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The one-million-year-old quartz assemblage from Pont-de-Lavaud (Centre, France) in the European context

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Abstract

The Pont-de-Lavaud site, located in the Centre of France (Creuse Valley), yielded a quartz lithic assemblage composed of a few hundred artefacts with cores, pebble tools, flakes and flake-tools, mixed with several thousand debris and pebbles. The archeological site is covered by a fossil fluvial deposit from the Creuse River (sheet I, with a relative altitude of +90 / 105 m), dated by ESR at the site itself to around 1 Ma.

We will focus in this paper on the lithic assemblage with clear anthropogenic features in order to describe the technological strategies applied to quartz pebbles, with the help of experiments. The core technology is based on short "chaînes opératoires" on local quartz aimed at producing pointed end-products on pebbles and flakes. The methods and techniques include both the bipolar technique on an anvil and direct percussion with a hard hammer. The reduction sequences were strongly conditioned by the morphology and the physical characteristics of the raw material. Few flakes are retouched.

The Pont-de-Lavaud lithic assemblage is one example of the diversity of the 1 Ma European industries. The assemblage shows techno-cultural behavioral variability at this period and adaptation to raw material constraints. Comparisons with series where the use of quartz is widespread demonstrate the ability of hominins to use stones of varying quality and to adapt technology to the raw material in zones located beyond the 45° North parallel.

Key-words: Lower Pleistocene, core-and-flake assemblage (Mode 1-type), proto-biface, artefacts, quartz, France, Pont-de-Lavaud

Introduction

Western Europe is considered to have been occupied before 1 Ma. *Homo antecessor* occupied the South of Europe, continuously or discontinuously, with several dispersals over time. The North, beyond the 45th parallel, would have been episodically occupied when climatic conditions were favorable (Carbonell et al., 2008, 2010; Carrion et al., 2011; Cuenca-Bescos et al., 2011; Mosquera et al., 2013; Rodriguez-Gomes et al., 2014). This could have led to the isolation of small hominin groups and interrupted source dynamics from the South when environmental conditions were unfavorable.

Among these groups, the use of quartz is rare due to the diversity of available raw materials. Early sites, with predominant or secondary use of quartz, are much more frequent in Africa, where they are either located in areas poor in other raw materials or are evidence of a selection by hominins of this stone (Omo

1 Valley in Kenya, Olduvai Gorge in Tanzania and Fejej site in Ethiopia for instance, Leakey, 1971; Torre and
2 Mora, 2005; Diez-Martin et al., 2009; Barsky et al., 2011; Delagnes et al., 2011; Gurtov and Eren, 2014;
3 Sánchez-Yustos et al., 2016).
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8 A brief overview of the current data attests that hominins present in the South Caucasus, Georgia, at
9 Dmanisi (1.8 Ma), used diverse local stones, with the occasional use of quartz. It was the same along the
10 Azov Sea at Bogatyri and Rodniki (1.6 to 1.1 Ma), and several sites in Dagestan and Tajikistan (dated to
11 more than 1 Ma) (Martinez-Navarro et al., 1997; Mithen and Reed, 2002; Lordkipanidze et al., 2007;
12 Messenger et al., 2011; Shchenlinsky et al., 2008, 2010). Georgian and Russian artefacts (Mgeladze et al.,
13 2011,) are technologically similar to artefacts from East Africa dated to more than 2 Ma (for instance, series
14 such as Kada Gona or Lokalelei, Semaw et al., 1997; Delagnes and Roche, 2005).
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19 In the southern part of Europe, several sites discovered over the past decades attest to the presence of
20 hominins during the Early Pleistocene (Fig. 1) and again to the use of varied local raw materials, including
21 quartz (mainly flint, limestone, sandstone, quartz and quartzite): Pirro-Nord (1.6-1.3 Ma) and Monte-
22 Poggiolo (900 ka) in Italy, Fuente Nueva 3 (1.4-1.2 Ma), Barranco Leon (1.3-1.2 Ma) and Sima del Elefante
23 and the lower levels of Gran Dolina (1.4-0.8 Ma) at Atapuerca in Spain and Le Vallonnet (900 ka) in France
24 (Lumley de et al., 1988; Martinez-Navarro et al., 1997; Peretto et al., 1998; Falguères et al., 1999, 2002;
25 Falguères, 2003; Arzarello et al., 2006, 2015; Lombera-Hermida de et al., 2016; Michel et al., 2017). These
26 assemblages and related technical behaviors last until 800 ka (Gran Dolina TD3/4 and TD6 and Vallparadis,
27 900 ka; Carbonell et al., 1999, 2008; Martinez et al., 2014).
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35 **Figure 1.**

36 In the northernmost part of Europe, assemblages also exist as early as 900 ka, mostly on siliceous rocks but
37 also occasionally on other stones: Happisburgh 3 (900 ka) and Pakefield (700 ka) in Great-Britain, Soleilhac
38 (900 ka?) and Lunery (1.1 Ma) in the Centre of France near Pont-de-Lavaud, and Kärlich A (900 ka) in
39 Germany, for instance (Bonifay et al., 1976; Bosinski et al., 1980; Würges, 1984;; Bosinski, 2006; Despriée et
40 al., 2006, 2010; Parfitt et al., 2005, 2010). The dating and paleoenvironmental data of these sites confirm
41 that hominins used the main locally available raw materials during favorable climatic phases (see the
42 English sites of Pakefield and Happisburgh; Parfitt et al., 2005, 2010, for instance or MacDonald et al.,
43 2012).
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50 The regional alluvial deposits and the sandy deposits sampled at the site of Pont-de-Lavaud were dated by
51 ESR. The results give an age of around 1 Ma for the fluvial formation overlying the site (Bahain et al., 2007;
52 Voinchet et al., 2010). Located in France beyond the 45° North parallel, it may be considered as additional
53 data for describing behaviors in an area situated between the South and North, beyond the 45th parallel,
54 and occupied during a temperate period (Marquer et al., 2011; Messenger et al., 2011).
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1 The lithic assemblage is a core-and-flake-type series and the study contributes to better describing
2 technological behaviors in Europe around 1 Ma and the abilities of European hominins to manage quartz,
3 considered as a poor-quality raw material. The Pont-de-Lavaud lithic assemblage stands out from most of
4 the other European sites in that the predominant raw materials are quartz pebbles and vein quartz blocks.
5 The lithic assemblages attest to the diversity of raw material choices, the flexibility of hominin technical
6 behaviors in Europe around 1 Ma and allow for a discussion of the degree of constraints imposed by the
7 exploited raw materials. This paper focuses on the first general study of the artefacts on quartz pebbles
8 from Pont-de-Lavaud with clear anthropogenic activities in order to reconstruct the *chaînes opératoires* on
9 this type of material in their chronological and stratigraphic context.
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18 **Geographic and geological background**

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20 The Pont-de-Lavaud site is located on the right slope of the Creuse Valley, on the commune of Eguzon-
21 Chantôme (Indre, center of France). Jackie Despriée discovered the site in 1982 during geological field
22 surveys and studies on the northern boundary of the Massif Central on the Aigurande Plateau. In this area,
23 the Creuse River, a tributary of the Loire River, flows through metamorphic and magmatic formations (Fig.
24 2A). The Pont-de-Lavaud site is located on the western slope of one interfluve between the Creuse Valley
25 and a small tributary (Fig.2B). The river flows along deep grabens because the Aigurande Plateau is a
26 tectonic area in which major faults and anticlines formed many tilted blocks. The Pont-de-Lavaud site is
27 located on the top of a block recently tilted to the west (Despriée and Gageonnet, 2003; Despriée et al.,
28 2006).
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35 During geological fieldwork, test pits revealed remnants of the alluvial formation Sheet 1 on the Fressignes
36 interfluve (Fig. 2B). Excavations were carried out on the top interfluve in the hamlet of Fressignes, revealing
37 a thickness of about 1.50 m.
38

39 On the western slope, at Pont-de-Lavaud, along a one-hundred-meter cross-section, remnants of Sheet 1
40 were also observed, overlying a diamicton deposited on the micaschist bedrock. Some fresh broken quartz
41 pebbles, abundant fresh quartz debris and one flake presenting signs of knapping and possible retouch,
42 were recovered *in situ*. These artefacts were mixed in a thin layer of quartz pebbles overlying the top of the
43 diamicton (Despriée and Gageonnet, 2003).
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49 **Figure 2.**

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52 At Pont-de-Lavaud, excavations were conducted over a period of twelve years (from 1984 to 1995). The
53 archaeological level stratified on a thin layer of quartz pebbles deposited on the top of diamicton and under
54 a fluvial sandy deposit was studied over a surface of one hundred and thirty square meters. This level
55 yielded abundant quartz lithic elements composed of about 8,000 broken cobbles, debris, and cores and
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1 flakes (whole pebbles not included). These artefacts were lying on and around two accumulations of large
2 vein quartz blocks and cobbles, interpreted as anthropogenic pavements (Despriée et al., 2006, 2010,
3 2011).
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8 **Stratigraphy of the Pont-de-Lavaud Site**

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10 Multidisciplinary research at the site and the geological background enable us to propose five successive
11 chronological phases of sedimentary formation at Pont-de-Lavaud in response to glacial-interglacial phases
12 (stages A to E, Fig.3):
13

14 A - Micaschists with veins of quartz and amphibolite (bedrock, unit 0), incised by the Creuse River.
15 Micaschists were then weathered in places into clayey alterites (Unit 1, Fig. 3A).
16

17 B - A coarse slope deposit, extending over a surface of about 200 m², overlaid part of this bedrock
18 (diamicton, unit 2, Fig. 3B). It contained various types of very altered rocks (amphibolite, gneiss,
19 micaschists) and weathered quartz mixed in a very clayey, gravelly and coarse sandy matrix. These
20 materials were transported by solifluction from the plateau and reworked former fluvial sediments
21 (Despriée and Gageonnet, 2003). This shape and the frontal edge of this deposit were similar to terminal
22 lobes of debris flow (Cojan and Renard, 2006).
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28 **Figure 3.**

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31 C - The diamicton was then disturbed by periglacial features, like clay injections (diapirs) and stone clusters
32 during freeze/thaw cycles during a Pleniglacial phase (Fig. 3C). The micaschist bedrock was also severely
33 cryoturbated, as attested by polygons and ice wedges. The regular circular and polygonal shapes indicate
34 that cryoturbation occurred at the top of a horizontal faulted block (Despriée and Gageonnet, 2003).
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39 D – At the beginning of the following interglacial, a thin alluvial layer of well-calibrated pebbles (4-6 cm)
40 was deposited by the Creuse River and covered the bottom of the diamicton (Despriée and Gageonnet,
41 2003). Hominins gathered quartz pebbles and cobbles in this layer for breaking and may possibly have
42 carried blocks for pavements. The part of the archaeological level identified during excavation extends both
43 over the micaschist bedrock (south area), and on this pebble layer (northern area) (Fig. 3D). According to
44 palaeobotanical studies, hominins settled in a forested context during a hot and wet temperate interglacial
45 period of the Early Pleistocene (Marquer et al., 2011; Messager et al., 2011)
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50 E - The archaeological level was covered by fluvial sands (unit 3, Fig. 3E) of the Pont-de-Lavaud/le Cerisier-
51 Formation (sheet I of the Creuse system, Fig. 4). These alluvia protected the archaeological level from
52 erosion during most of the Pleistocene (Despriée and Gageonnet, 2003; Despriée et al., 2004, 2006).
53
54

55 F - After Pleistocene tectonic events (fault displacement and thrust, and the recent tilting of the Pont-de-
56 Lavaud block (Holocene), the sandy sheet was then eroded and the site is now largely exposed (Fig. 3F)
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(Despriée and Gageonnet, 2003). Fortunately, no heavy farm machinery was ever used on the site. The meadow was cultivated in the past with ox and a wooden swing-plough, and furrows were observed at a depth of around 10 cm}.

Geochronological data

In the Eguzon area, the Creuse River fluvial system is made up of 11 fossil fluvial formations stepped on the two slopes and named from the lowest to the highest A to K. All the sheets and remnants are dated by the ESR method applied on bleached fluvial quartz. The ages range between 130 ka (sheet A, 0 / + 5 m and 1.7 Ma (sheet K, +115- + 130 m rel. (Voinchet et al., 2007, 2010) (Fig. 4).

In the Eguzon area, many remnants or outliers of the fossil fluvial sheet I are located over about 15 km along the slopes of the Creuse Valley. Thirteen ESR dates on quartz sands sampled in the best-preserved remnants provided coherent results with good reproducibility. Hence, the ESR ages of Sheet I, covering the Pont-de Lavaud archaeological layer, are scattered between 1.2 and 1.1 Ma (Falguères et al., 2002; Falguères, 2003; Despriée and Gageonnet, 2003; Despriée et al, 2004, 2006, 2010; Voinchet et al., 2007). The best ESR weighted mean age estimate of the sandy fluvial deposits from the Pont-de-Lavaud/le Cerisier formation is presently $1,055 \pm 55$ ka (Lombera –Hermida et al., 2016).

Figure 4.

Eight ESR samples were taken directly from the Pont-de-Lavaud site. Three of them were sampled in a thick sandy lens in the diamicton underlying the archaeological level. The ages obtained are 964 ± 100 ka, 1031 ± 150 ka and 1054 ± 100 ka respectively (Fig. 3, F, samples 1). Three other samples were taken in the fluvial deposits overlying the archaeological level. The results are 905 ± 100 ka, 1001 ± 150 ka and 977 ± 100 ka respectively (Fig. 4, F, samples 2). One sandy sample from the archaeological layer, at the same level as the palaeobotanical samples, was dated to 960 ± 60 ka (Fig. 3, F, sample 3) (Voinchet, 2002; Despriée et al., 2004; Voinchet et al., 2010 . Lastly, an age of 220 ± 40 ka obtained on a sample taken in the sandy deposit close to the diamicton termination is absurd (Fig. 3, F, sample 4, Garon, 2014)

The ages obtained from sands sampled at the site of Pont-de-Lavaud are slightly younger than the ages obtained for the sands sampled in Sheet I. This was interpreted as a consequence of the important weathering of the sediments (Despriée and Gageonnet, 2003). For the samples taken from the archaeological level and in the underlying alterite, geomagnetic polarity is normal and could correspond to the normal Jaramillo subchron (1,06 to 0,9 Ma, Cande and Kent, 1995), during the Matuyama Chron reversal.

1 These ESR and paleobotanical data enable us to propose a record of the early glacial, pleniglacial and
2 interglacial deposits at Pont-de-Lavaud. The short gap between the ESR ages should indicate that these
3 levels were deposited during the same glacial/interglacial climatic cycle.

