribed to various phases
154 of the Pietersburg Industry, and an early Later Stone Age assemblage (Beaumont, 1978). The lithic
155 assemblages were later attributed to MSA 1, MSA 2/HP, MSA 3/post-HP and Early Later Stone Age
156 (ELSA) (Grün and Beaumont, 2001). Human remains recovered include an Iron Age skeleton missing
157 the skull (BC4) that was found near the surface in the southern part of the cave, which was directly
158 dated to 340 ± 45 ^{14}C BP (Pta-777) and 480 ± 45 ^{14}C BP (Pta-1318) (Beaumont et al., 1978; Beaumont,
159 1980; Vogel et al., 1986). In 1974, Powell and Beaumont found a nearly complete adult mandible (BC5)
160 while collecting sediment samples from the South section of excavation 3A. It was directly dated by
161 electron spin resonance (ESR) to 74 ± 4 ka (Grün et al., 2003). A humerus (BC6), proximal ulna (BC7),
162 and two metatarsals (BC8a and BC8b) were recovered from disturbed deposits (Grün and Beaumont,
163 2001) but have since been lost. In 1987 Beaumont, Todd and Miller conducted another round of
164 extensive excavations in the shelter (Figure 2, EXC. 4A and EXC. 4B). Changes were made to the
165 stratigraphic sequence, resulting in the oldest deposits, initially called BACO A-D, being renamed
166 Members 5 WA, 5 BS, 6 BS.UP and 6 BS.LR (Figure 2). The BACO A unit was divided into an upper part
167 (Member 4 WA) and a lower part (Member 5 BS). The BACO B unit was renamed 5 WA, BACO C was
168 renamed 6 BS.UP and BACO D changed to 6 BS.LR. Member 1 GBS changed to 4 BS and Member 1
169 BS.UP.S to 1 BS.LR A (Beaumont et al., 1992).



170

171 **Figure 2. A.** Site plan showing the position of the various excavations from 1934 to 2019. The orange
 172 overlay shows the position of point-plotted artefacts in excavations conducted by us from 2015 to
 173 2019 along the North wall of excavation (EXC.) 3A and South wall of EXC. 4A. The inset (top right)
 174 shows the square names excavated by us according to North and East lines. The grid is the original
 175 one established by Cooke et al. (1945) in yards and followed by Beaumont. **B.** Stratigraphic sequence
 176 along the North wall showing all plotted lithics and grass mats/bedding represented by dipping
 177 horizontal black lines. The dashed line indicates the bottom limit of Beaumont's excavations. **C.**
 178 Stratigraphic sequence along the South wall with plotted lithics and grass mats/bedding shown as
 179 black lines. The asterisks mark the squares studied in this manuscript. Figure A: Lucinda Backwell.
 180 Figure B and C courtesy of Guilhem Mauran.

181

182 **1.4. Chronology**

183 The MSA deposits at Border Cave have been dated by Grün and Beaumont (2001) and Grün et al.
184 (2003) using ESR on tooth enamel and with Bayesian modelling of ages conducted by Millard (2006).
185 New luminescence ages derived from feldspar grains in MSA sediments are reported by Tribolo et al.
186 in this volume, who also report new Bayesian age intervals for the different stratigraphic units, and
187 these intervals are derived from the recalculated ESR measurements published by Grün et al. (2003),
188 as well as the ¹⁴C data of d’Errico et al. (2012a) and Villa et al. (2012). In Table 1 a synthesis of the
189 Bayesian age estimates for the members analyzed in this paper is provided.

190

191 **Table 1. Bayesian model age estimates (Tribolo et al. this volume) of the members analyzed in this**
192 **study based on individual ESR (Grün et al., 2003) and ¹⁴C measurements (d’Errico et al., 2012; Villa**
193 **et al., 2012). The Highest Posterior Density (HPD) at 95 % is shown. Cultural attributions are those**
194 **given in Grün and Beaumont (2001).**

195

			All ESR measurements	
Member	Sub-division	Industry	HPD max	HPD min
2 BS	Upper	MSA 3	50.3	43.3
	Lower A	MSA 3	52.0	47.2
	Lower B	MSA 3	54.4	48.5
	Lower C	MSA 3	57.9	50.3
2 WA	Lower	MSA 3	63.7	53.6
3 BS	1	HP	65.5	57.5
	2	HP	69.0	60.0
	3	HP	71.4	62.1
1 RGBS		HP	81.3	68.9

196

197

198 **1.5. Previous technological analyses of the material in Members 1 RGBS to 2 BS**

199 Beaumont’s Masters thesis presents the most complete lithic analysis conducted for this site
200 (Beaumont, 1978) and includes a thorough blank analysis, taking into account morphometry,
201 technology and typology of the excavation 3A lithic assemblage. In his study, Beaumont stressed
202 several aspects concerning the typology and technology of the post-HP/MSA 3 at Border Cave. He

203 concluded that the MSA 3 at Border Cave was characterized by the absence of 'crescents' (sic) and a
204 low number of points. He also distinguished an early phase (Members 2 WA and 2 BS.LR C),
205 characterized by 'modified butts' (sic) (faceted platforms) and low values of chalcedony and scaled
206 pieces; and a late phase (the upper part of Member 2 BS) with high values of the latter two. Another
207 aspect stressed for this later phase is the high number of dihedral and polyhedral platforms and radial
208 prepared cores, and very low number of points and retouched pieces (Beaumont, 1978: 103). One of
209 the conclusions of his techno-typological study was that the assemblage of Members 2 BS and 2 WA
210 was probably a 'terminal occurrence within the MSA' (Beaumont, 1978: 103). Although he highlighted
211 the absence of backed pieces, he included trapeze or double truncated backed pieces in the only
212 graphic representation that he made of the MSA 3 (Beaumont, 1978: 137, Fig. 88; Beaumont et al.,
213 1978: 411, Fig. 4B) (Figure S1).

214 Regarding Member 3 BS, Beaumont (1978) mentioned briefly that trimmed base points are typical of
215 Members 2 BS.LR and 2 WA but also occur occasionally in Member 3 BS. The description of the industry
216 for Member 3 BS was presented together with lithics from Members 3 WA and 1 RGBS. He highlighted
217 the abundance of blades (that he associated with the 'punch' technique (sic)), the presence of backed
218 elements (some of them similar to *Châtelperon* and *Abri Audi* knives) and the occasional
219 representation of small 'pressured flake' triangular items (Figure S1). In his thesis, he attributed these
220 lithostratigraphic members to the 'Epi-Pietersburg' variant of the old 'Second Intermediate'
221 (Beaumont, 1978). However, he later attributed all of them to the HP Industry (e.g. Beaumont et al.,
222 1992; Grün and Beaumont, 2001).

223 Villa and colleagues (2012) also made a technological analysis of Members 2 WA and 2 BS in order to
224 compare the lithic technology to what Beaumont and colleagues (1992) called the Early Later Stone
225 Age (ELSA) Industry in Members 1 WA and 1 BS.LR. In that study, Member 2 WA was characterized as
226 mainly containing blades and elongated flakes with parallel sides 'as the main objectives of the
227 debitage' (Villa et al., 2012: 13209). Core exploitation with bidirectional removals was the main
228 reduction sequence identified (Figure S1). Members 2 BS.LR A and B were characterized as having a
229 decline in blade production, disappearance of unifacial points, drastic reduction in retouched pieces
230 and an increment in bipolar knapping and the use of chalcedony and crystal quartz as raw materials.

231 **2. MATERIALS AND METHODS**

232 **2.1. Sample for the technological analysis**

233 We analysed all of the lithic material excavated from 2015 to 2018 and a sample from 2019 from
234 Members 2 BS, 2 WA, 3 BS and 1 RGBS. Most of the material derives from the North profile left by

235 Beaumont's 3A rear trench excavation (excavated 2015–2019), and a small portion corresponds to the
 236 South profile of his 4A trench excavation (excavated only in 2018 and 2019) (Figure 2). In total, we
 237 analysed 6,450 lithic artefacts/pieces (Table 2).

238 **Table 2. Lithic total counts, weights, and densities by member.**

	Member	Total count	Sum count per member	Total weight (gr)	Sum weight per Member	Density (count/volume)	Density (weight/volume)
North profile	2 BS.UP	1074	2523	2826	8095	7.39	23.74
	2 BS.LR	1449		5269			
	2 WA.UP	707	2507	2362	6048	13.55	32.69
	2 WA.MD	1156		2652			
	2 WA.LR	644		1034			
	3 BS	1263	1263	1695	1695	6.161	8.268
	1 RGBS	91	N/A	657	N/A		
South profile	2 BS	4					
	2 WA	62					

239

240 The archaeological layers studied in the lithic analysis are presented in Data S1. Figure 2 shows a
 241 general plan of the cave with the location of the areas considered in this analysis, and the distribution
 242 of point-plotted lithic artefacts from excavations conducted along the North and South profiles. To
 243 group the industries in the lithic analyses we followed the allostratigraphic units proposed by Stratford
 244 and colleagues (this volume). The allostratigraphic approach divides depositional sequences into units
 245 and packages based on the presence of sedimentary discontinuities. It provides the opportunity to
 246 identify sequences and breaks within compositionally similar sediments. The study distinguished
 247 between allostratigraphic members: gradational change, paraconformities and disconformities
 248 (Stratford et al., this volume). The allostratigraphic members included in this analysis are: 2 BS.UP, 2
 249 BS.LR, 2 WA.UP, 2 WA.MD, 2 WA.LR, 3 BS and 1 RGBS.

250

251 **2.2. Technology and particle size**

252 Technological investigation of the sample involved an attribute analysis following previous lithic
253 methodological studies (Bernaldo de Quirós et al., 1981; Pelegrin, 1995; Inizan et al., 1999, Tostevin,
254 2012; de la Peña, 2015b) which has been adapted for this collection. Our analysis applied the *chaîne*
255 *opératoire* concept (Karlin et al., 1991), however, we tried to control the subjectivity of this approach
256 through univariate and multivariate statistical analyses, as proposed elsewhere (e.g. de la Peña,
257 2015b). These included normality tests (Shapiro-Wilk), t-tests, and Mann-Whitney U tests, which were
258 applied to the typometrical attributes, and chi-squared/contingency tables, correspondence analysis,
259 and non-metric multidimensional scaling in order to explore significant relationships between the
260 different attributes. In many instances, there were zero inflated values in the different attributes
261 studied, so non-metric multidimensional scaling was applied to complement the traditional
262 correspondence analysis as we considered it to be more suitable for these data.

263 As most of the reduction varieties in this assemblage can be referred to as centripetal ‘core-prepared’
264 strategies, we have followed the work of Boëda et al. (1990), Boëda (1993) and Meignen (2019).
265 Regarding core reduction strategies, we also grouped the different varieties into the core classification
266 system of Conard et al. (2004), as it has been used in several recent technological analyses of the South
267 African MSA (e.g., Conard et al., 2012; Douze et al., 2015). Regarding the core categories, we have
268 added the categories ‘core on flake’ (explained more extensively for MSA contexts in de la Peña and
269 Wadley, 2014a) and ‘bipolar’, meaning knapping on anvil cores (as defined in de la Peña, 2011).

270 There are other pieces generated through knapping reduction that denote different technological
271 choices that can occur during the knapping process, such as trimming gestures, preparation in order
272 to initiate a specific type of blank such as blades, removal of knapping accidents (hinge/step scars),
273 change of direction, etc. These pieces can offer key information for understanding the reduction
274 process. We have named these pieces ‘core-related by-products’ as in previous analyses (see de la
275 Peña and Wadley, 2014a).

276 All the blanks that could provide technological or archaeological information were included in an
277 exhaustive attribute analysis. Our technological analysis involved recording both typo-metrical and
278 technological attributes which, indirectly, inform us about the knapping techniques and knapping
279 methods used (as in Inizan et al., 1999; Pelegrin, 2000). The variables considered were raw material
280 type, fragment (Yes/No), presence of cortex (following Tostevin, 2012), maximum length, maximum
281 breadth, maximum thickness (all these measurements with the artefact technologically oriented and
282 measured with plastic callipers so as not to damage the tool), weight, type of platform, platform
283 length, platform width, external platform angle (measured with a plastic goniometer), number of
284 dorsal scars, cross section, dorsal scar pattern (Figure S2), blank curvature, knapping accidents,

285 heating attributes and residues (for a more detailed description, see List S1). As a novelty, we also
286 incorporated the attribute 'ridges and nodes', which consisted of counting the points of intersection
287 of dorsal flake negatives or, instead, if there were no intersections between flake scars, the number
288 of ridges (Figure S3). This variable was designed to explore intensity of recurrence in the knapping
289 process. The raw material classification of the attribute analysis considered the specific varieties of
290 rhyolites and basalts in our sample, and a refined classification considering grain size, colour and
291 crystal inclusions was made (see Data S2 for a description of this classification).

292 All the variables and attributes cover the general typometry of the pieces (length, breadth, thickness
293 and weight of all the blanks), the technique used (platform type, size of the platform and external
294 platform angle), the morphology of the blanks, and therefore related knapping method (shape of the
295 blank, number of scars, dorsal scar pattern, cross-section, curvature), the presence of knapping
296 accidents, and finally attributes on the recurrence of the knapping reflected on the dorsal scar pattern
297 of the flakes (ridges and nodes). The occurrence of these attributes was explored throughout the
298 members.

299 All the flake fragments and chips that could only offer limited information were classified according to
300 raw material (xenomorphic quartz (X-quartz), automorphic quartz (A-quartz), opaline/agate or
301 rhyolite/basalt (R/B)), weighed, and counted by size class (<2 cm, 2-4 cm, >4 cm). A more general
302 classification for the raw materials was performed for these pieces, as particularly the smaller chips
303 and fragments (<2 cm) were impossible to assign to a specific raw material.

304 We also tracked heating attributes in all of the lithic assemblage (complete flakes, fragments and
305 chips), in order to see if there were areas, layers or groups of layers particularly disturbed by post-
306 depositional and/or intentional heating. The attributes considered were the ones defined in Wadley
307 et al. (2017), notably: rough surface, potlids, white or reddish colour (white for agates, and
308 reddish/orangish colour for chalcedonies), presence of two types of gloss on different scar removals.

309 We identified as residue any macroscopic particle attached to the lithic and identifiable to the naked
310 eye.

311 For the statistical analyses we used PAST software (Hamer et al., 2001).

312 All microscopic observations were made with a Leica Zoom microscope. Photographs were taken with
313 a Canon MD500 digital camera with a 1.8F lens in the Archaeology Laboratory at the Evolutionary
314 Studies Institute, University of the Witwatersrand.

315 **2.3. Sample for the spatial analysis**

316 For the distribution study, a total of 955 piece-plotted lithics with three spatial coordinates (X, Y, Z)
317 were used. We analysed the plotted material from Members 2 BS, 2 WA and 3 BS from the North
318 profile of excavation 3A rear in squares X117, 118, 119 and 120, and Y 109. There is an unexcavated
319 section of deposit in X118.5–119, thus, for the vertical projection analysis (XZ) the area studied was
320 divided into two groups: E and W, to avoid the void generated by the absence of data in this area
321 (Figure 2).

322 **2.4. Spatial analysis**

323 With the aim of exploring spatial distribution, occupation intensity and potential areas of post-
324 depositional alteration, a combination of spatial techniques were employed, namely Geographic
325 Information Systems (GIS) and inferential statistics (density analysis and hot spot analysis). The spatial
326 distribution analysis (SDA) mainly focused on analysing whether the lithic artefacts were clustered,
327 dispersed or randomly distributed. It also provided the statistical significance of clusters according to
328 their spatial location, and data on the variables that define the groups. In this work, we applied the
329 Getis-Ord G_i^* and Anselin Local Moran's I methodologies to analyse the spatial patterns (Anselin and
330 Getis, 1992; McKillup and Dyar, 2010; Mora et al., 2020).

331 We also performed a spatial density analysis. Kernel density analysis permits calculating the zones
332 with high or low concentrations of artefacts, according to the location and spatial proximity of features
333 under study.

334 The SDA was conducted in two geometric planes corresponding to the projection of the assemblage
335 on the XY and XZ axes. The SDA on the XZ plane is related to the stratigraphic position and both
336 projections (XY and XZ) explored preferential distribution areas.

