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## Anthropogenic hydrological staging of an upper Palaeolithic carved shelter in Paris basin

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**Abstract**

The Ségognole 3 carved shelter in Noisy-sur-Ecole (France) is known for its Palaeolithic-style panel engraved with two horses. They are arranged in file on either side of three slots, initially assumed to be natural, evoking a pelvic triangle. A thorough re-examination revealed the artificial character of the slots as well as numerous anthropogenic interventions to modify the hydrology of the shelter to drain water to the slot representing the vulva.

The shelter has two galleries offset in height and separated by a thin wall. The upper gallery passes behind the engraved panel. It encompasses a basin that overhangs the pelvic triangle and often fills with rainwater. This disposition is the key part of the hydraulic system. Two particular interventions were made: (1) the slots at the front of the pelvic panel had been widened by percussion and grooving; and (2) the basin at the rear of the panel had been deepened by percussion, thus opening fractures on its floor. As a result, infiltration of meteoric water into the sandstone was encouraged and directed to the base of the pelvic triangle.

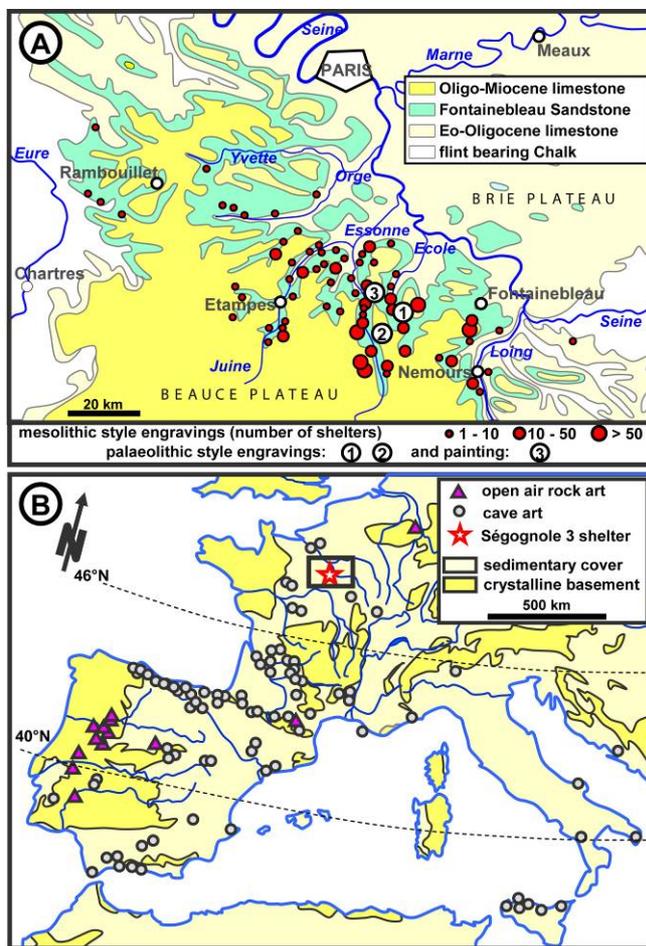
An experiment demonstrated that filling the basin with 50 L of water caused the vulvar slot to drain after two days. The Palaeolithic people could potentially have operated the ‘vulvar outflow’ on demand and without weather constraints. It is likely that this setup had symbolic and ritual purposes and formed with the parietal arrangement an integral part of a complex and dynamic installation linked to the feminine sex symbol.

**Keywords:**

Palaeolithic; rock art; percussion; grooving; hydraulics; female symbolism; ritual

59 **1 Introduction and issues**

60 A substantial aggregate of more than 2,000 engraved shelters occurs within the  
 61 sandstone that crops out along the valleys incising the Beauce Plateau, south of Paris in the  
 62 Fontainebleau Sandstone region, and extends over nearly 1,500 km<sup>2</sup> (Fig. 1A) (Bénard, 2014).  
 63 The engravings are essentially non-figurative and geometric. The most characteristic patterns  
 64 are parallel straight grooves and grids (Tassé, 1982; Collective of authors, 2016). Human and  
 65 animal representations are rare. The lithic artefacts collected in the engraved shelters, mainly  
 66 grooving tools, suggests that at least some of these non-figurative engravings were made by  
 67 hunter-gatherers at the end of the first part of the Mesolithic Period, i.e. VIIIe millennium  
 68 BCE (Guéret and Bénard, 2017).



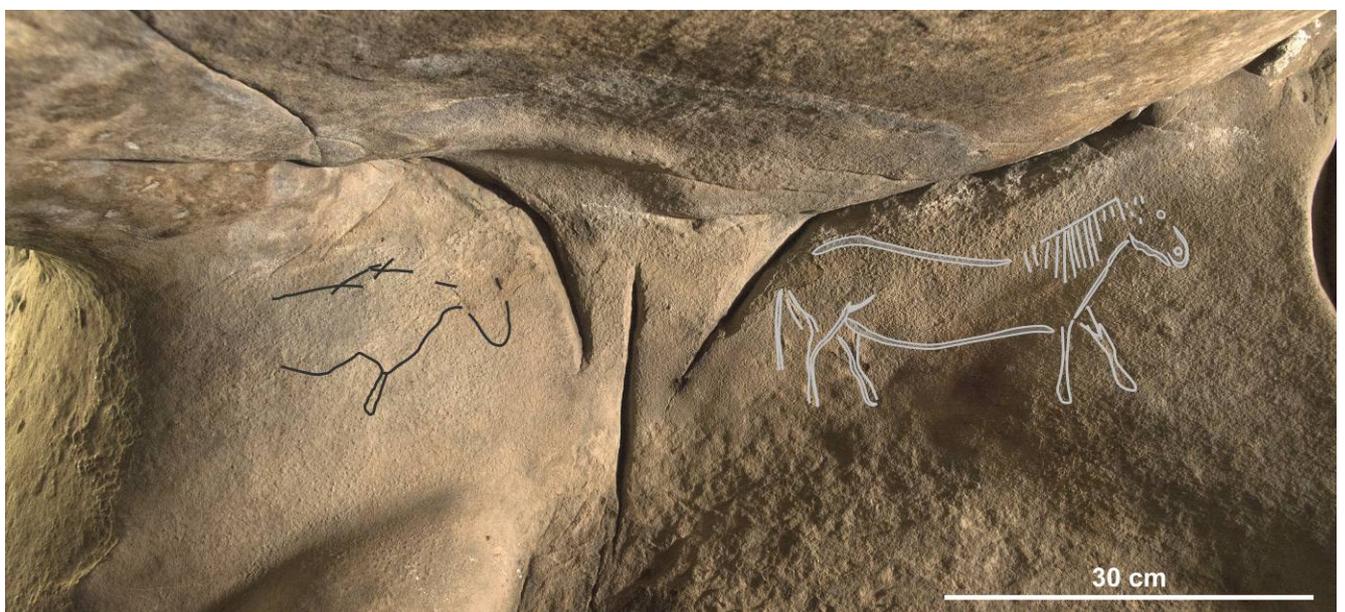
69  
 70 *Figure 1 – Location. (A) Geological sketch of southern Paris Basin with location and number*  
 71 *of engraved shelters in the Fontainebleau Sandstone. Point 1 corresponds to the Ségognole 3*  
 72 *shelter presented herein. Shelter count from Bénard (2016). (B) Location of Ségognole 3*  
 73 *shelter within European Upper Palaeolithic rock art with frame of map A. Modified from*  
 74 *Aubry and Luis (2012).*  
 75

76 Amongst this body of engraved shelters there are only three known to have figurative  
 77 representations of Palaeolithic style: a painting of an incomplete animal on a split plate from a

78 shelter destroyed by a quarry (Leroi-Gourhan, 1976); an engraved aurochs in a shelter located  
79 at Buno-Bonnevaux (Essonne) (Bénard and Valois, 2014); and the engraving of two horses at  
80 the site Ségognole 3 in Noisy-sur-Ecole (Seine-et-Marne) (Bénard, 2010). These Palaeolithic  
81 rock art occurrences are invaluable as only a few are known above 46°N latitude (Fig. 1B). As  
82 the scarcity of open air rock art in northern regions is mainly due to more intense weathering  
83 in these regions than in drier southern ones, shelters in the Fontainebleau Sandstone provide a  
84 chance for engraved panels to be protected from weathering.

85 The Ségognole 3 shelter shows the fine engraving of a horse (right profile) about thirty  
86 centimetres wide, accompanied by a second one, eroded and incomplete, which essentially is  
87 only the front portion of a horse (Fig. 2). The proportions of the complete horse as well as  
88 some parallels with several horses in the Lascaux cave led to it being attributed to a  
89 chronoculture between the Solutrean and the early Magdalenian (Bénard, 2010; Guy, 2017;  
90 Petrognani, 2018), which make it an exceptional feature in the regional context. The horses  
91 are arranged symmetrically on both sides of three slots that distinctly evoke a female pelvic  
92 triangle: two slots were suspected have been locally reworked to enhance resemblance  
93 (Bénard, 2010). The overall composition with an enhanced female sexual figuration  
94 associated with the engraving of two horses, gives an indubitable Upper Palaeolithic character  
95 to this panel and thus reinforces the chronological attribution (Tosello, 2016).

96



97

98 *Figure 2 – Engraved panel of Ségognole 3 shelter with two engraved horses arranged on both*  
99 *sides of a female pelvic triangle. Photo by Émilie Lesvignes/PCR ARBap; horses drawn on*  
100 *photography after Bénard 2010.*

101

102 The slots in the carved panel will be one of the foci of our investigations, as well as  
103 the surroundings of the horse engravings and several natural morphological elements that  
104 have been modified.

## 105 **2 Methodology**

106 With regard to Paleolithic rock art, studies of the artificial arrangement of caves,  
107 shelters and their walls are just beginning (Lorblanchet, 1993; Rouzaud *et al.*, 1996;  
108 Theunissen *et al.*, 1998; Lorblanchet, 2010; Delannoy *et al.*, 2012; Jaubert *et al.*, 2016). The  
109 analysis of the Ségognole 3 shelter actually takes the form of geomorphological studies  
110 applied to underground sites (Burns, 2005; Heydari, 2007; Delannoy *et al.*, 2004; Ferrier *et*  
111 *al.*, 2017). The approach aims to distinguish and explain, by means of objective criteria, the  
112 morphogenetic processes at the origin of each of the elements that make up a shelter, thus  
113 distinguishing natural morphologies from those related to anthropogenic action or  
114 modification and then to demonstrate the intentional character of the latter.

115 In the landscape we are studying, the approach is based on deciphering the  
116 morphologies that make up a shelter by interpreting them in terms of their origin, namely:  
117 silica cementation of sands to form sandstone, post-cementation alteration, and alteration after  
118 exposure at the landsurface by erosion and thus direct or indirect exposure to weathering. The  
119 method requires an in-depth knowledge of sandstone morphologies as they occur in situ  
120 within modern sand quarries and of characteristic morphologies resulting from weathering of  
121 outcrops (Thiry *et al.*, 1984; Thiry, 2005). Added to this are the specific alterations that have  
122 occurred and overlap them in the shelters (Thiry, 2017). Observations are mostly made at the  
123 decimetric and metric or even the centimetric scale and method could be termed ‘meso-  
124 geomorphological archaeology’.