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6 These ESR dates and vegetation suggest that the Pont-de-Lavaud site is related to an Early Pleistocene
7 temperate period around MIS 31 (Liesiecki and Raymo, 2005).
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10 11 **Quartz assemblages**

12
13 At Pont-de-Lavaud, excavations and geological observations were conducted over a surface of 130 m², in
14 order to recover quartz elements resulting from anthropogenic actions, to locate the stratigraphic position
15 of the artefacts, record the precise location of each piece and characterize their deposition mode and
16 distribution.
17

18
19 Excavations concerned the southern surface of the micaschist bedrock, the layer of pebbles (130 m²) (Fig.
20 5), then the diamicton itself (50 m²) and below that, the surface of the bedrock (30 m²). In this way, each
21 quartz item was collected with zenithal and plane square meter view photos or planes (scale=1/10), then
22 described in the laboratory.
23

24
25 In order to locate the original deposits of quartz present in the different sedimentary units at Pont-de-
26 Lavaud, fieldwork observations were conducted on the Aigurande Plateau and Marche area, (Fig 2A) with
27 petrological analysis. Extensive experimental work was added to prospection in the neighboring cultivated
28 fields to check whether broken pieces and pieces with scars are artefacts or geofacts, or, because of the
29 limited thickness of the overlaying sand, recent clasts produced by heavy farm machinery.
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35 **Original deposits of quartz materials**

36
37 Around the Pont-de-Lavaud site, the structural units making up the Aigurande Plateau are thrust sheets of
38 metamorphic rocks and intrusive magmatic batholiths. These different units are visible along tectonic
39 accidents, or on the eroded surfaces of the plateaus (Fig.2 A) (Rolin, 1981; Cohen-Jullien et al., 1989, 1998).
40 In the metamorphic units, there are many series of amygdaloid gneiss with numerous almonds (amygdales)
41 of quartz, elongated and flattened by foliation. These ovoid and flat almonds of grey quartz were generally
42 heavily recrystallized during new phases of metamorphism and new thrusting or subsequent magmatic
43 extrusions and have a quartzitic aspect (Chenevoy, 1968; Bouloton, 1974; Rolin, 1981; Rolin and Quenardel,
44 1980; Cohen-Jullien et al., 1989, 1998). In the magmatic units, plutonic batholiths of intrusive leucogranite
45 contain a profusion of vein quartz (Rolin and Quenardel, 1982). This white quartz was also metamorphized
46 and recrystallized and has a metaquartzitic aspect. Despite their hardness, almond or vein quartz included
47 in metamorphic and magmatic units were fractured during subsequent tectonic events.
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54 During Tertiary Periods, after the erosion of the metamorphic or magmatic formations, the quartz elements
55 were carried and spread by high-energy river-flow over the surface of the Aigurande Plateau. The cobbles
56 and blocks observed on the surface of the plateau show whole well-rounded surfaces, and no fractured
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1 surfaces. During the Quaternary Period, the non-porous quartz was not sensitive to frost. In the
2 sedimentary deposits of the Middle Creuse River valley, we found no marks of frost-shattering in
3 cryoturbation features, slope deposits, no cracks, no scars, or joining fragments on the surface.
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8 At Pont-de-Lavaud, almonds of metamorphic quartz and weathered cobbles and boulders of vein quartz are
9 present. In the archaeological level, three groups of quartz objects were initially distinguished (Fig. 5):

10 - A thin layer of small well-calibrated quartz pebbles and cobbles (4-6 cm long) with whole weathered
11 morphology and smooth surfaces (fluvial pebbles and whole quartz almonds (Despriée and Gageonnet,
12 2003). The layer was deposited at the beginning of phase D and was spread on the bedrock (northern area),
13 on alterites (eastern area), on the bottom of the diamicton (central area), and on sands (southern area)
14 (Fig.3d);
15
16

17 - Underlying this pebble layer were many big cobbles and weathered vein quartz boulders aggregated on
18 two coherent surfaces named Pont-de-Lavaud 1 and Pont-de-Lavaud 2 (Suppl 1 and 2A and B, Fig. 5).
19

20 These two regular ovoid surfaces are about 9 m long and 3.5 m wide. The shape of these two similar
21 accumulations is very different from the circular or polygonal shapes of the periglacial features observed in
22 the diamicton. The large cobbles (> 10 cm wide) and boulders are aligned on the perimeter. We observed
23 an accumulation of artefacts and debris quartz on these perimeters (type wall-effect). Holes filled with
24 beige sand from the overlying fluvial formation were associated with wedging cobbles (type post-holes).
25 We advanced the hypothesis of a primitive shelter (Despriée et al, 2011).
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33 **Suppl. 1.**

34 **Suppl. 2A**

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36 - As scars due to human breaking were not visible straightaway, all the quartz elements were recorded on
37 the excavation surface. In the laboratory, each piece was sorted and the following characteristics were
38 described: raw material, type of clastic element, shape and size, mechanical or chemical weathering, or
39 anthropogenic marks. More than 8,000 freshly fractured quartz elements were found, mixed in with the
40 pebble layer and between the cobbles and boulders of Pont-de-Lavaud 1 and 2. All in all, 4,800 presumed
41 anthropogenic broken cobbles, pebble fragments, pebble debris, and flakes from cobbles were identified.
42 Rare cores were also recorded. 3,500 pieces of fresh local vein quartz were also densely distributed on and
43 around Pavement 1, and more sparsely spread in and around Pavement 2.
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52 However, since the different types of metamorphic quartz are very hard, hominins would have had to break
53 them on site, as suggested by the recorded anvils, passive hammer and hammer stones (Fig. 5). So, typical
54 marks should be observable on the products, as described on similar sites or after experimentations
55 (Crabtree 1972; Shott, 1989; Leakey and Roe, 1994; Curtoni, 1996; Mourre, 1996; Mourre and Jarry, 2004).
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1 They have clear anthropogenic scars or strong percussion impact marks, described as anvils, passive
2 hammers, and hammer-stones, broken pebbles with one or several angular fresh surfaces, fresh edges with
3 scars looking like impacts, with cracks and some retouch, fragments and debris, pebbles with organized
4 removals (considered as cores) and flakes.
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8 Studies of the fresh vein quartz elements are in progress. In this paper, we present the experiments and
9 studies of the broken pebbles.
10

11 12 **Figure 5.**

13 14 15 **Quartz Industry**

16 The pebble layer thus provided a source of pebbles and cobbles that could be used by hominins. As
17 observed (see above) on the surface of this layer, apart from the blocks grouped together in oval surfaces,
18 the mean length of the cobbles is between 40 and 60 mm and the mean width and thickness are about 40
19 mm Fig. 6).
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26 **Figure 6.**

27 The 4,800 presumed broken cobbles were classified into four categories:

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29 1) The first category comprises almonds, well-rolled or weathered pebbles, cobbles, and quartz blocks, with
30 smooth surfaces and edges. These morphologies and weathering are typical features of high-powered and
31 long-distance fluvial Tertiary transport, as described above. They have no fresh scars, impacts or acute
32 angles. Some of them, with an orthogonal flat surface, broken by tectonic events before fluvial transport,
33 also bear such weathered fractured surfaces that the crystal surfaces are no longer visible (types 1 and 2,
34 Fig. 7).
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40 **Figure 7.**

41
42 2) The second is composed of the same cobbles and pebbles with impact points and scars that seem to be
43 due to crushing, peeling or flaking (hammers?). All the scars are very fresh, with no signs of weathering, but
44 with local alterite clay and very thin iron deposits on the damaged surfaces (types 3 and 4, Fig. 7).
45
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47 3) The third class comprises broken cobbles and pebbles with plane, salient or re-entrant angles. Breaking
48 surfaces are fresh with apparent crystallization and angular edges. These pieces have partially preserved
49 the morphology of the original quartz materials (types 5 and 6, Fig. 7).
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52 4) Fragments of cobbles and pebbles, which generally have three surfaces with dihedral angles: a well-
53 rounded surface and two freshly broken surfaces intersecting at acute or right angles. The surfaces are
54 generally plane, but not smooth, with visible fine aggregation of small crystals. Older and more recent
55 surfaces are intersected by two trihedral ends. These ends display visible crushing, associated with cracks
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1 and small negative debris. Other impact marks are also visible on other parts of the perimeter, generally on
2 the opposite edge, linked to the main scar by one or two ridges (types 7a, b, c and d, Fig. 7). Generally,
3 similar scars are observed on these pieces: one or more circular impacts ($\varnothing = 2$ mm) on the edge of the
4 natural smooth surface and the more recently broken surface. Numerous shocks or impacts are often
5 visible on the opposite surfaces. These impacts are associated with other scars such as cracks, small breaks,
6 ridges or rises.
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12 In order to verify if these broken pieces and pieces with fresh scars are artefacts or geofacts, or recent
13 clasts produced by heavy farm machinery, given the limited thickness of the overlaying sand, extensive
14 fieldwork observations in addition to experimental works, were conducted.
15

16 Natural processes and marks, clearly resulting from transportation by rivers, solifluction or gelifluction and
17 frost clasticity, are well known and helped us to distinguish marks due to natural or anthropogenic
18 processes. ~~Natural pieces may be very similar to artefacts~~ and researchers have clearly described common
19 geofact features, such as thin removals related to the natural shape of the stones but also the lack of clear
20 percussion points or striking platforms (Commont, 1909, Obermaier, 1912, Pei, 1936, Raynal et al., 1995,
21 1996; Raynal and Magoga, 2000; Niang, 2014; Wisniewsky et al., 2014).
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28 At Pont-de-Lavaud, the remetamorphised quartz is very hard and cannot be broken by transportation
29 (energy river-flow). The cobbles and blocks show completely well-rounded surfaces. When resiliified, they
30 are not porous and are not sensitive to frost. We found no evidence of frost-shattering, such as cracks,
31 scars, or joining fragments in the cryoturbated diamicton, or on its surface, or in the layer of small cobbles
32 and almonds where hominins gathered the raw material.
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37 These truncated cobbles, fragments or cobble debris with unweathered surfaces and angular edges, as well
38 as the blocks of quartz with impacts on their surface edges, suggest that the very hard metamorphic quartz
39 pebbles may have been broken by hominins. So, experiments breaking of quartz were requisite and
40 essential to characterize evidences of anthropogenic processes.
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46 **Breaking experiments**

47 First, breaking experiments were tested, using direct percussion with quartz hammer. We could not
48 obtained flakes or debris because of the hardness of quartz almonds. So, we experiments with anvils with
49 quartz hammers as those that were discovered in situ during excavation (Fig. 5).
50

51 1) Tests on anvils

52
53 Several blocks of vein quartz were used as anvils. Three of them display similar dimensions to those found
54 at the excavation. One hundred quartz pebbles were broken on these anvils using a quartz hammer stone,
55 also gathered on site.
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1 During experimentation, we observed a white powder deposit on the surface of the anvil. This powder
2 results from the crushing of the quartz surfaces when impacted by the hammer stone and from points of
3 contact with the surface of the anvil on the other side. These crushing scars are clearly visible on the
4 broken pebbles and fragments (Fig. 8).
5
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7
8 Hammer impacts with the upper surface of the anvil are quite rare but they produce typical impacts. These
9 only occur when a stone or fragment slips. After use, some strikers only bear characteristic crushing. Others
10 have a broken tip after prolonged use. Some split quickly due to mica planes in the almond quartz.
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12

13 **Figure 8.**

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16 For the experimentations, we used the same type of quartz and reproduced similar marks to those
17 described at similar sites (Crabtree, 1972; Shott, 1989; Leakey and Roe, 1994; Curtoni, 1996; Mourre and
18 Jarry, 2004; Barsky et al., 2015; Hayden, 2015; Li, 2016, Torre and Hirata, 2015; Li Feng , 2016 Rodríguez-
19 Álvarez, 2016; Li Hao et al., 2017). Geological data indicate that the pebble layer was a possible source of
20 raw material for hominins. The mean length of the pebble layer cobbles is comprised between 40 and 60
21 mm and the mean width and thickness are about 40 mm (Fig. 6). They are well rounded (Fig 8). The
22 different types of available metamorphic quartz are very hard. Since pebbles with clear impact marks were
23 recorded on the site, we considered that hominins could have broken pebbles and cobbles directly on the
24 site (Fig. 5). As these marks were not immediately visible during the excavation, all the quartz pieces from
25 the layer were recorded in the laboratory, and each piece was described on the basis of the following
26 criteria: raw material type, type of clastic element, shape and size, mechanical or chemical weathering and
27 possible marks.
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37 Experimentation was conducted with local raw materials in order to reproduce the same marks as the
38 recurrent marks observed in the second, third and the fourth classes and compare them. We used similar
39 cobbles and pebbles to those with strong impact marks (described as anvils and hammer stones) found
40 during the excavation. The experiments lasted for 20 years and increased in intensity over the past five
41 years (Lombera-Hermida et al., 2016). They involved between two and 10 specialists with diverse expertise.
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46 **2) The breaking tests**

47
48 More than 1,000 cobbles chosen for the experiment were gathered according to the dimensions and quartz
49 types recorded in statistical studies. Some of them were impossible to break (3%) because they were
50 remetamorphized and lateritized and thus too hard to fracture. The others were broken by the first, second
51 or third blow. When they break at the first blow, they break anywhere, depending on the contact zone with
52 the surface of the anvil. Two fragments of unequal size were generally obtained (Fig. 9, types 5 and 7a).
53 However, cobbles can also be broken into three parts (Fig. 9, types 5, 6 and 7c -7d). Breakage occurs when
54 the shock wave reverberates through each point of contact with the surface of the anvil. It is not conchoidal
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1 breaking. Due to the very hard recrystallized quartz grains, the shock wave follows the facets of the small
2 crystals. The freshly ruptured surfaces are generally orthogonal to the smooth surface struck by the
3 hammer stone, they intersect at right angles and do not bear cutting edges. Other cobbles were broken
4 after several blows, resulting in the production of smaller and sharper debris owing to the presence of
5 multiple cracks opening during the last blow (Fig. 9, types 5, 7 and 8).

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9 Some marks are systematically observed: (1) One or more circular impacts (2 mm) with a dent in the quartz
10 rock (1 mm), on the upper surface, (2) On the edge of the broken surfaces, these impacts are associated
11 with cracks, breaks and elevations connecting hammer impacts and crushing on the opposite side, (3) For
12 one blow to the upper surface, one or more scars are visible on the opposite surface, depending on contact
13 with the anvil surface, and (4) All these scars are similar to the marks observed on the presumed
14 anthropogenic artefacts recorded in the pebble layer.
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20 **Figure 9.**

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23 Experimentation obtained similar morphologies and typical scars, such as impacts, crushing, and fresh
24 broken pebble surfaces (Supp. 3). Fragments and debris are consistent with the fragments and debris
25 recorded during the excavation (see Fig. 10). Impact marks on the hammer stones and anvils are also
26 similar and provide evidence of fragmentation of human origin. The numerous impacts on the anvils
27 discovered on the site suggest more prolonged use than during experimentation, accounting for the
28 discovery of the large number of fragments or debris.
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34 As demonstrated by the experiments, **conchoidal fractures** do not occur on this type of quartz and cannot
35 be taken as a criterion of hominin intervention. When quartz is broken, there is neither a bulb on the
36 artefacts nor bulb negatives on the block. The wave moves linearly and the scar negative has a slightly
37 curved profile and section. The petrographic history and characteristics of the Pont-de-Lavaud quartz
38 demonstrate that natural processes could not have fractured these rocks. No breakage at Pont-de-Lavaud
39 corresponds to the action of long depositional processes on natural materials, described for instance by De
40 la Torre and Mora (2005) in some African sites. Our series incorporates by-products and end-products
41 resulting from percussion flaking on quartz. Our experiments therefore show that part of the quartz
42 artefacts are due to anthropogenic action and are not geofacts.
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49 **Supp. 3.**

50 51 **The anthropogenic record. Fragments of pebbles, debris, cores, flakes and** 52 **retouched pieces.** 53

54
55 We present here the results on 1,321 pieces made on rolled or used pebbles and cobbles. They were
56 selected on the basis of their marks with regard to the experiments, and systematically analyzed in detail
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1 (Table 1). We will not presently discuss the assemblage composed of vein quartz, which is still being
2 studied, on account of the difficulties inherent to the interpretation of this kind of raw material.
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6 The series is composed of: (1) Fragments and pebble debris with percussion marks and with marks
7 considered to be by-products of percussion flaking, (2) Pieces with several organized removals considered
8 as cores (with striking platforms and scars) or pebble tools, (3) Unretouched flakes, and (4) Flakes or debris
9 with retouch (Table 1).
10
11

12 The spatial distribution of the different categories does not show any particular organization. This could be
13 explained by the accumulation of several periods of occupation and/or by the dense activity at the site. Few
14 pieces have been refitted due to the large quantity of fragments and debris. Most of the refits come from
15 the same square. The only types of pieces that seem to be associated with the two concentrations of
16 artefacts are the retouched blanks and the partial bifacial piece that were found in these zones (Fig. 5).
17 Eight squares are also characterized by the absence of lithic material. This is not due to the presence of
18 blocks and these zones are considered to be true negative areas.
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25 **Figure 10.**

26 **Modes of percussion and processes performed on the site**

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31 As a result of the experiments, we can assume that two techniques of percussion are documented in the
32 assemblage: direct hard hammer percussion or bipolar percussion on an anvil, depending on pebble
33 morphology (Table 1, Fig. 11). Cores with organized removals and flakes with a striking platform indicate
34 that direct hard hammer percussion was performed at the site.
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39 **Figure 11.**

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41 The bipolar percussion technique is observed on half pebbles through the identification of one or two
42 opposite butts and the presence of trimming or marginal retouch on the extremity of the half pebbles. It
43 was used during knapping depending on the quartz structure and the pebble shape. The pebble was struck
44 on the anvil with a hammer stone (see Vergès and Ollé, 2011). There is no bulb due to the physical
45 characteristics of the raw material, and it is often difficult to distinguish the positive and negative parts of
46 the pebble (two half pebbles at least). The fracture is referred to as a “split fracture”. This type of breakage
47 produces pieces with specific marks; several shattered sides and a polygonal section. These characteristics
48 are frequently cited in the literature (e.g. Cancellieri et al., 2001; Mourre, 1996; Mourre and array, 2004;
49 Faivre et al., 2010; Lombera-Hermida et al., 2011; Garcia et al., 2013; Zaidner, 2013; Gurtov and Eren, 2014;
50 Rodríguez-Álvarez, 2016) and are in keeping with our own experiments (see above) on the same type of
51 quartz.
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Cores and flakes from direct percussion core technology

More than 60 % of the ovoid and polyhedral pebbles/cobbles (between 40 and 110 mm) of our corpus were broken by direct hard hammer percussion (Fig. 12, n°1, 3, 4). This method seems to have been oriented towards the production of flakes (whole or broken).