337 In the XZ plane an analysis grid of hexagonal cells was created (6 cm size), whereas in the XY the grid
338 was composed of squares. The hexagon's size does not offer a preferential orientation. The 6 cm size
339 was specifically chosen because of the size of the artefacts, as the majority of them fall under this cut-
340 off size.

341 The statistical methods were implemented using QSIG software (version 3.16.16-Hannover) and,
342 specifically, with the Hot spot Analysis plugin (version 2.0.0).

343 **3. RESULTS**

344 **3.1. Results of the technological analysis**

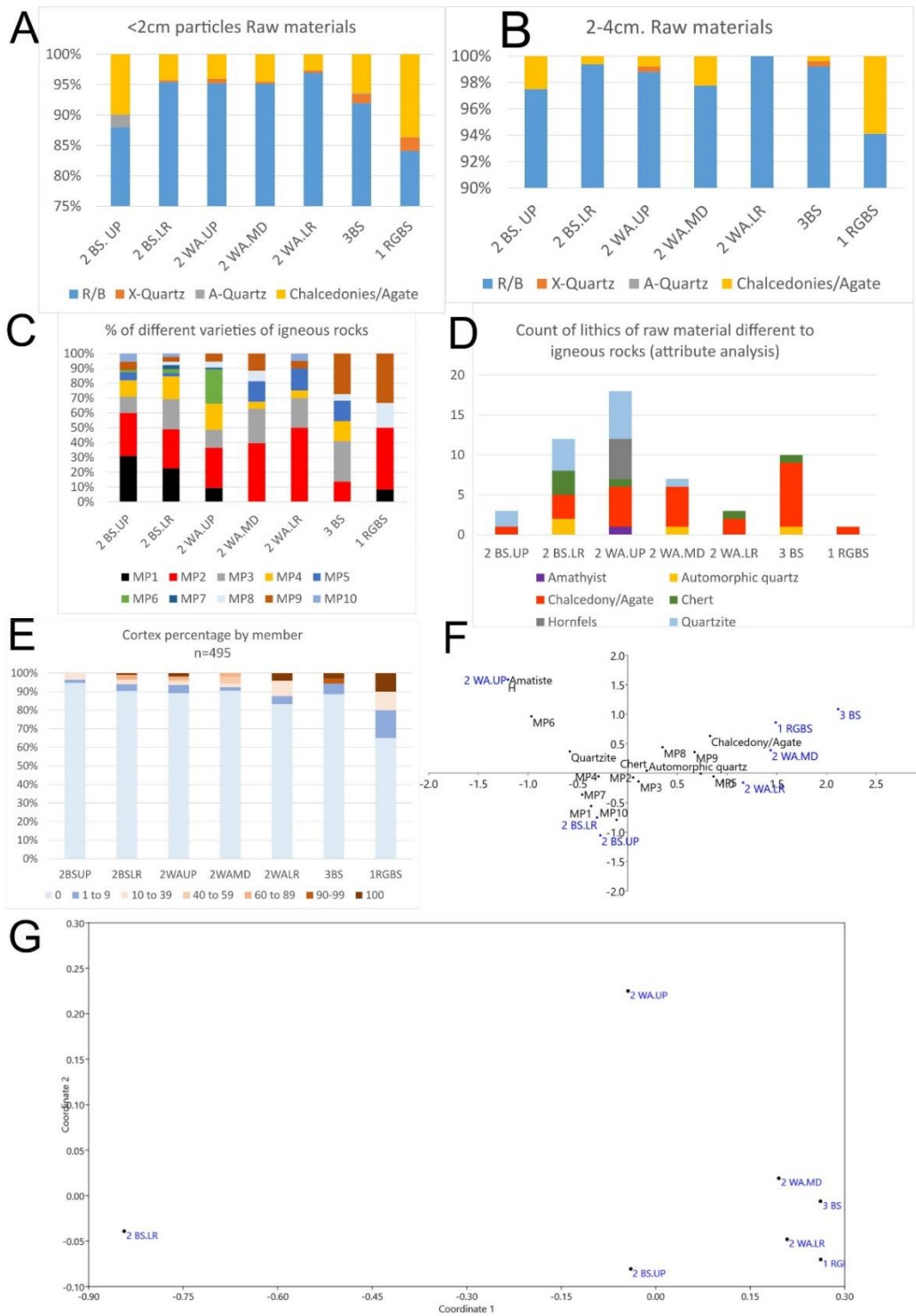
345 **3.1.1. General counts**

346 The attribute analysis and the fragments and chips classification table are provided in Data S3, S4, S5
347 and S6. A summary of the total count, weight, densities (count/volume and weight/volume) and
348 number of cores and retouched pieces is presented in Table 2. The lowest densities (count/volume
349 and weight/volume) are in Member 3 BS, whereas 2 WA has the highest densities. Most of the lithic
350 remains are flakes, fragments and chips, and there is a low percentage of cores and retouched pieces.
351 Thus, most of our conclusions derive from the *debitage* and chips (attributes and frequencies).

352 3.1.2. Raw materials

353 From the counts of the classification of flake fragments and chips (2 cm, 2-4 cm and >4 cm) according
354 to raw material, the category R/B (which included rhyolite and basalt) is dominant in all of the
355 members (Figure 3A, B). The main aspects to highlight are how chalcedonies and agates are relevant
356 at the beginning and at the end of the series, that A-quartz appears in Member 2 BS.UP, and that X-
357 quartz occurs in 3 BS and 1 RGBS.

358 For the pieces that could offer more technological information, we analysed the raw materials in more
359 depth. This classification paid attention to the macroscopic differences between rhyolites, looking at
360 colour, texture, and crystal inclusions (see Data S2 and Figure 3C, D). This assemblage also showed
361 the predominance of the different varieties of igneous rocks (mainly rhyolites) and the presence of
362 other raw materials such as hornfels, quartzite and chert (Figure 3D), with an amethyst chip in 2
363 WA.UP. This more refined classification shows how 2 WA.MD and LR have MP2 (reddish-orange, fine
364 grain, with crystal inclusions and veins) as the most abundant rhyolite variety, and that they are quite
365 distinct from 2 WA.UP. The three upper allostratigraphic members and sub-member units show the
366 highest variability in the number of raw materials. The chi-squared test of all allostratigraphic
367 members and sub-member units shows that there are significant differences in the distribution of raw
368 materials by member and sub-member unit, p (no assoc.): $5.38E-16$. When the relationships are
369 explored by pairs of members and sub-member units that are in stratigraphic contact (Table 3), it
370 shows that 2 BS.LR and 2 WA.UP, and 2 WA.UP and 2 WA.MD show statistically significant differences,
371 whereas the two 2 BS sub-member units and all the lower allostratigraphic members and sub-member
372 units (from 2 WA.MD to 1 RGBS) cannot be distinguished in this regard. The correspondence analysis
373 groups the allostratigraphic members and sub-member units as follows: a first group with the two
374 allostratigraphic members of 2 BS, another group 2 WA.UP, and then 2 WA.MD, 2 WA.LR, 3 BS and 1
375 RGBS (Figure 3F, Table S1). The non-metric dimensional analysis (Figure 3G) also separates 2 BS.UP
376 from 2 BS.LR.



377

378 **Figure 3. Percentage of raw materials for fragments and chips <2 cm (A), and 2-4 cm (B) in the entire**
 379 **assemblage. C. Percentage of the different varieties of rhyolites/basalts in the attribute analysis. D.**
 380 **Count of all the lithics that were not rhyolite or basalt in the attribute analysis. E. Percentage of**
 381 **cortex. F. Correspondence analysis of raw materials (in blue the layers and in black the attributes).**
 382 **G. Non-metric dimensional analysis of raw materials showing only the layers. Note how all the lower**
 383 **allostratigraphic members (from 1 RGBS to 2 WA.MD) group together.**

384

385 **Table 3. Results of contingency tables of raw materials by allostratigraphic member and sub-**
386 **member and comparisons between pairs in stratigraphic contact. The bold numbers denote a**
387 **statistically significant difference.**

N=634	p (no assoc.)	V Cramer
All members	5.38E-16	0.296
2 BS.UP-2 BS.LR	0.501	0.221
2 BS.LR-2 WA.UP	9.51E-07	0.445
2 WA.UP-2 WA.MD	1.10E-04	0.546
2 WA.MD-2 WA.LR	0.654	0.326
2. WA.LR-3 BS	0.114	0.509
3 BS-1 RGBS	0.055	0.608

388

389 In all the stratigraphic units the percentage of pieces with no cortex is more than 50% of the sample
390 studied (Figure 3E). There is a trend from 1 RGBS to the upper part of the sequence towards a decrease
391 in cortex percentage.

392

393 3.1.3. Cores and core-related by-products

394 A synthesis of the main types of cores found in the sample is presented in Table 4, and in Data S7 a
395 more detailed description of all the attributes of these cores (typometry and qualitative attributes) is
396 given.

397 There are some interesting aspects to the core assemblage even though the sample size from the new
398 collection is small and the data are thus not statistically significant.

399 -The most abundant types of cores are parallel and inclined varieties (Figures 4 and 5).

400 - The parallel variant represented is *Levallois* recurrent centripetal (as defined by Boëda, 1993) and it
401 occurs in Members 3 BS, 2 WA.UP and 2 BS.LR (Figure 4). These cores show angles between the striking
402 platform and knapping surface ranging from 30 to 60 degrees. In all the cases, the cores appear
403 knapped until exhaustion. In other words, additional preparation and exploitation would have been
404 difficult due to their small size.

405 -The most complete inclined core appears to follow Boëda's definition (1993) (see example from
 406 Member 3 BS in Figure 5D, E), although there are fragments that could be classified as what Terradas
 407 (2003) calls 'multifacial discoidal'.

408 -There are at least three examples of small platform cores with residual scars towards the production
 409 of bladelets. The one from Member 2 BS.LR is a parallel core 'recycled' into a bladelet one (Figure 5F).
 410 In Member 2 WA.LR there are two examples of platform cores with two opposed striking platforms
 411 and a sub-prismatic volume.

412 -Bipolar cores and cores on flakes only appear in Members 2 WA.UP and 2 BS.UP with one example in
 413 each.

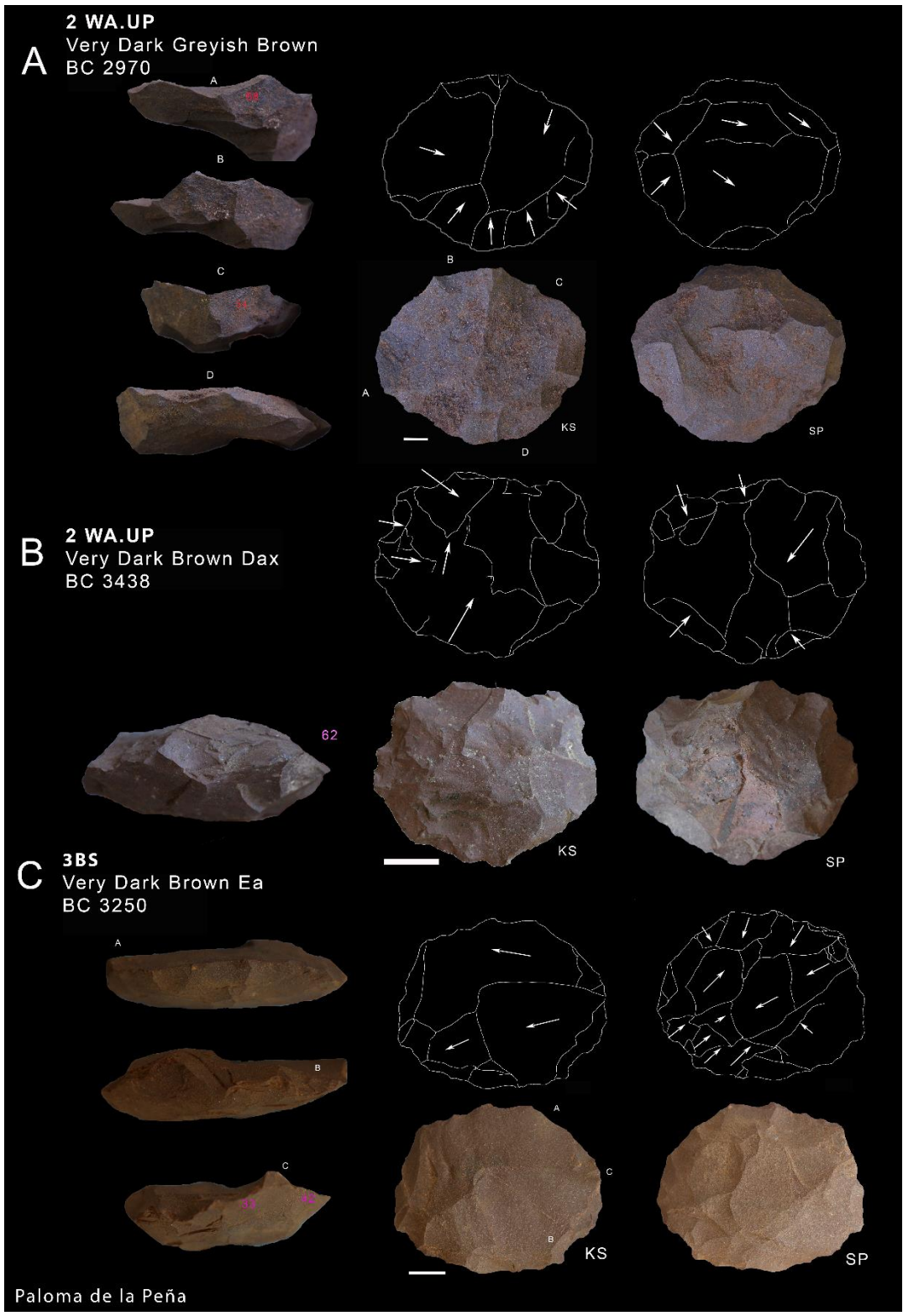
414 **Table 4. Synthesis of the main types of cores, core related by-products, *Levallois* and chordal flakes,**
 415 **and retouched pieces found in the assemblage studied from Members 1 RGBS, 3 BS, 2 WA and 2 BS.**

CORES	2 BS.UP	2 BS.LR	2 WA.UP	2 WA.MD	2 WA.LR	3 BS	1 RGBS
Bipolar core	1						
Inclined	2		1	1		2	
Parallel		2	2			2	
Platform	1	1	1		2		
Core on flake			1				
Test core or nodule						1	2
Fragment						3	
CORE RELATED BY-PRODUCT	2 BS.UP	2 BS.LR	2 WA.UP	2 WA.MD	2 WA.LR	3 BS	1 RGBS
Change of knapping direction						2	1
Semicrest		1			3		
Plunging flake	1	1	3		2	1	1
LEVALLOIS AND CHORDAL FLAKES	2 BS.UP	2 BS.LR	2 WA.UP	2 WA.MD	2 WA.LR	3 BS	1 RGBS
<i>Levallois</i>	2	18	1	4	2	3	
Chordal	5	22	14	3		4	2
RETOUCHED	2 BS.UP	2 BS.LR	2 WA.UP	2 WA.MD	2 WA.LR	3 BS	1 RGBS
Backed piece						1	1
Denticulate		1					
Macrosars		4	1	3	2	1	1
Notch	1	1				1	
Retouched flake		6			1		