125 With regard to Ségognole 3, the walls of the shelter and the engraved grooves are  
126 covered with an infra-millimetric crust, mainly formed of gypsum crystal rosettes (see  
127 supplementary file 1 for detailed description). This crust, combined with the granular nature  
128 of the sandstone, makes it impossible to discern microscopic wear traces of tools such as  
129 those sometimes found on bones (Fritz, 1999) or on other more homogeneous rocks such as  
130 shale or limestone (D’Errico, 1998; Mélard, 2008; Rivero, 2016). On the other hand, the crust  
131 does not obliterate milli- to centimetric traces. In our studies, these traces were analysed by  
132 direct observation and three-dimensional photogrammetry. The 3D models were acquired  
133 using a Nikon 750D camera (35.9 x 24 mm sensor, 24.93 million pixel resolution), equipped  
134 with an AF-S Micro NIKKOR 60mm f/2.8G lens and a ring flashlight. The models were  
135 generated and processed with ©Agisoft *Photoscan*, ©*MeshLab* and ©*GeoMagic* software. In  
136 addition, experimental engravings were made on hand-picked sandstone blocks and *in situ* in

137 cavities accessible in modern quarries (Cantin, 2019a) to determine particular properties that  
138 could affect anthropogenic working of the Fontainebleau Sandstone and to analyze the  
139 morphometric characteristics of test grooves in comparison with those in the shelters.

### 140 **3 Shelter description**

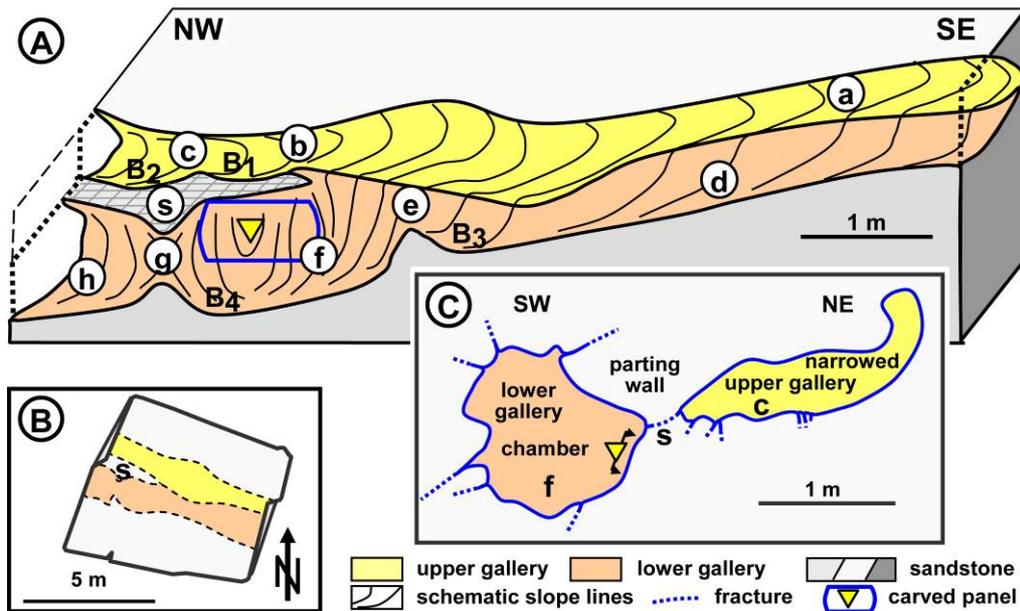
141 The Ségognole 3 shelter is in a sandstone block that had its origins in a sandstone  
142 ridge which broke apart, releasing quadrangular blocks that slid downslope into a jumbled  
143 mass (Fig. 3). It is an elongated non-silicified structure from which the loose sand was  
144 drained, leaving a tubular cavity within the sandstone. The horse engravings were made in a  
145 friable sandstone cortex, partially silicified, that marked the transition zone between the hard  
146 sandstone and the uncemented sand (Thiry, 2017; Cantin, 2019a, b).  
147



148  
149 *Figure 3 – Oblique view of the sandstone blocks on the slope of La Ségognole hill. SEG3 is*  
150 *Ségognole 3 shelter, notice its SE entrance. Picture by Summum 3D.*  
151

#### 152 **3.1 Layout of the shelter**

153 The Ségognole 3 shelter slopes from SE to NW and has a bifid morphology (Fig. 4A  
154 & B). It is open to light at both extremities and consists of a succession of distinct volumes  
155 (see supplementary file 2 for detailed morphological description and photographs). Upstream,  
156 in the SE, there is an ample accessway about 2 m wide opening into a roomy cavity. This  
157 divides downstream into two narrower galleries separated by a wall about 30 cm thick. The  
158 openings in the NW are smaller than in the SE and are offset in height by about 1 m.



159

160 *Figure 4 – Shelter layout. (A) Block diagram showing the morphological features of the*  
 161 *shelter. (a) flat terrace, (b) bottleneck, (c) narrows of the basins, (d) ramp, (e) threshold, (f)*  
 162 *chamber, (g) narrowing, (h) vestibule, (s) parting wall between upper and lower galleries,*  
 163 *(B1 –B4) basins. (B) Plan view of the two galleries. (C) Section through the carved panel.*  
 164 *Note the height offset between the two galleries and the meagre sandstone wall (about 30 cm*  
 165 *wide) separating them. The upper gallery passes behind and above the carved panel.*  
 166

167 The upper gallery forms a rather regular terrace (a), which is approximately horizontal  
 168 until it reaches the opening in the NW. The ceiling height is 80 cm at the SE opening but  
 169 restricted to 30-40 cm at a bottleneck (b) near the bifurcation of the two galleries (Fig. 4).

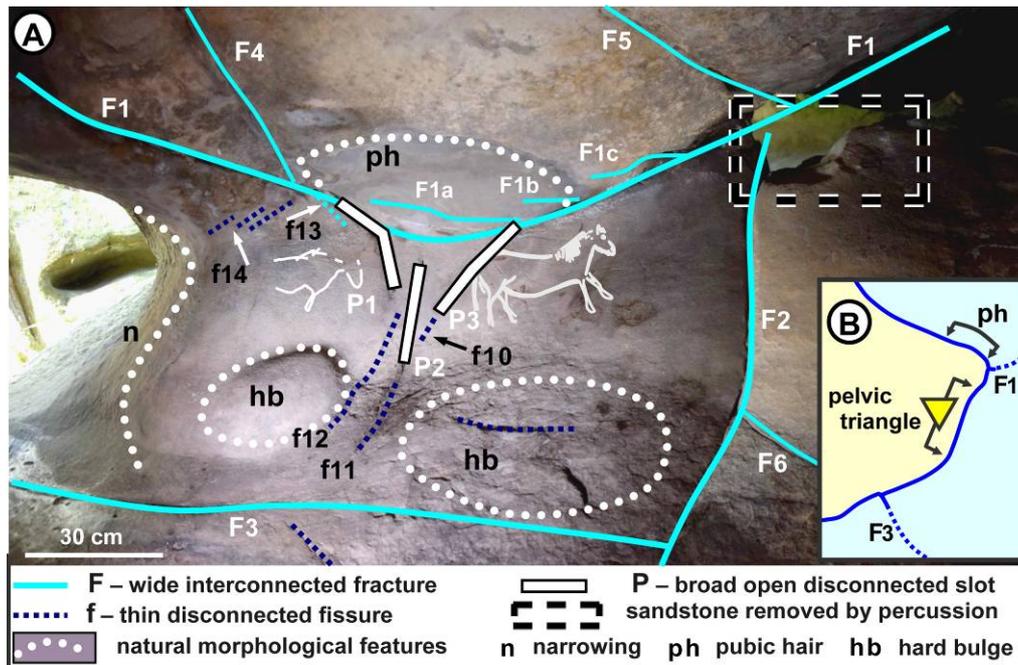
170 The lower gallery is more complicated. The floor at the SE opening forms an inclined  
 171 ramp (d) that extends to the middle of the shelter, then crosses a rather low threshold (e) and  
 172 settles about 80 cm below (Fig. 4). A characteristic feature of the lower gallery is its widening  
 173 downstream of the threshold (e) that delimits a larger and more comfortable chamber (f) that  
 174 contains the studied carved panel. The chamber (f) closes by a narrowing (g) before widening  
 175 into a vestibule (h) that gives way to the NW opening.

176 The cross-section of the galleries through the carved panel (Fig. 4C) shows the  
 177 differences in section, their height offset and specifically their proximity, with a thin wall  
 178 (about 30 cm thick) between the floor of the upper gallery and the top of the panel. This  
 179 configuration was key for the hydraulic layout of the shelter.

### 180 **3.2 Carved panel layout**

181 The carved panel of interest is approximately 1.2 m long and 0.60 - 0.70 m high. It  
 182 occurs on a concave wall sloping 60° southwards at the top and flattening to 30° at the floor  
 183 (Fig. 5A; supplementary file 1). It is clearly delineated and framed by the morphology and  
 184 structure of the surrounding sandstone. The top of the panel is marked by a slightly curved

185 fracture F1 and the right-hand part is limited by a second fracture F2 which is vertical and  
 186 also curved. The base is marked by a third fracture F3 that continues towards the NW opening  
 187 of the gallery. Finally, the panel is limited to the left by the narrowing (n) that opens the  
 188 chamber to outside. The fractures that frame the panel at the top and bottom tally with the  
 189 transition of the inclined panel surface to the roof and the floor of the chamber (Fig. 5B). Two  
 190 decimetric hard sandstone bulges (hb) occur at the base of the panel.



191  
 192 *Figure 5 – Carved panel layout. (A) Structural and morphological elements that frame the*  
 193 *panel and placement of the two carved horses. The large interconnected fractures that frame*  
 194 *the panel and the more limited unconnected pelvic slots are clearly different. Slots and*  
 195 *fractures have been numbered for easier identification. (B) Panel cross-section.*  
 196

197 The horses were engraved on either side of three slots (P1, P2 and P3) that evoke a  
 198 pelvic triangle. The left hand horse is now fragmentary: only its front is visible and relatively  
 199 blurred whereas its back seems to have been largely altered by moisture coming in through  
 200 the NW opening (see supplementary file 1). The horse image on the right, in a more protected  
 201 position inside the shelter, is complete and there are only small patches of scaling of the  
 202 sandstone surface on its rear.

203 Another element of this arrangement is a natural, dark, organo-mineral coating above  
 204 the pelvic triangle and which, given its position and extent, could evoke pubic hair (ph) thus  
 205 strengthening the sexual figuration (Thiry and Cantin, 2018; supplementary file 1). The  
 206 geometric configuration of the dark coating displays growth in concentric aureoles from a wet  
 207 area linked to fracture F1 at top of the triangle.

208 Finally, the curve of the fracture F2 that closes the panel on the right and the  
209 narrowing (n) that delimits the chamber on the left, facing each other, could evoke the  
210 widening of thighs at the pelvic belt.

## 211 **4 Anthropogenic workings**

212 Analysis of the horse engravings and their setting raised questions as to whether the  
213 pelvic triangle slots were natural or anthropogenic. It was pointed out that the right pelvic slot  
214 and the central vulvar slot may have been ‘rubbed’ (Bénard, 2007, 2010). A re-examination of  
215 the panel revealed numerous additional and more extensive human interventions than initially  
216 suggested.

217 All morphological features of the sandstone, particularly the slots, were examined  
218 using objective criteria to distinguish elements linked to natural processes or anthropogenic  
219 alteration. Subsequently, this meso-geomorphological survey was backed up using parietal  
220 traceology to identify and analyse features that could be related to lithic reduction and  
221 grooving techniques in order to demonstrate anthropogenic action.