Three types of cores are documented: (1) unipolar and unifacial cores (or chopper-cores, see below), with scars on the largest pebble surface or on the pebble edge with a cortical or a striking platform created by one removal, a fracture or a cortical surface (Fig. 12, 15A), (2) cores with two orthogonal flaking surfaces and alternate flaking which could be assimilated to the S.S.D.A flaking mode for the latter mode (Ashton et al., 1992; Forestier, 1993) (Fig. 12, n°4, Fig. 13), and (3) cores with centripetal removals (mainly unifacial) (Fig. 14).

Figure 12.

Figure 13.

The *chaîne opératoire* is rather short, both for cobbles and pebbles, generally resulting in the production of two to four flakes (or six at the most), using the unidirectional reduction of one to three orthogonal striking platforms. The results are thick flakes with oval or quadrangular contours, and they almost always bear cortical zones or cortex along one edge with at least one cutting edge (Table 1; Fig. 14, 18, 19 and 20). The reduction phase is longer when direct hard hammer percussion is used, as confirmed by smaller core morphologies (Fig. 15A and 15B). For unipolar/multipolar core technology and centripetal core technology, flakes with and without cortex are included. The graphs show that the dimensions are similar regardless of the core technology applied. The non-cortical flakes have the same average dimensions with lower variability, and are generally smaller than the cortical flakes. This is related to the morphology of the raw material. The core/flake ratio is less than 1 to 2. For ovoid pebbles, the core/flake ratio is almost the same (1.5). For polyhedral pebbles, the ratio is 0.9 and there is a clear deficit of flakes.

Several explanations can be advanced to explain this deficit: (1) Most of the cores did not yield a lot of flakes or (2) Flakes were exported or moved to other areas of the site. The most likely explanations for these short reduction sequences are related to the characteristics of the raw material (the hardness of the raw material is not conducive to the exploitation of blocks of reduced dimensions), and to the final aim of production and raw material availability. As production seems to be very opportunistic and the main aim is to obtain thick flakes with at least one cutting edge, it was not necessary to continue the exploitation of cobbles until the raw material was depleted. Moreover, the presence of abundant raw materials near the site provided hominins with constant pebble availability. This consideration also provides information about the "timing of production": it is possible that knapping was carried out when required and not

1
2 beforehand. If this is the case, production would be restricted to the number of “implements” necessary to
3 perform a specific action.
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8 **Figure 14.**
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11 **Figure 15.**
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13 **Broken pebbles and pointed fragments or flakes from bipolar percussion core technology (split fractures)** 14 15

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17 The bipolar technique is the second most widespread method at the site. 39 % of the ovoid and polyhedral
18 pebbles (40 to 70 mm long) of our corpus were reduced using bipolar percussion, which produced a variety
19 of flakes and debris with a relatively limited range of morphologies (half-pebbles or broken pebbles) (Fig.
20 12).
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22

23
24 Regardless of the type of pebbles used or the reduction method employed, the *chaîne opératoire* is always
25 complete and short:
26

27
28 -When the pebble was struck perpendicularly to its longest axis, as was the case for most of the ovoid
29 pebbles, the resulting product morphology is half-pebbles, typical of split fractures (*i.e.* Mourre and Jarry,
30 2004; Faivre et al., 2010; Boëda and Hou, 2011). These half-pebbles did not, in most cases, undergo further
31 modification.
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35 -Ovoid pebbles or pebbles with a flat transversal section were split in two ways. In the first case, percussion
36 was localized near one of the edges. This results in two products characterized by pointed tips due to the
37 shape of the breakage surfaces (two convergent parts). In the second case, percussion was applied to the
38 middle of the surface, producing three products, which are again all characterized by a pointed tip, defined
39 by the intersection of the breakage surfaces (Fig. 12).
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45 **Heavy-duty tools and flake-tools** 46

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48 Several groups of artefacts provide evidence of retouch or series of short removals in order to create a
49 point or, more rarely, a new cutting edge (Table 1). We have added what we named chopper-cores to this
50 group, which could also be described as pebble tools in some cases.
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55 -Choppers-cores and/or pebble tools:
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1 Some pebbles and cobbles with scars on one surface can be characterized as chopper-cores or pebble tools
2 (Fig. 14). These artefacts have been differentiated from pebbles with a single isolated removal and cores by
3 the cutting edge angle which is less than 70°, while it is more than 80° for the unifacial cores (see Fig.12,
4 13). Two groups were identified:

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6
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8 1) A single cortical surface was used to detach two or three parallel flakes to create a more or less straight
9 edge or a pointed edge. The main difference between this kind of production and unipolar debitage is that
10 the removals produced are thinner and shorter and the resulting cutting edge does not show any
11 denticulation. The removals were organized in order to delimit a continuous cutting edge. This cutting edge
12 is in most cases parallel to the major axis of the cobble (Fig. 12, 13 and 14);

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15 2) A break was used as a striking platform to detach a second flake, thereby creating a pointed tip (Fig. 13
16 for instance).

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21 -Partial bifacial tool:

22 This artefact is unique and consists in partial shaping aimed at creating a convergent tool on a 70 mm long
23 piece (Fig. 16). Both sides of the pebble were shaped by alternate striking. Several series of scars are visible
24 (at least two or three), and the first are more invasive than the final removals on an abrupt edge on one
25 surface creating two asymmetrical cutting edges. The cross-section is plano-convex and removals are less
26 frequent on the flatter surface despite being invasive. Cortical patches remain on the two faces and the
27 selected pebbles seem to have already been asymmetrical (preform). Shaping follows the natural form of
28 the pebble. The distal part is abrupt and could have been broken. Owing to the density and organization of
29 the removals, this artefact cannot be considered as a core or a geofact. It has been considered as a
30 peripheral chopping-tool by the slight convergence of the two edges, perhaps made by additional series of
31 removals, or a partial bifacial tool (genuine Large Cutting Tool).

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39 **Figure 16.**

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41 **Suppl. 4.**

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44 -Flake-tools or retouched debris:

45 A total of 43 retouched flakes and debris were identified among the whole series (Fig. 14, n°7 and Fig. 18,
46 19). Blanks were not selected for retouch because of their size as they are of disparate dimensions, with
47 lengths comprised between 20 and 100 mm, in keeping with the general series of flakes and debris (Fig.
48 18). Also, from a technological point of view, the retouched blanks (composed of 90 % flakes) are not issued
49 from a specific debitage method when this is possible to determine. In all cases, the flakes bear some
50 cortex, generally in a lateral position.

51
52 The aim of the retouch seems to be the slight modification or re-sharpening of the cutting edge. Retouch is
53 marginal or more invasive, from semi-abrupt to abrupt, and we can distinguish a regular retouched edge
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1 (considered as a side-scraper, Fig. 14 n°7) and a denticulated edge (considered as a denticulate, Fig. 14, n°5
2 and Fig. 17, n°4). The retouched zone is generally continuous, situated on the longer edge, and cannot be
3 due to natural crushing owing to its size and regularity, even for the denticulated edge. The retouch is
4 always direct (on the convex face).
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9 **Figure 17.**

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11 **Figure 18.**

12
13 **Figure 19.**

14 15 16 **Discussion**

17 18 19 **Pont-de-Lavaud: short chaînes opératoires by direct percussion and bipolar technology**

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22 The Pont-de-Lavaud lithic assemblage dated to 1.1 Ma is characterized by short *chaînes opératoires* on local
23 quartz aimed at producing half-pebbles, fragments of pebbles and flakes. Bipolar and direct percussion on
24 pebbles produce pointed half-pebbles and pointed pebble fragments, raising questions as to the
25 significance of such quantities of pointed end-products (intentional or accidental). The core technologies
26 and techniques used (direct percussion and the bipolar technique) were heavily influenced by the raw
27 material (morphology and physical characteristics), as quartz is hard to flake using direct percussion, as
28 demonstrated by our experiments and the petrographic characteristics of the quartz used *in situ*. These
29 factors probably account for the high frequency of bipolar reduction on anvils in this assemblage.
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32 It also bears emphasizing that raw material nodules were never very extensively reduced. Quartz was very
33 abundant near the site, either as pebbles/cobbles or vein deposits.
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36 Shaping is a secondary reduction sequence. It is mainly represented by chopper-cores and unifacial pebble
37 tools. Retouched flakes are rare (3.9 %) and, when present, they are mainly lightly retouched side-scrapers,
38 notches or denticulates, always modified on their longest edge. Note also the presence of a single tool with
39 evidence of partial bifacial shaping.
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46 **Common technological behaviors in Europe at around 1 Ma**

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49 From a general point of view, if we compare the technological characteristics of the Pont-de-Lavaud lithic
50 assemblage to other South and North European Early Palaeolithic series dated to around 1 Ma, for instance
51 the artefacts of Sima del Elefante (Rosas et al., 2001; Carbonell and Rodríguez ., 2006; Parés et al., 2006;
52 Lombera-Hermida t al., 2016), Barranco León and Fuente Nueva 3 in Spain (Barsky et al., 2010; Toro-
53 Moyano et al., 2003, 2009), Pirro Nord in Italy (Arzarello et al., 2006, 2010, 2012, 2015), Monte Poggiolo
54 (Peretto et al., 1998; Peretto, 2006) and Le Vallonnet in France (Lumley et al., 1988; Michel et al., 2017), or
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1 Habbisburgh 3 and Pakefield in Great-Britain (Parfitt et al., 2005, 2010), we observe first of all consistent
2 technical behavior characteristic of the earliest lithic skills, and secondly, strategies strongly influenced by
3 raw materials. In all these sites, the raw materials were collected from a secondary position very close to
4 the site.
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8 In all the sites, the main debitage method is (1) "opportunistic", poorly structured, highly influenced by the
9 geometry of the stone and (2) generally associated with some centripetal cores.
10

11 Generally, the reduction sequences are short and raw materials are rarely fully depleted. Percussion is
12 either direct or bipolar. In Sima del Elefante, Pirro Nord, Le Vallonnet and the British sites, bipolar
13 percussion was not used. If we expand our comparison to earlier sites, such as Dmanisi in South Caucasus,
14 dated to 1.8 Ma, providing the earliest evidence of "Out of Africa" expansion, bipolar percussion is not used
15 there either (Mgeladze et al., 2011). This may possibly be related to the reduced number of artefacts for
16 some series but above all to the raw materials, which are siliceous rocks, volcanic rocks or limestone.
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22 The heavy-duty component is present in Pont-de-Lavaud, with chopper-cores and unifacial pebble tools,
23 and in the other sites where flint is not the only raw material used. In Europe, only the Italian sites of Pirro
24 Nord and Cà Belvedere di Monte-Poggiolo do not include a shaping component, probably because flint is
25 the only exploited raw material.
26
27

28 The presence of some retouched products at Pont-de-Lavaud and the sites of Orce and the Italian area is a
29 singular feature. They account for less than 3 % of the lithic assemblage. Retouch is generally located on the
30 longest edge and covers the whole edge.
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35 At 1 Ma, among the earliest European sites, the site of Cà Belvedere di Monte Poggiolo (Peretto et al.,
36 1998; Peretto, 2006; Arzarello and Peretto, 2010) bears the most similarities with Pont-de-Lavaud despite
37 the use of different raw materials, but with a similar initial morphology. Both these sites are located on the
38 raw material deposit and local ovoid pebbles/cobbles were preferentially selected. They were worked by
39 bipolar percussion on an anvil or by direct percussion, regardless of the stone type: flint for Monte Poggiolo
40 and quartz for Pont-de-Lavaud. In both sites the reduction sequences are short and primarily
41 "opportunistic", and unipolar debitage from one or more orthogonal striking platforms is dominant. Once
42 again, raw material morphology is likely to have influenced the presence of retouch and the shaping
43 process in Pont-de-Lavaud, both of which are absent in Cà Belvedere di Monte Poggiolo. The poor cutting
44 qualities of some types of quartz may have required the production or resharpening of thick and strong
45 cutting edges using unifacial or bifacial shaping.
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53 **Common strategies on quartz assemblages at 1 Ma in Europe**

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1 The few European sites using quartz at 1 Ma share common trends with our Pont-de-Lavaud corpus (Table
2 2). At Sima del Elefante (Atapuerca), the earliest hominin activity is documented in TE9 (1.2-1.1 Ma;
3 Carbonell and Rodríguez, 2006), with a small series of Neogene and Cretaceous chert artefacts. Knapping
4 was simple and produced flakes using the unidirectional method. The TD 6 (0.8 Ma) levels yielded quartz
5 assemblages on local raw materials (Lombera-Hermida et al., 2016). In TD6, the largest series indicates the
6 selective use of bipolar percussion on quartz, whereas angular blocks or nodules of chert/flint were flaked
7 differently (using multidirectional, orthogonal and centripetal methods) (Carbonell et al., 1999). Flint flakes
8 are the only retouched pieces.

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14 At Vallparadis (0.8 Ma), 70 % of the artefacts are in quartz and present short reduction sequences, which
15 are either simple or orthogonal, with the use of bipolar percussion (Martinez et al., 2010; Garcia et al.,
16 2012, 2013; Rodríguez-Álvarez, 2016). Note also the presence of pointed products at this site.

20 **Sporadic onset of a bifacial technology?**

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24 If we consider that the partial bifacial artefact is not a chopping-tool but a genuine Large Cutting tool, the
25 discovery of this bifacial piece at Pont-de-Lavaud raises the hypothesis of a sporadic emergence of bifacial
26 technology in core-and-flake traditions, as observed in a few early sites in Europe but with no real
27 development of the technique, before the first clear evidence of bifacial technology (la Noira, Moncel et al.,
28 2013, 2015). In some sites, we observe one or two pieces with the partial bifacial management of two
29 convergent edges and sometimes a pointed or round tip.

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33 The sites of Pradayrol (900 ka), Soleilhac (500-700 ka), assemblages from the Upper Roussillon and Rhône
34 terraces in France or the site of Bogatyri (1.4-1.1 Ma) in Russia may record some attempts at bifacially
35 worked pieces in parallel with the arrival of external bifacial technologies (Bourdier, 1958; Tavano, 1986;
36 Bracco, 1991; Shchelinsky et al., 2010; Guadelli et al., 2012). Some shaped tools are described on basalt and
37 granite at Soleilhac, made by some removals slightly modifying a large flake (Bonifay et al., 1976). Similarly,
38 at Pradayrol, a limited zone of a broken slab was bifacially shaped by non-invasive removals. La Boella, with
39 two bifacial pieces, dated to around 900 ka, is currently the best example to discuss the early arrival of
40 bifacial technology in Europe, either introduced on a pre-existing foundation or as a local development
41 (Vallverdu et al. 2014). However, the two pieces at La Boella differ from the partial bifacial tool of Pont-de-
42 Lavaud. In pit 1, level 2, a pick made on a split schist cobble was shaped by some deep and large removals
43 on the half-cobble, creating a pointed tip, and secondary small removals, creating an abrupt cutting edge
44 on one side. A schist cleaver is also described in level 2 at the EF site, which is partially bifacial on a split
45 cobble. The younger site of Notarchirico, at around 670 ka, can no longer be considered as evidence of the
46 local origin of bifacial technology since some bifaces with bifacial management of the volume occur at this
47 site (Piperno ed., 1999; Santagata, 2016, and personal observation), despite the numerous bifacial and
48 pointed pebble-tools made by small series of deep removals.