416

417

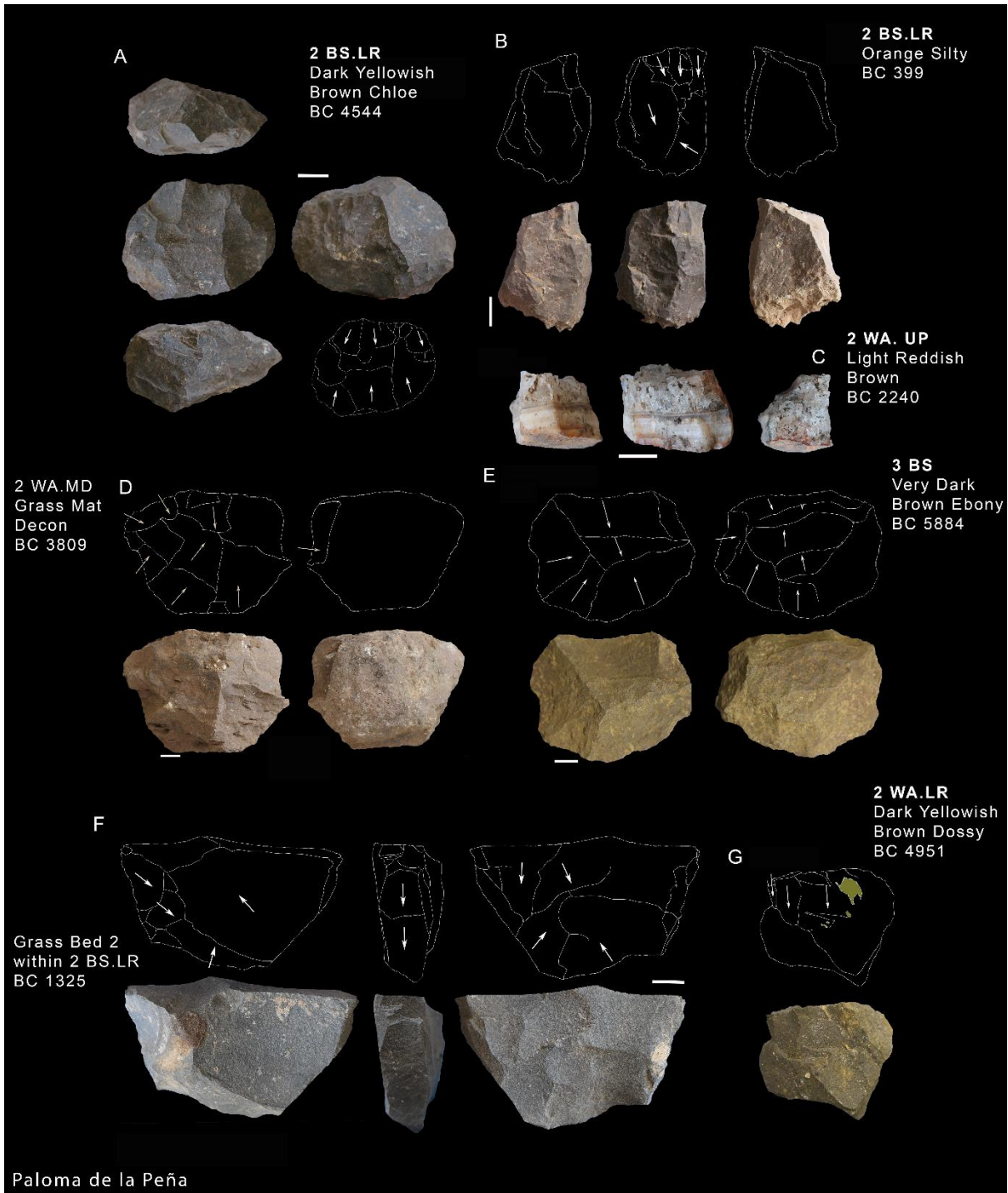
418



419

420 **Figure 4. Examples of parallel (*Levallois* recurrent centripetal) cores in Members 2 WA.UP (A and B)**
 421 **and 3 BS (C). KS = knapping surface; SP = striking platform. The pink numbers denote angle between**
 422 **SP and KS. Scales = 1 cm. All raw materials are different varieties of rhyolites. All photographs: P.**
 423 **de la Peña**

424



425

426 **Figure 5. Examples of platform (B and C) and inclined cores (A, D, E) and a parallel core reshaped**
427 **into a platform bladelet core (F) in 2 BS.LR, 2 WA.UP, 2 WA.MD and 2 WA.LR. All raw materials are**
428 **different varieties of rhyolites except for C that is an agathe and F that is a hornfels. Scales = 1 cm.**
429 **All photographs: P. de la Peña**

430

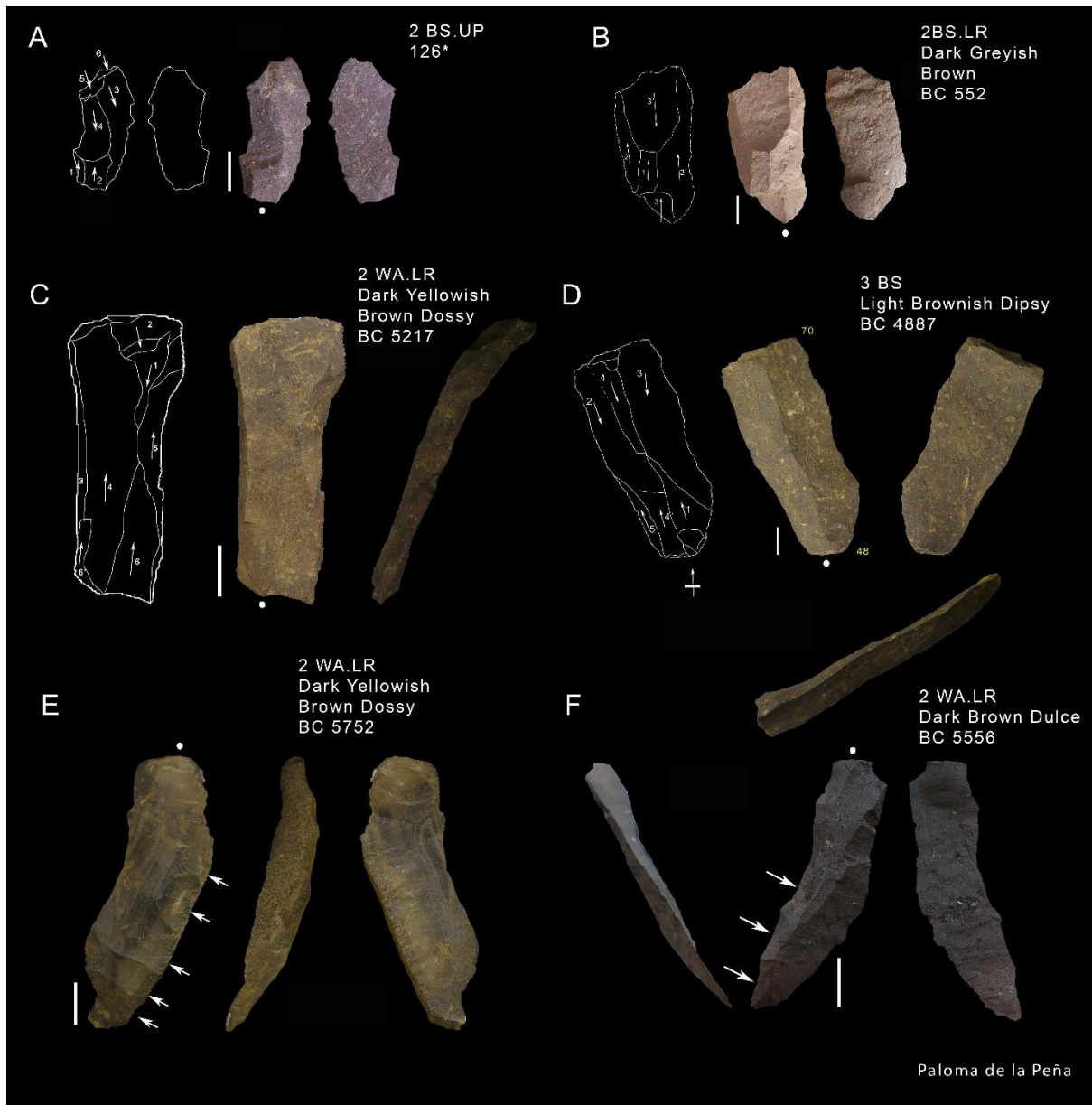
431 Regarding the core-related by-products, we found 16 of these pieces. These elements point out
432 several technological aspects related to core reduction (Table 4). The most relevant qualitative
433 conclusions deduced from these few pieces are:

434 -The presence of platform cores for bladelets with two opposed platforms in Members 2 BS.UP and 2
435 BS.LR (Figure 6A, B).

436 -The presence of another variant of *Levallois* core in 2 WA.LR and 3 BS with two opposed platforms.
437 As can be seen in Figure 6C, D there are examples of long overshoot blades (probably due to knapping
438 accidents) that are showing two opposed platform cores with quite an acute angle between the
439 striking platform and the knapping surface (around 40-50 degrees), and alternation between the two
440 striking platforms. Because of this angle we classify the cores from where these pieces derive as
441 parallel/*Levallois* cores. Alternating between the two striking platforms (Figure 6C, D) produced blanks
442 with rectilinear profiles.

443 -The occasional initiation or re-arrangement of blade cores through semicrests in Members 2 WA.LR
444 and 3 BS (Figure 6E, F). The example of BC 3752 from Member 2 WA.LR shows a semicrest produced
445 on a cortical surface, and it was probably at the initial phases of exploitation of the core to produce
446 blades, whereas with the other example it is impossible to tell if it was a maintenance activity to re-
447 shape the core volume in order to continue producing blades, or if it is a residual set of removals from
448 the initiation of the core (BC 5553 from Member 2 WA.LR).

449



450

451 **Figure 6. Examples of core-related by-products from Members 2 BS.UP, 2 BS.LR and 3 BS. A, B, C**
 452 **and D. Knapping surface face with overshoot. E and F semicrests. C and D show the alternation of**
 453 **two opposed platforms. All raw materials are different varieties of rhyolites except for E that is an**
 454 **agate and F that could be a basalt. Scales = 1 cm. All photographs: P. de la Peña**

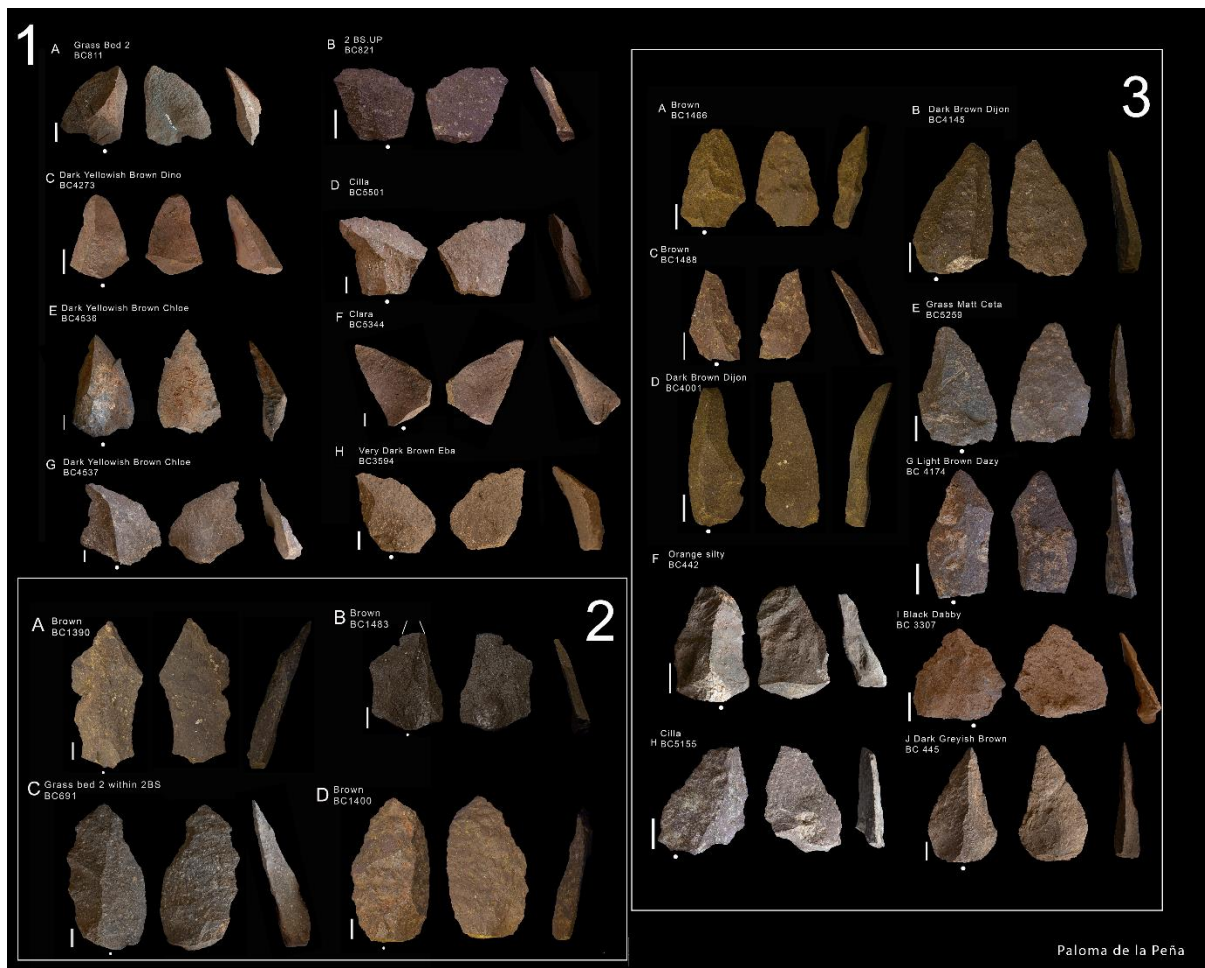
455

456 3.1.4. Other technological pieces

457 In the assemblage, there are other types of blanks among the *debitage* that are indicative of specific
 458 modalities of knapping methods. In this regard, among our sample there are 'chordal flakes'. These
 459 blanks were defined by Boëda (1993), and they are characterized by a knapping reduction along the
 460 chordal orientation of the core. As a result, the technological axis is oblique to the morphological axis

461 of the piece. There are two types of chordal flakes: ‘the ones that have a distal point created by the
 462 intersection of two either unilineal or crossed removals opposite the ‘back’ (core edge), referred to as
 463 a “pseudo-*Levallois* point” by Bordes (1961), while the other type (also called *éclat débordant*) has a
 464 lateral back oriented along the technological axis of the flake that is opposite one or two edges (Favre
 465 et al., 2017: 118). These technological pieces can be produced in *Levallois* and discoid reductions and
 466 they appear in our sample. In particular, there are *éclat débordants* taking a small portion of the core
 467 edge and pseudo-*Levallois* points with triangular shapes (Figure 7, Figure S4 and Table 4). Moreover,
 468 there are a number of these blanks that have triangular shapes, and they fall into the category that
 469 Douze et al. (2020) call ‘technological points’. All of the triangular blanks from Members 2 BS to 1
 470 RGBS are presented in an in-depth study of technology and geometric morphometrics by Timbrell and
 471 colleagues (this volume).