### 222 **4.1 Fracture patterns**

223 Whatever their origin, fractures and fissures in rocks are a response to deformation. In  
224 the near-surface environment, fractures are always interconnected, overlapping or  
225 intersecting, geometrically coupled, and form networks characteristic of stress and strain  
226 regimes that generated them (Peacock *et al.*, 2018). In sandstone shelters, somewhat protected  
227 from the weathering environment, the fractures are sharp and narrow, generally with matching  
228 sidewalls and irregular openings; the sidewalls do not flare or gape at the surface. The floor of  
229 the Segognole 3 shelter has good examples of natural fractures (Fig. 6). At their extremities  
230 fractures become progressively thinner and commonly taper out into fewer and finer fissures,  
231 never ending abruptly.



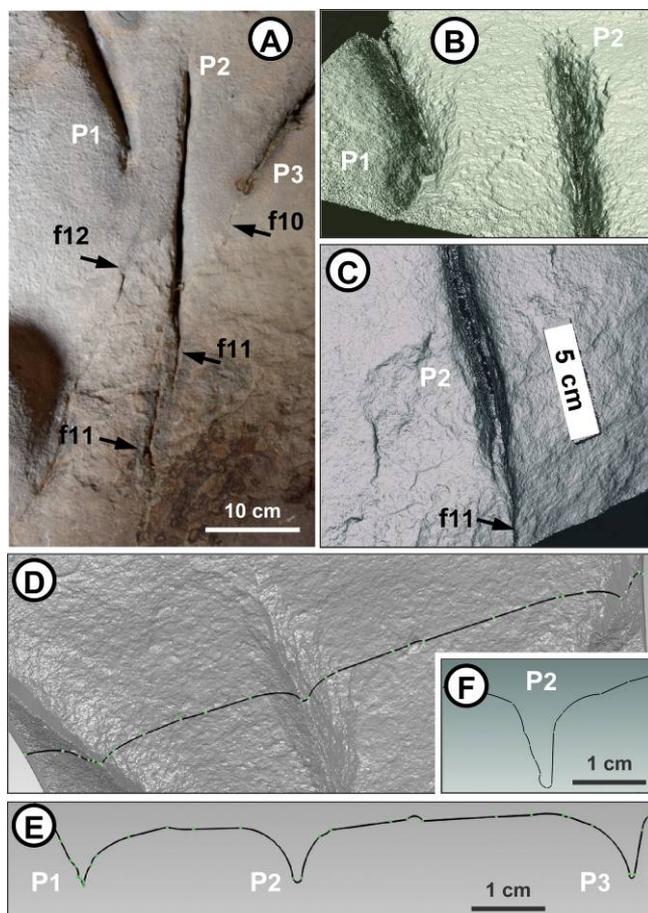
232  
233 *Figure 6 – Irregular and chipped pattern of natural fractures on floor of upper gallery (in*  
234 *between basins B1 and B3). Pictures Fantine Bellanger/PCR ARBap.*

235  
236 The main fractures delineating the panel, namely F1, F2 and F3, are interconnected  
237 (Fig. 5A). Their pattern reflects natural fracturing in response to stress in the sandstone. The

238 F1 fracture at the base of the ‘pubic hair’ is accompanied, in the centre and to the right, by  
 239 thin oblique ones (F1a, b and c) which also conform to the pattern of fractures set up during  
 240 global tension. Three major fractures at the periphery of the panel (F4, F5 and F6) are  
 241 connected to the others and are also part of the natural fracture network.

242 However, the three pelvic triangle slots P1, P2 and P3 are of restricted extent and do  
 243 not intersect. This arrangement suggests a non-natural origin. The wide lateral slots of the  
 244 triangle (P1 and P3 averaging 8-10 mm of width) merge with fracture F1. Slot P1 consists of  
 245 two segments that touch without intersecting and form a wide open angle: this does not match  
 246 a natural fracture pattern, nor does its abrupt closure. A tiny fracture f10 reaches out of slot P3  
 247 (Fig. 7A). The ‘vulvar’ slot P2 ends abruptly at its upper end but has a fine and irregular crack  
 248 f11, poorly outlined and crooked, extending it downwards (Fig. 7A & C). Another oblique  
 249 fracture occurs to its left f12. The contrast between the large pubic triangle slots and the fine  
 250 infra-millimetre cracks that accompany them is obvious. It is not consistent with a distribution  
 251 of physical stresses, nor with a widening by weathering that would be more irregular and  
 252 more progressive at the extremities.

253 A fine crack f13 also occurs on the left of the pelvic triangle (Fig. 5A) more or less  
 254 extending fracture F4. A series of 6 other sub-parallel fissures f14 is perpendicular to f13 and  
 255 ‘*en echelon*’ in conformance with extension stresses associated with fracture F4.



256

257 *Figure 7 –Opening and profiles of the pelvic slots. (A) Side slots P1 and P3 close abruptly at*  
258 *their lower and upper end respectively. On the other hand, fine cracks f11 extend the vulvar*  
259 *slot P2 at its lower end. (B) 3D model showing the abrupt closure of the pelvic slots P1 and*  
260 *P2. (C) 3D model showing the contrast between regular wide open section and irregular fine*  
261 *crack f11 extension of vulvar slot P2. (D) General view with indication of the profile shown in*  
262 *next picture. (E) Profile of the pelvic slots P1 and P3 in their middle sections and vulvar slot*  
263 *P2 at its top. (F) Profile of the vulvar slot P2 at its lower part (same scale as picture E).*

## 264 **4.2 Fracture openings**

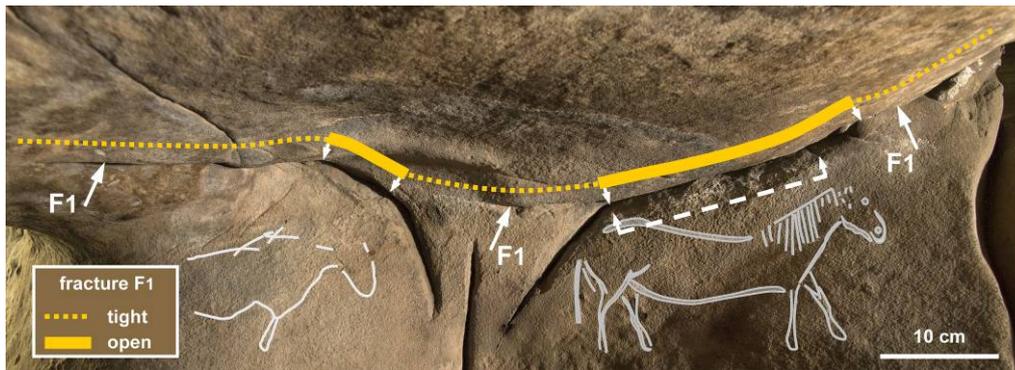
265 Analysis of the mutual relationships of the fractures and slots has been supplemented  
266 by analysis of the morphologies of their openings. They all have a regular and symmetrical  
267 opening with a wide-open V-profile and smooth sidewalls. This is distinct from the irregular  
268 and chipped natural fractures seen elsewhere in the shelter (Fig. 6) and clearly suggest  
269 anthropogenic morphological modification.

270 Profiles of the pelvic slots extracted from the 3D photogrammetric model (Fig. 7D)  
271 show that they are alike (Fig. 7E), with slight asymmetry for lateral slots P1 and P3. On the  
272 other hand, if the vulvar slot P2 is quite comparable to the lateral pelvic slots at its upper end,  
273 it is deeper and narrower in its middle part (Fig. 7F). This deepening without widening is  
274 contrary to a weathering effect that would widen the slot at the same time as it would deepen  
275 it. These properties and those described above are consistent and suggest that the pelvic slots  
276 have been made by widening existing fine cracks, or even created *ex nihilo* in the case of P1  
277 since there are no cracks extending it.

278 Fracture F2 has likewise a regular and smooth opening, without chipping or ripping of  
279 the edges, as well as a very regular V-profile that point to its anthropogenic modification.

280 The opening of fracture F1 is variable along its length. It is closed (without a clear  
281 opening between the two edges) in its middle part beneath the ‘pubic hair’ but wide open with  
282 a regular V-profile on either side of this (Fig. 8). It closes again abruptly to the right and to  
283 the left of the pelvic triangle. Fracture F1 is therefore only open in the extensions of the lateral  
284 pelvic slots P1 and P3. These strong morphological contrasts in different sections of the  
285 fracture F1 suggest anthropogenic reworking in the extension of the pelvic slots P1 and P3.

286 At the rear of the panel, in the upper gallery, the extensions of fractures F1 and F2 at  
287 the bottom of basin B1 are as irregular as natural fractures elsewhere in the shelter, and their  
288 openings are variable and marked by associated oblique cracks.



289

290 *Figure 8 – Fracture F1 between ‘pubic hair’ and pelvic triangle shows successive openings*  
 291 *and closures. The fracture is tight and partially concealed by the organo-mineral crust that*  
 292 *forms the pubic hair. It is enlarged on both sides, and then becomes tight again to the left and*  
 293 *the right, with an especially abrupt closure to the right. White dotted line with arrows shows*  
 294 *extension of Fig. 11C.*

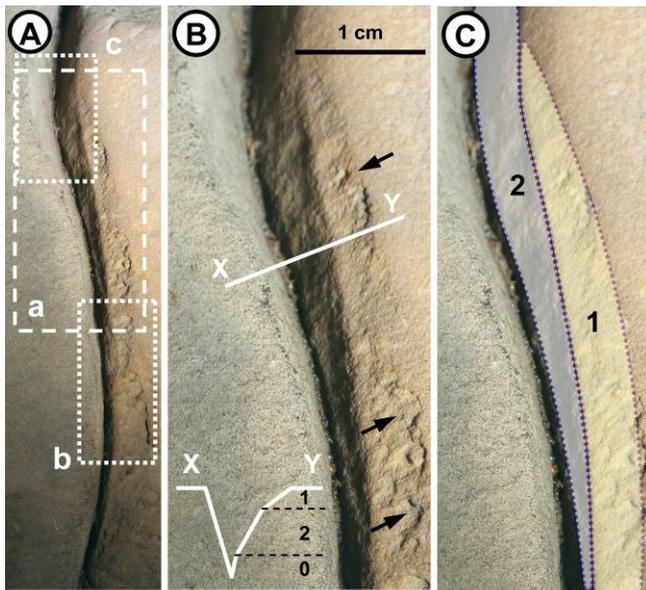
### 295 **4.3 Enlargement of the slots and fractures**

296 Parietal analysis of the slot sidewalls shows various features related to anthropogenic  
 297 grooving and percussion actions.

#### 298 **4.3.1 Grooving marks**

299 Grooving consists of deepening, widening and regularizing a slot by unidirectional or  
 300 bi-directional movements of a tool (Guéret and Bénard, 2017; Cantin, 2019a). Traces on the  
 301 grooves can reflect the dynamics of the working.

302 Fracture F2 is not rectilinear but curved to the right (Fig 5 and 9A). At the top of this  
 303 curve, the right hand side of the slot has distinct facets (Fig 9B & C) which are typical of  
 304 grooved furrows and result from the involuntary friction of different parts of the working tool  
 305 in the curve. A change in direction of movement together with the amplitude of movement  
 306 has tended to pressure the tool against the right side as it scraped. The lack of facets on the  
 307 left side of this curve suggests a one-way grooving movement going from top to bottom. The  
 308 deepest facet could match what remains of the natural fracture or correspond to a last and  
 309 deepest grooving phase (facet 0 on the profile on Fig. 9B). The narrowing of fracture F2  
 310 downwards on the panel (40 mm width at top and 4 mm at bottom near slot F6) could match  
 311 its natural opening but it is also possible that it results from anthropogenic action. In this latter  
 312 scenario, the narrowing would result from a stronger pressure at start-up as in other types of  
 313 uni-directional engravings (D’Errico, 1994; Fritz, 1999) and/or an easier grooving gesture in  
 314 the wider upper part of the chamber than in the lower part where it is more cramped.  
 315 Concerning the cupules on the upper facet of the right flank (Fig. 9A & B), we cannot decide  
 316 if they were formed as a result of percussion chipping during working or an alteration by  
 317 natural scaling of the sandstone before or after shaping of the slot.