1 In some ways, this problem parallels the issue in East African assemblages described as Developed Oldowan
2 or Early Acheulean, where it is still unclear whether there are tangible links or a rupture over time (Torre et
3 al., 2005, 2008, 2011). A local European origin for bifacial working seems unlikely given that there is
4 currently little evidence of the *in situ* development of partial bifacial working (Moncel et al., 2015). The
5 partial bifacial tool at Pont-de-Lavaud could provide evidence at 1 Ma of attempts at bifacially worked
6 pieces among a core-and-flake industry.
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11 **Conclusion**

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16 The comparison between our experiments and the description of the quartz artefacts on pebbles enables
17 us to consider the quartz artefacts found at Pont-de-Lavaud as evidence of anthropogenic action. The site is
18 consequently one of the earliest representative European and French sites, not only on account of its age of
19 1.1 Ma, but also because it is the largest known lithic assemblage. It provides a good overview of the
20 technical behavior and strategies adopted by hominins exploiting quartz during the first wave of European
21 expansion.
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25 The study of the site of Pont-de-Lavaud, in parallel with our experiments, confirms that the bipolar
26 technique was an expedient debitage, well adapted to rounded quartz pebbles, but also a regularly used
27 method, as it was also applied to polyhedral quartz pebbles. This technique was effective for initiating small
28 and ovoid/polyhedral pebble breakage and producing fragments and flakes, as demonstrated by other
29 technological experiments (Lombera-Hermida et al., 2016). It was not only used for a specific geometry
30 of quartz blanks but was applied to all the categories of quartz stones available in the surroundings. It is
31 consequently clearly part of the technical skills of European hominins at 1.1 Ma and was a flexible
32 technique indicating a high degree of hominin cognition and the ability to adapt to various raw materials of
33 mixed quality.
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39 The presence of a small set of retouched flakes and a partial bifacial piece (“proto-biface”) indicates the
40 ability of hominins to develop longer processes on quartz if necessary.
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44 The choice of bipolar debitage on quartz is frequently attributed to raw material constraints (in terms of
45 initial morphology and petrology) and is considered to require less skill than freehand percussion (Barham,
46 1987; Shott, 1999; Stout and Semaw, 2005; Tallavaara et al., 2010; Diez-Martin et al., 2011; Braun, 2012).
47 However, the bipolar technique indicates the ability of hominins to find technical solutions for breaking
48 ovoid quartz nodules that are difficult to break with freehand percussion, and to produce pieces suitable
49 for use (Peña de la, 2015; Hiscock, 2015; Pargeter and Duke, 2015; Rodríguez-Álvarez, 2016; Li Hao et al.,
50 2017).
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55 Recent experiments at Olduvai (BK and FLK-North sites, Gurtov and Eren, 2014) confirm that the bipolar
56 technique does not produce specific flakes in terms of cutting edge length or other significant features
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1 (Gurtov et al., 2015). Products are characterized by the variability of the implements commonly produced
2 by Mode 1-behavior hominins.
3

4 The Ugandan site of Nyabusosi 18, dated to 1.5 Ma, shows that in some cases quartz may provide a
5 complex and well-organized core technology. This site yielded centripetal cores and a lot of flakes without
6 cortex, suggesting long reduction sequences (Texier, 1995). Moreover, use wear analyses performed on
7 quartz and quartzite Oldowan artefacts found at Kanjera South (Kenya) indicate that these types of stones
8 were operative (Lemorini et al., 2014). Likewise, the lithic material from Bizat Ruhama in Israel indicates
9 that the bipolar technique can also be applied to small flint pebbles, confirming the flexibility of Oldowan
10 hominins (Zaidner, 2013).
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17 Pont-de-Lavaud presents common features with the Early European sites and indicates common technical
18 behaviors at 1 Ma both in the South, the North and the intermediary area of the Center of France.
19 Reduction processes are short, flake-tools are sparse and the core technology clearly reflects adaptation to
20 raw material forms and types. At Pont-de-Lavaud, faunal remains were not preserved and we cannot relate
21 the strategies observed to a specific type of occupation or activity. We cannot explain why hominins settled
22 at this place and used such quantities of quartz, except if we consider that they used the main stones
23 available at the site. The diversity of the technological strategies possibly suggests either different needs or
24 traditions. Pont-de-Lavaud confirms the ability of early hominins to exploit stones of varying quality,
25 including those considered to be of bad quality, and to adapt technology to the raw material in areas
26 located beyond the 45° North parallel where siliceous rocks are available. The high number of artefacts
27 suggests recurrent occupations and the exploitation of raw materials collected on the slope. Huge
28 quantities of quartz were used and the technical strategies observed at the site correspond well to
29 behaviors throughout Europe around 1 Ma, based on core-and-flake technologies with some attempts at
30 bifacial working, although there may not be any connection with the onset of bifacial technology at around
31 700 ka.
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41 Finally, the Pont-de-Lavaud site attests hominid adaptation to northern latitudes. However, hominids came
42 when the climate was favorable as shown by the palynological record, which points to a temperate climate
43 with dense forest. Hominids were present during an interglacial and at the beginning of the following
44 glacial event. Compared to the other contemporaneous sites and the earliest evidence from Dmanisi, the
45 environmental context was different and indicates the ability of 1 Ma-hominids to adapt to different
46 contexts.
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Figure captions

Figure 1. Location of the Pont-de-Lavaud site, commune of Eguzon-Chantôme, department of Indre, Centre-Val de Loire region, France (Latitude: 46° 26'32" North; longitude: 1°58'25" East) and location of the main sites occupied during the Early Pleistocene.

Figure 2. 1. Location of the Pont-de-Lavaud site: A. on the Aigurande plateau; B. on the Fressignes interfluvium. 1. Paris Basin sediments; 2. Migmatitic unit; 3. Dun-Gargilesse gneiss unit; 4. Eguzon amygdaloidal gneiss unit; 5. Fougères-Culan micaschist unit; 6, 7. Leucogranite and granite; Boussac metamorphic and magmatic formations; 9. Marche granite; 10. Guéret granite; 11. Chéniers granite (after Despriée and Gageonnet, 2003, modified). The arrows indicate the direction of the transportation of different types of quartz during Tertiary and Quaternary periods.

Figure 3. Reconstruction of the successive stages of the Pont-de-Lavaud sequence deposition

Figure 4. A. The stepped fossil fluvial system of the Creuse River (after Voinchet et al., 2010). For each alluvial sheet the weighted ESR age is indicated. The Pont-de-Lavaud site is associated with sheet I.

Figure 5. Spatial analysis of the studied retouched quartz blanks (~~red pentagons~~). As shown on the diagram, they are mainly associated with the two pavements, but their spatial distribution is also consistent with the general distribution of quartz tools. More than 60 % of the retouched artefacts are concentrated in the two pavements and do not show any preferential orientation.

Figure 6. Evolution of pebble/cobble/ boulder sizes from the bottom to the surface. Pebbles represent most of the material in the archaeological surface (pebble layer), cobbles are characteristic of the diamicton and boulders are located on the micaschist bedrock at the bottom of the diamicton.

Figure 7. Classes of pebbles and debris from the Pont-de-Lavaud site. (1) Well-rounded pebble or cobble; (2) Pebble with natural break; (3) Pebble with impacts at the top; (4) Pebble with peels; (5, 6) Pebble broken into two parts with plane, salient or re-entrant angles; (7) Pebble broken into three fragments with right or acute angles; (8) Pebble broken into three fragments with thin triangular debris. Impacts are visible.

Figure 8. Tests consisting of breaking very hard quartz pebbles or cobbles. (1) Pieces are placed flat on the anvil surface and struck with an amygdaloid quartz cobble used as a hammer stone. (2) After one blow, the pebble is broken into two parts. (3) After two blows, remetamorphized quartz is broken into four fragments. (4) During the shock, some fragments remain on the anvil surface, but others are dispersed over one or two meters. (Experimentation by J. Despriée and P. Alilaire, photos P. Touchard).

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3 Figure 9. Results of the breaking experiment. (1, 2) Blanks gathered on the diamicton; (3, 4) Hammer stones
4 with scars visible on the tip; (5 to 8) Fragmentation of quartz cobbles on the anvil surface with fragments
5 smaller than half of the original surface; 5. Cobbles truncated at one or two ends, with right-angled fracture
6 and skullcap-shaped fragments; 6, 7. Cobbles broken in one blow with two triangular debris or two
7 segment-shaped pieces; 8. Cobble broken by numerous blows with segment-shaped fragments and sharp-
8 edged debris.
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13 Figure 10. Photographs of different types of pieces with presumed anthropogenic features. (1) Block of vein
14 quartz with numerous impact marks on the upper surface and removal scars on the orthogonal edges; (2, 3)
15 Amygdaloid quartz cobbles with crushing scars on one end or with splintered tip (Types 3 and 4); (4,
16 5) Fragments of quartz cobbles with orthogonal fresh surfaces, impacts, circular apex of the cone, cones
17 and elevations. Some crushing is visible on the opposite surfaces (Types 5 and 7a); (6) Amygdaloid quartz
18 cobble with two fresh orthogonal surfaces and acute tip. Two impact marks are visible on the obverse side,
19 as well as crushing on the reverse face (Type 6) (n°7, 8, 9). Fragments of quartz cobbles with fresh angular
20 surfaces, impacts visible on the apex of the angle and crushing on the opposite trihedral apex (Types 7b, 7c
21 and 7d) (Photos G. Courcimault).
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28 Figure 11. Percussion techniques and related blanks. Direct percussion is mainly associated with the
29 production of blanks intended for "retouch". Bipolar percussion is primarily associated with the initiation of
30 block breakage or very short reduction sequences. Cores and flakes from direct percussion core
31 technology.
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36 Figure 12. Examples of quartz cores (or chopper-cores) with cortical platforms (1, 3) and flat pebbles broken
37 by the bipolar technique (2) or the platform of a previous removal (4). The arrow indicates the impact point
38 (photos M-H. Moncel and M. Arzarello).
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42 Figure 13. Examples of quartz cores (or chopper-cores) on one or two orthogonal surfaces perpendicular to
43 the cortical surfaces (drawings A. Theodoropoulou).
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46 Figure 14. Quartz core-pebble tools (n°1, 2, 3), denticulates on a fragment of quartz (n°5) or a flake (n°4, 7),
47 and core-tool with centripetal scars? (n°6) (drawings J. Despriée)
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51 Figure 15. A: Estimated volume of the cores (mm³) made by direct percussion by hard hammer and by
52 bipolar percussion on anvil. The reduction phase is longer when direct hard hammer percussion is used, as
53 is confirmed by smaller core morphologies. B: Boxplot of the maximal dimension (in mm) of all the whole
54 flakes (quartile method rounding; Whisker type: standard error); for unipolar/multipolar core technology
55 and centripetal core technology, flakes with and without cortex are included. The graphs show that the
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1 dimensions are similar regardless of core technology. The non-cortical flakes have the same average
2 dimension with lower variability, generally smaller than the cortical flakes. This is related to the
3 morphology of the raw material.
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7 Figure 16. Partial bifacial piece on quartz. Both sides of the pebble were shaped by alternate striking
8 (drawings A. Theodoropoulou).
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12 Figure 17. Examples of cortical quartz flakes with some removals (1, 2, 3). Denticulate on a cortical flake (4)
13 (drawing J. Despriée)
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16 Figure 18. Maximum dimensions (in mm) of the retouched (red columns) and non-retouched (blue
17 columns) whole flakes. No evident selection based on dimensions is observed for the retouched pieces.
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20 Figure 19. Reduction processes on quartz pebbles at Pont-de-Lavaud according to pebble geometry and the
21 type of percussion A. Bipolar technique with pebbles broken on the longest face; B. Bipolar technique with
22 pebbles broken on the tip; C. Pebbles with one removal; D. Pointed or linear pebble-tools with two
23 removals ; E. Pointed pebble-tools including the proto-biface; F. Cores on oval pebbles with unipolar
24 removals on one flaking surface with cortical platform; G. and L. Cores on pebbles with unipolar removals
25 and two orthogonal flaking surfaces; H. and K. Cores on rectangular pebbles with unipolar removals on one
26 flaking surface located on the side of the pebble with a cortical platform; I. Rectangular pebbles with one
27 removal on the edge; J. Cores on rectangular pebbles with unipolar removals on one flaking surface located
28 on the largest face of the pebble with a cortical platform.
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37 **Supplementary data**

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39 Suppl. 1. View of the accumulation surfaces (Pavement) Pont-de-Lavaud 1 and Pont-de-Lavaud 2,
40 corresponding to concentrations of blocks with linear borders and peripheral holes. 1: Spatial distribution
41 of the vein quartz manuports (blocks ≥ 10 cm long). 2 and 3: Vertical sections show the links between paving
42 stones (2) and accumulation of lithic artefacts (3) with wall-effect (after Despriée et al, 2010, 1011).
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47 Suppl. 2A: Stone accumulation of Pont-de-Lavaud 1. The view from the south also shows the large isolated
48 peripheral blocks on the micaschist bedrock. Suppl. 2 B: Holes surrounded with quartz cobbles on the
49 northern edge (photos J. Despriée).
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54 Suppl. 3. Photographs of experimental artefacts. (1) Block of vein quartz used as an anvil with impacts on
55 the obverse end and lateral crushing; (2, 3). Amygdaloid cobbles used as hammer stones, with use scars;
56 (4,5) Cobbles broken by one blow (types 5 and fragments 7 a, 7c): impact marks, cone and crushing on
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1 reverse face; (6, 7) Cobbles broken by two blows (types 6 and fragments 7c, 7d); impact marks, cones and
2 crushing on the opposite surface; (8). Cobble broken by three blows (type 6 with debris type 8)
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4 (Experimentation by J. Despriée and P. Alilaire, photos G. Courcimault).
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9 Suppl. 4. Partial bifacial piece on quartz. Both sides of the pebble were shaped by alternate striking (photos
10 M-H. Moncel).
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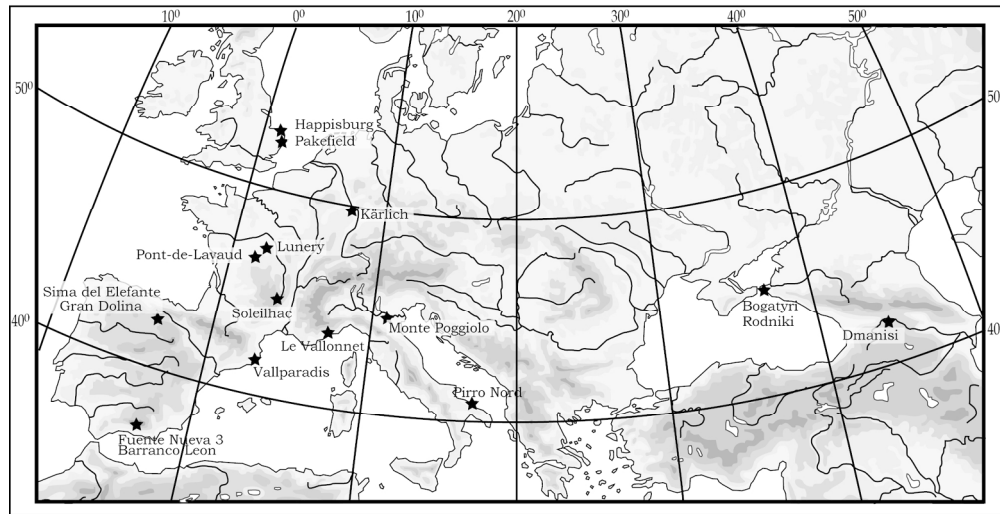


Figure 1. Location of the Pont-de-Lavaud site, commune of Eguzon-Chantôme, department of Indre, Centre-Val de Loire region, France (Latitude: 46° 26'32" North; longitude: 1°58'25" East) and location of the main sites occupied during the Early Pleistocene.