472



473

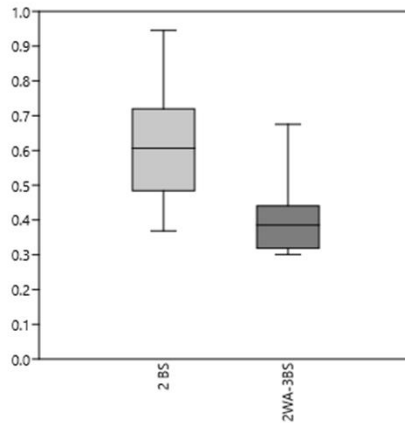
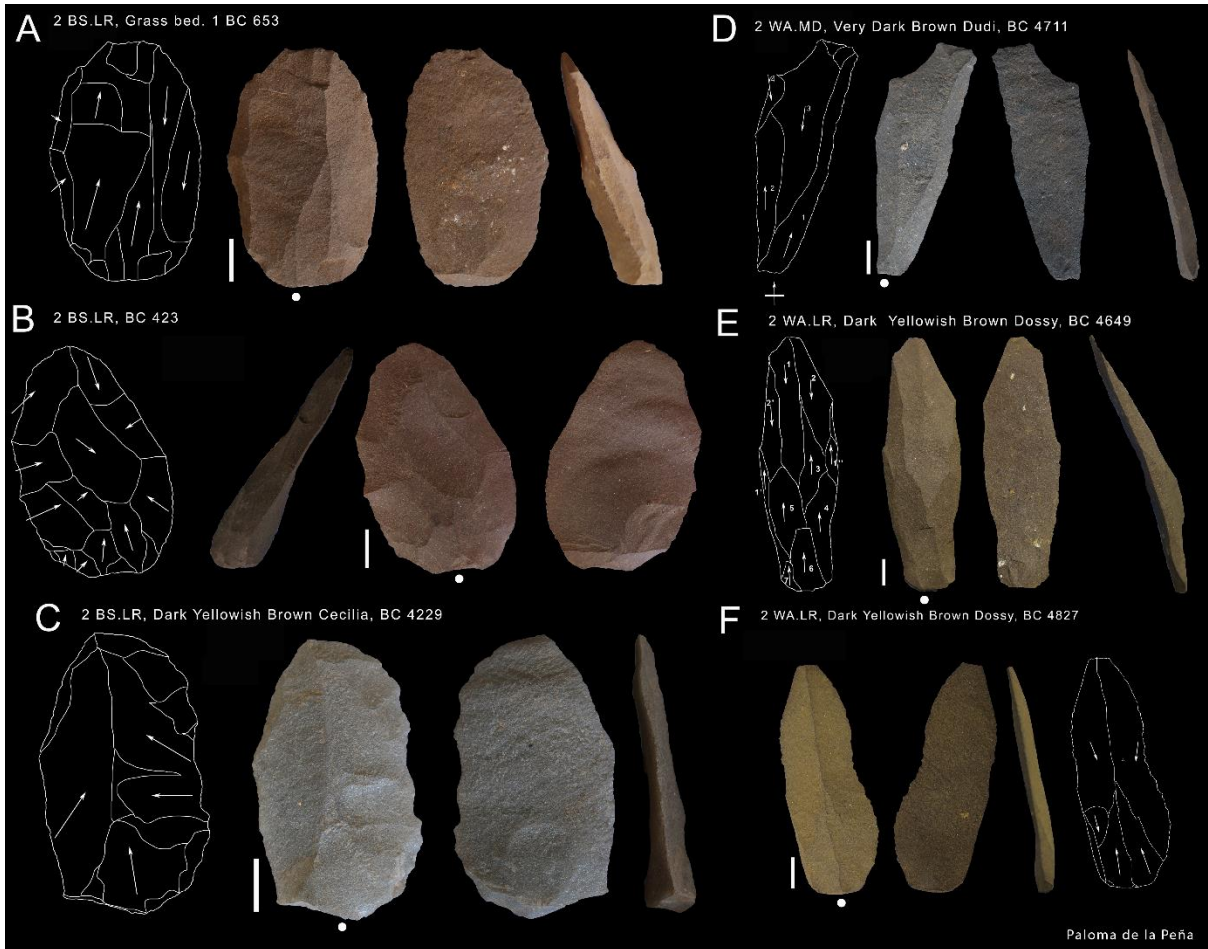
474 **Figure 7. Examples of triangular blanks from Members 3 BS, 2 WA and 2 BS. 1. Chordal flakes:**
 475 **pseudo-*Levallois* points and partially *débordant* flakes. 2. *Levallois* flakes. 3. *Levallois* and pseudo-**

476 **Levallois points. All raw materials are different varieties of rhyolites except for 2.B that is a chert.**

477 **Scales = 1 cm. All photographs: P. de la Peña**

478

479 There are also flakes and blades that could fall within what has been defined as *Levallois* flakes and
480 blades. In Table 4 we present these items by allostratigraphic member. A qualitative distinction
481 between the *Levallois* flakes stands out; on the one hand, there are flakes in Members 2 WA.UP and
482 2 BS.LR that are characterized by thick platforms (Figure 8A, B, C), probably due to hard mineral
483 percussion (Pelegrin, 2000). On the other hand, in Members 2 WA.LR and 3BS there are *Levallois*
484 blades with bidirectional scar patterns, rectilinear in profile, and with an acute angle between the
485 striking platform and the knapping surface that is probably related to core-related by-products (Figure
486 8D, E, F). In the *Levallois* blades there are small removals on the dorsal face close to the platform, and
487 a smooth surface, probably due to passing the hammer over that specific spot, what Pelegrin (1995)
488 defines as 'abrasion' (Figure S3). A comparison of the length/breadth ratio of these two 'types' of
489 *Levallois* blanks shows how they appear to be different. The ones coming from 2 BS.LR are wide and
490 thick, whereas the ones from 2 WA.LR and 3 BS are more elongated (Figure 8G). A Mann-Whitney U
491 test of the length/breadth ratio showed that they are statistically different p.same:0.00041 (Table S2
492 and S3). There is a small proportion of these two variants of *Levallois* flakes that also have triangular
493 shapes (Figure 7), see Timbrell and colleagues (this volume).



494

495 **Figure 8. A, B and C. *Levallois* blanks probably coming from a recurrent centripetal core. D, E and F.**
 496 ***Levallois* blanks coming from two opposed platform cores. All the examples are from Members 2**
 497 **BS.LR, 2 WA.MD, 2 WA.LR and 3 BS. All raw materials are different varieties of rhyolites except C**
 498 **that is a quartzite. Scales = 1 cm. All photographs: P. de la Peña.G. Boxplots of elongation index of**
 499 **different *Levallois* blanks.**

500

501 There are also a number of flakes in the assemblage that fall under the definition of typical and atypical
502 *Levallois* points (Figure 7). These blanks are studied in depth by Timbrell et al. (this volume). These
503 types of blanks have a triangular shape and unidirectional convergent scar patterns. They might come
504 from *Levallois* and discoid reductions or, possibly, a specific unipolar convergent *Levallois* variant,
505 though we have not found any other qualitative clues (such as cores or core-related by-products) to
506 support the presence of this knapping modality. Thus, it seems likely that they were produced through
507 discoidal and *Levallois* reduction sequences.

508 3.1.5. Typometry and attribute analysis of flakes

509 Regarding the typometrical measure of the blanks (length, breadth, thickness, and weight) in our
510 assemblage there were several members that were statistically not normal after the Shapiro Wilk test
511 (Figure S5 and Table S4, 5, 6). Therefore, in order to compare these variables between the different
512 members, we used the non-parametric Kruskal Wallis test. For the length there are significant
513 differences between members ($p(\text{same})=0.00008249$) and the Mann-Whitney results show that there
514 are statistical differences between all of the contiguous stratigraphic members, except for the
515 lowermost ones from 1 RGS to 2 WA.MD (Table 5). For the breadth, the Kruskal-Wallis test did not
516 find significance differences between sample medians. Finally, for the thickness, there was a
517 significant distinction between the medians, and in this case all the members are different from 1
518 RGS except 2 BS.LR (see Tables S7, 8, 9, 10).

519 **Table 5. Mann-Whitney U test results for lengths of the blanks. In the lower left the value for the**
520 **test and in the upper right the p (same) values. The results in bold indicate statistically significant**
521 **differences.**

522

523

524

525

526

527

528

529

	2 BS.UP	2 BS.LR	2 WA.UP	2 WA.MD	2 WA.LR	3 BS	1 RGBS
2 BS.UP		7.76E-05	0.439	0.007	0.000	0.088	0.536
2 BS.LR	7.76E-05		0.001	0.660	0.185	0.402	0.041
2 WA.UP	0.439	0.001		0.049	0.004	0.305	0.957
2 WA.MD	0.007	0.660	0.049		0.122	0.691	0.145
2 WA.LR	0.000	0.185	0.004	0.122		0.084	0.006
3 BS	0.088	0.402	0.305	0.691	0.084		0.335
1 RGBS	0.536	0.041	0.957	0.145	0.006	0.335	

530

531 Owing to the fact that blades and elongated blanks have been one of the hallmarks of the HP
532 technological tradition (Wurz, 2000) we explored the elongation index among all the members
533 considered in this study. As can be seen in the boxplot of the elongation index, Members 2 WA.LR and
534 3 BS have the lowest values, which indicates greater elongation. The elongation index was not
535 normally distributed, and so we performed a Kruskal-Wallis test for equal medians. The results indicate
536 that lithics from Members 3 BS and 2 WA.LR are not distinct from each other, whereas all the rest of
537 the contiguous members are.

538 **Table 6. Mann-Whitney U test results for elongation index. The results in bold indicate statistically**
539 **significant differences**

	2 BS.UP	2 BS.LR	2 WA.UP	2 WA.MD	2 WA.LR	3 BS	1 RGBS
2 BS.UP		0.001	0.5423	0.057	3.85E-05	0.091	0.178
2 BS.LR	0.001		1.44E-05	0.519	0.002	0.567	0.018
2 WA.UP	0.543	1.44E-05		0.016	5.65E-06	0.045	0.266

2 WA.M D	0.057	0.519	0.016		0.005	0.571	0.032
2 WA.LR	0.000	0.002	5.65E-06	0.005		0.064	0.001
3 BS	0.091	0.567	0.045	0.571	0.063		0.128
1 RGBS	0.178	0.018	0.266	0.032	0.001	0.128	

540

541 Concerning the typometry of platforms, the lowest values were registered for Members 3 BS and 2
542 WA.LR. The Kruskal-Wallis test showed significant differences between the sample medians for
543 breadth and length of the platform values. The Mann-Whitney U test results showed differences
544 between most of the members, although Members 3 BS and 2 WA.LR showed no significant
545 differences in these typometrical attributes (Tables S12 to S15).

546 For the rest of the qualitative attributes (ridges and nodes, number of scars, dorsal scar pattern, shape
547 of the blanks, profile curvature, sections) chi-squared and Monte Carlo tests (more suitable for smaller
548 samples) of each attribute studied do not show significant differences between the members (Table
549 7). Nonetheless, there are some aspects worth mentioning regarding the frequencies of the different
550 attributes, which could indicate some differences between the allostratigraphic members and sub-
551 member units (Figure S6). The intensity of the knapping (recurrence) seems higher in 2 WA.MD (see
552 number of scars and ridges and nodes) for the assemblage studied. The dorsal scar pattern in the
553 lower units (3 BS, 2 WA.LR, 2 WA.MD) show how bidirectional and unidirectional convergent patterns
554 are more abundant in the lower units, whereas in the upper units multidirectional patterns are in the
555 majority (2 WA.UP, 2 BS.LR and 2 BS.UP). This is in accordance with the presence of two opposed
556 platforms core-related by-products in the lower members and the *Levallois* recurrent centripetal in 2
557 WA.UP and 2 BS.LR (*vide supra*). Members 1 RGBS and 3 BS have the highest proportion of straight
558 and medium profile blanks.

559 Table 7. Chi-squared and Monte Carlo test results of the qualitative attributes comparing all the
560 members.

	Chi-square p (no assoc.)	Monte Carlo
Number of scars	0.603	0.603
Ridges and nodes	0.366	0.357

Dorsal scar pattern	0.396	0.375
Shape	0.396	0.376
Cross section	0.396	0.394
Curvature	0.948	0.957

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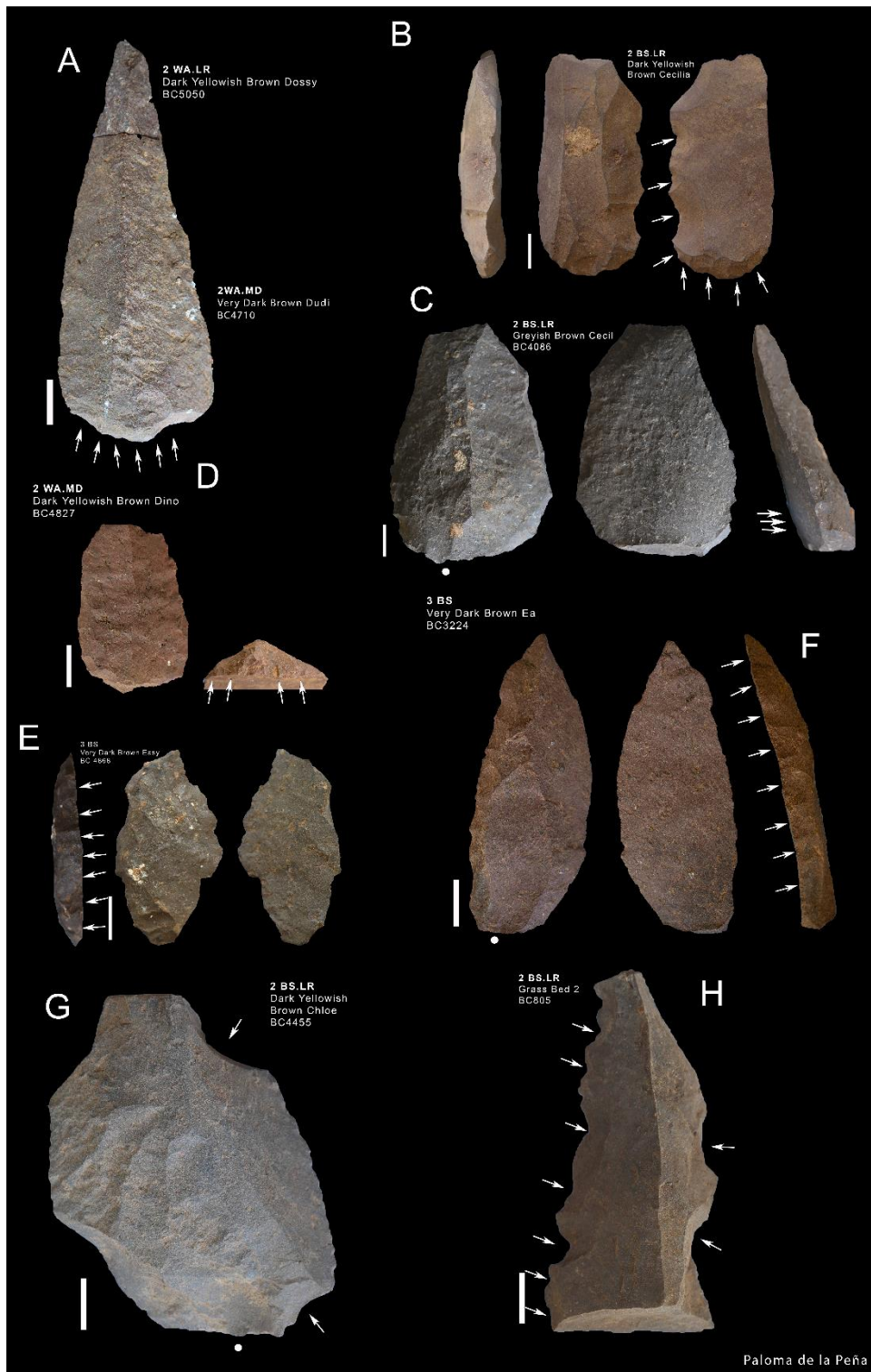
562 3.1.6. Retouched pieces

563 The percentage of retouched pieces in all of the members (except 1 RGS) does not pass 1% of the
564 sample analysed in the attribute analysis (Table 1). Most of the retouched pieces were documented
565 in unit 2 BS.LR. The main categories by order of representation are retouched points (see Timbrell et
566 al., this volume), retouched flakes (pieces with simple retouch somewhere on the dorsal or ventral
567 face), backed pieces, notches and denticulates (Table 4 and the attribute analysis of all these blanks
568 in Data S8). There are also pieces that present macroscopic scars, and these might be due to use,
569 hafting amendments, or trampling. In-depth use-wear analysis will be necessary to assess the causes
570 of these scars.

571 The retouched points/triangular elements include 10 complete pieces and one fragment. There are
572 several aspects worth noting in this small sample of retouched points (the morphometry and
573 technology of these pieces are presented in Timbrell and colleagues (this volume)). Firstly, the two
574 *fossiles directeurs* that Beaumont (1978) highlighted - *Châtelperron/Abri Audi* knives and trimmed
575 points – are present in our sample. In Very Dark Brown Ea (Member 3 BS), BC3224 fits the description
576 by Beaumont of '*Châtelperronian*' points, with abrupt direct retouch to the lateral left (unique in this
577 sample) and a plain platform (Figure 9F). There is also a refit of BC5050 and BC4710 (Figure 9A), which
578 is a good example of the 'trimmed points' that Beaumont observed at the bottom of Member 2 WA,
579 with the base being shaped through an inverse simple retouch. BC4728 (Figure 9D) from Dark
580 Yellowish Brown Dino shows a similar 'template', as the retouch is identical to the base of the refitted
581 pieces. In unit 2 BS.LR, there are three retouched points in which the platform has been removed (see
582 BC543, BC5209, BC1222 in Timbrell et al., this volume). This could be to facilitate hafting.

583 Besides the '*Châtelperronian*'-like point there are two other pieces with abrupt retouch (close to 90
584 degrees) that could be classified as quite irregular backed pieces (segments) (Figure 9E).