318

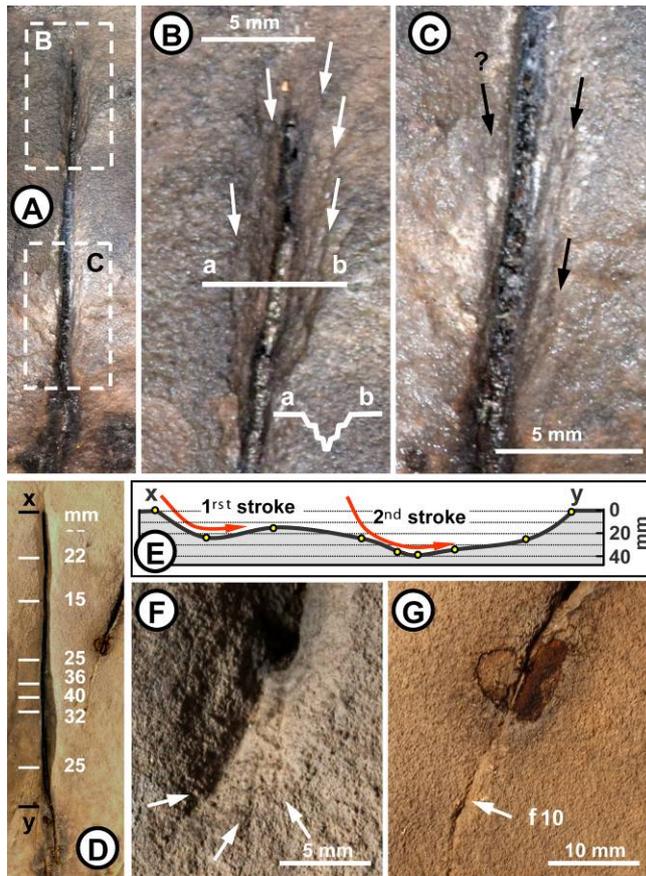
319 *Figure 9 – Grooving marks on fracture F2. (A) Overall view. The rectangles give the framing*  
 320 *of enlarged photos: (a) location of images B and C; (b) and (c) locations of images in Fig.*  
 321 *12A & B. (B) Enlargement with a schematic section of the three facets of the right sidewall:*  
 322 *arrows indicate sites of sandstone chips. (C) Shading showing extent of facets 1 and 2.*

323

324 Other marks of grooving are visible on the vulvar slot P2 that shows a fan of small  
 325 converging incisions at its apex (Fig. 10B). This fan is characteristic of unidirectional  
 326 grooving from top to bottom: once the tool has reached the bottom end of the slot, the  
 327 engraver would withdraw it to put it back in at the top without finding exactly the same  
 328 starting point, which caused a proliferation of small fan incisions. Similar incisions further  
 329 down in the slot (Fig. 10C) are the application marks of the tool at the start of a second  
 330 downward engagement in the slot and indicate work to extend the slot downwards and/or  
 331 deepen it. Measured depths throughout this slot have been used to sketch a longitudinal  
 332 section (Fig 10D & E). Two digging phases are clearly distinguished in the profile: they are  
 333 characterised by a gradual decrease in depth as the downward stroke progresses and this is  
 334 related to decreasing thrust force as the engraver moved away from the attack point (D’Errico,  
 335 1994; Fritz, 1999).

336

337 Finally, slot P1 is extended by small furrows at its lower end (Fig. 10F). These are  
 338 likely to be incisions caused by the skidding of the tool out of the slot at the end of reach of  
 339 the grooving action. These short straight and divergent grooves are in any case very different  
 340 from fine sinuous and natural cracks which extend slots P2 and P3 downwards (respectively  
 Fig. 7A & 10G).



341  
 342 *Figure 10 – Grooving marks on pelvic slots. (A) Overall view of slot P2 with rectangles*  
 343 *locating the following images (B) and (C). (B) Sheaf of incisions at the top of slot P2 and*  
 344 *sketch of its composite profile. (C) Second stroke point for groove generation with incisions*  
 345 *towards the base of the slot P2. (D) Depths of vulvar slot P2. (E) Profile along slot P2*  
 346 *showing deepening by re-grooving the lower half of the slot. (F) Skidded grooves at the lower*  
 347 *closure of slot P1. (G) For contrast fissure f10 in extension of slot P3. A, B, C in winter, wet*  
 348 *weather; D, F, G in summer, dry weather.*

349

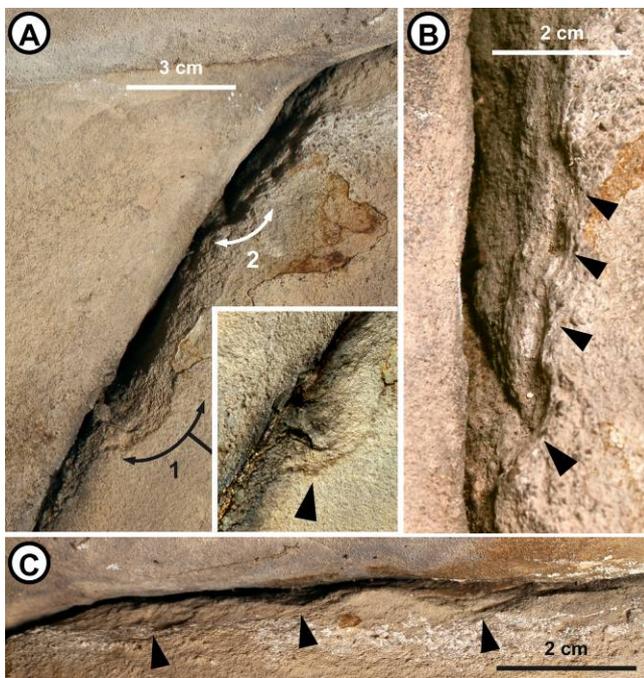
### 350 **4.3.2 Percussion marks**

351 Percussion spalls rock using a launched tool (direct percussion) or an intermediary  
 352 tool placed on the rock being struck with a hammer (indirect percussion) (Inizan *et al.*, 1995).  
 353 Several marks on P3, F1 and F2 are attributed to this type of operation.

354 Pelvic slot P3 is marked by two depressions which have sharply widened it by opening  
 355 its lower flank (Fig. 11A). Bénard (2010) had already noticed the first one (zone 1 on  
 356 Fig. 11A) and interpreted it to be the result of an intentional working of the sandstone. The  
 357 morphology of these depressions corresponds to negatives of removals although their pattern  
 358 is more irregular than on easily knappable rocks such as obsidian and flint because the  
 359 sandstone is grainier (Griselin, 2015).

360 The upper depression (zone 2 on Fig. 11A) is accompanied by a furrow reaching  
 361 towards the full depth of the slot (Fig. 11B). This furrow was not made by grooving but rather

362 matches the mark of the tip of a tool propelled towards the rear of the slot. Besides, small  
 363 notches etched immediately above on the same right hand side of pelvic slot P3 (Fig. 11B) are  
 364 likely to be softer chippings to regularise the top of the slot. Other negative of removal mark  
 365 the lower side of slot F1 in its extension to slot P3 (Fig. 11C). On the other hand, the left hand  
 366 side of this pelvic slot P3 is straight and smooth and reflects either its original form or has  
 367 been shaped and regularized by grooving as for slots P2 and F2. In addition, slot P3 is 32 mm  
 368 deep at its upper part where there are percussion marks and diminishes abruptly to only 5 mm  
 369 deep in its lower part where there is no percussion mark. Thereby, percussion actions would  
 370 have been used to widen and deepen the slot afterwards in particular places. It should be  
 371 noted that the scaling of the gypsum crust at the edge of the slot tends to blur the detail of the  
 372 marks left by anthropogenic working. However, the crust is only on the surface and when  
 373 scalled off does not distort or degrade sculptural marks in the sandstone itself.

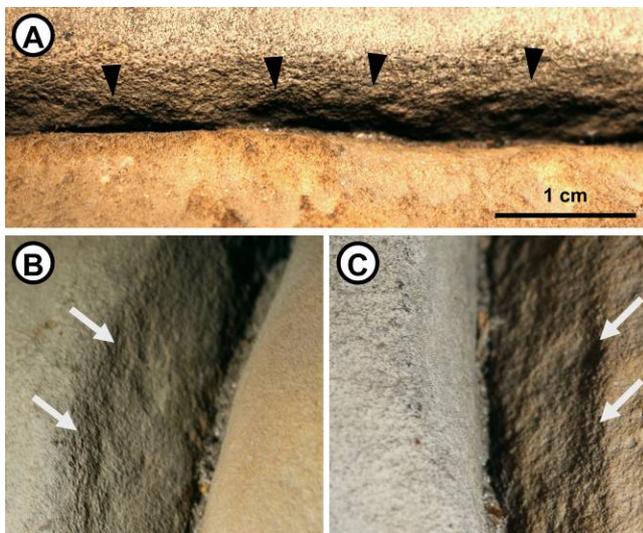


374  
 375 *Figure 11 – Percussion marks along slots P3 and its adjoining portion of F1. (A) Overall*  
 376 *view of slot P3 with the main percussion marks 1 and 2 and a close up view of mark 1. (B)*  
 377 *Detail of the percussion mark 2 with hints of secondary percussions. (C) Opening percussions*  
 378 *along fracture F1 in its extension to P3; see frame of the picture on Fig. 8. Arrows indicate*  
 379 *probable striking points and inferred direction.*

380  
 381 Depressions occur also at regular intervals on the left sidewall of F2 (Fig. 12A). They  
 382 could match remaining negatives of removals and are comparable to those described on pelvic  
 383 slot P3 and fracture F1. However, they have a smoothed and regularized appearance, and were  
 384 probably scraped or smoothed afterwards by grooving. This percussion step would therefore  
 385 have taken place in a preliminary phase of the fracture opening. Finally, on the upper part of  
 386 fracture F2 are two small cupules on the left sidewall (Fig. 12B) and two others facing them

387 on the opposite sidewall (Fig. 12C). Although their natural origin cannot be completely ruled  
388 out, these marks could be from the impacts of a pointed tool.

389 To conclude, the regular intervals between these flaking negatives, as well as the  
390 associated pointed tool marks, argue for indirect percussion with an intermediate piece of hard  
391 rock (i.e. flint or hard/lustrous sandstone available on site). Use of a percussion technique is  
392 justified by the toughness of the worked sandstone. The joint use of percussion and grooving  
393 for the digging and/or regularization of grooves has been identified in other Upper  
394 Palaeolithic rupestrian contexts such as sandstone of Qurta in Egypt (Huyge et al., 2007) and  
395 phyllites of the Côa Valley in Portugal (Baptista, 2001; Bicho et al., 2007). At the latter site,  
396 functional analysis and experimental studies have demonstrated use of local quartzite points  
397 to strike and groove the rock (Plisson, 2009; Aubry et al., 2011).