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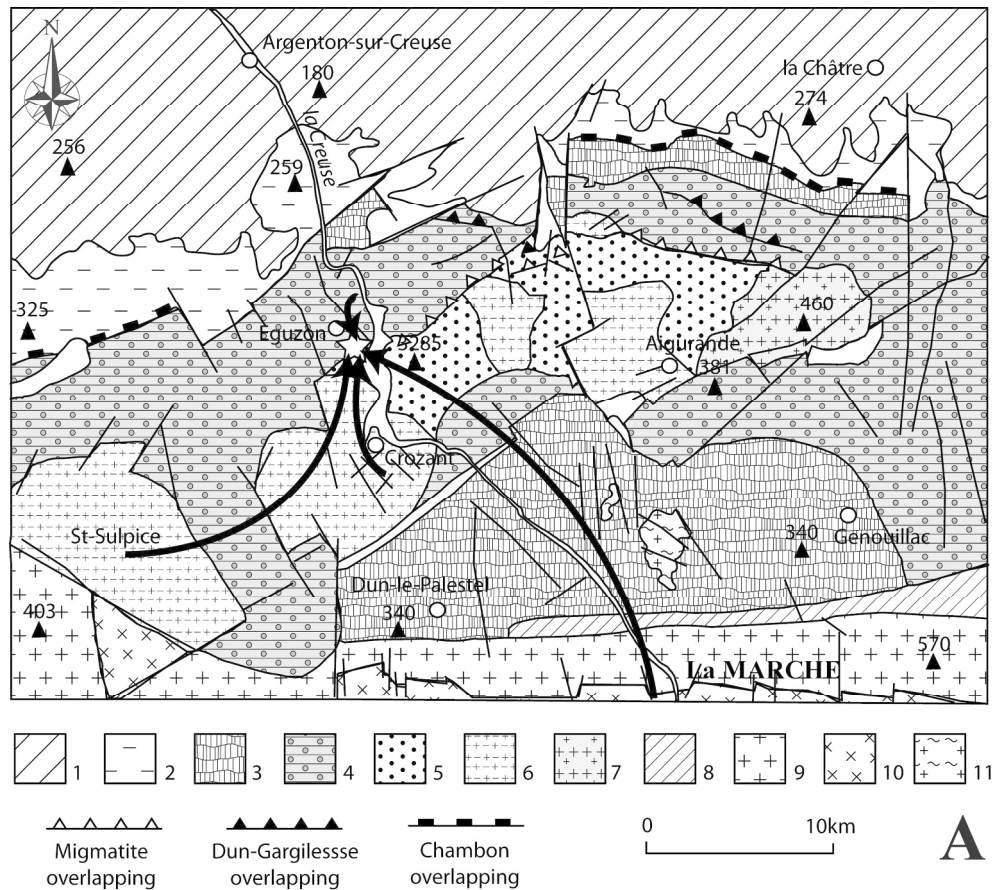
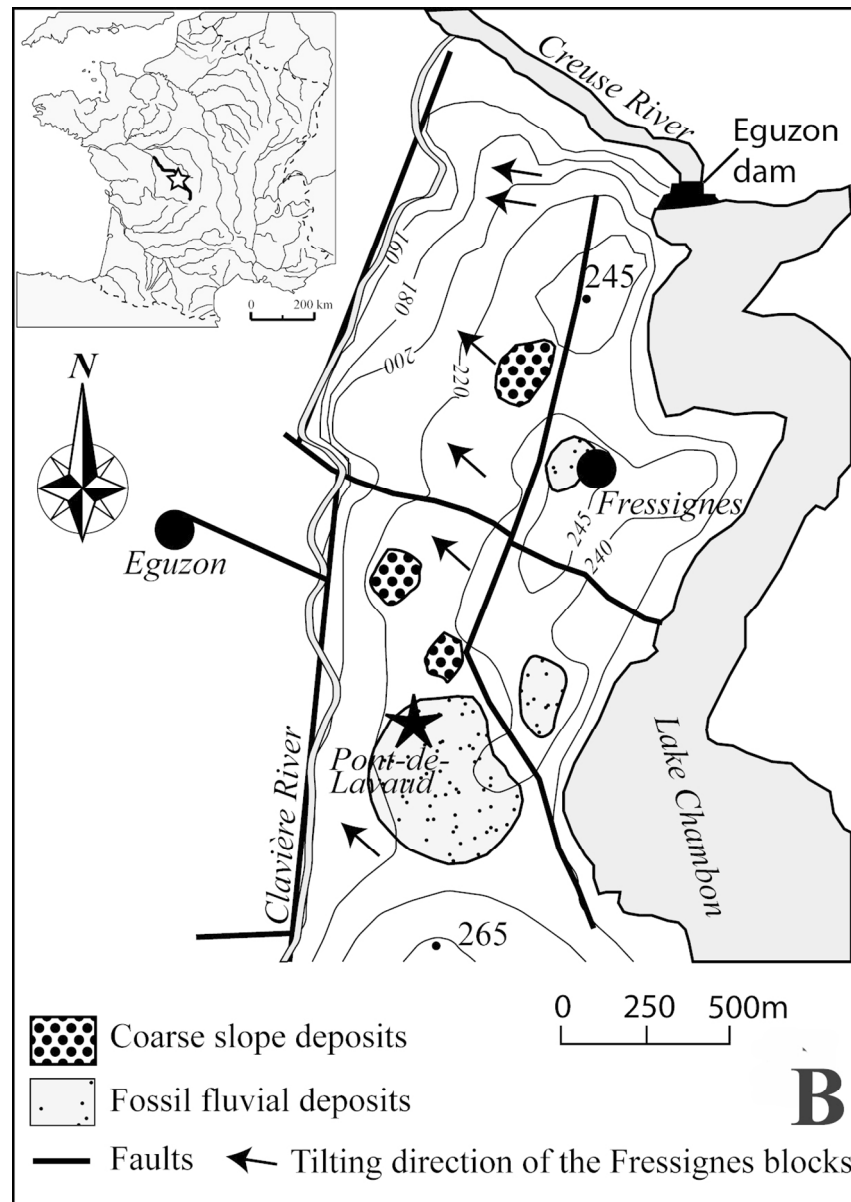


Figure 2. 1. Location of the Pont-de-Lavaud site: A. on the Aigurande plateau; B. on the Fressignes interfluve. 1. Paris Basin sediments; 2. Migmatitic unit; 3. Dun-Gargillesse gneiss unit; 4. Eguizon amygdaloidal gneiss unit; 5. Fougères-Culan micaschist unit; 6, 7. Leucogranite and granite; Boussac metamorphic and magmatic formations; 9. Marche granite; 10. Guéret granite; 11. Chéniers granite (after Despriée and Gageonnet, 2003, modified). The arrows indicate the direction of the transportation of different types of quartz during Tertiary and Quaternary periods.

194x171mm (300 x 300 DPI)



45 Figure 2. 1. Location of the Pont-de-Lavaud site: A. on the Aigurande plateau; B. on the Fressignes
46 interfluve. 1. Paris Basin sediments; 2. Migmatitic unit; 3. Dun-Gargillesse gneiss unit; 4. Eguzon
47 amygdaloidal gneiss unit; 5. Fougères-Culan micaschist unit; 6, 7. Leucogranite and granite; Boussac
48 metamorphic and magmatic formations; 9. Marche granite; 10. Guéret granite; 11. Chéniers granite (after
49 Despriée and Gageonnet, 2003, modified). The arrows indicate the direction of the transportation of
50 different types of quartz during Tertiary and Quaternary periods.

51 104x147mm (300 x 300 DPI)

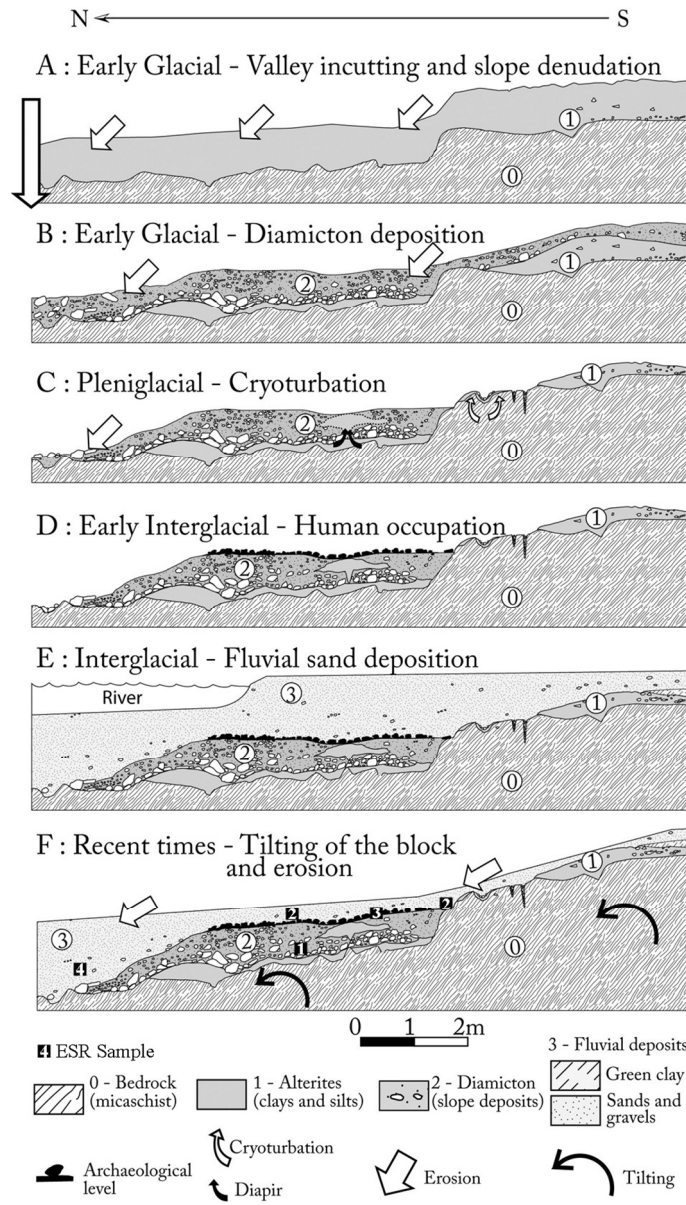


Figure 3. Reconstruction of the successive stages of the Pont-de-Lavaud sequence deposition

80x141mm (300 x 300 DPI)

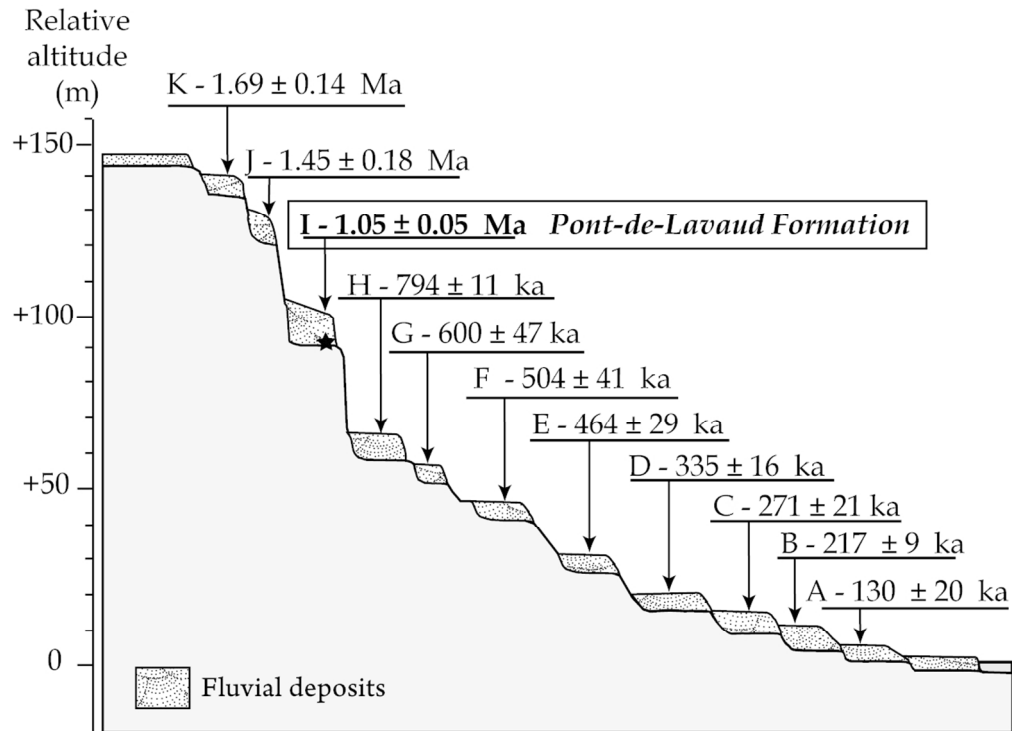


Figure 4. A. The stepped fossil fluvial system of the Creuse River (after Voinchet et al., 2010). For each alluvial sheet the weighted ESR age is indicated. The Pont-de-Lavaud site is associated with sheet I.

105x76mm (300 x 300 DPI)

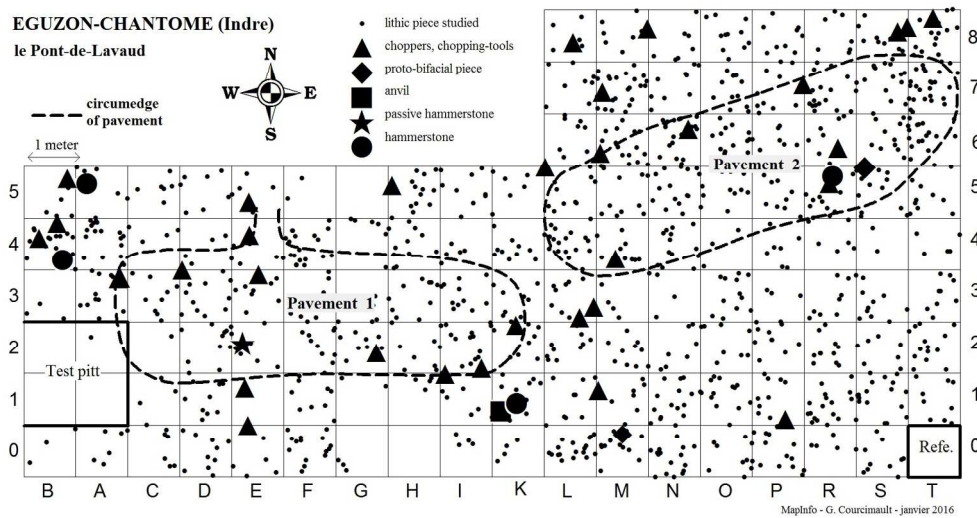


Figure 5. Spatial analysis of the studied retouched quartz blanks (red pentagons). As shown on the diagram, they are mainly associated with the two pavements, but their spatial distribution is also consistent with the general distribution of quartz tools. More than 60 % of the retouched artefacts are concentrated in the two pavements and do not show any preferential orientation.

167x91mm (300 x 300 DPI)

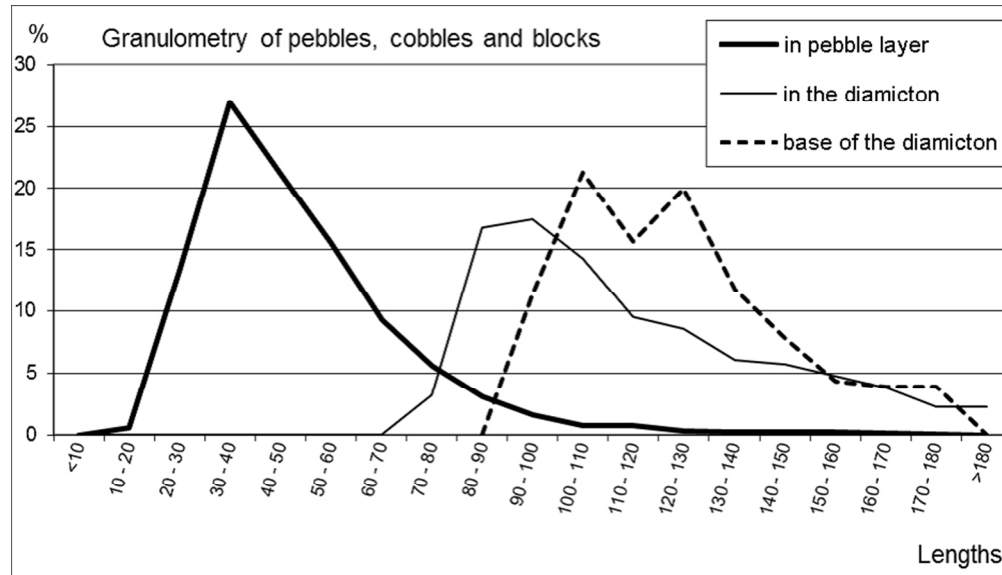


Figure 6. Evolution of pebble/cobble/ boulder sizes from the bottom to the surface. Pebbles represent most of the material in the archaeological surface (pebble layer), cobbles are characteristic of the diamicton and boulders are located on the micashit bedrock at the bottom of the diamicton.

247x141mm (96 x 96 DPI)

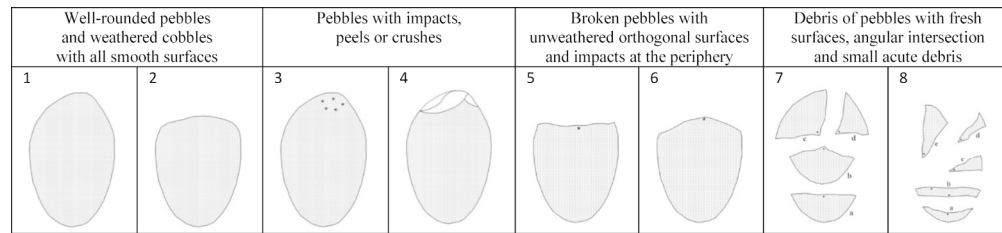


Figure 7. Classes of pebbles and debris from the Pont-de-Lavaud site. (1) Well-rounded pebble or cobble; (2) Pebble with natural break; (3) Pebble with impacts at the top; (4) Pebble with peels; (5, 6) Pebble broken into two parts with plane, salient or re-entrant angles; (7) Pebble broken into three fragments with right or acute angles; (8) Pebble broken into three fragments with thin triangular debris. Impacts are visible.