585 Regarding the 'retouched flakes', which is the next largest category after the 'points', all of them
586 present simple retouch (around 45 degrees), and the retouch does not usually cover a complete edge.
587 Some of them have this retouch on the proximal lateral areas of the flake and it could be related to
588 hafting (Figure 9C). Finally, there is a notched piece and a fragmented denticulate in 2 BS.LR (Figure
589 9G and H).



590

591 Figure 9. Examples of retouched pieces in the layers studied. A and D. Retouched points in Member
 592 2 WA.MD and 2 WA.LR that are similar to the 'Emireh points' described by Beaumont (1978) in the
 593 post-Howiesons Poort. B. Retouched flake. C. Retouched *Levallois* flake with macroscopic scars in the
 594 proximal area E. Backed piece. F. Straight-backed retouched point that falls into the
 595 'châletperronian' definition of Beaumont (1978). G. Notched piece. H. Denticulate. Scales = 1 cm. All
 596 raw materials are different varieties of rhyolites. All photographs: P. de la Peña

597 The frequency of retouched pieces per layer is not statistically significant, but the frequency of their
 598 type of raw material (Figure S7) is (p (no assoc.): 0.000529). When the chi-squared test is run on
 599 contiguous pairs of units, 2 WA.UP and 2 BS.LR show statistically significant differences (Table 8).

600 **Table 8. Chi-squared test of representation of raw materials of retouched pieces per member. The**
 601 **result in bold indicates a statistically significant difference.**

	p (no assoc.)	V Cramer
All members	0.001	0.709
2 BS.UP-2 BS.LR	0.240	0.685
2 BS.LR-2 WA.UP	0.021	1.000
2 WA.UP-2 WA.MD	0.221	1.000
2 WA.MD-2 WA.LR	0.422	0.742
2. WA.LR-3 BS	0.377	0.817
3 BS-1 RGBS	0.199	1.000

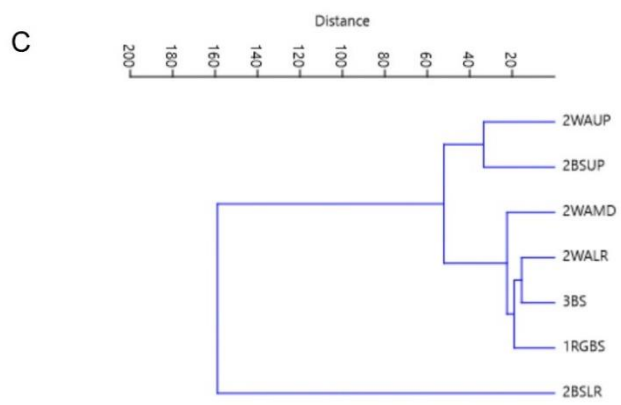
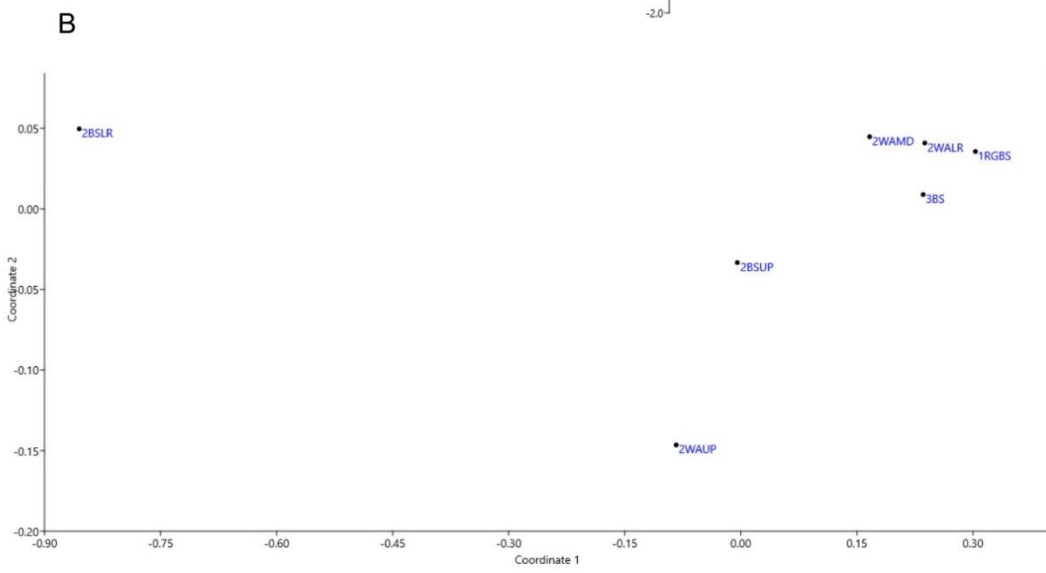
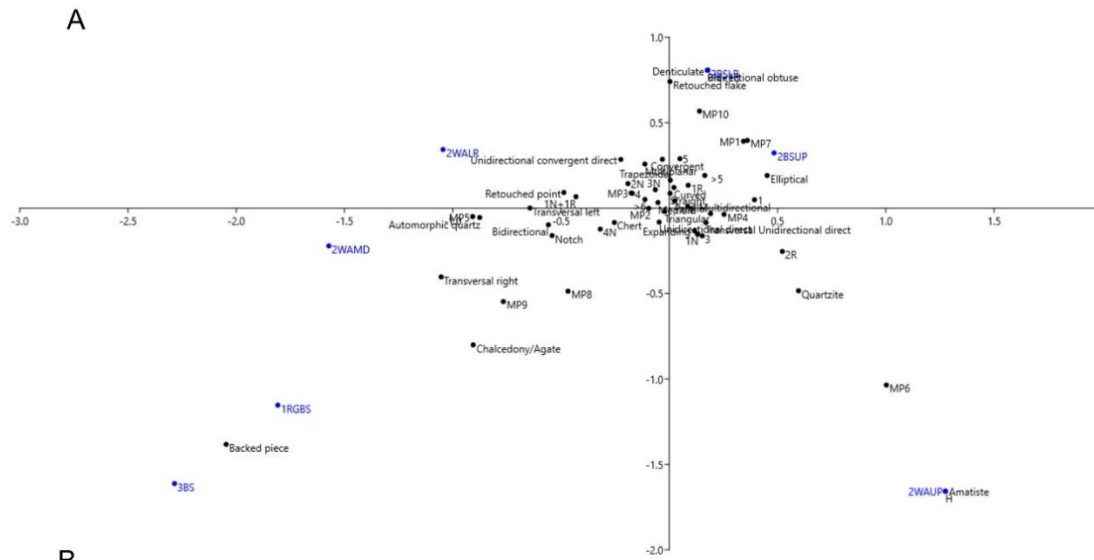
602

603 3.1.7. Multivariate analysis of all the attributes

604 As a last step in our technological analysis we made a correspondence analysis of all the technological
 605 qualitative attributes of the blanks, the raw material distributions (of the attribute analysis) and the
 606 retouched pieces. The first axis explains around 59% of the variance. The first axis clearly separates all
 607 the units below 2 WA.MD from the ones in the upper half. From this analysis we can tentatively
 608 propose four groups based on their proximity: 1 RGBS-3 BS, 2 WA.LR-2 WA.MD, 2 WA.UP, and 2 BS.LR-
 609 2 BS.UP (Figure 10A).

610 The non-metric dimensional analysis of the same attributes gives a slightly different picture, grouping
 611 all the lower units (from 1 RGBS to 2 WA.MD) and separating from each other 2 WA.UP, 2 BS.LR and
 612 2 BS.UP (Figure 10B).

613 Finally, the classical cluster of all these attributes shows how 2 BS.LR separates from all the rest of the
 614 units, and groups 2 WA.UP and 2 BS.UP, and then all the lower units from 3 BS to 2 WA.MD. In this
 615 last group of the lower members, three sub-groups are distinguished: 1 RGBS, 3 BS and 2 WA.LR, and
 616 2 WA.MD (Figure 10C).



617

618 **Figure 10. Correspondence analysis (A), non-metric dimensional analysis (B) and classical clustered**
 619 **analysis (C).**

620 The main results of the technology analysis are summarized as follows: lithics from units 2 WA.UP, 2
621 BS.LR and 2 BS.UP are characterized by discoidal and *Levallois* reduction, and an abundance of
622 unretouched triangular blanks. However, the three of them have notable differences regarding raw
623 material percentages and frequencies of technical features, and in the multivariate statistical analysis
624 they were clearly separated from each other. Units 2 WA.MD and 2 WA.LR have a much lower
625 percentage of chordal flakes (typical of discoidal reduction) in comparison with the upper lithic
626 assemblages, and instead a specific variant of *Levallois* reduction towards the production of elongated
627 blanks with two opposed platforms was documented, deduced from core-related by-products. These
628 two sub-member units also have triangular blanks, but they are different from the triangular blanks in
629 Member 2 BS with regard to dorsal scar pattern and elongation. Indeed, the highest elongation index
630 between units 1 RGBS and 2 BS.UP was recorded in unit 2 WA.LR (showing no statistical difference
631 from 3 BS). Unit 2 WA.LR also has crested blades, which are typical of initiation of the cores in some
632 blade reduction knapping methods. In Member 3 BS discoidal and *Levallois* recurrent reduction
633 methods were also documented on two cores. Member 1 RGBS did not provide any cores (except two
634 tested nodules), but the attribute analysis of the flakes demonstrated continuities with Member 3 BS.
635 Regarding raw material distribution, different varieties of rhyolite were dominant in all four members.
636 Finally, the number of cores and core-related by-products is very low. This fact, together with the very
637 low percentage of cortex recorded in all the members, might reflect that relatively little knapping
638 activity took place in this part of the shelter. There are also very few retouched pieces, although
639 together with blanks with macroscars they constitute an important group of our sample given the
640 small area excavated. Some of the morphotypes coincide with previous analysis conducted by
641 Beaumont (1978). The most represented groups are retouched flakes and triangular blanks with some
642 retouch.

643 **3.2. Preliminary particle size analysis**

644 As already mentioned, the member with the greatest lithic density is 2 WA (Table 2). However, if we
645 observe the particle size distribution per sub-member unit, there are sometimes remarkable
646 differences between contiguous layers, with some of them having an abundance of chips and bigger
647 flakes, while the immediately adjacent layer show comparatively very low values (Figure 11A).

648 The particle size analysis by size groups (<2 cm, 2-4 cm, >4 cm) follows a similar particle size pattern
649 of other knapped experimental and archaeological assemblages, with the number of particles
650 decreasing rapidly as the size of particles increases (Schick, 1986; Bertran et al., 2012; Thomas et al.,
651 2019). This is the case for all the units considered, as shown in the stacked chart (Figure 11B). However,
652 the chi-squared test of the particle size frequencies by groups compared to contiguous members and

653 sub-member units shows, on the one hand, significant differences between all the units from 2
 654 WA.MD to 2 BS.UP and, on the other hand, a similarity in distribution from 3 BS to 2 WA.MD. This
 655 could be due to cultural behaviour (frequency of occupation and intensity) or taphonomic factors
 656 (Table 9).

657 The particle size distribution of rhyolite/basalt (R/B) as shown in the ternary plot highlights an
 658 interesting aspect. For the R/B (Figure SX) it shows how units 3 BS to 2 WA.MD have a similar pattern
 659 distribution with the greatest abundance of small particles. It also groups 2 WA.UP and 2 BS.UP.
 660 Finally, 1 RGBS and 2 BS.LR both have distributions distinct from all of the other members and sub-
 661 member units (Figure 11C). In chalcedonies/agates, the distribution is different, with units 3 BS and 2
 662 WA.LR forming one group and units 2 WA.MD, 2 WA.UP and 2 BS.UP forming a second group, and
 663 with units 1 RGBS and 2 BS.LR in between these two groups.

664 **Table 9. Chi-squared test of particle size distribution separated by groups (<2 cm, 2-4 cm, >4 cm)**
 665 **comparing all the members and pairs of members that are stratigraphically contiguous. The results**
 666 **in bold indicate significant differences.**

	p (no assoc.)	V Cramer
All members	1.41E-35	0.133
2 BS.UP-2 BS.LR	5.18E-12	0.158
2 BS.LR-2 WA.UP	2.56E-05	0.110
2 WA.UP-2 WA.MD	6.05E-12	0.176
2 WA.MD-2 WA.LR	0.313	0.037
2. WA.LR-3 BS	0.010	0.072
3 BS-1 RGBS	7.28E-05	0.126

667

668 The distribution of residues and heating attributes is inversely proportional for units 3 BS, 2 WA.LR
 669 and 2 BS.UP (Figure 11D), but not for the rest of the members, which is surprising as one would expect
 670 these two qualitative attributes to be inversely proportional to each other.

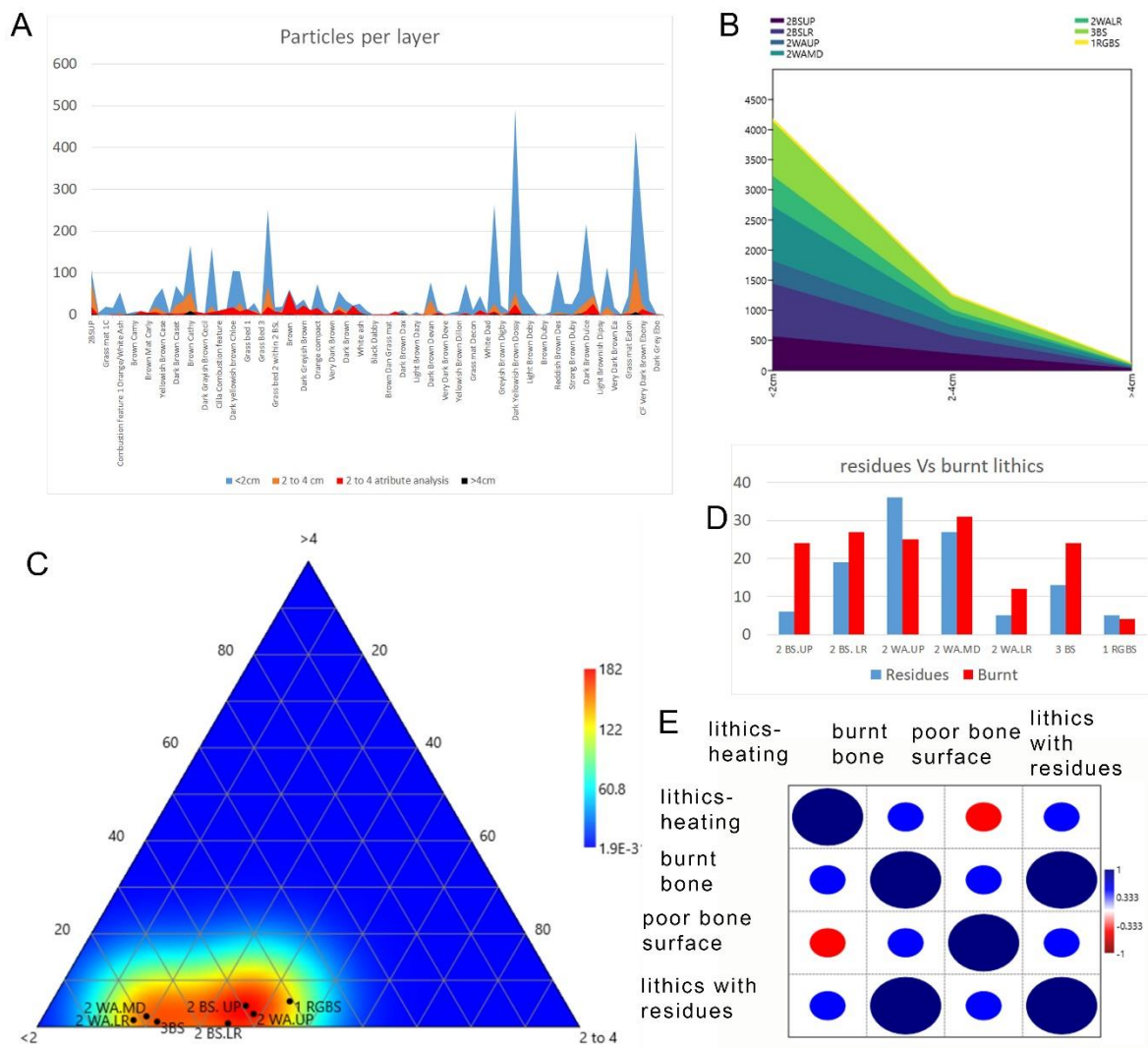
671 We also explored the relationship between lithic heating attributes, lithics with residues, poor bone
 672 preservation, and bone heating attributes (the latter two features provided by JLC in Stratford et al.
 673 (this volume)) for Member 2 WA (Table 10). This was an exploratory exercise in order to look for
 674 potential meaningful relationships between different types of items, similar to the one presented in
 675 Rodríguez-Rellán & Valcarce (2015). The Spearman's rank comparison (Figure 11E) shows how lithics
 676 with heating attributes have a positive correlation with bones with some degree of burning. This

677 seems logical, although it must be highlighted that this correlation is not very high. However, the lithics
 678 with heating attributes have an inverse correlation with bone with poor surface preservation, which
 679 again was unexpected. Moreover, the lithics with heating attributes also have a positive correlation
 680 with pieces with macroscopic residues. Burnt bone has a positive correlation with poor surface
 681 preservation, which was expected, and has an even higher correlation with lithics with residues. These
 682 results could be indicating either that there were different sets of activities within the units evaluated
 683 here and that lithics and bones are reflecting different sets of activities in some instances, or that the
 684 units of analysis are not sensitive enough to assess this. We are aware that these comparisons are
 685 inappropriate in data with significant sampling differences. However, as the assemblage is relatively
 686 small and the surface excavated too we present this preliminary data as a mere exploratory exercise.