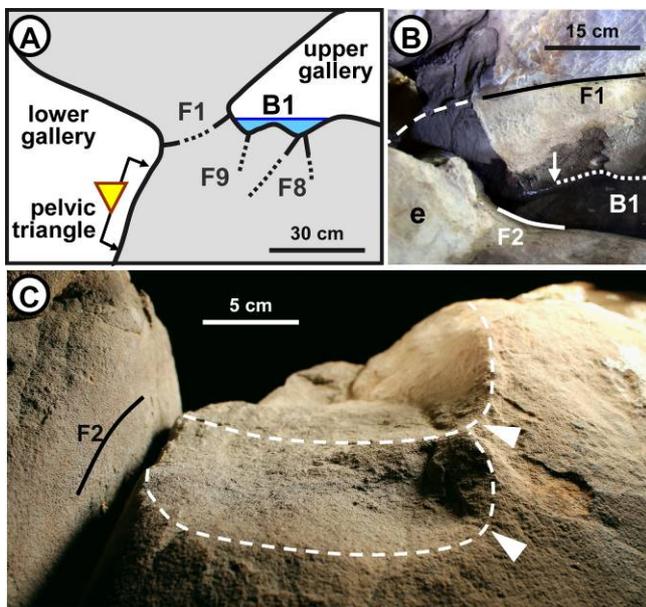
398  
399 *Figure 12 – Percussion marks on fracture F2. (See Fig. 9A for location of images).*  
400 *(A) Depressions at regular intervals on the left sidewall of F2. (B) and (C) Probable*  
401 *percussion marks facing each other on both sidewalls.*

#### 402 **4.4 Morphological characteristics of basin 1**

403 The downstream part of the upper gallery comprises B1 and B2 basins (Fig. 4;  
404 supplementary file 2) that are at the same level and just rear of fracture F1 and the ‘pubic hair’  
405 (Fig. 13A). Natural basins in Fontainebleau Sandstone are rounded depressions, somewhat  
406 limited in size but regularly concave and with a smooth bottom. Water stagnates regularly in  
407 these depressions and regulates their morphology by slow weathering of the sandstone (Thiry,  
408 2005). The regularity of the edges and bottoms of natural basins can be taken as reference to  
409 identify any anthropogenic modification. Basin B1 has features that distinguish it from natural  
410 structures.

411 **4.4.1 Modifications to the margin of basin B1**

412 Examination of the contours of basin B1 revealed a gap in the threshold (e) that  
413 separates it from the chamber of the engraved panel. The gap (15 cm long, 5 cm high and  
414 10cm wide) corresponds to the removal of about 1 dm<sup>3</sup> of material at the top of fracture F2  
415 (Fig. 5 & 13B). There are two obvious concavities that contrast with the rounded and convex  
416 morphologies of natural basin borders (Fig. 13C). These mark the locations of large  
417 conchoidal flakes of sandstone that were removed by percussion from the chamber. The  
418 flaking of the sandstone in this place was favoured by the discontinuity provided by fracture  
419 F2, the left sidewall of which remained in place. Due to their size, the flakes must have been  
420 detached with a heavy hammerstone.  
421

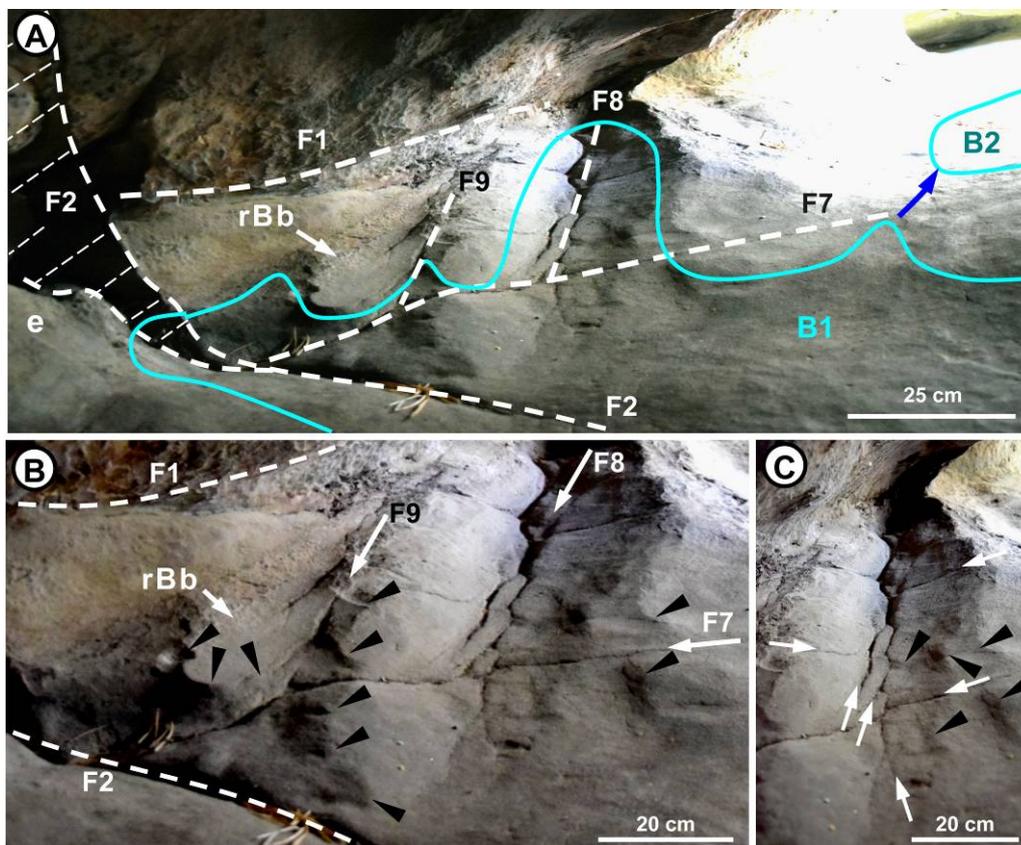


422  
423 *Figure 13 – Morphology of basin B1 and surrounds. (A) Schematic section showing position*  
424 *of basin B1 and its water-filled state relative to the pelvic triangle and estimated fracture*  
425 *orientations. (B) Rear view from the upper gallery showing location of threshold (e) gap*  
426 *between basin B1 and fracture F2 from which sandstone was removed. White arrow marks*  
427 *water level in basin B1 at an intermediate state. (C) Front view from the carved panel*  
428 *chamber showing locations from which conchoidal flakes of sandstone were removed by*  
429 *percussion, with probable impact at arrowed sites. See frame of this front view in Fig. 5.*  
430

431 **4.4.2 Deepening of basin B1**

432 Basin B1 has an atypical multi-lobed shape. It features elongated gutters separated by  
433 ridges centred on a network of interconnected fractures (Fig. 14A). This arrangement differs  
434 from natural basins which are depressions with clean outlines and smooth, regular bottoms  
435 like basin B2, immediately adjacent to basin B1, or basin B3 downstream of the ramp  
436 (supplementary file 2). When it is full, water reaches fractures F1 and F2 and covers the  
437 network of fractures F7-F8-F9 that occupy the central gutter in the basin (Fig. 14A).

438 Only a small concave surface, located above the modified bottom of the basin, retains  
 439 the regularity typical of the bottom of natural basins (Fig. 14A & B) and appears to be  
 440 residual, with material removed all around it. The flanks of the gutters centred on fractures F8  
 441 and F9 show series of depressions only explained by flake removal along the fractures (Fig.  
 442 14B & C). The most obvious are those above the fill level of the basin: those at the bottom of  
 443 the basin have rounded edges and angles and appear to have been weathered by the frequency  
 444 of their flooding. Effective removal of flakes of sandstone relied on natural fractures to direct  
 445 and aid the effects of percussion. By examining the remnant bottom of basin B1 in relation to  
 446 the new surface generated by percussion and removal of sandstone, together with the flow  
 447 threshold between basins B1 and B2, it has been estimated that the main gutter centred on  
 448 fracture F8 was deepened by about 10 cm.



449  
 450 *Figure 14 – Artificial morphological features of basin 1. (A) Layout of the various structural*  
 451 *elements and the multilobed contour of basin B1 in its filled state (curved line). The pelvic*  
 452 *panel is to the left, behind the back wall. Fracture F2 is below and left where some of*  
 453 *threshold (e) was removed. (B) Residual parts of a regular concave bottom surface of a*  
 454 *former basin (rBb) after flakes (black arrows) were removed to deepen the basin towards*  
 455 *fracture F2. (C) Main gutter with natural network of fractures (white arrows) and a series of*  
 456 *marks (black arrows) indicating sites from which material has been removed by percussion.*

457  
 458 Photogrammetry of the end of the main gutter reveals other details that corroborate its  
 459 modification (Fig. 15). A jagged micro-scarp underlines the ridge of the SW flank of the

460 gutter (Fig. 15-1). Its irregular and angular outline getting in places over the ridge does not  
461 conform to alteration/erosion morphologies: it probably results from a series of removals;  
462 their sharpness having been eroded since they were made. The same applies to a notch on the  
463 same side of the gutter (Fig. 15-2). Finally, a series of parallel elongated depressions, oblique  
464 with regard to the greatest gutter slope, can't be explained by natural alteration linked to water  
465 flow on the flank of the gutter. They are probably what's left of man-made grooves.

466 In conclusion, modifications to basin 1 have resulted in a significant change to the  
467 initial layout of the shelter. Three changes have to be kept in mind: (1) opening of a spillway  
468 to allow water overflowing the basin to move towards the foot of the pelvic panel (basin B4)  
469 via fracture F2; (2) deepening of the initial basin to increase its water-holding capacity; and  
470 (3) clearing out the fractures in the bottom of the basin.



471  
472 *Figure 15 – 3D photogrammetric model of the central gutter of basin 1. The photogrammetric*  
473 *processing highlights several man-made marks and morphologies.*

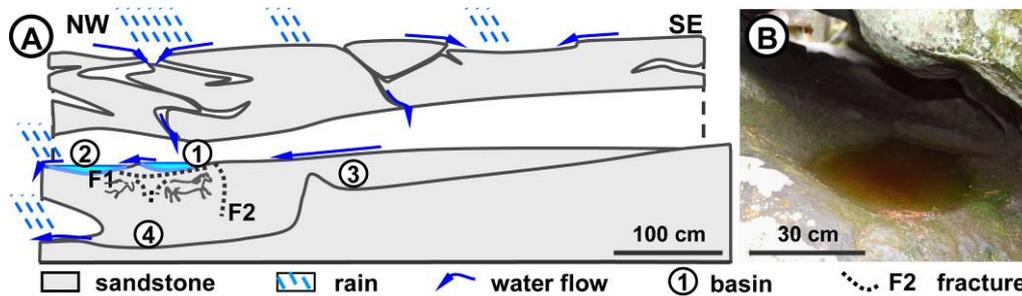
## 474 **5 Hydrology of the shelter**

475 The described workings, in particular the artificial deepening of basin B1 and the  
476 opening of a spillway towards carved chamber via Fracture F2, suggest that there was a  
477 specific role for water in this shelter. Particular questions focus on how all of these features  
478 relate to and interact with the symbolism of the carved panel. The various hydrological  
479 aspects, that is, the exchanges between the atmosphere and the sandstone mass of the shelter,  
480 are important, as is the arrival of water into the shelter, its distribution and its behaviour.

### 481 **5.1 Water inflow**

482 Rainwater enters the shelter through surface openings in the northwest parts of the  
483 sandstone block (Fig. 16A). The two entrances to the upper and lower galleries also receive  
484 rainfall directly from southwestern winds which are the current prevailing and rain-bearing  
485 winds and were also during the Last Glacial Maximum (Ludwig *et al.*, 2016). In addition to  
486 direct precipitation, basins 1 and 2 in the upper gallery receive infiltrating water through a  
487 network of anastomosed joints, fractures and cavities that link to the sandstone surface. As a

488 result, both basins are flooded if rain persists for about a day. Basin 2, which is downstream  
 489 of the upper gallery and closest to the NW entrance and therefore the external environment, is  
 490 regularly flooded during the winter (Fig. 16B).