170x38mm (300 x 300 DPI)



Figure 8. Tests consisting of breaking very hard quartz pebbles or cobbles. (1) Pieces are placed flat on the anvil surface and struck with an amygdaloid quartz cobble used as a hammer stone. (2) After one blow, the pebble is broken into two parts. (3) After two blows, remetamorphized quartz is broken into four fragments. (4) During the shock, some fragments remain on the anvil surface, but others are dispersed over one or two meters. (Experimentation by J. Desprée and P. Alilaire, photos P. Touchard).

104x101mm (300 x 300 DPI)



Figure 8. Tests consisting of breaking very hard quartz pebbles or cobbles. (1) Pieces are placed flat on the anvil surface and struck with an amygdaloid quartz cobble used as a hammer stone. (2) After one blow, the pebble is broken into two parts. (3) After two blows, remetamorphized quartz is broken into four fragments. (4) During the shock, some fragments remain on the anvil surface, but others are dispersed over one or two meters. (Experimentation by J. Despriee and P. Alilaire, photos P.Touchard).

412x385mm (72 x 72 DPI)



Figure 8. Tests consisting of breaking very hard quartz pebbles or cobbles. (1) Pieces are placed flat on the anvil surface and struck with an amygdaloid quartz cobble used as a hammer stone. (2) After one blow, the pebble is broken into two parts. (3) After two blows, remetamorphized quartz is broken into four fragments. (4) During the shock, some fragments remain on the anvil surface, but others are dispersed over one or two meters. (Experimentation by J. Desprée and P. Alilaire, photos P. Touchard).

118x88mm (300 x 300 DPI)



Figure 8. Tests consisting of breaking very hard quartz pebbles or cobbles. (1) Pieces are placed flat on the anvil surface and struck with an amygdaloid quartz cobble used as a hammer stone. (2) After one blow, the pebble is broken into two parts. (3) After two blows, remetamorphized quartz is broken into four fragments. (4) During the shock, some fragments remain on the anvil surface, but others are dispersed over one or two meters. (Experimentation by J. Desprée and P. Alilaire, photos P. Touchard).

152x101mm (300 x 300 DPI)

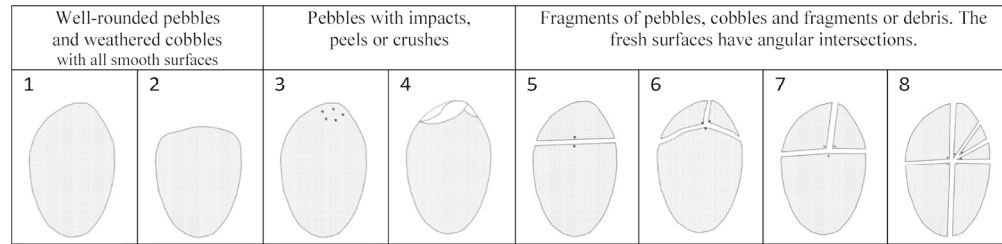


Figure 9. Results of the breaking experiment. (1, 2) Blanks gathered on the diamicton; (3, 4) Hammer stones with scars visible on the tip; (5 to 8) Fragmentation of quartz cobbles on the anvil surface with fragments smaller than half of the original surface; 5. Cobbles truncated at one or two ends, with right-angled fracture and skullcap-shaped fragments; 6, 7. Cobbles broken in one blow with two triangular debris or two segment-shaped pieces; 8. Cobble broken by numerous blows with segment-shaped fragments and sharp-edged debris.

170x40mm (300 x 300 DPI)

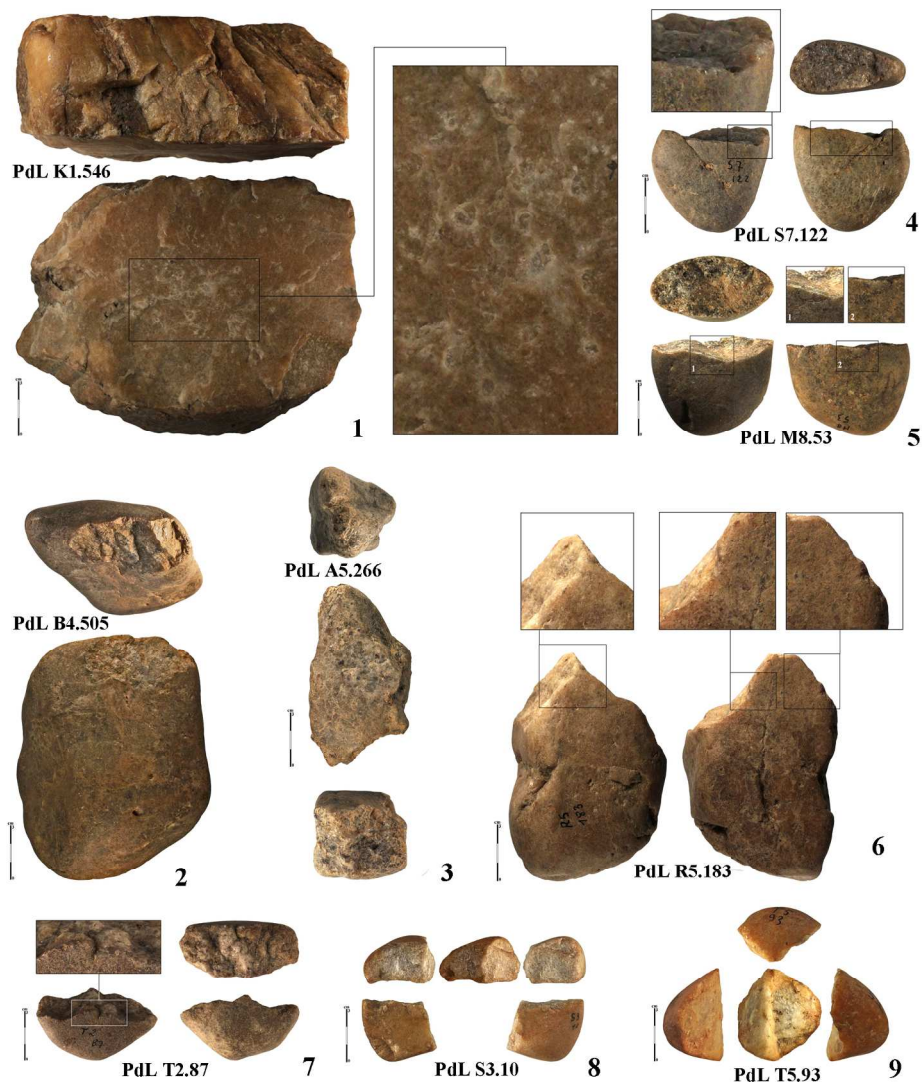


Figure 10. Photographs of different types of pieces with presumed anthropogenic features. (1) Block of vein quartz with numerous impact marks on the upper surface and removal scars on the orthogonal edges; (2, 3) Amygdaloid quartz cobbles with crushing scars on one end or with splintered tip (Types 3 and 4); (4, 5) Fragments of quartz cobbles with orthogonal fresh surfaces, impacts, circular apex of the cone, cones and elevations. Some crushing is visible on the opposite surfaces (Types 5 and 7a); (6) Amygdaloid quartz cobble with two fresh orthogonal surfaces and acute tip. Two impact marks are visible on the obverse side, as well as crushing on the reverse face (Type 6) (n°7, 8, 9). Fragments of quartz cobbles with fresh angular surfaces, impacts visible on the apex of the angle and crushing on the opposite trihedral apex (Types 7b, 7c and 7d) (Photos G. Courcimault).

170x219mm (300 x 300 DPI)

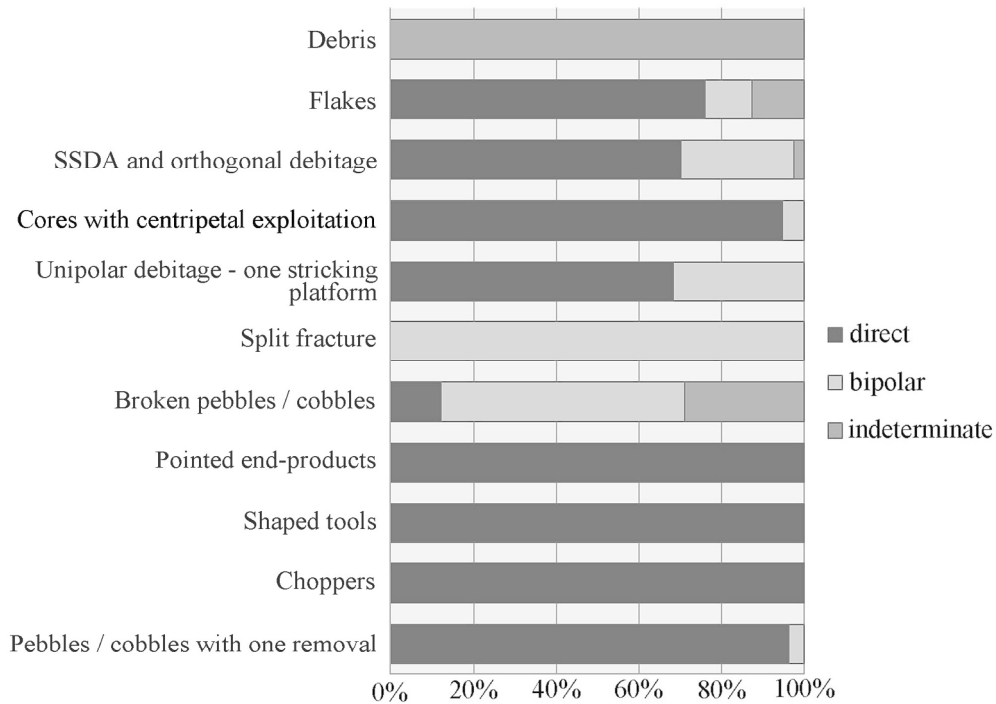
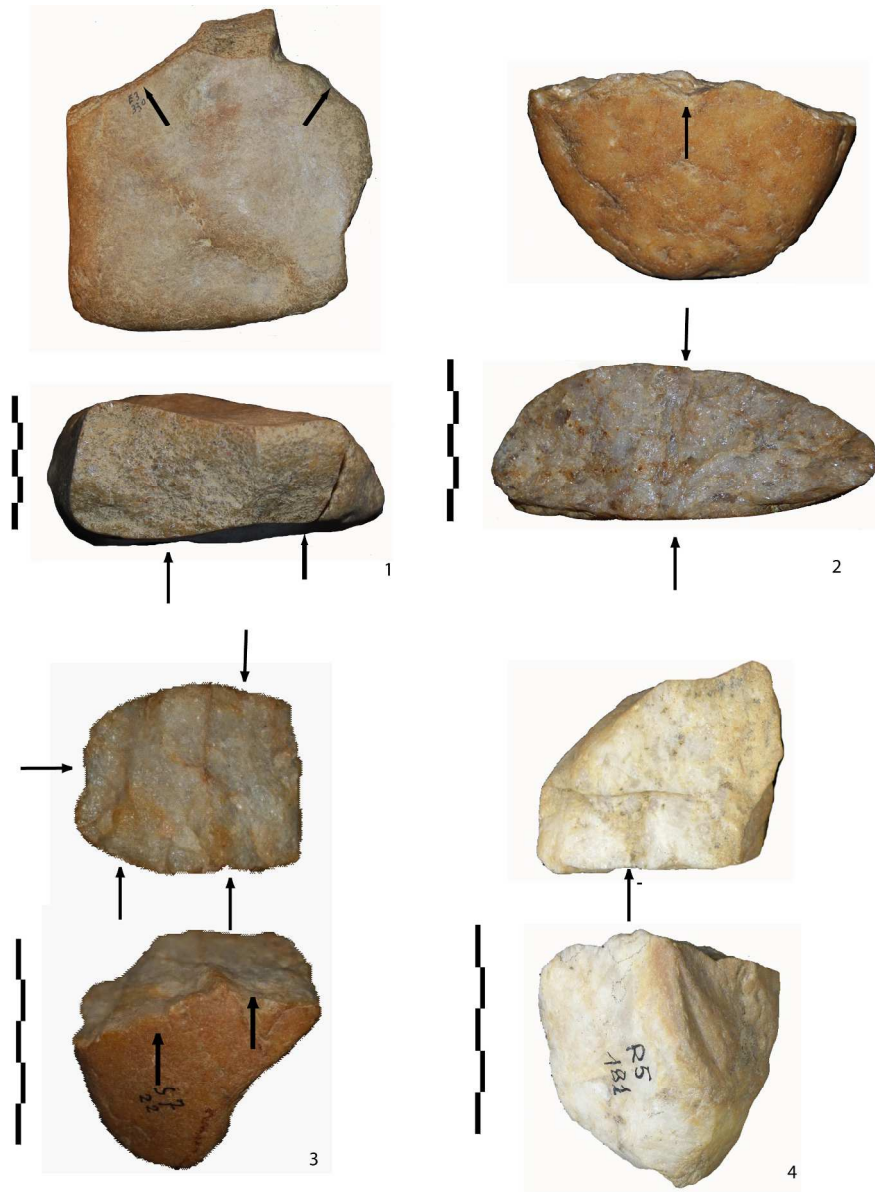


Figure 11. Percussion techniques and related blanks. Direct percussion is mainly associated with the production of blanks intended for "retouch". Bipolar percussion is primarily associated with the initiation of block breakage or very short reduction sequences. Cores and flakes from direct percussion core technology.

170x130mm (300 x 300 DPI)



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Figure 12. Examples of quartz cores (or chopper-cores) with cortical platforms (1, 3) and flat pebbles broken by the bipolar technique (2) or the platform of a previous removal (4). The arrow indicates the impact point (photos M-H. Moncel and M. Arzarello).

193x265mm (300 x 300 DPI)

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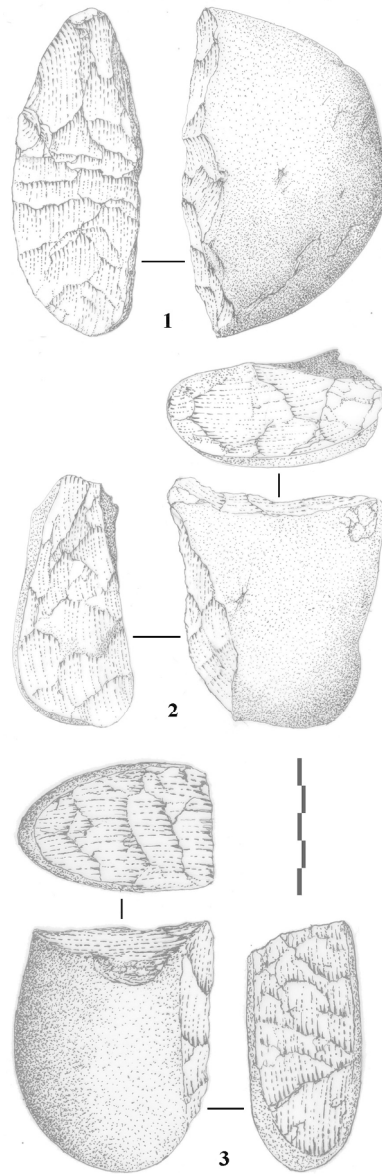


Figure 13. Examples of quartz cores (or chopper-cores) on one or two orthogonal surfaces perpendicular to the cortical surfaces (drawings A. Theodoropoulou).