687 **Table 10. Number of lithics with heating attributes, burnt bone (moderate+highly), poor bone**
 688 **surface preservation, and lithics with residues in the three sub-member units of 2 WA. The data on**
 689 **bones is from J. Clark (Stratford et al., this volume).**

	Lithics with heating attributes	Burnt bone (moderate and highly)	Poor bone surface	Lithics with residues
2 WA.UP	25	1272	197	36
2 WA.MD	31	189	25	27
2 WA.LR	12	156	54	5

690



691

692 **Figure 11. A. Stacked chart showing the particle size distribution per layer of all the artefacts in the**
 693 **lithic assemblage reported in Table 2. B. Stacked area showing the distribution of particle size groups**
 694 **in all the members considered. C. Ternary plot of particle size distribution of rhyolite/basalt. D.**
 695 **Number of pieces with visible residues and burnt attributes per allostratigraphic member. E.**
 696 **Spearman's rank analysis comparing lithics with heating attributes, burnt bone (moderate+highly),**
 697 **poor bone surface preservation, and lithics with residues. The bone data for E is from Stratford et**
 698 **al. (2022).**

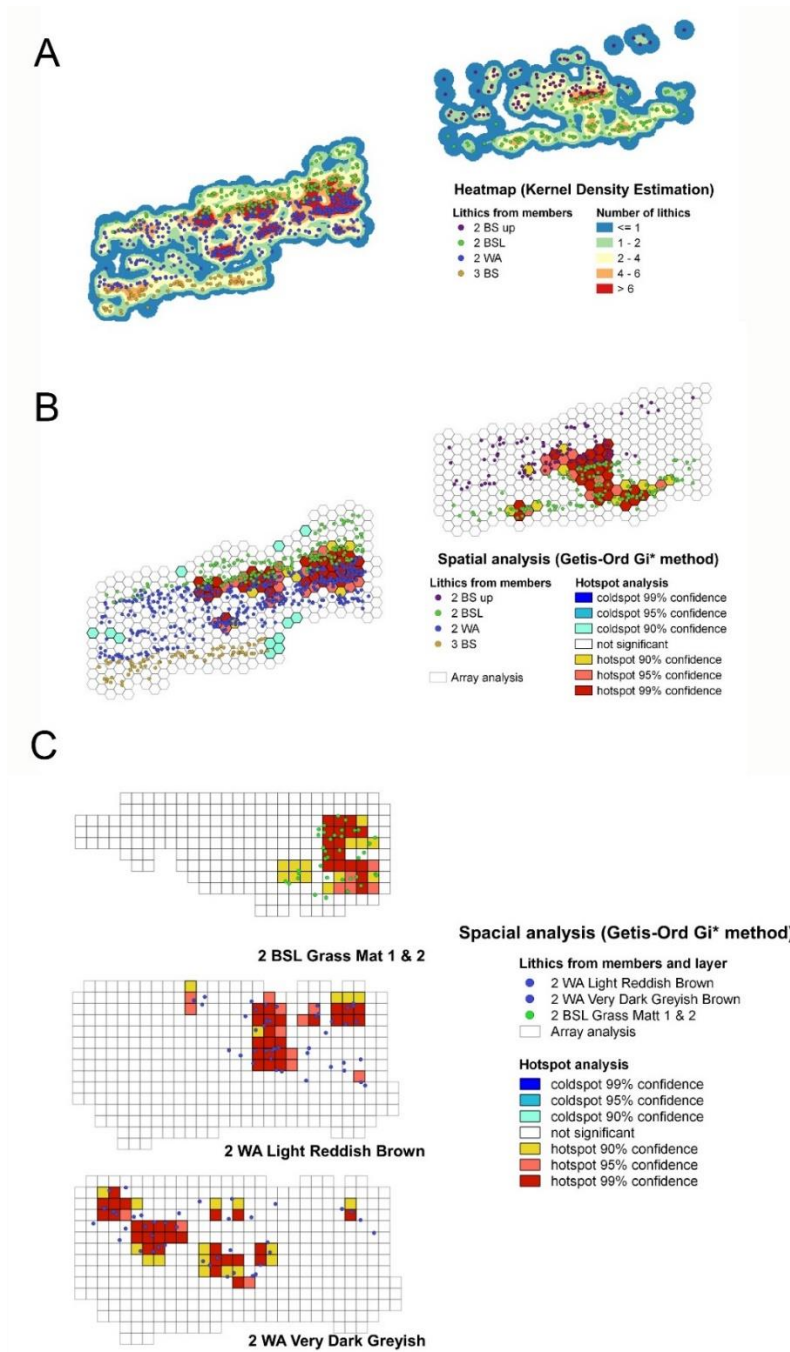
699

700 3.3. Spatial analysis

701 3.3.1. XZ (vertical view)

702 The two spatial distribution analyses (Getis-Ord G_i^* and Moran I test) and the kernel density analysis
 703 (Figure 12 A, B, Figure S8) show similar results regarding the areas of low and high concentration of

704 artefacts (and their corresponding significant values). The spatial distribution analysis shows several
 705 distinct areas of significant concentrations. Moreover, the distribution of the densities shows a similar
 706 direction regarding slope of the layers excavated within the members, although there are two areas
 707 where this does not apply (*vide infra*).



708

709 **Figure 12. A. Kernel density estimation of lithics in Members 3 BS, 2 WA and 2 BS in excavation**
 710 **squares X117, 118, 119 and 120, XZ projection. B. Hot spot analysis conducted with Getis-Ord Gi* of**
 711 **the same squares and members, XZ projection. C. Getis-Ord Gi* spatial analysis of layers Grass Mat**
 712 **1 (2 BS.LR), Light Reddish Brown (2 WA.UP) and Very Dark Greyish Brown (2 WA.UP), XY projection.**

713

714 Member 3 BS shows spatial distribution coherence in the sense that there are not significant spatial
715 distinctions (Figure 12B). This might be due to a low number of artefacts (> 2 cm) in comparison with
716 the upper units (in X118 there is a cold spot).

717 The artefacts in Member 2 WA do not show a uniform distribution and there are several spatial
718 differences to highlight. There is a significant concentration in the eastern uppermost part (X118)
719 where there are probably several occupation events, which show continuity with the lowermost limit
720 of Member 2 BS.LR. Considering only the distribution of the artefacts, Member 2 WA could be
721 tentatively divided in two vertical zones, an upper and a lower one. The upper zone shows several
722 events and higher rates of concentration, whereas the lower zone shows a remarkable continuity with
723 Member 3 BS, displaying no significant distribution pattern, with the exception of a concentration spot
724 at the contact between X 117 and X118, and a negative one a few centimetres towards the East.

725 Member 2 BS also shows several spatial differences. The first one is the significant hot spot at the base
726 of the member, coinciding with the lowest part of Member 2 BS.LR. This concentration seems to be a
727 continuation of the top of Member 2 WA.UP. It is not entirely continuous in square X119. It is
728 interesting to note that just above this high concentration in X118 a negative correlation (meaning a
729 low density of artifacts) is highlighted, which indicates different occupation events within this sub-
730 member (2 BS.LR).

731 In the upper part of Member 2 BS (coinciding with the stratigraphic distinction of 2 BS.UP) there is no
732 significant relationship between artefacts. However, there is a vertical dispersion hot spot at the
733 contact between X119 and X120, linking sub-member units 2 BS.UP and 2 BS.LR. in that specific area.
734 This spot, together with the negative correlation (meaning a low density of artifacts) in Member 3 BS
735 is the only area with a vertical dispersion in this spatial analysis. Although the hot spot between 2
736 BS.LR and 2 WA.UP in X117-118 has a notable vertical distribution, particularly in the area to the West
737 (Figure 12B).

738 3.3.2. XY (Plan view)

739 In order to explore the lithic spatial associations in the hot spot between the top of units 2 WA.UP and
740 the base of unit 2 BS.LR, an exploration of the XY projection of different stratigraphic layers
741 distinguished during excavation in this area of lithic concentration was made. In this regard, three
742 different layers were selected for their close proximity to each other (together measuring less than 15
743 cm in depth) and their designation to different members: layer Grass Mat 1 in unit 2 BS.LR and layers
744 'Very Dark Greyish Brown' and 'Light Reddish Brown' in unit 2 WA.UP. The Getis-Ord G_i^* method

745 shows how these three layers display significantly different areas of distribution between the three of
746 them (Figure 12C). This exploratory analysis demonstrates that the large concentration of lithic
747 artefacts at the top of unit 2 WA.UP and the base of 2 BS.LR is not homogeneous in plan view.

748 3.3.3. Distribution of technologically and taphonomically significant pieces

749 In this section we explore the association between hot spots and technological (chordal and *Levallois*
750 flakes) and 'taphonomic' pieces (burnt lithics and lithics with macroscopic residues).

751 The cores do not show any association with the hot spots in the vertical distribution. *Levallois* flakes
752 appear in the lowermost part of unit 2 BS.LR where there is a high concentration with significant
753 spatial correlation, as well as in the lower part of unit 2 WA.UP, where there is no hot spot.

754 The chordal flakes fit quite well in those places with the hot spots (Figure S9). Only those that are
755 located at X117 remain rather isolated. Again, the basal part of 2 BS.LR concentrates most of these
756 pieces and reflects a spatial and qualitative difference with respect to the top of 2 WA.UP, which is
757 part of this hot spot but does not have these pieces. The distribution of the triangular blanks or points
758 is similar to that of the *Levallois* flakes. These artefacts overlap with the high concentration of pieces
759 in the lowermost part of unit 2 BS.LR and with the lower part of unit 2 WA (Figures 12 and S8).

760 The analysis of pieces with evidence of residues highlights the marginal relationship that exists
761 between them and the areas of intense concentration (Figure S10). These pieces are quite scattered
762 within the series. The pieces at the far end to the West in X117 are striking because it is an area with
763 an already low concentration. The only exception to this is the lowermost part of Member 2 BS.LR.

764 Finally, the pieces with potlids show a wide distribution throughout the record, but they fit well with
765 the areas of highest concentration of elements (Figure S10). Again, Members 2 WA and 2 BS.LR
766 evidence the greatest number of them, although in 2 WA there is a concentration of them that does
767 not overlap.

768

769 4. DISCUSSION

770 As stated in the introduction, we consider lithics (encompassing characterization, frequency, size,
771 distribution, raw material, etc.) as potential means by which to glean information (sometimes merely
772 clues) on site formation processes, spatial distribution, and cultural behaviour. In this discussion, we
773 synthesize the evidence offered by the lithics with regard to these three matters and compare our
774 findings with the archaeological record of the MSA of southern Africa for MIS 4 and MIS 3 (see Wurz,
775 2013; Wadley, 2015 for some of the most recent syntheses).

776

777 **4.1. Lithics as clues to taphonomy and spatial distribution**

778 The preliminary observation of the density of lithics per layer was that they were seemingly low (in
779 general for all of the layers) in comparison to other archaeological sequences, such as Sibhudu (see
780 for example the HP data provided in de la Peña, 2015b-SM1). At Border Cave, in most of the layers the
781 number of pieces over 2 cm is less than 10, and the median number of pieces per layer between 2-4
782 cm is five. Stratford et al. (this volume) report that the density of faunal remains in the assemblage is
783 $\sim 5.21 \text{ kg/m}^3$. This number is significantly lower than that recorded at other Late Pleistocene sites in
784 southern Africa, such as the Still Bay deposits at Blombos, which record 15-34 kg/m^3 (Reynard and
785 Henshilwood, 2018), and the HP and Still Bay deposits at Sibhudu, where faunal density is 60 kg/m^3
786 (Clark, 2017, 2019). Thus, the low density of lithics in the assemblage studied here is in accordance
787 with the similarly low density of faunal remains, indicating that visits to the shelter were relatively
788 short and/or were made by smaller groups of people. Comparing the lithic count per member and
789 sub-member unit with stratigraphic layers from other assemblages with a similar chronology would
790 be inappropriate, as we would be comparing different units of analysis. In this study the lithics were
791 grouped according to allostratigraphic units as defined by Stratford et al. (this volume). In other MSA
792 lithic analyses, the densities were assessed per layer (see for example Shipton et al., 2021). Moreover,
793 we know that geogenic factors played a significant role in site formation at Border Cave, and that the
794 geogenic sedimentation rate varied, so volume of sediment is not a constant that can be used to gauge
795 occupation intensity.

796 The particle size analysis by size groups (<2 cm, 2-4 cm, >4 cm) follows a similar particle size pattern
797 as knapped experimental and other archaeological assemblages, with the number of particles
798 decreasing rapidly as the size of particles increases (Schick, 1986; Bertran et al., 2012, 2018). However,
799 some differences between sub-member units can be highlighted within our assemblage. The rhyolites
800 and basalts from the lowermost units (1 RGS to 2 WA.MD) have a similar distribution of particles,
801 whereas from 2 WA.MD upwards the distributions are dissimilar. A comparable pattern was found for
802 the chalcedonies/agates. The reasons for this similarity in the lowermost members could be several;
803 (1) they result from similar depositional and post-depositional processes (Stratford et al., this volume
804 document mixing in the base of 2 WA, 3 BS and 1 RGS), or (2) similar number of knapping reduction
805 sequences and/or activities performed in the past in these groups of layers.

806 The data show that not all the variables are related as one would expect, for example an unexpected
807 correlation was observed between burnt lithics and residues. Conversely, lithics with heating
808 attributes and poor bone preservation in the 2 WA sub-member units are not directly correlated in

809 the Spearman's rank correlation using the faunal data of Stratford et al. (this volume) and the lithic
810 data provided in this analysis. This could be due to different sets of activities in relation to bones and
811 lithics in the same allostratigraphic unit, or to the fact that the selected sub-member divisions do not
812 provide enough resolution to assess these taphonomic questions. Moreover, this could also be due to
813 taphonomic processes in parts of Member 2 WA that are masking correlations (e.g. Aldeias et al.,
814 2012).