491  
 492 *Figure 16 – Schematic diagram of hydrological flows into and through the shelter. (A)*  
 493 *Rainfall enters from the surface openings. (B) Basin 2 at its overflow level on 23/01/2018.*  
 494 *The organic-rich (brown colour) of the water is derived from and characteristic of peaty*  
 495 *surface soils overlying the sandstone.*

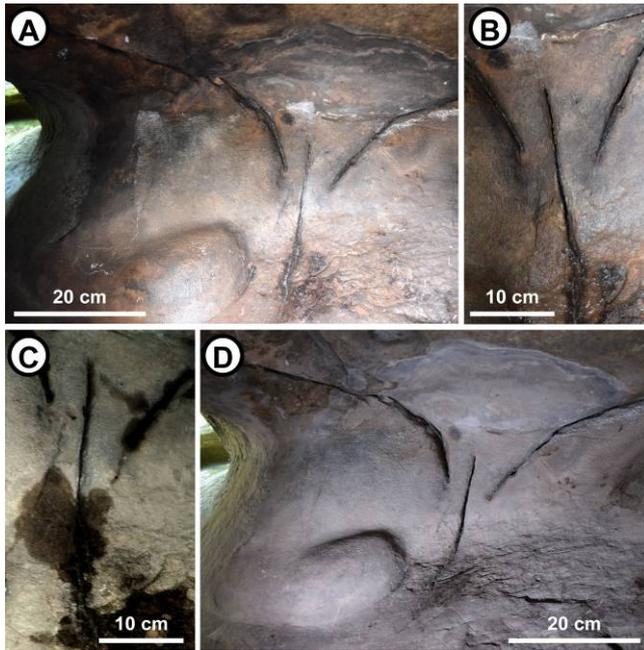
496  
 497 Both basins were full on 23/01/2018 after a long period of rain that led to a major  
 498 flooding of the River Seine. Basin 2 actually spilled out of the shelter. Basin 1 was not full but  
 499 its perimeter was wet. Thus, the level of water in basin 1 had already fallen at the time of the  
 500 observation while basin 2 was at its near-maximum level.

## 501 **5.2 Hydrological changes at the pelvic panel: the ‘vulvar fountain’**

502 Observations confirm that the pelvic triangle panel responds to climatic conditions in  
 503 such a way that its appearance can change completely. Water exudes from its whole surface  
 504 after long rain periods (Fig. 17A & B) but there are only damp patches when there are  
 505 scattered rains interspersed with days or weeks without precipitation (Fig. 17C). It is  
 506 completely dry during summer (Fig. 17D).

507 The most spectacular metamorphosis of the pelvic triangle panel was observed on  
 508 23/01/2018 after a long rain period previously mentioned. Saturation of the panel led to a  
 509 ‘fountain’ of water outflowing from the vulvar slot (Fig. 18A). A small flow escaped directly  
 510 at the basal end of middle slot P2 and was strengthening along the thin crack f11 that extends  
 511 the slot. Other significant seeps occurred 5 to 7 cm below the vulvar slot, on a darker area that  
 512 has many scars due to scaling of the gypsum crust. Further down, the discharge formed  
 513 several flows, one of which originated on the thin crack f12 which borders the sandstone  
 514 bulge at the bottom left of slot P2. The two harder sandstone bulges that are more tightly  
 515 cemented and have reduced porosity were just moist. The sandstone in the lower part of the  
 516 panel was saturated: water pooled on the surface of the gypsum crust, exuded from pores in  
 517 the crust and flowed from cracks in its surface (Fig. 18B).

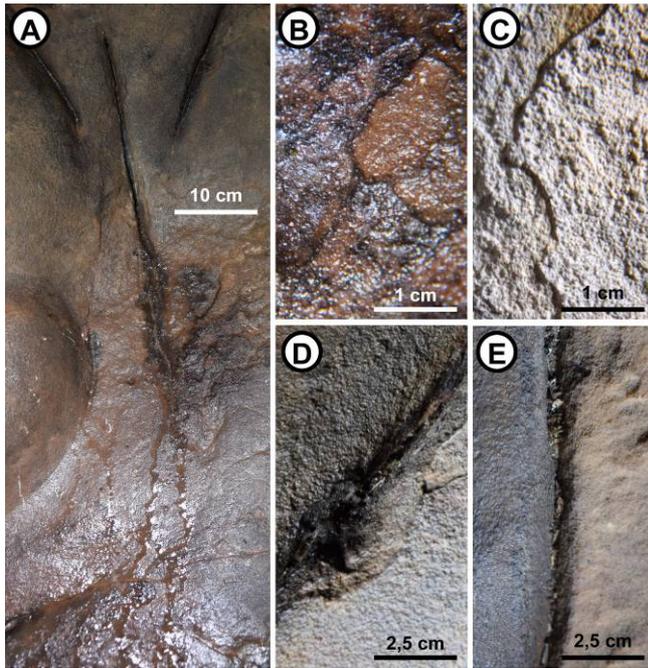
518



519

520 *Figure 17 – Sequentially variation in wetness of the pelvic panel. (A) 23/01/2018 – after a*  
 521 *long winter rainy period, the panel is exuding moisture as indicated by stronger colours.*  
 522 *(B) 23/01/2018 - pubic slots seep and have lips darkened by moisture. (C) 19/02/2018 –*  
 523 *despite some additional rain periods, the moisture on the panel has abated in less than a*  
 524 *month. (D) 19/10/2018 – after a long summer drought, the panel is fully dry and colours pale.*  
 525

526 The sandstone in the upper part of the panel, above the basal flow of the vulvar slot,  
 527 was not water-saturated and not wet. The crust over the horse engravings was dull and dry  
 528 (Fig. 18C). But there was a contrast in moisture on each side of the slots. The encrusted  
 529 surface above the right pelvic slot P3 was glossy with moisture, while below the slot, the crust  
 530 of the horse’s rump was dull and dry (Fig. 18D). Similarly, the encrusted surfaces on either  
 531 side of fracture F2, to the right of the panel, showed a strong moisture contrast with the pelvic  
 532 triangle panel moist (colour reinforced by moisture) while the sandstone beyond F2 was dry  
 533 (Fig. 18E).



534

535 *Figure 18 – Appearance of the water saturated panel on 23/01/2018. (A) Leakage and water*  
 536 *outflow at base of vulvar slot P2. Note enhanced wetness at the lower end of the panel and*  
 537 *less on the bulge. (B) Water exuding from cracks in the gypsum crust about 5 cm below the*  
 538 *vulvar slot. (C) Dry crust in the upper part of the panel, below the right pelvic slot P3 on the*  
 539 *back of the horse engraving. (D) Slot P3 with moist crust (darker colour) on the pubic left*  
 540 *side and almost dry (lighter colour) on the opposite right side. (E) Fracture F2 forms the*  
 541 *boundary between the wet part of the panel and the opposite dry part.*  
 542

## 543 **6 Hydraulic workings of the pelvic panel**

544 Field experiments were undertaken to map the hydrological changes in the panel as a  
 545 consequence of water flows through the sandstone and the shelter by supplying water to  
 546 basins B1 and B2.

### 547 **6.1. Field experiments**

548 Four experiments were carried out successively during dry periods with adjustments  
 549 made following each.

550 The first two were simple tests carried out by filling basin B1 at more or less regular  
 551 intervals (between 1 and 5 hours) to allow it to drain into downstream basin B2 until it  
 552 overflowed. The initial test was conducted by leaving basin B1 in its original state and the  
 553 second after removing leaves and sand deposits that had accumulated in its bottom as well as  
 554 in fractures F8 and F9. The tests showed that: (1) water added to basin B1 seeps into the  
 555 sandstone; (2) the rate of infiltration of the water into the sandstone increased after it had been  
 556 cleaned, indicating that infiltration pathways had been opened; (3) more water infiltrated in

557 the sandstone in basin B1 than in basin B2; and (4) there was no wetting of the pelvic triangle  
 558 panel.

559 A third experiment was conducted while maintaining the water level in the basins by  
 560 electro-mechanical control over 5 days. The hydrological data and the results of the  
 561 experiment summarised in Table 1 are as follows:

- 562 • basin B2 has twice the capacity of basin B1 (9 and 4 L, respectively);
- 563 • after filling the basins and thus wetting the sandstone, infiltration rates (flow rate) in basin  
 564 B1 remain stable at around 0.75 - 1.00 L/h, while those in basin B2 decrease steadily from  
 565 0.75 to 0.15 L/h;
- 566 • after 5 days of continuous water supply, the uptake in basin B1 was 101 L whereas in  
 567 basin B2 it was 53.5 L;
- 568 • the pelvic triangle panel became progressively wet over the period of the experiment. An  
 569 outflow from vulvar slot P2 appeared after 2.5 days when basin B1 had accepted 55 L of  
 570 water. Basin B4 at the base of the panel was flooded by the end of the experiment  
 571 (Fig. 19);
- 572 • two days after the experiment, the panel was already dry, there remained only localized  
 573 wet spots similar to those observed after 1 day water supply.

574

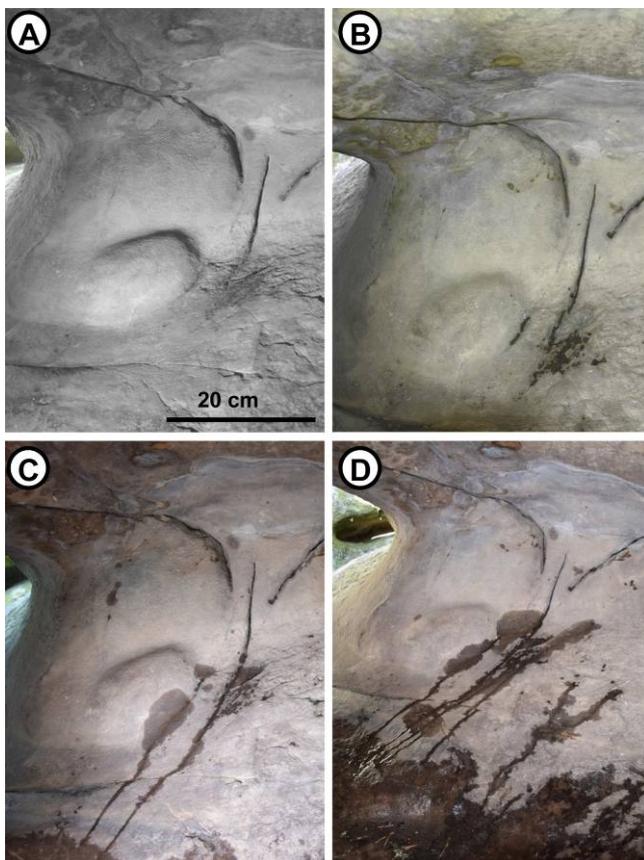
575 *Table 1 - Data on the water infiltration from the upper gallery basins along experiment 3 with*  
 576 *automated water level monitoring.*  
 577

date	hour	Σ h	bowl 1		bowl 2		pelvic panel description
			amount L	flow rate L/h	amount L	flow rate L/h	
25/03/2019	16h30	0,0	4,00		09,00		dry
	17h30	1,0	7,00	3,00	10,50	1,50	dry
26/03/2019	11h30	19,0	21,50	0,80	28,50	0,72	appearance of wet spots
27/03/2019	17h00	48,5	43,50	0,74	41,50	0,44	extended wet spots
<b>water resurgence</b>							
28/03/2019	09h00	64,5	55,50	0,75	48,50	0,44	flow from pelvic slot P2
	17h30	73,0	63,50	1,00	51,50	0,35	flow at base of fracture F2
29/03/2019	09h00	88,5	79,00	0,95	56,50	0,32	
	17h00	96,5	87,00	1,00	59,50	0,37	5 trickles flowing out at base
30/03/2019	11h30	115,0	105,50	0,97	62,50	0,16	bowl 4 flooded (1-2 L)

578

579 A fourth experiment was carried out with intermittent impoundment after 6 to 8 hours  
 580 of drying overnight. This final test generated wetness of the vulvar slot P2 after 2 days, in the  
 581 same sort of time frame that had been achieved by maintaining a continuous water supply.  
 582 However, there was no outflow from slot P2 and the appearance of the panel did not change  
 583 for the following 3 days.