75x230mm (300 x 300 DPI)

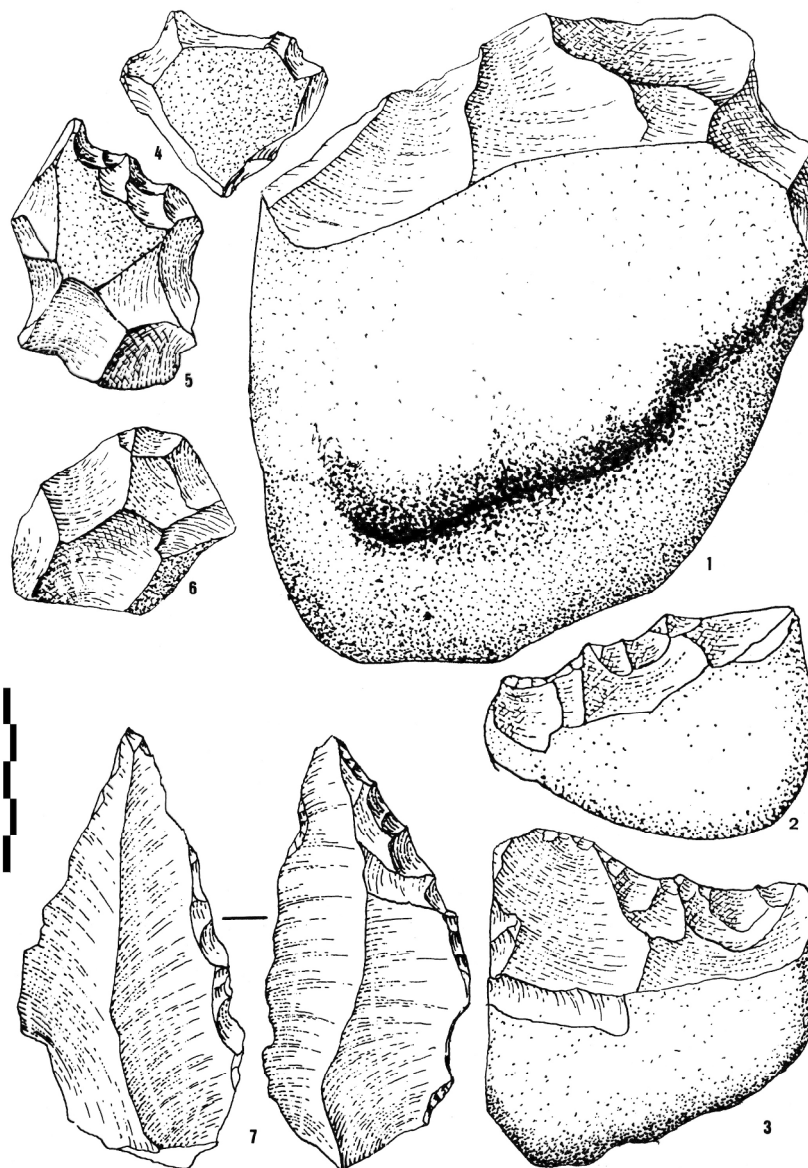


Figure 14. Quartz core-pebble tools (n°1, 2, 3), denticulates on a fragment of quartz (n°5) or a flake (n°4, 7), and core-tool with centripetal scars? (n°6) (drawings J. Despriée).

186x258mm (300 x 300 DPI)

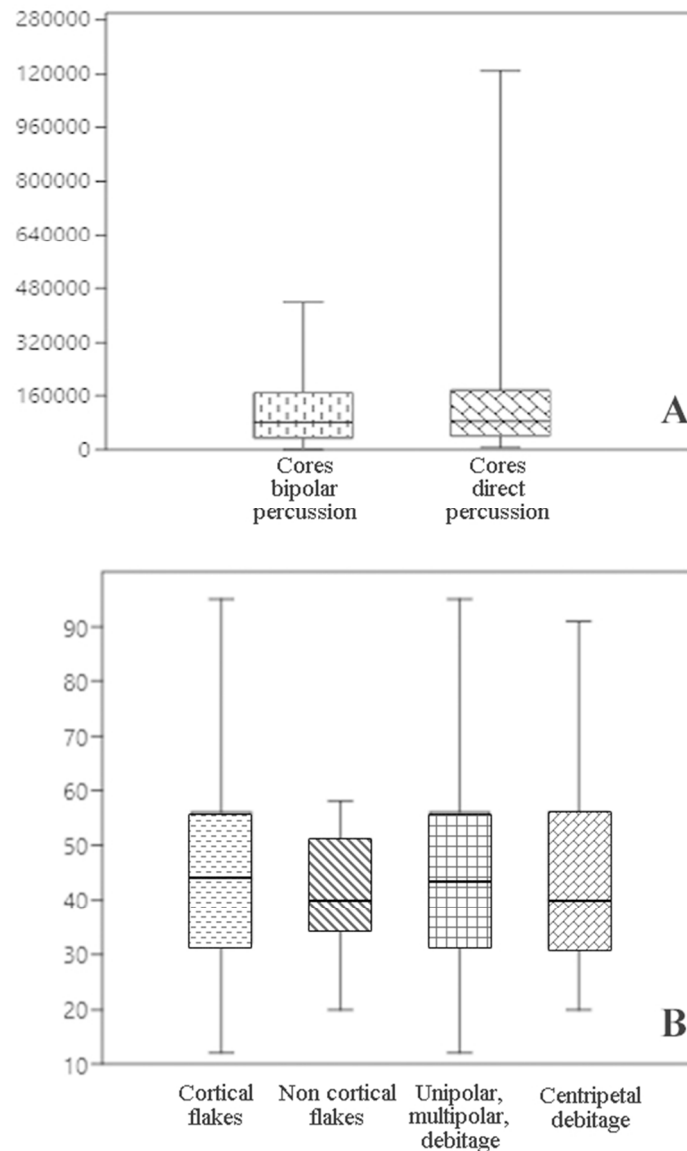


Figure 15. A: Estimated volume of the cores (mm³) made by direct percussion by hard hammer and by bipolar percussion on anvil. The reduction phase is longer when direct hard hammer percussion is used, as is confirmed by smaller core morphologies. B: Boxplot of the maximal dimension (in mm) of all the whole flakes (quartile method rounding; Whisker type: standard error); for unipolar/multipolar core technology and centripetal core technology, flakes with and without cortex are included. The graphs show that the dimensions are similar regardless of core technology. The non-cortical flakes have the same average dimension with lower variability, generally smaller than the cortical flakes. This is related to the morphology of the raw material.

156x249mm (96 x 96 DPI)

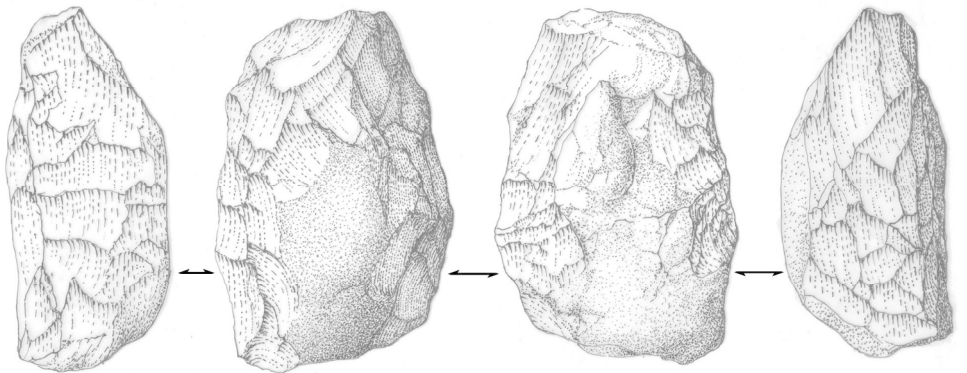


Figure 16. Partial bifacial piece on quartz. Both sides of the pebble were shaped by alternate striking (drawings A. Theodoropoulou).

170x66mm (300 x 300 DPI)

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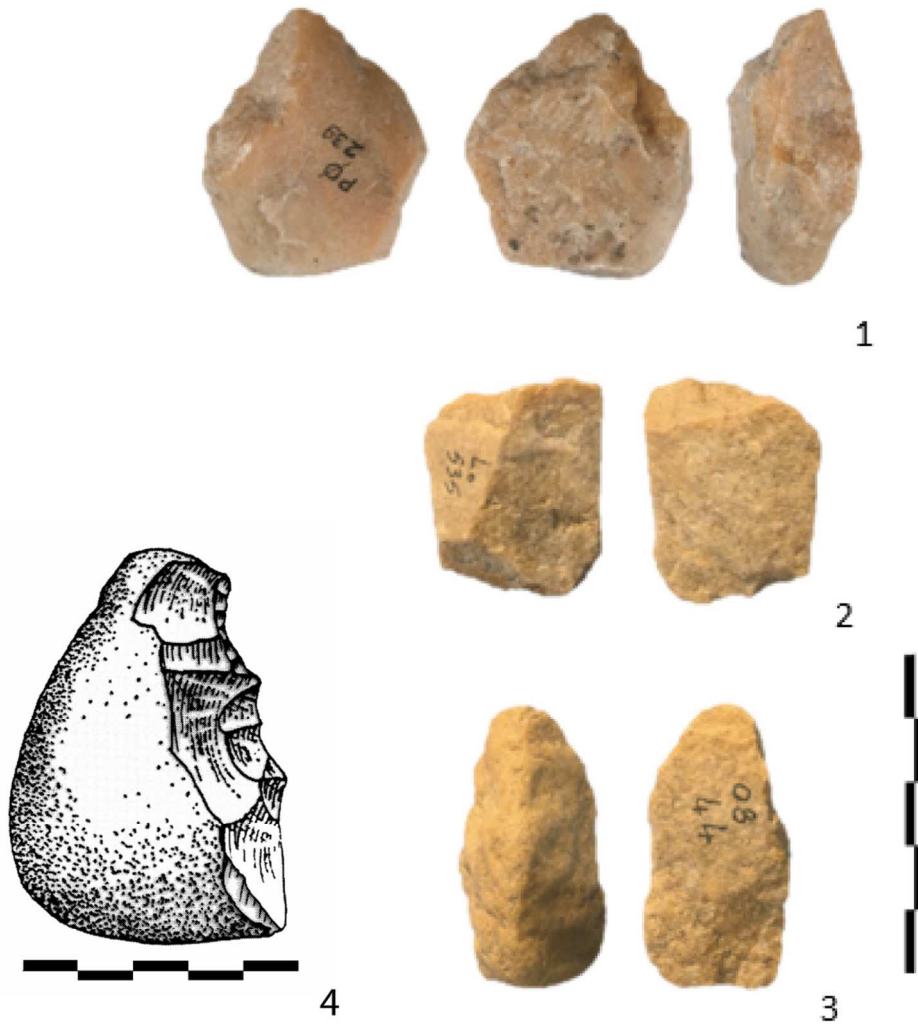


Figure 17. Examples of cortical quartz flakes with some removals (1, 2, 3). Denticulate on a cortical flake (4) (drawing J. Despriée)

107x112mm (300 x 300 DPI)

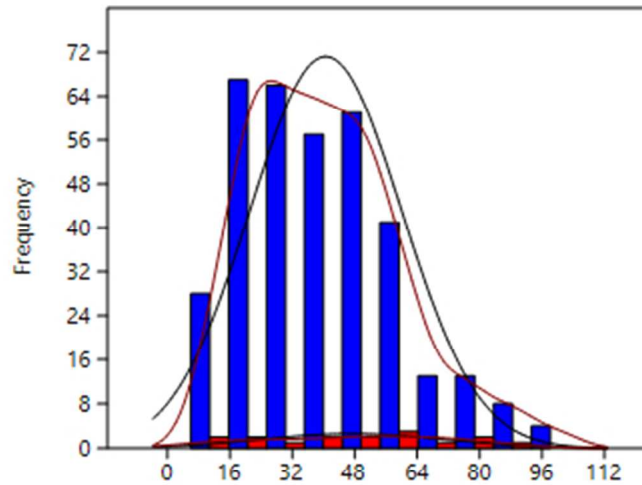
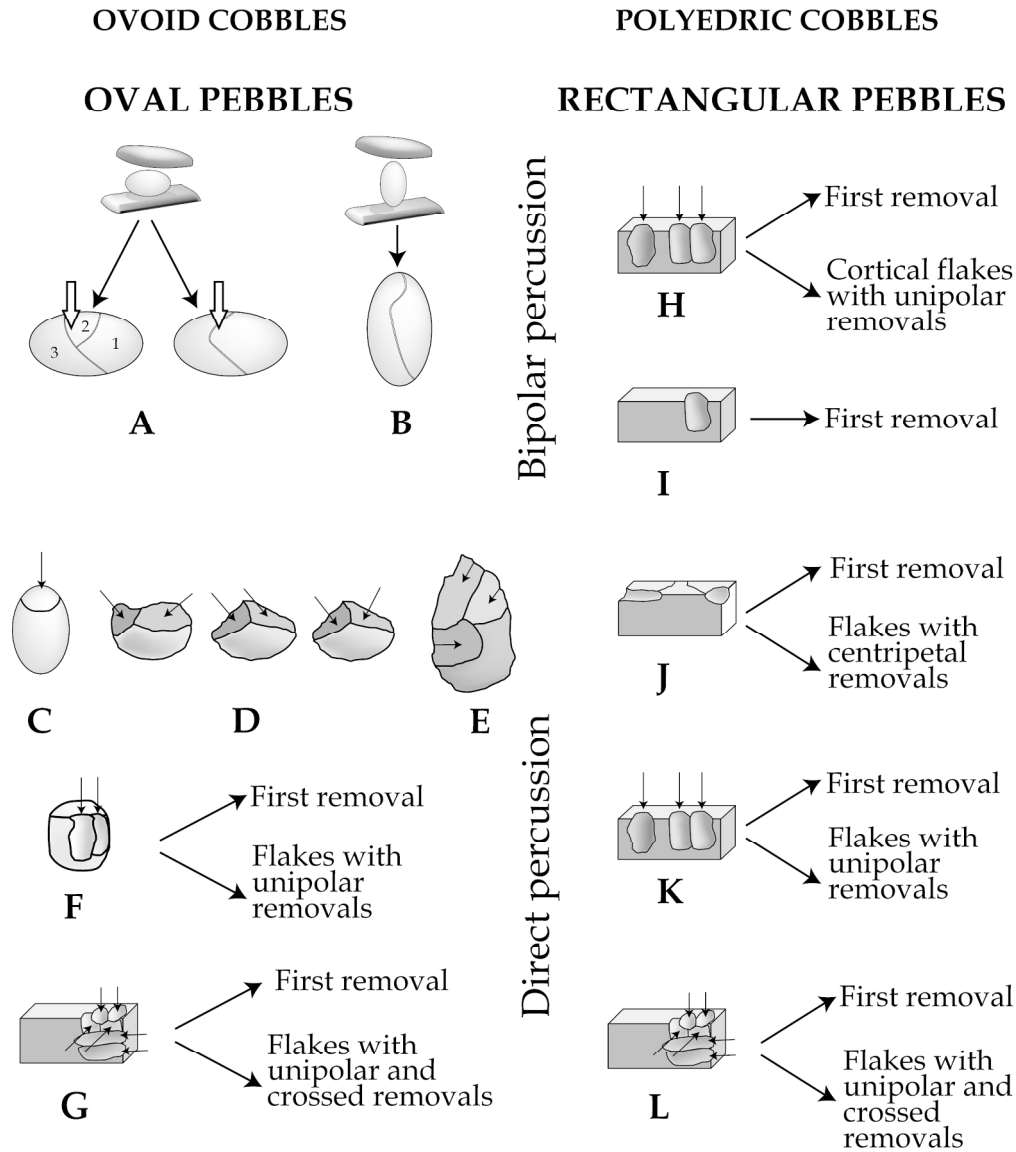


Figure 18. Maximum dimensions (in mm) of the retouched (red columns) and non-retouched (blue columns) whole flakes. No evident selection based on dimensions is observed for the retouched pieces.

103x95mm (96 x 96 DPI)



44 Figure 19. Reduction processes on quartz pebbles at Pont-de-Lavaud according to pebble geometry and the
45 type of percussion A. Bipolar technique with pebbles broken on the longest face; B. Bipolar technique with
46 pebbles broken on the tip; C. Pebbles with one removal; D. Pointed or linear pebble-tools with two removals
47 ; E. Pointed pebble-tools including the proto-biface; F. Cores on oval pebbles with unipolar removals on one
48 flaking surface with cortical platform; G. and L. Cores on pebbles with unipolar removals and two orthogonal
49 flaking surfaces; H. and K. Cores on rectangular pebbles with unipolar removals on one flaking surface
50 located on the side of the pebble with a cortical platform; I. Rectangular pebbles with one removal on the
51 edge; J. Cores on rectangular pebbles with unipolar removals on one flaking surface located on the largest
52 face of the pebble with a cortical platform.