815 The spatial distribution of the piece plotted material (artefact distribution of pieces larger than 2 cm)
816 has shown the complexity of this archaeological deposit, and different areas of high significance in
817 spatial relationships (higher densities). There are several noteworthy aspects concerning this line of
818 analysis. In particular, the hot spot at the bottom of Member 2 BS and the top of 2 WA indicates a
819 concentration of activities involving pieces larger than 2 cm. It is worth noting that the distribution of
820 these lithics in plan view (XY), comparing different layers within this hot spot, changes from one layer
821 to another (it is not uniform in plan view), which perhaps implies that different activities were
822 conducted at the site, probably at different moments in time. Stratford et al. (this volume) in their
823 facies analyses described the upper part of 2 WA as 'ashy packets' corresponding to intense
824 anthropogenic activity. However, the absence of structure in that part of the sequence suggested that
825 it was formed through the redistribution of combustion feature bases and ashes through rake-out or
826 dumping, with potentially a later hearth being constructed over the mass of the unit. Unit 2 WA.UP is
827 truncated by a succession of grass mats that overlay the ashy packets (the base of 2 BS.LR). It is
828 interesting to note that the technological analyses have shown different strategies regarding raw
829 material selection and flaking systems for 2 WA.UP and 2 BS.LR. Thus, the base of 2 BS and the top of
830 2 WA imply a period of intense human occupation, including the construction of hearths and bedding,
831 but the lithic analysis denotes different technological activities related to the two stratigraphic units
832 and associated formation histories. The hot spot in 2 WA. UP extends to 2 WA.MD, which also
833 comprises two laterally extensive combustion features that have been deformed, fragmented, and
834 significantly altered by overlying grass mats (Stratford et al., this volume). From 2 WA.MD to 3 BS the
835 spatial distribution analyses show no significant relationships, and this is potentially in accordance
836 with the post-depositional mixing described for 3 BS, which resulted in the homogenisation of most
837 of the sediments until 1 RGBS (in some parts of the north profile more evident than others) (Stratford
838 et al., this volume). However, the paraconformity described in Stratford et al. (this volume) between
839 3 BS and 2 WA.LR was not picked up by the different spatial distribution analyses. Members 1 RGBS
840 and 3 BS are described as being mixed (Stratford et al., this volume) and this finding is supported by
841 the similar particle size distribution of lithics in these units, as well as in sub-member 2 WA.LR (for
842 rhyolite/basalts and chalcedonies/agates).

843 Other MSA assemblages in southern Africa have also shown spatial complexity and the mixing caused
844 by clearly anthropic episodes and other post-depositional processes that have disturbed or attenuated
845 the archaeological signals. Perhaps the best example is Sibhudu Cave (Goldberg et al., 2009), where,
846 in the post-HP deposits, several layers have been recognised, whereas for the HP fewer archaeological
847 layers are distinguished. Similar examples come from Bushman Rock Shelter, where several layers and
848 'features' were distinguished in the 28 unit (Porraz et al., 2015), and the MIS 4 deposits at Pinnacle
849 Point 5-6, which exhibit a palimpsest of anthropic occupations (Karkanas et al., 2015).

850 **4.2. Lithics and cultural behaviour**

851 The in-depth technological analysis has shown different technological trends from 1 RGBS to 2 BS.UP.
852 Moreover, following the allostratigraphic divisions identified by Stratford et al. (this volume),
853 variability within Brown Sand and White Ash members has been documented in terms of the lithics
854 (in raw materials and flaking systems). This is apparent in the differences in raw material and flake
855 attributes recorded in 2 BS.UP and 2 BS.LR, and in the distinction between 2 WA.UP and the underlying
856 2 WA.MD and LR units.

857 4.2.1. Raw material comparisons and implications

858 Following the *chaîne opératoire* approach (from raw material procurement to the finished tools), the
859 raw material selection data have pointed out statistically significant changes. The most abundant rocks
860 knapped at the site were rhyolites, however, within rhyolites there were specific varieties that were
861 preferred at different times (Figure 3). In addition, at the beginning and at the end of the series (2
862 BS.UP and 1 RGBS) chalcedonies/agates and A-quartz (for 2 BS.UP) have more representation among
863 the chips. It seems that there are several rock varieties knapped at the site that appear in the
864 immediate surroundings of the cave in secondary context, such as MP1, MP2 (see Data S2) and
865 chalcedonies. The abundance of these raw materials in the immediate surroundings could be a reason
866 for the low rate of retouched implements, meaning that the proximity of local (secondary sources)
867 eliminated the necessity to resharpen tools by retouch as there were plenty of readily available rocks
868 for knapping. Nonetheless, the low rate of retouch could also be related to the specific area excavated
869 (sample spatial bias) or the specific activities conducted on site, which perhaps did not demand
870 'robust' retouched functional edges or the resharpening of tools. The percentage of non-cortical flakes
871 (0) is high in all the allostratigraphic units and in all of them surpass 50%. There is a decrease from 1
872 RGBS to 2 BS regarding the presence of cortex, which may indicate a gradual change in terms of raw
873 material management. With the information at hand, it is difficult to assess what the specific strategies
874 for people at Border Cave were, but what is clear is that there were raw material preferences (specific
875 rhyolite variants) linked to the different periods.

876 The provisioning and management of raw materials have been amongst the most discussed topics in
877 relation to lithic technological strategies in the past few decades, particularly for MIS 4 (e.g. Minichillo
878 and Ambrose, 2006; Will, 2021). Some authors have linked MIS 4 assemblages to fine-grained raw
879 materials and non-local rock at the archaeological sites studied (although this is the case in sites like
880 Klasies River, other sites do not show this pattern). If we look at the distributions at Border Cave, it
881 does not seem to be the case as 2 BS.UP (associated with MIS 3) has a high percentage of A-quartz
882 and chalcedonies and agates among the chips. Mackay et al. (2014) proposed for southern Africa that
883 during MIS 4 there was more 'place provisioning' rather than 'individual provisioning', whereas for the
884 post-HP at Klein Kliphuis he proposed the contrary; individual provisioning. Place provisioning implies
885 the transportation of raw materials to a selected place for the manufacture of artefacts (Parry and
886 Kelly, 1987). Individual provisioning implies the continuous transport and maintenance of tools that
887 are used on a daily basis by hunter-gatherers (Binford, 1979). Between these two theoretical models
888 there is probably a lot of variation in the solutions applied in the MSA. These differences depend on a
889 complex interaction between raw material availability, differential site use, and the position of the
890 localities in the settlement system (Will, 2021). Cochrane (2006, 2008), Will (2019), de la Peña and
891 Wadley (2017) highlight how in the change from the HP to the post-HP at Sibhudu there were more
892 local rocks knapped at the site. De la Peña and Wadley (2017) described how local raw materials such
893 as sandstone, quartz, dolerite, and even certain varieties of local ochre increased in the lowermost
894 layers attributed to the post-HP (~58 ka). This was interpreted as one of the many clues in that
895 comparison to indicate lower mobility during the post-HP in comparison to the HP. At Pinnacle Point
896 5-6 Wilkins et al. (2017) reached different conclusions from their assemblage. During MIS 4 the coast
897 was around 20 km away so silcrete pebbles were beyond the daily foraging range. In MIS 3 the coast
898 and thus cobblestone beaches with silcrete pebbles were much closer and consequently the MIS 3
899 assemblage contains higher frequencies of cobble cortex. These changes in the landscape are
900 considered to be related to lithic curation and occupation intensity. The authors propose an opposite
901 model to that of de la Peña and Wadley (2017) for Sibhudu. They propose that during MIS 4 the site
902 would have seen longer occupations and less movement, resulting in more intense exploitation of the
903 raw materials because the outcrops were further away than during MIS 5 and MIS 3.

904 4.2.2. Flaking systems: comparisons and implications

905 The presence of cores and core-related by-products imply that there was a certain amount of on-site
906 knapping. In addition to this clue, the percentage of small particles (<2 cm) varies notably between
907 closely associated layers (Figure 11A). As mentioned, this denotes variability in the use of space,
908 reflecting episodes or events of occupation when knapping or resharpening was conducted, in

909 contrast to other layers which are perhaps related to the use of tools or other activities (therefore the
910 drastic drop in small particles).

911 The type of cores and core-related by-products, together with the attribute analysis of the flakes, have
912 highlighted several technological similarities and differences between the sub-member unit lithic
913 packages. In several attributes (e.g. typometry of the blanks and platforms, elongation index,
914 presence/absence of certain technologically significant items or bidirectional scar pattern) the lower
915 sub-member units (from 1 RGS to 2 WA.MD) show a certain degree of similarity, whereas from 2
916 WA.MD upwards each of the sub-member units show distinct characteristics. In terms of reduction
917 sequences, it seems that discoidal and *Levallois* recurrent centripetal varieties of knapping appear
918 and disappear. Crested blades appear only in 2 WA.LR and they are the only sign in the technological
919 analysis that indicates clear blade preparation of cores. Platform cores for bladelet production appear
920 and disappear, and they are proof that during MIS 3 there were knapping modalities for the
921 production of small blanks too (as proposed for the HP at Sibhudu by de la Peña and Wadley, 2014).

922 *Levallois* recurrent centripetal and discoidal are common in MIS 3 contexts (e.g. Conard and Will, 2015;
923 Will and Conard, 2018; Will, 2019) although they are not exclusive. Soriano et al. (2007), Douze et al.
924 (2018) and de la Peña (2015b) describe independent flaking methods associated with MIS 4-HP and of
925 course much older chronologies (Schmidt, 2019). The presence of semicrests for blank production
926 have been described in the MIS 4-HP layers at Sibhudu (de la Peña and Wadley, 2014; de la Peña,
927 2015b), and two opposed platform (parallel) cores were described by Villa et al. (2012). In the
928 assemblage studied here, this type of reduction was also documented, but we identified it as a
929 *Levallois* variant, though this should be checked when a larger sample is available. In terms of lithic
930 knapping methods, the two opposed platform core is prominent in 2 WA.LR, whereas discoidal is
931 foremost in 2 WA.UP and 2 BS.LR, and it does not disappear. The absence of certain lithic flaking
932 strategies described in other MIS 4 and MIS 3 sequences is noteworthy. In this vein, Villa et al. (2010)
933 described the 'HP cores' as for the production of blades in the HP at Klasies River, which also appear
934 at Sibhudu for the HP (de la Peña and Wadley, 2014a; de la Peña, 2015b; Soriano et al., 2015; Will and
935 Conard, 2020). At Border Cave, this is completely absent in the members studied. There is also a total
936 absence of bipolar knapping, which has been described as associated with quartz for the HP (de la
937 Peña, 2015) and quartzite for the post-HP at Sibhudu Cave (de la Peña and Wadley, 2017). This absence
938 is particularly striking for the 2 BS.UP assemblage (*vide infra*).

939 4.2.3. Implements

940 The percentage of retouched pieces is very low in all the sub-member units studied here. This is a
941 normal characteristic of many MSA lithic assemblages, and sometimes when a great number of

942 retouched pieces are encountered, they are pseudo-retouched pieces created by post-depositional
943 processes (de la Peña and Witelson, 2018 and references therein). The most abundant retouched
944 pieces in our assemblage are 'points' or triangular blanks (Timbrell et al., this volume). All the
945 triangular blanks/points from the sub-member units were studied separately in a focused analysis
946 combining technology and morphometry. The results show how different morphologies can be
947 associated with the varieties of knapping (discoidal, *Levallois* recurrent and *Levallois* with two opposed
948 platforms). Additionally, the Border Cave sample from Members 2 WA and 2 BS overlaps
949 morphometrically with the Sibudan morphotypes described by Conard et al. (2012) and Conard and
950 Will (2015).

951 For Member 3 BS and sub-member units 2 WA.LR-MD it is also worth mentioning the documentation
952 of trimmed base points (*Emireh* points) and backed knives (*Audi* knives) described by Beaumont (1978)
953 for 2 WA and 3 BS (respectively). To our knowledge, these pieces have only been described at Border
954 Cave for the MSA of southern Africa. In the new collection, there are two examples of trimmed base
955 points and backed (*Audi*) knives. The small number of these pieces does not allow us at this stage to
956 further investigate their technological and morphometrical characteristics.

957 The low number of retouched pieces could mean that there was no need for resharpening in the
958 activities conducted (as there was a nearby source of rocks available), or because the activities
959 conducted at the site did not demand secondary shaped edges. The high representation of triangular
960 blanks (Timbrell et al., this volume) and the low number of backed pieces is striking, as is the complete
961 absence of grindstones, in contrast to the lowermost post-HP layers at Sibhudu Cave, where 18
962 grindstones or grindstone fragments were documented in layers BYA2i to YA (de la Peña and Wadley,
963 2017).

964 4.2.4. Other technologies

965 Other specialists working on the same assemblage have highlighted other relevant aspects of the
966 material culture associated with Members 1 RGS to 2 BS. For example, regarding bedding, Sievers et
967 al. (this volume) describe changes in their construction. In units 3 BS, 2 WA and 2 BS.LR sedge nutlets,
968 including *Cyperus prolifer* and *Cyperus pseudovestitus*, were documented in the bedding, whereas no
969 sedge remains were recovered from younger bedding in 2 BS.UP.

970 Within the assemblage from Members 2 WA and 2 BS it is worth mentioning other implements such
971 as the *Vachellia karroo* thorns interpreted as awls (Beaumont 1978: 37, Fig. 22), warthog tusks with
972 traces of scraping and grinding interpreted as daggers (Figure S1C; Beaumont 1978: 38, Fig. 25;
973 Beaumont et al., 1978: 412) and awls (d'Errico et al., 2012), and a bone in Member 2 WA in the form

974 of a charred rib fragment with notches along one edge (Figure S1; Beaumont 1978, Vol. II: 302, Figs. 7
975 and 8; d’Errico et al., 2012).

976 It is interesting to see how technological traditions change through time in this organic assemblage in
977 comparison with lithic technology trends. It is also worth mentioning that these items are associated
978 with MIS 3, because they are often forgotten about in MSA revisions.

979

980 **4.3. Comparison with previous lithic analyses**

981 The lithic assemblage from Members 1 RGS and 3 BS was assigned to the epi-Pietersburg (Beaumont,
982 1978) and later to the HP by Beaumont and Grün (2001); whereas the lithics from Members 2 WA and
983 2 BS were assigned to MSA 3/post-HP by Beaumont (1978). The MSA 3/post-HP attribution of 2 WA
984 and 2 BS was also proposed in a more recent analysis conducted by Villa et al. (2012). In the publication
985 of Grün and Beaumont (2001) an industrial sequence was proposed, but the lithics were not part of
986 the discussion. Thus, for the putative HP the more in-depth analysis is the one of Beaumont (1978)
987 concerning excavation 3A rear.

988 Starting with 1 RGS and 3 BS Beaumont (1978) highlighted the abundance of blades (that he
989 associated with the ‘punch’ technique (sic)), the presence of backed elements (some of them similar
990 to *Châtelperron* and *Abri Audi* knives) and the occasional representation of small ‘pressured flake’
991 triangular items (Figure 1C and Figure 9). For Members 2 WA and 2 BS the excavation 3A rear
992 assemblage was characterized by the absence of ‘crescents’ (sic) and a low number of points. He also
993 distinguished an early phase (Members 2 WA and 2 BS.LR C), characterized by ‘modified butts’ (sic)
994 (faceted platforms) and low values of chalcedony and scaled pieces; and a late phase (the upper part
995 of Member 2 BS) with high values of the latter two. Another aspect stressed for this later phase is the
996 high number of dihedral and polyhedral platforms and radial prepared cores, and very low number of
997 points and retouched pieces (Beaumont, 1978: 103). One of the conclusions of his techno-typological
998 study was that the assemblage from Members 2 BS and 2 WA was probably a ‘terminal occurrence
999 within the MSA’ (Beaumont, 1978: 103). Even though he highlighted the absence of backed pieces, in
1000 the only graphic representation that he made of the MSA 3 material he included trapeze or double
1001 truncated backed pieces (Beaumont, 1978: 137, Fig. 88; Beaumont et al., 1978: 411, Fig. 4B). The
1002 revision of a small sample of excavation 3A rear material by Villa et al. (2012) highlighted that 2 WA
1003 was characterized by blades and elongated flakes with parallel sides and considered as ‘the main
1004 objectives of the debitage’. They also characterized the cores from this part of the sequence as having
1005 two opposed striking platforms and therefore with bidirectional removals. This type of knapping was
1006 associated in that study with a variety of end-products, but mainly ‘pointed forms’ (sic). They also
1007 highlighted an independent flake production in 2 WA by the presence of *Levallois* flakes and one

1008 *Levallois* core. They also proposed that the knapping technique was direct percussion by stone
1009 hammer, and the blows were probably away from the platform edge, making a clear distinction with
1010 the lower HP members (which were associated with soft hammer percussion with a stone hammer).
1011 For 2 BS Lower A+B and 2 BS.UP they documented in their analysis a decrease in blade production and
1012 retouched pieces, the disappearance of unifacial points and rise of bipolar knapping (associated not
1013 with rhyolite varieties but chalcedony and xenomorphic and automorphic quartz). The increase in
1014 bipolar knapping from 2 BS.UP was interpreted as 'a change towards the Later Stone Age'.