584 It should be emphasized that a regular water supply to basins B1 and B2, without a  
585 long interruption, caused outflow from vulvar slot P2 after a relatively short time (2.5 days)  
586 and with a relatively small water supply (about 50 L per day, equivalent to about 5 buckets).  
587 The infiltration rate is higher at the start because the sandstone in the bottom of the basin is  
588 dry and acts as a sponge. When the superficial layers of the sandstone become saturated, all  
589 pores are filled and water then continues to move downwards by gravity. Thus, the infiltration  
590 rate decreases until it attains a stable value which reflects the volume of the pores, their  
591 geometry and the interconnections between them. Faster infiltration measured in basin B1 is  
592 due to additional infiltration pathways provided by the fractures in its bottom (Fig. 14). Only  
593 continuous filling of the basins leads to vulvar flow.



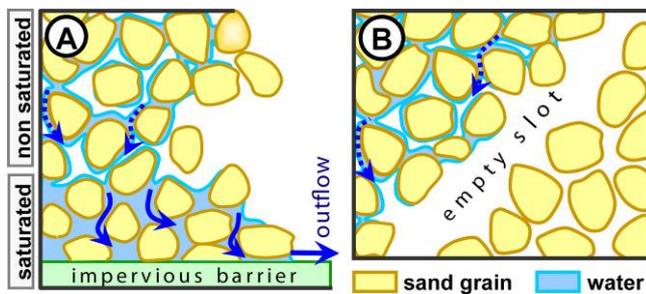
594  
595 *Figure 19 – Progressive wetting of the pelvic panel during the infiltration experiment. (A)*  
596 *Start – dry panel. (B) 1 day – wet spots. (C) 2.5 days – outflow from vulvar slit P2 and*  
597 *neighbour fissure f12. (D) 5 days – saturation of the whole base of the panel.*

## 598 **6.2 Impact of anthropogenic modifications on percolation**

599 The superposition of two galleries (Fig. 16A) is the fundamental feature of the shelter  
600 which permits the particular hydrological system we describe to operate. Basin B1 in the  
601 upper gallery is the keystone of the installation: it feeds and saturates the pelvic triangle panel  
602 by supplying water. The staggered arrangement of the basins and the panel provides the  
603 hydrological gradient necessary for water to infiltrate and periodically saturate the panel.

604 However, working of the natural features of the panel has optimized and concentrated the  
 605 saturation towards important components, particularly the base of the vulvar slot. The step-  
 606 by-step movement of water in the shelter has to be examined to unravel the importance and  
 607 shrewdness of the interventions.

608 The flow of water in a porous medium forms the basis for understanding the behaviour  
 609 of water pathways within the sandstone in the shelter. In unsaturated sandstone, pore water is  
 610 subjected to capillary forces that hold it stuck to grains and gravity that induces its  
 611 downwards movement along pores (Fig. 20A). If it meets an impermeable barrier, or a less  
 612 porous layer, water accumulates above that barrier and entirely saturates the pores. Then the  
 613 force of gravity exceeds the capillary holding forces and the water can flow out (Fig. 20A). In  
 614 an unsaturated medium with no impermeable barrier, capillary forces can hold the water  
 615 around grains and prevent it from draining. Thus, cavities or fractures are bypassed by  
 616 infiltration (Fig. 20B).



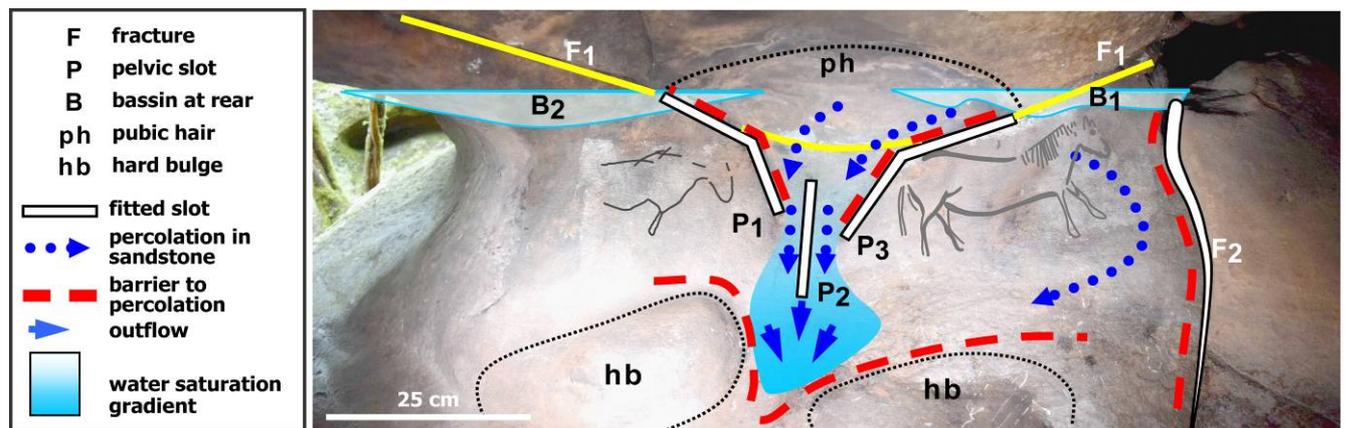
617  
 618 *Figure 20 – Behaviour of water in porous media. (A) In a non-saturated sandstone above an*  
 619 *impermeable barrier, water migrates around grains, accumulates, saturates the pores and*  
 620 *then flows away. (B) In non-saturated sandstone with no impermeable barrier, water films*  
 621 *are attached to grains and do not drop to empty holes or slots.*  
 622

623 The water enters the sandstone of the pelvic triangle through fractures on the bottom  
 624 of basin B1 at the back of the panel (Fig. 21). The fractures fill with water that gradually  
 625 infiltrates the adjacent porous sandstone. The water then meets barriers that prevents further  
 626 vertical percolation and forces the flow along these barriers to a certain direction.

- 627 • Voids of pelvic triangle slots P1 and P3 force percolations to flow along their slope to the  
 628 tip of the triangle. It is the barrier effect of the lateral pelvic slots that explains the  
 629 moisture contrast of the panel-encrusted surface on either side of the slots: moistened  
 630 above the slot and dried under it (Fig. 18D). The same effect explains the similar moisture  
 631 contrast on both sides of fracture F2 which closes the panel on the right (Fig. 18E). The  
 632 deeper the slot, the more the barrier effect is accentuated.
- 633 • The hard sandstone bulges are less porous than their surrounds and, protruding at the base  
 634 of the panel, form a less permeable horizon. They act as another impervious barrier over

635 which percolations accumulate and progressively saturate the panel base. The front  
 636 between the saturated and unsaturated zone rises up in the panel as and when pores  
 637 become saturated with water. Seeps and flows occur when pore water is no longer  
 638 retained by capillarity.

639 Thus, the arrangement of the modified slots and the impermeable barrier at the panel  
 640 base lead to panel saturation and emergence of the ‘vulvar fountain’ when basins B1 is filled  
 641 continuously. If the water supply is not sufficient or is interrupted, saturation is not achieved  
 642 or only locally achieved, producing only scattered wet spots.



643  
 644 *Figure 21 –Diagram of the hydrological functioning of the horse panel. Hydrological features*  
 645 *channel pore water to saturate the sandstone and thus generate outflows at the base of the*  
 646 *pelvic triangle.*

647  
 648 It may seem strange that vulvar slot P2, a fundamental component of the sexual  
 649 representation, is not as wide as the lateral slots P1 and P3 of the pubic triangle. It may be no  
 650 coincidence. Enhanced widening of the lateral slots relative to the vulvar slot optimizes the  
 651 water seeping towards the base of the pubic triangle. An expanded opening of the central part  
 652 of slot P2 would have diverted some of the seepage water around its periphery. On the other  
 653 hand, deepening it has made it possible to collect more water and to obtain a localized  
 654 outflow on its bottom end when the saturation front rises.

655 Another component of this sexual arrangement is the ‘pubic hair’. It is a striking  
 656 organo-mineral coating with concentric halos that were formed through capillary rise of  
 657 wetness from fracture F1 at the top of the pelvic triangle (Thiry and Cantin, 2018;  
 658 supplementary file 2). However, events that moisten and generate seepage in the pelvic  
 659 triangle panel do not currently affect this particular area of fracture F1. This suggests that the  
 660 primary water regime that led to development of this particular encrusted area has been  
 661 disturbed or changed since the time of crust formation. This could have resulted from the  
 662 deepening of basin B1 and the opening of a spillway towards fracture F2 that lowered the fill  
 663 level in the basin and deprived fracture F1 of water.

## 664 **7 Summary**

665 Detailed analysis of Ségognole 3 shelter has identified a number of natural features  
666 that have been worked and modified to change their properties. The results are a true  
667 'installation' in the modern artistic sense, both functional and evolutionary, and focussed on a  
668 representation of feminine sex and animals. Considering all the components we have  
669 described, we should try to discern the many that are unquestionably intentional interventions  
670 from others that may only be side effects and were not intended.

### 671 **7.1 Worthy features from a Palaeolithic perspective**

672 The main characteristics of Ségognole 3 shelter are its two-tiered gallery arrangement  
673 and the presence of internal basins that periodically retain water. These are rare and  
674 remarkable configurations. More often than not, when water infiltrates into other shelters in  
675 the region it seeps directly into porous sandstone or sand in the shelter floor and is not  
676 retained. In addition, the overall morphology of the shelter was probably a determining factor  
677 in it being selected for this installation. Indeed, the central chamber with the carved panel is  
678 isolated within the sandstone block and curtails access (see supplementary file 2). After  
679 gaining access into the vestibule, it is necessary to crouch and then crawl to pass an oval  
680 narrowing before reaching the intimacy of the chamber where the key panel is located  
681 (Fig. 4A; supplementary file 2). The pubic triangle is therefore integrated into a natural space  
682 that possibly has feminine connotations, a characteristic not surprising in the context of  
683 European Upper Palaeolithic rock art (Leroi-Gourhan, 1965; Testart, 2016).

684 The pubic triangle itself has been described in the past as an essentially natural  
685 attractive element (Bénard, 2010). The analysis of the fracture networks and their  
686 morphologies now demonstrates that the three pubic slots, so apparent and suggestive, have  
687 been worked to this end. It is possible that at the origin of the vulvar slot P2 there were  
688 originally fine irregular and possibly periodically wet cracks that could have inspired  
689 engravers to construct a more formal representation of female sex. In addition to these  
690 original thin cracks, the presence of the dark-coloured organo-mineral coating evoking pubic  
691 hair may have been another decisive element to encourage engraving of the pubic triangle.  
692 While this is currently well marked, it may have been even more striking before the water  
693 flows were diverted by remodelling the hydraulics as moisture increases the contrast with the  
694 surrounding sandstone. Drying out of the pubic hair coating is clearly a side effect of  
695 deepening basin B1. Additionally, the presence of fracture F2 framing the panel should not be  
696 overlooked. Although probably less shapely before its modification by grooving, it could have  
697 reminded one with a sharp eye of a hip-thigh silhouette. This silhouette is reinforced by the  
698 extensions to the pelvic slots P1 and P3 to the modified fracture F1 to highlight 'groin folds'

699 and complete the framing of thighs and hips. Nonetheless, the bottom-up view of the  
700 transition of the pubic triangle to the ceiling of the chamber, as it appears when one enters the  
701 chamber by crawling through the narrowing, evokes a woman's belly (pregnant?) with its  
702 pubic tuft overhanging the triangle (see supplementary file 2). This view links the whole  
703 chamber's volume to a feminine representation overlooking and dominating the visitor and is  
704 particularly striking.