53 179x206mm (300 x 300 DPI)

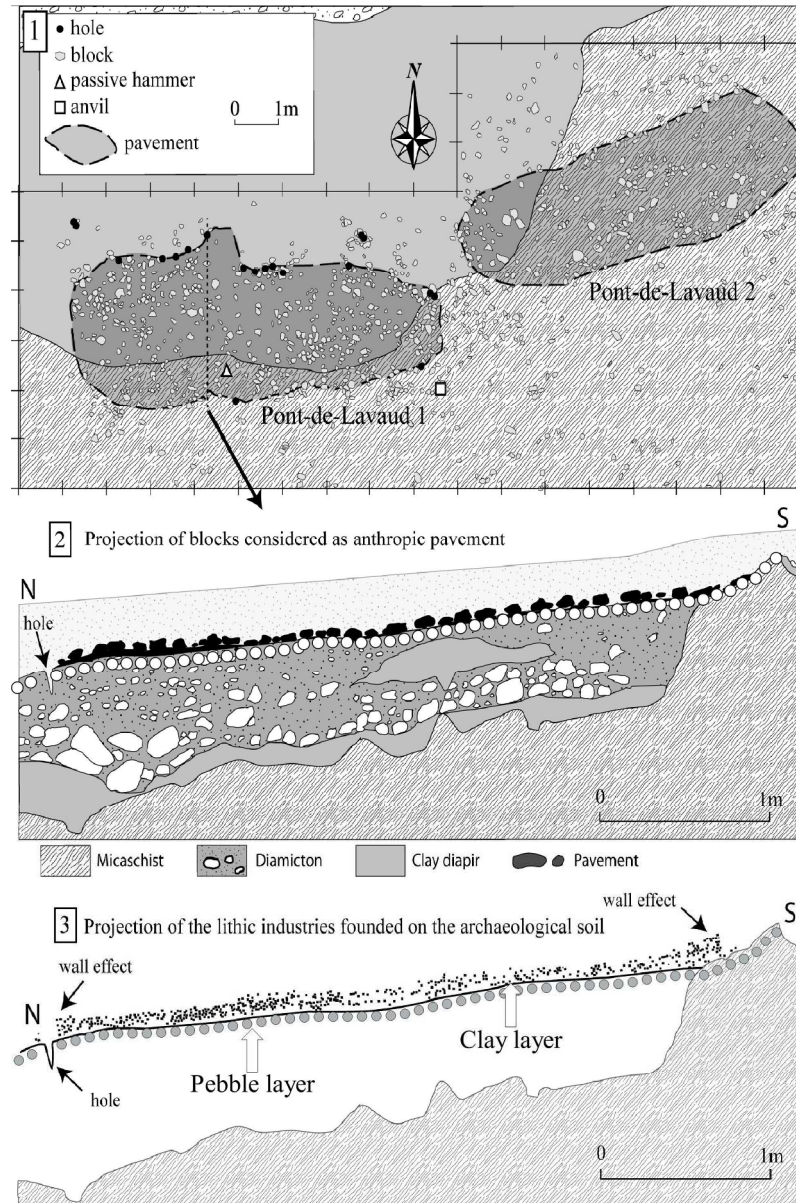
8 **Table 1: Composition of our corpus with artefacts attesting clear hominin activity (in number and ratio) in relation to quartz morphology**

	Ovoid pebbles/cobbles		Polyhedral pebbles/cobbles		Indeterminate pebbles/cobbles	
Direct percussion						
1 isolated removal	21	1.6%	48	3.6%	0	-
Unipolar unifacial cores	46	3.5%	31	2.3%	0	-
Cores with 2 orthogonal flaking surfaces	34	2.6%	35	2.6%	3	0,2 %
Centripetal cores	17	1.3%	7	0.5%		
Broken pebbles	13	1%	20	1.5%	5	0,4%
Flakes	132	10% including 60% first cortical flakes	110	8.3% including 70% first cortical flakes	37	2,8%
Retouched pointed products	48	3.6%	0	-	0	-
Other flake-debris-tools	3	0.2%	0	-	0	-
Choppers	27	2%	10	0.7%	0	-
Bipolar percussion						
Unipolar	17	1.3%	19	1.4%		
2 orthogonal surfaces	11	0.8%	13	1%	4	0,3%
1 removal	1	0.1%	3	0.2%		
Broken pebbles	126	12.1%	63	4.8%	1	0.1%
Split pebbles	25	1.9%	0	-		
Flakes	36	2.7%	6	0.4%	2	0.1%
Indeterminate percussion						
Cores with 2 orthogonal flaking surfaces	-	-	1	0.1%	1	0.1%
Flakes	-	-	5	0.4%	41	3.1%
Broken pebbles	-	-	63	4.8%	28	2.1%
Debris	-	-	105	7.9%	103	7.8%
TOTAL	557	-	539	-	225	-

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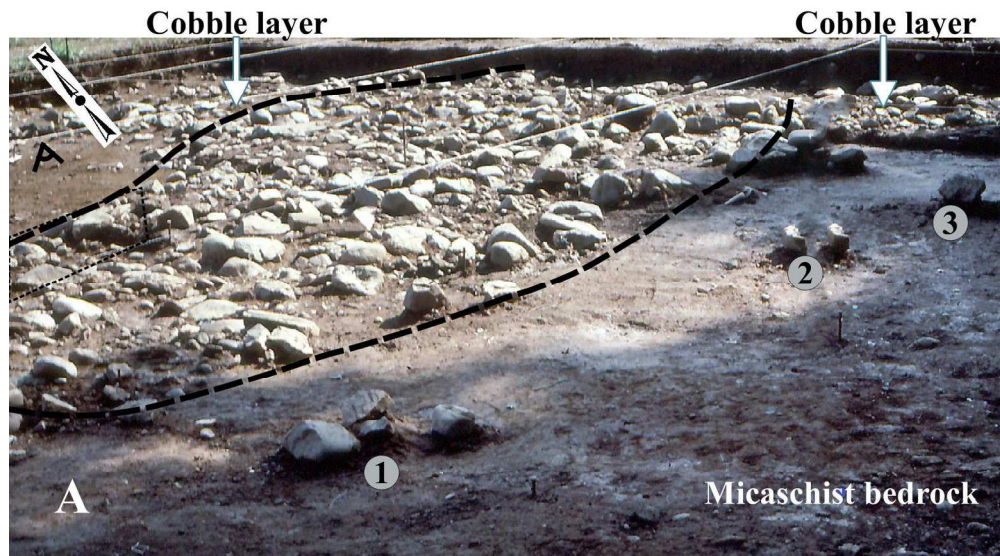
Sites	Other raw materials	Quartz	References
Dmanisi (Georgia)	Local Basalt/Andesite 35.9%/18% Tuff/Silicified Tuff 27.1%/4.2% Sandstone 3.3% Quartzite 1.7%	2.1%	Mgeladze et al., 2011
Bogatyri (Russia)	Local Gray dolomite Siltstone	-	Shchenlinsky et al., 2008, 2010
Rodniki (Russia)	Local Gray dolomite Siltstone	-	Shchenlinsky et al., 2008, 2010
Pirro-Nord (Italy)	Local Cretaceous flint 100%	-	Arzarello et al., 2006, 2013, 2015;
Monte-Poggiolo (Italy)	Local Flint Rare limestone and chert	-	Peretto et al., 1998;
Fuente Nueva 3 Barranco Leon (Orce, Spain)	Local and semi-local Flint Local silicified limestone and limestone	-	Toro-Moyano et al., 2009 Barsky et al., 2010
Sima del Elefante TE7-TE14 (Spain) Gran Dolina TD3-4 (Spain)	Neogene and Cretaceous chert (< 2 km) 72.1% Limestone 27.1%	3.5%	Lombera-Hermida de et al., 2015 Carbonell et al., 1999
Gran Dolina TD6 (Spain)	Local and semi-local Neogene chert 39.1% Cretaceous chert 9.8% Quartzite 13.1% Sandstone 9% Limestone 9.5%	7.7%	Lombera-Hermida de et al., 2015
La Boella (Spain)	Local Chert 76.2% Quartzite Schist Sandstone Granite	3.7%	Vallverdu et al., 2014
Vallparadis (Spain)	Local Lydite Flint Quartzite Metamorphic rock	70%	Martinez et al., 2009,2014
Le Vallonnet (France)	Limestone 100%	-	Lumley de et al., 1988
Pradayrol (France)	Quartzite Limestone	-	Guadelli et al., 2012
Soleihac (France)	Local Basalt Flint Granite	57.6%	Bracco, 1991
Happisburgh 3 (UK)	Local flint	-	Parfitt et al., 2010
Pakefield (UK)	Local flint	-	Parfitt et al., 2005
Kärlich A (Germany)	Quartzite	presence	Bosinski, 2006

Table 2. Proportion of quartz and raw materials in a selection of Early sites.



Suppl. 1. View of the accumulation surfaces (Pavement) Pont-de-Lavaud 1 and Pont-de-Lavaud 2, corresponding to concentrations of blocks with linear borders and peripheral holes. 1: Spatial distribution of the vein quartz manuports (blocks ≥ 10 cm long). 2 and 3: Vertical sections show the links between paving stones (2) and accumulation of lithic artefacts (3) with wall-effect (after Despriée et al, 2010, 1011).

167x250mm (299 x 299 DPI)

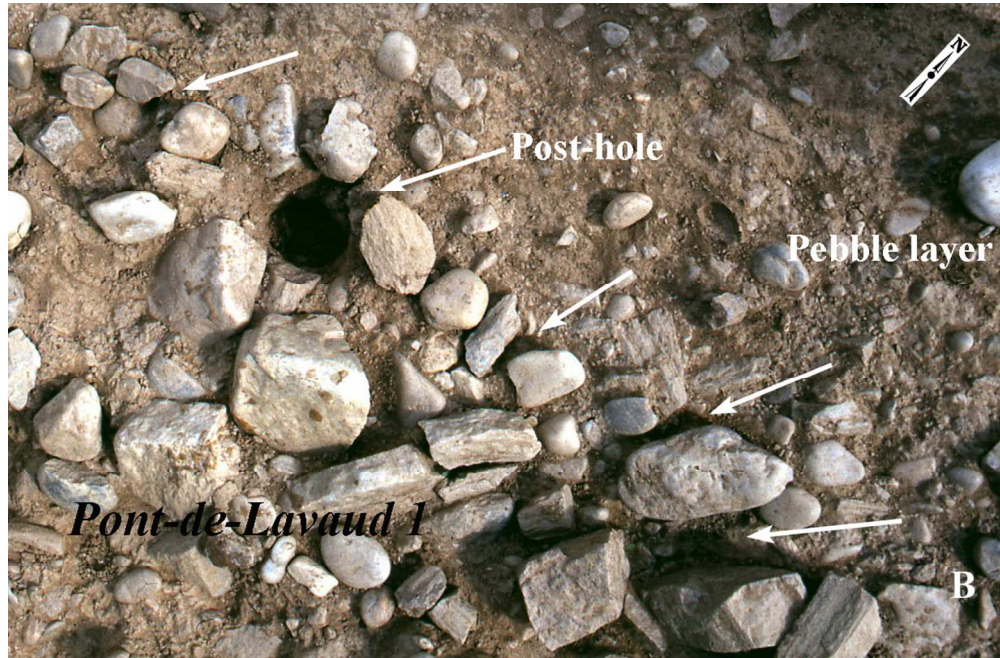


--- Edge of Pont-de-Lavaud 1 pavement ① Wedding
 <---- View supp 2b

Supp. 2A: Stone accumulation of Pont-de-Lavaud 1. The view from the south also shows the large isolated peripheral blocks on the micaschist bedrock. Suppl. 2 B: Holes surrounded with quartz cobbles on the northern edge (photos J. Despriée).

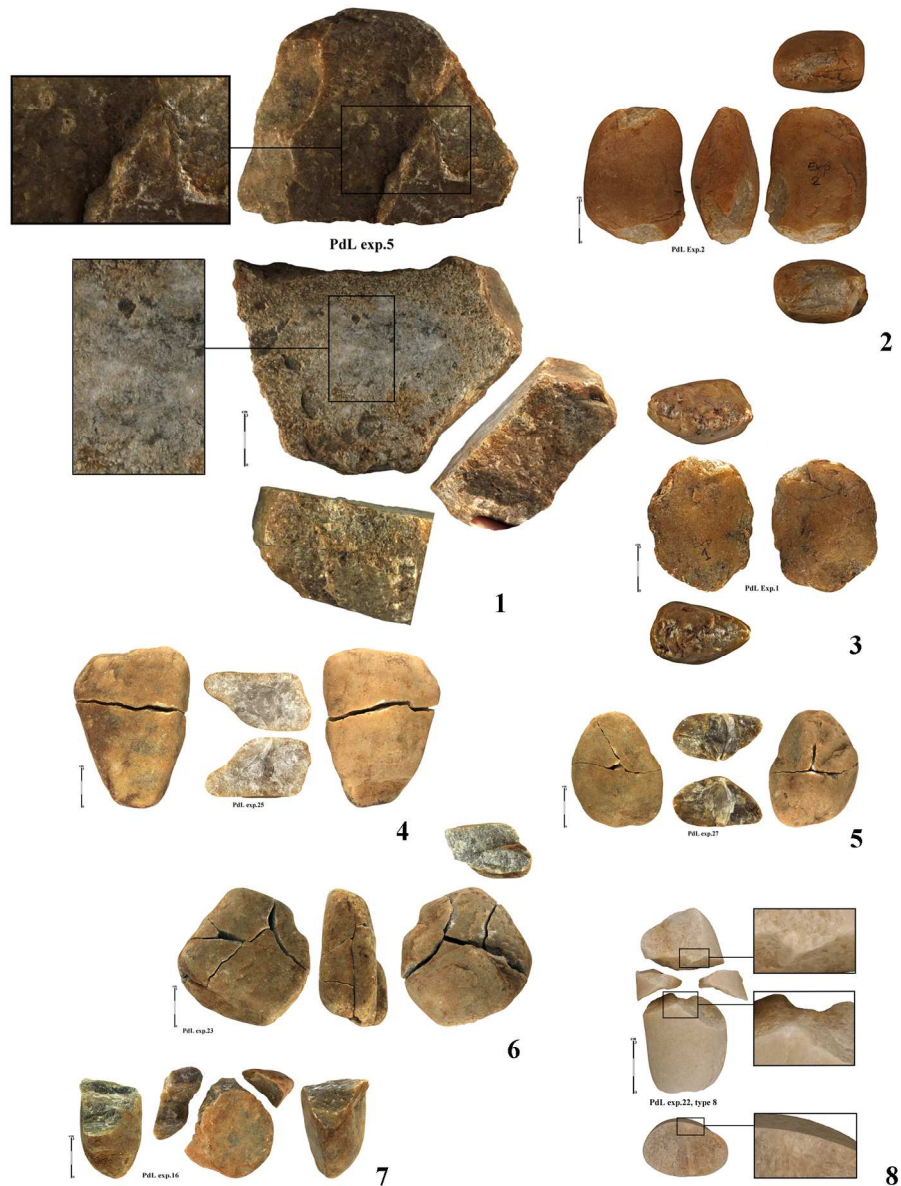
170x112mm (299 x 299 DPI)

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Supp. 2A: Stone accumulation of Pont-de-Lavaud 1. The view from the south also shows the large isolated peripheral blocks on the micaschist bedrock. Suppl. 2 B: Holes surrounded with quartz cobbles on the northern edge (photos J. Despriée).

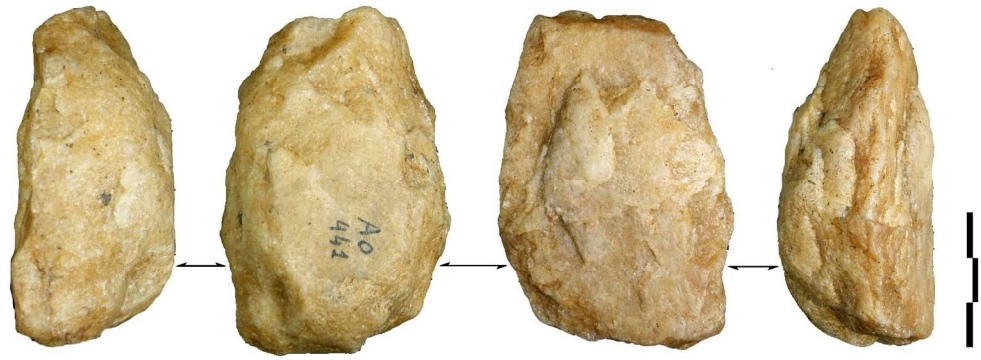
435x285mm (72 x 72 DPI)



Supp. 3. Photographs of experimental artefacts. (1) Block of vein quartz used as an anvil with impacts on the obverse end and lateral crushing; (2, 3). Amygdaloid cobbles used as hammer stones, with use scars; (4,5) Cobbles broken by one blow (types 5 and fragments 7 a, 7c): impact marks, cone and crushing on reverse face; (6, 7) Cobbles broken by two blows (types 6 and fragments 7c, 7d); impact marks, cones and crushing on the opposite surface; (8). Cobble broken by three blows (type 6 with debris type 8) (Experimentation by J. Despriée and P. Alilaire, photos G. Courcimault).

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Suppl. 4. Partial bifacial piece on quartz. Both sides of the pebble were shaped by alternate striking (photos M-H. Moncel).

187x68mm (300 x 300 DPI)