1015 Before highlighting the specific technological aspects and comparing Beaumont's and Villa et al's.
1016 (2012) results with the present analysis, it must be stressed that there is a striking difference in the
1017 Villa et al. (2012) paper in comparison with our assemblage, which is the much higher percentage of
1018 cores (2 WA-0.8%, 2 BS-1.7%) and retouched pieces (2 WA-5.2%, 2 BS-3.4%) in their analysis.
1019 Moreover, for 2 BS.UP our assemblage only has one core, whereas for their 2 BS.UP these cores
1020 constitute 5.4% of the lithic assemblage. Our analysis has highlighted different flaking strategies and
1021 raw material selection. In some instances, we are in accordance with some of the previous
1022 propositions, but in others, we offer some nuances and a different set of technological trends.

1023 In our analysis, 1 RGSB was the smallest group and difficult to characterize technologically. However,
1024 the different attributes observed (and frequencies of these), and the raw material characterization
1025 linked it to 3 BS and 2 WA.LR-MD (see non-metric dimensional analysis in Figure 10). Contrary to Villa
1026 et al. (2012), we did not observe clear blade production in 1 RGSB, whereas this was attested for 3 BS
1027 and 2 WA.LR. Moreover, regarding the knapping techniques, we observed smaller platforms for 3 BS
1028 and 2 WA.LR (with no statistical difference between the two), but 1 RGSB had much higher values (and
1029 statistically different from the other members). Knapping techniques are extraordinarily difficult to
1030 assess (cf. Driscoll et al., 2014 and Pelegrin, 2000), particularly for southern African rocks (further
1031 experimentation is needed as proposed by de la Peña, 2015b). The data regarding platforms
1032 contradicts the expectation that platforms in 2 WA should be bigger than in 3 BS and 1 RGSB (as one
1033 would expect smaller platforms in blade production), and analyses show a correlation between 2 WA.
1034 LR and 3 BS.

1035 In our assemblage, we see the clearest blade production, meaning elongated blanks (double the length
1036 than the breadth, and parallel edges) in 2 WA.LR-3 BS. This is in accordance with Villa et al's. (2012)
1037 knapping modality from two opposed platform cores for 2 WA (that we described from the debitage
1038 attributes and core-related by-products). However, we have distinguished within 2 WA different sets
1039 of technical characteristics for the upper and lower parts of this member. Unit 2 WA.UP is
1040 characterized by an abundance of chordal flakes and the presence of *Levallois* recurrent centripetal
1041 cores. Moreover, the raw materials and the flake attributes distance this sub-member from the lower-

1042 middle part. Sub-member 2 WA.UP has more continuity with 2 BS.LR where chordal flakes, *Levallois*
1043 centripetal flakes and cores are well represented. Finally, 2 BS.UP can be distinguished,
1044 technologically, from 2 BS.LR. As already mentioned, our assemblage has only one bipolar core for 2
1045 BS.UP, whereas for Villa et al. (2012) cores constitute over 5 % of the lithic assemblage. This could be
1046 because there are lateral technological changes within the same sub-member units, as attested in our
1047 analysis for example of 2 WA. However, the contrast is so remarkable that a different resolution in the
1048 method of excavation between Beaumont's and the recent excavations (Backwell et al., 2018, 2022)
1049 should not be ruled out. Indeed, amongst the material from 1 WA and 1 BS from the new excavations
1050 bipolar cores are documented (personal observation PdIP).

1051 This comparison, taking into account only the technological characteristics, points to gradual change
1052 from 1 RGBS to 2 WA.MD, and differences in technology in each sub-member above. Moreover, it
1053 differentiates two sets of technological characteristics within 2 WA and 2 BS.

1054

1055 **4.4. On the cultural attribution of this assemblage and technological comparisons**

1056 In the past decade, different lithic technological researchers have shown the enormous variability
1057 associated with the MSA in southern Africa. Not only for the Still Bay and HP but also for earlier and
1058 later time spans (Soriano et al., 2007; Will and Bader, 2014; Bader, 2015; Douze et al., 2015; Pazan et
1059 al., 2022, among others). Stone tools have also been instrumental in discussions on human complexity
1060 in the MSA.

1061 All of this research highlighted a great amount of variability, different from the image proposed in
1062 previous decades, which characterized the MSA as monotonous, apart from the Still Bay and HP
1063 Industries (see Wurz, 2013 for a synthesis). Even if there have been notable efforts of going beyond
1064 mere technological description and trying to explain population dynamics, mobility patterns, and
1065 evolutionary strategies during this period (Mackay et al., 2014; d'Errico et al., 2017; de la Peña and
1066 Wadley, 2017; Wilkins et al., 2017; Archer, 2021; Way et al., 2022, among others), a great deal of the
1067 debate regarding lithics still revolves around the definition of culture-historic units (e.g. Porraz et al.,
1068 2013). Indeed, the debate is still heavily influenced by the *fossiles directeurs*, such as backed pieces or
1069 bifacial/unifacial points. Even knapping methods are used as *fossiles directeurs*, in a similar manner to
1070 the technological debate on the Upper Palaeolithic of Europe (de la Peña, 2012; Reynolds and Riede,
1071 2019).

1072 The HP has received much attention by scholars of African prehistory because it shows technical and
1073 symbolic characteristics that only developed in an extensive manner much later in other parts of the
1074 world. Therefore, the African Middle Stone Age, through the material of the HP, holds some of the
1075 oldest symbolic and complex technologies known (see de la Peña, 2020 and references therein).

1076 In the last two decades a great deal of research effort has focused on refining the technological
1077 definition of the HP (Wurz, 2000; Soriano et al., 2007; Mackay, 2008; Villa et al., 2010; Porraz et al.,
1078 2013; de la Peña and Wadley, 2014a, b, 2017; de la Peña, 2015a, b; Soriano et al., 2015; de la Peña et
1079 al., 2018; Wilkins et al., 2017; Tabrett, 2017; Douze et al., 2018; Will and Conard, 2020). Some authors
1080 have highlighted its coherence within South Africa, in terms of technological trends (Porraz et al.,
1081 2013; Mackay et al., 2014; Soriano et al., 2015) or the fact that different phases can be distinguished
1082 techno-typologically (Porraz et al., 2013; Douze et al., 2018).

1083 The HP has been associated with the presence of large, backed pieces (Thackeray, 1991), blade
1084 production (Wurz, 2000) (first associated with indirect percussion by Wurz and later associated with
1085 soft stone percussion by Soriano et al., 2007), and the putative greater use of non-local rocks
1086 (sometimes referred to as 'exotic' (Minichillo and Ambrose, 2006). Mackay and colleagues (2014: 36)
1087 highlighted three technological aspects that can be traced across South Africa during the HP: the form
1088 of implements (backed pieces with crescent morphologies), the production of small blades, and the
1089 fact that assemblage sizes are either proportionally very large (total numbers of artefacts) or very
1090 dense (numbers of artefacts per unit volume) relative to other industries. Other authors have
1091 identified technological strategies that are not necessarily found across southern Africa, such as
1092 bifacial production (de la Peña et al., 2013; Porraz et al., 2013), bipolar knapping associated with the
1093 production of small blanks (de la Peña and Wadley, 2014, de la Peña, 2015a, b) and *Levallois* core
1094 recycling into bipolar cores (Tabrett, 2017). Notwithstanding these efforts, the main feature used to
1095 identify this technological tradition is the presence of backed pieces. In particular, a proliferation of
1096 backed pieces specifically seems to be the main criterion used to identify this industry (Way et al.,
1097 2022), because backed pieces also occur before and after the HP in the MSA archaeological record
1098 (e.g. Brown et al., 2012; Wadley, 2012). Recently, Archer (2021) observed that both site numbers and
1099 backed artefact discard rates increase during the HP across all of southern Africa and suggests that it
1100 is the interaction between increased climatic variability and increased population density that
1101 accounts for the increased frequency in the production of this tool. Backed artefacts were proposed
1102 to correlate with proxy measures of demographic changes, while other tools, such as points, scrapers
1103 and denticulates did not show a statistically significant correlation. Way and colleagues (2022) have
1104 argued that during this proliferation event backed pieces appeared to follow a very similar template
1105 in morphology across southern Africa, and this might be related to cultural similarities, and marks a
1106 strengthening of long-distance social ties during MIS 4, as previously proposed by Mackay et al. (2014)
1107 and d'Errico et al. (2017).

1108 The presence of a backed piece in 1 RGS and another in 3 BS should be taken with caution as a *fossiles*
1109 *directeurs* of the HP. As highlighted, backed pieces are not exclusive to the HP, as they appear before

1110 and after it. In this vein, it is worth mentioning that in the entire area of the large excavation 3A rear
1111 trench of Beaumont (around 21 m²), Member 1 RGS provided less than 20 pieces (including
1112 fragments), and Members 3 BS and 3 WA provided even fewer backed pieces (Beaumont, 1978, Vol.
1113 II). At the site of Sibhudu, layer Grey Sand alone recorded 183 pieces (from Wadley's excavation in 6
1114 m²) (de la Peña and Wadley, 2014). It must be borne in mind that the absence of backed pieces could
1115 be conditioned by the use of the site. We know that on some occasions these pieces were related to
1116 projectile use (e.g. Lombard and Parpater, 2008; de la Peña et al., 2018), but also to other domestic
1117 activities (Igreja and Porraz, 2013).

1118 Concerning blade production as a technological trait for the HP. In our sample there are technological
1119 clues to sustain the presence of this knapping modality in 3 BS and 2 WA.LR (such as the presence of
1120 semicrests and the elongation index data). At Sibhudu different blade knapping methods are
1121 associated with the HP, such as 'HP-cores' (Soriano et al., 2015), prismatic cores (de la Peña, 2015)
1122 and bladelet cores (de la Peña and Wadley, 2014a, b; Soriano et al., 2015; de la Peña, 2015; Will and
1123 Conard, 2020). None of these variants, except some examples of platform/bladelet cores, has been
1124 observed in the Border Cave assemblage analysed here.

1125 Regarding non-local raw materials as a trait for HP recognition, 2 BS.UP and 1 RGS show higher
1126 percentages of A-quartz and chalcedonies/agates. However, the latter two fine-grained raw materials
1127 are locally available at Border Cave, and on the path to the cave these pieces are abundant in
1128 secondary context (colluvium).

1129 Concerning a greater occupation intensity (Mackay et al., 2014), the previously attributed HP
1130 members (1 RGS and 3 BS) show no significant hot spots in this part of the stratigraphy (Figure 12A).
1131 Unlike the HP Industry, the post-Howiesons Poort or MSA 3 has attracted little attention in the past
1132 two decades (but see Cochrane 2006, 2008; Conard et al., 2012 or Will, 2019 for a synthesis). Some
1133 years ago, Mitchell (2008) wrote that 'post-HP' was a catch-all category and that much work was
1134 needed in order to refine a somewhat biased view of this part of the MSA sequence. Mackay and
1135 colleagues (2014) subsequently noted that lithic assemblages associated with MIS 3 are more
1136 heterogeneous than other MSA industries. The general trend technologically for the beginning of MIS
1137 3 assemblages is a decrease in backed pieces and substitution with side-scrapers (or "knives") and
1138 unifacial points. Moreover, in most of the assemblages documented there is a decrease in blade
1139 production compared to the HP (see for example the case of Sibhudu (de la Peña and Wadley, 2017)).
1140 In the last 10 years the new team of researchers excavating Sibhudu has defined a new technocomplex
1141 within MIS 3 for the eastern part of southern Africa: the Sibudan, named after the type site Sibhudu
1142 Cave in KwaZulu-Natal (Porraz et al., 2012; Conard and Will, 2015; Will and Conard, 2018; Will, 2019).
1143 Will (2019) defines this technocomplex as characterized by different diachronic variations in the

1144 sequence of Sibhudu. The general technological trends for this technocomplex are as follows: “Raw
1145 material procurement is predominantly local, with the use of various rock types of different granularity
1146 and knapping qualities (dolerite, hornfels, quartzite, sandstone, quartz). Knappers used multiple
1147 reduction methods alongside each other within each assemblage, encompassing Levallois, discoid,
1148 platform, and bipolar methods. The frequency of each method varies markedly throughout the
1149 sequence. In terms of blank production, (convergent) flake and blade assemblages characterize the
1150 Sibudan”. It must be borne in mind that the Sibudan at Sibhudu Cave is restricted to an age of around
1151 58 ka, and much work still needs to be done in terms of comparisons with other sites for the period
1152 that spans the end of the HP to the Later Stone Age.

1153 Regarding the post-HP/MSA 3, Will (2019) has summarized how this terminology explains away the
1154 variability associated with MIS 3 lithic strategies. Members 2 BS and 2 WA have been associated with
1155 this period in previous analyses conducted by Beaumont and Villa et al. (2012). Regarding the
1156 unretouched and retouched points (from 3 BS to 2 BS), Timbrell et al. (this volume) have shown a
1157 morphometric overlap with the Sibudan morphotypes described by Conard et al. (2012) and Conard
1158 and Will (2020). In addition, the technological traits highlighted for 2 WA.UP, 2 BS.LR and 2 BS.UP
1159 match the description of the Sibudan by Will (2020): raw material predominantly local, *Levallois*,
1160 discoidal and platform as the main knapping methods, and an abundance of convergent flakes
1161 (unretouched) (Timbrell et al., this volume).

1162 In summary, the previously attributed HP members (1 RGSB and 3 BS) (Beaumont, 1978; Villa et al.,
1163 2012) show similarities with the lowermost part of 2 WA (previously attributed to the post-HP). The
1164 set of attributes in 1 RGSB and 3 BS, with the evidence at hand, does not match the more recent
1165 technological trends associated with the HP. In our analysis, Members 2 WA and 2 BS show different
1166 technological trends constrained to specific spatial areas, giving a much more complex perspective of
1167 the use of the site for the period 80–40 ka. It is difficult to argue for the presence of the HP in this
1168 collection. As recently proposed by Wilkins (2020), it seems that heuristically trying to force the lithic
1169 record into cultural categories does not offer much in terms of understanding the past and
1170 evolutionary strategies. What seems relevant is the different strategies registered in such a small
1171 sample of lithics.

1172

1173 **4.5. Final remarks**

1174 Palaeolithic sites are complex entities to analyse. As proposed by Bailey (2006) in his analysis of
1175 archaeology and time, archaeological sites usually (if not always) constitute palimpsests to a different
1176 degree (also see Schiffer, 1983). Bailey distinguished between different types of palimpsests
1177 depending on how the different occupations preserved and are still distinguishable over time. He

1178 differentiated, for example between true palimpsests (archaeological deposits that record “a
1179 *sequence of depositional episodes in which successive layers of activity are superimposed on preceding*
1180 *ones in such a way as to remove all or most of the evidence of the preceding activity”* (Bailey,
1181 2006:204)) or cumulative palimpsests (archaeological deposits that record “*the successive episodes of*
1182 *deposition, or layers of activity, which remain superimposed one upon the other without loss of*
1183 *evidence, but are so re-worked and mixed together that it is difficult or impossible to separate them*
1184 *out into their original constituents” activity”* (Bailey, 2006:204)). Following this lithic technological and
1185 spatial analysis there are different reasons to argue that the layers studied record the sporadic
1186 presence of different groups for short stays, each characterized by the use of similar raw materials,
1187 different but still related knapping strategies, and different sets of techniques and methods. This is
1188 consistent with the low content of remains per sediment volume. There is also evidence that in part
1189 of the assemblage studied there have been notable post-depositional processes that complicate
1190 understanding of the archaeological record, leading to some deposits that may be more time-
1191 averaged than others. Dedicated spatial analyses will need to be applied to tease out patterns within
1192 these units (e.g., Reeves et al., 2019). Border Cave seems to be a special case in terms of MSA sites, in
1193 that it samples broader behavioural variability both synchronically and diachronically than other sites,
1194 and thus complements what sites with more continuous palimpsests (as defined by Bailey) tell us.
1195 Thus, from a site formation point of view, it suggests a sporadic type of palimpsest.

1196

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1215

1216 **Author contributions**

1217 Conceptualization PdIP; Data curation PdIP; Formal analysis PdIP, FC; Funding acquisition LB;
1218 Methodology PdIP, FC; Project administration LB; Writing - original draft PdIP, FC, LB, FD, LW, WEB,
1219 DS; Writing - review and editing draft PdIP, FC, LB, DS.

1220

1221 **Declaration of competing interest**

1222 The authors declare that they have no competing financial interests or personal relationships that
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1224

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