705 The natural geomorphological characteristics of Ségognole 3 shelter thus provided  
706 appropriate disposition to imprint this fragmented representation of femininity, a theme that  
707 shows clear importance during the Upper Palaeolithic (Leroi-Gourhan, 1965; Bourrillon,  
708 2009; Bourrillon et al., 2012; Testart, 2016), although it is relatively rare compared to animal  
709 representations in cave art (Sauvet, 2019). The integration of a modified hydraulic flow  
710 regime, that activates a vulvar flow (pre-parturial water losses ?), generated a novel and  
711 unprecedented installation that presumably had symbolic force.

## 712 **7.2 Sequence of anthropogenic workings**

713 Our proposal is that the pubic triangle was created to integrate the pubic hair feature  
714 with initial rock fractures into an evocative whole. Originally, there was perhaps also a  
715 periodically wet area at the base of the original vulvar slot P2. But the current hydraulic  
716 characters have resulted mainly from deepening the lateral slots of the triangle and modifying  
717 basin B1. Fracture F2, which limits the panel on the right, does not appear to play any obvious  
718 role in the hydraulic operation of the vulva. One hypothesis might be that it was worked to  
719 mirror the curvature in the sandstone narrowing that limits the panel on its left (Fig. 5A;  
720 supplementary file 2), thus evoking the widening of hips and thighs.

721 Following this line of reasoning, it may be that the initial carving of the pubic slots  
722 revealed the hydraulic potential of the panel: enhancing it was attempted by gradually  
723 deepening the slots, perhaps when successive wetting events occurred. Thus, optimization of  
724 the hydraulic system was probably made through successive adjustments, in conjunction with  
725 enhancement of the sexual representation, in the manner of an interaction between graphic  
726 and functional layout. With this in mind, the intervention by percussion on pelvic slot P3 after  
727 it had been grooved could make sense as a plausible hydrological 'retouching'.

728 We have pointed out the importance of the fractures at the bottom of basin B1 in terms  
729 of facilitating saturation of the pubic triangle panel by water. The efficiency of saturation of  
730 the panel depended greatly on the flow rate through these fractures and therefore on the state  
731 of the bottom of the basin. It is possible that this was also controlled by gouging open  
732 fractures F8 and F9. The configuration of the upper basin B1, in terms of deepening it and  
733 constructing the spillway, is therefore understandable in the context of organizing the whole

734 space and water resources around the feminine sexual representation. The changes were  
735 probably made gradually according to changes in the physical appearance of the panel.

736 The motive for lowering the fill level in basin B1 by flaking out sandstone at the top  
737 of fracture F2 is not clear. This may effectively reduce its ability to regulate infiltration  
738 towards the pelvic panel. On the other hand, providing water to the base of the pelvic panel  
739 almost surely promoted and accelerated its saturation there. This could have been a subtle  
740 regulation of panel saturation by using excess water rather than allowing it to drain into basin  
741 2 and then flow out of the shelter.

### 742 **7.3 How far modifications were intended?**

743 Comments made above about the interactions among the different adjustments and  
744 modifications and their succession led us to suggest that the entire installation was probably  
745 implemented gradually, in steps, based on observations and experience. Otherwise,  
746 unrestrained interventions could have completely unbalanced the system and deflected  
747 infiltrating waters to the rear of the panel. While the hydraulic mechanisms seem at first  
748 glance to be complex, ongoing water gathering experience, observation of water flows  
749 interacting with regional sandstones, and familiarity with the shelter and its environment,  
750 could well have sharpened the intuition and understanding of those who were responsible for  
751 it.

752 Finally, our analyses and experiments lead to the hypothesis that Palaeolithic people  
753 could potentially have operated the ‘vulvar outflow’ on demand and without weather  
754 constraints. Water supply was not a problem since the shelter is less than 500 m from the  
755 valley of the Ecole River which was a marsh before its drainage in historical times. Once the  
756 flow rates of the fractures had been adjusted so that water exuded from the panel and the  
757 vulvar fountain flowed, the system could be tested to determine the time needed to reach  
758 saturation and from there the event could have been staged in a reliable way as part of some  
759 presently unknown symbolic or cultural occasion.

### 760 **8 Ségognole 3: a new perception of palaeolithic rock art**

761 With the identification of the hydraulic anthropogenic modifications, our perception of  
762 the thematic characterising the shelter is largely renewed. The analysis of the fittings changed  
763 the pubic triangle of Ségognole 3 shelter from a pre-existing and evocative natural relief,  
764 featured in three dimensions, to a complex and functional installation including the fourth  
765 dimension of moistening and flowing cycles, for which morphological and hydraulic  
766 resources have been exploited. The vulva occupies a central place in the panel and our study  
767 highlights that major fittings have a role to stage and enhance it. The horses, which were

768 initially considered the main subject of Ségognole 3 shelter, may have been engraved to  
769 enhance it as well. In this hypothesis it is noteworthy that the horses seem to be sized in order  
770 to be closely related to the pubic triangle, both in dimensions and symmetry, subordinating  
771 them directly to this vivid feminine sexual representation in a meaningful symbolic  
772 association.

773         We know that in many other cases, Palaeolithic artists have interacted with the walls  
774 in both caves and rock shelters. They have sometime been inspired by the morphologies of the  
775 location but did not modify them deeply very often. In particular, Upper Palaeolithic sites  
776 exhibit female sexual representations that have been revealed or enhanced onto morphological  
777 elements of the rock (Bourillon, 2009). These sexual representations are very variable in size,  
778 sometimes engraved, often simply suggested by a slight reshaping of a natural slot and in  
779 some cases enhanced by the application of red pigment that adds a symbolic load. In contrast,  
780 the voluntary staging of the parietal composition of Ségognole 3 shelter reached proportions  
781 unprecedented in Palaeolithic art and reveals a new and original aspect of the behaviour of  
782 Palaeolithic artists. The probable anthropic activation of the panel may also be one of the few  
783 testimonies of plausible staged ritual practices in rock art sites.

784         In addition, some Palaeolithic caves show parietal arrangements that also integrate  
785 water into their layout. Although it seems disconnected from the parietal figures, a hydraulic  
786 arrangement is known in the Galerie du Cierge from the Grotte Chauvet (Pont-d'Arc, 07)  
787 where two collapsed blocks have been rotated and sealed by clay in order to create basins  
788 whose meaning remains to be defined (Ministry of Culture, 2015). In general, water is  
789 obviously present in karst environments, and some sites have highlighted possible links  
790 between water flows and paintings, especially in the Quercy region. Thereby, in Pech Merle,  
791 the location of some panels is related to underground resurgences like the “pearl waterfall”  
792 that flows over the panel of the “women-bison” (Lorblanchet, 2010), while in the cave of the  
793 Moulin, two bison are on either side of a crack which overhangs an orifice on the ground  
794 where passes a stream towards which they lean. In Pergouset cave, a long narrow gallery ends  
795 with the carving of a large fish gleaming of moisture and from whose mouth flows a spring  
796 (Lorblanchet, 2001, 2010). All those examples show that Palaeolithic artists occasionally  
797 included water flows in their works but never in a way comparable to Ségognole 3 shelter.

798         The feminine thematic finds in Ségognole 3 shelter a central expression around a  
799 pelvic triangle powerfully staged by a real “installation”. From a more general point of view,  
800 the hydrological arrangement of Ségognole 3, with the effort that was granted to its  
801 realization, testifies to an unprecedented behaviour. This should lead to special attention being  
802 paid to clues of anthropogenic modifications leading to recognition of possibly staged  
803 installations in Palaeolithic caves or shelters.

804

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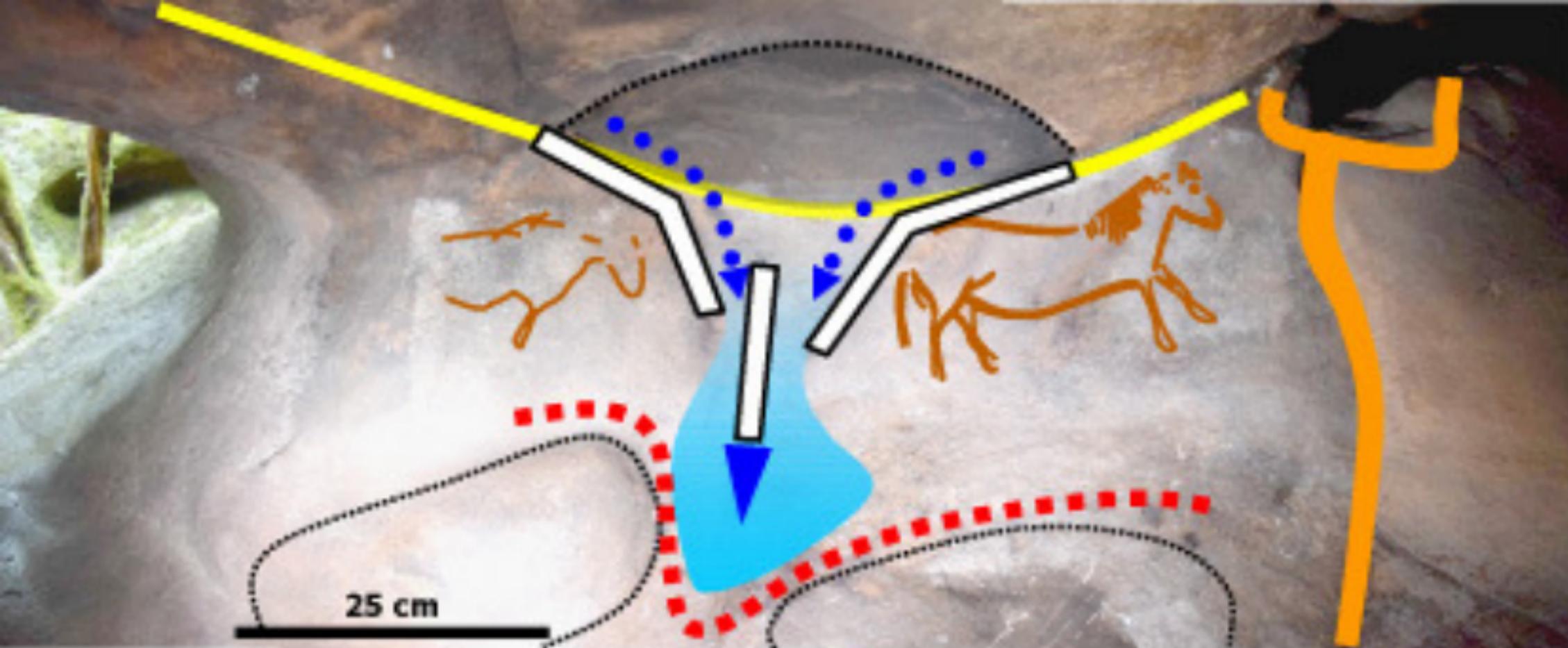
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25 cm

— natural fracture     fitted feature    ••• water percolation    ▶ outflow