Experiments in manufacturing handaxes: spatial analysis and flexibility of the knapper under constraints

Agnès LAMOTTE, Florent LE MENÉ & Léa BIDAULT

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1. Introduction – Preamble

Considered as an enigma in itself (Wynn, 1995), the handaxe animates so much of us: allometry, typology, technology, symmetry, raw materials, transport, function, symbol, aesthetism, environment marker and now the literature is weighty from Africa to Europe and from the Lower Palaeolithic towards to the transition between Middle and Upper Palaeolithic.

Some archaeologists, in their experiments, question the role of hammers (Crabtree, 1967a; Wenban-Smith, 1989; Dibble & Pelcin, 1995), the nature of raw materials (Crabtree, 1967b; Jones, 1979), quantity and morphology of artifacts issue of the shaping (Dibble & Whittaker, 1981; Brenet, 2011), the role of language and transmission (Chazan, 2012; McPherron, 2010). Some researchers have focused their work and experiments around the function of handaxes and experiments are now numerous with foody part of animals (Potts & Shipman, 1981; Machin *et al.*, 2005; De Juana *et al.*, 2010), woodworking activities (Domingo-Rodriguez *et al.*, 2001), projectile (O'Brian, 1981). They are helped in micro-wear analysis (Keeley, 1980; Mitchell, 1997; Bello *et al.*, 2009) and by experiments with fauna (Machin *et al.*, 2007).

Some works are making in link the knappers abilities and their flexibility among a wide range of factors (Whittaker, 1994; Hayden *et al.*, 1996) and some authors tried to cross three or more of those factors because we are dealing about the author of a multi-task tool (McPherron, 1994, 2003; Lamotte, 2001; Winton, 2005; Stahl, 2008; Machin, 2009).

Looking for years to knappers in specialized sessions or private demonstrations end day of summer excavation, how many times we've been surprised that any of the results whisked away without any trace such as a video, a drawing or an article. Of course some are published, but generally speaking they are under-represented compared to the number of experiments done.

The article is based on 3 experiments of handaxe manufacture (with or without constraints for the knapper), based on the result of the spatial flakes recorded on the floor and the article is also based on the result of an inquiry of 124 questions tested directly with the knapper or sent by postal way.

For each part, different aims motivate our research: ability to replicate a regional handaxe morphology (case of Pont-de-Planches in eastern France, Lamotte *et al.*, 2012), recording and drawing the spatial analysis of each experiment, making clarification about the mood of the knapper under constraints of raw materials, time of knapping, replication of a type of handaxe.

The inquiry was built around 124 questions for each knapper: those are coming from Belgium and France. The enquiry has been sent to 8 knappers: their skills are very varied as they are beginners, less than 2 years of practice, half (2-10 years) and experienced knappers (more than 10 years). The sexual population is built of 7 men and 1 woman.

15 questions were about personal information, 63 were about their feelings during the handaxe manufacture, 5 were about their reactions towards failures, 25 were about external and internal conditions of shaping including 14 questions about raw materials, 13 about their feeling and relationship to the handaxe and in final, 3 were about the final status of the handaxe and their relationship with their realization.

The experiments were designed to test the spatial scatter of all flakes: those of length up to 20 mm, under 20 mm, dimension of special areas such as the hammer storage, the non-tested raw materials storage, the circulation area of the knapper, the global geometry of the accumulation of flakes and different areas on the ground.

Taking all this in consideration, the aims of the study and of the article are to cross the results of this inquiry including 8 knappers, writing about our experiments with a knapper under various constraints and drawing the results on the floor.

2. Studies protocol

2.1. General Protocol conditions for the experiments

Three experiments have been realized in order to explore the degree of the knowledge and the adaptation to constraint when shaping a handaxe. For us, modern man, we built our constraints around the time of the realization, the size and morphology of the raw material, the morphology of the handaxe to be realized. The environment that day was cold in December in eastern France with continental conditions that is, 12° at the midday, 8° at the end of the afternoon but with sunshine. We were therefore, outside with natural light.

Were the constraints the same for the knappers during the Palaeolithic times? We don't know of course, but we can propose some lines of thought. First, we think that if the knapper was the collector of the raw material in the landscape, we can imagine that the morphometry and the quality were the first parameters he had in mind: he will clearly make the best connections between the potential of parameters concerning the raw material and the final aim and he'll thus make then his best choices. But if the knapper was not at the origin of the selection undertaken rather by children, teenagers, hunters, then the size, the morphometry and the quality can be more or less a huge constraint. In our case, raw materials have been chosen in the tertiary Oligocene basin of Mont-les-Etrelles. Two mains types of nodules are found there: angular slabs with a huge diversity of size and rounded and bi-convex nodules. A final consideration, our knapper is a man of 20 years of experience, he is 1.92 m tall. Knapping is his job.

2.2. Protocol for the spatial analysis

On the floor has been put a plastic tarp, which was gridded out all meters and half meters. On that tarp, the position of the seat (a stool) has been recorded. The total space is a horizontal platform without incline (private terrace of an individual house). Very quickly walking on that tarp produced long creases, which had favoured the location of flakes in the deepest part of the tarp. We didn't try to reset the traptarp, thinking that in natural conditions, at the Palaeolithic time, the floor was full of pits, vegetables or plants which could also be a natural barrier for accumulation of flakes. Two photographs made a great quantity of pictures of each experiment. At the end, they took pictures from the seat and all around the seat in 360 degrees. All flakes received a code (up to 20 mm, under 20 mm) in Illustrator for the spatial analysis illustration and for this article, but at any moment we are able to produce a wider range of flakes sizes. The tarp has been swept after each experiment. All wasted flakes have been conserved and measured, even the flakes under 10 mm length and the flint powder. Refittings have been made on each experiment in order to welcome the demonstration of the stage of the handaxe manufacture.

2.3. Global area around the knapper

We observed a difference between the place of the knapper and the area of the knapper. The place of the knapper is considered, most of the time, as static. The area of the knapper is much more dynamic as observed for other experiments (Boëda & Pélegrin, 1985). If the knapper is a right-handed person (which is our case), his hammer storage area and his raw material storage area have better chances of being on his right too (Fig. 1).

Our enquiry specifies too that the raw material storage area is the immediate area that the knapper needs for two or three realizations (cores, handaxes). We can specify that

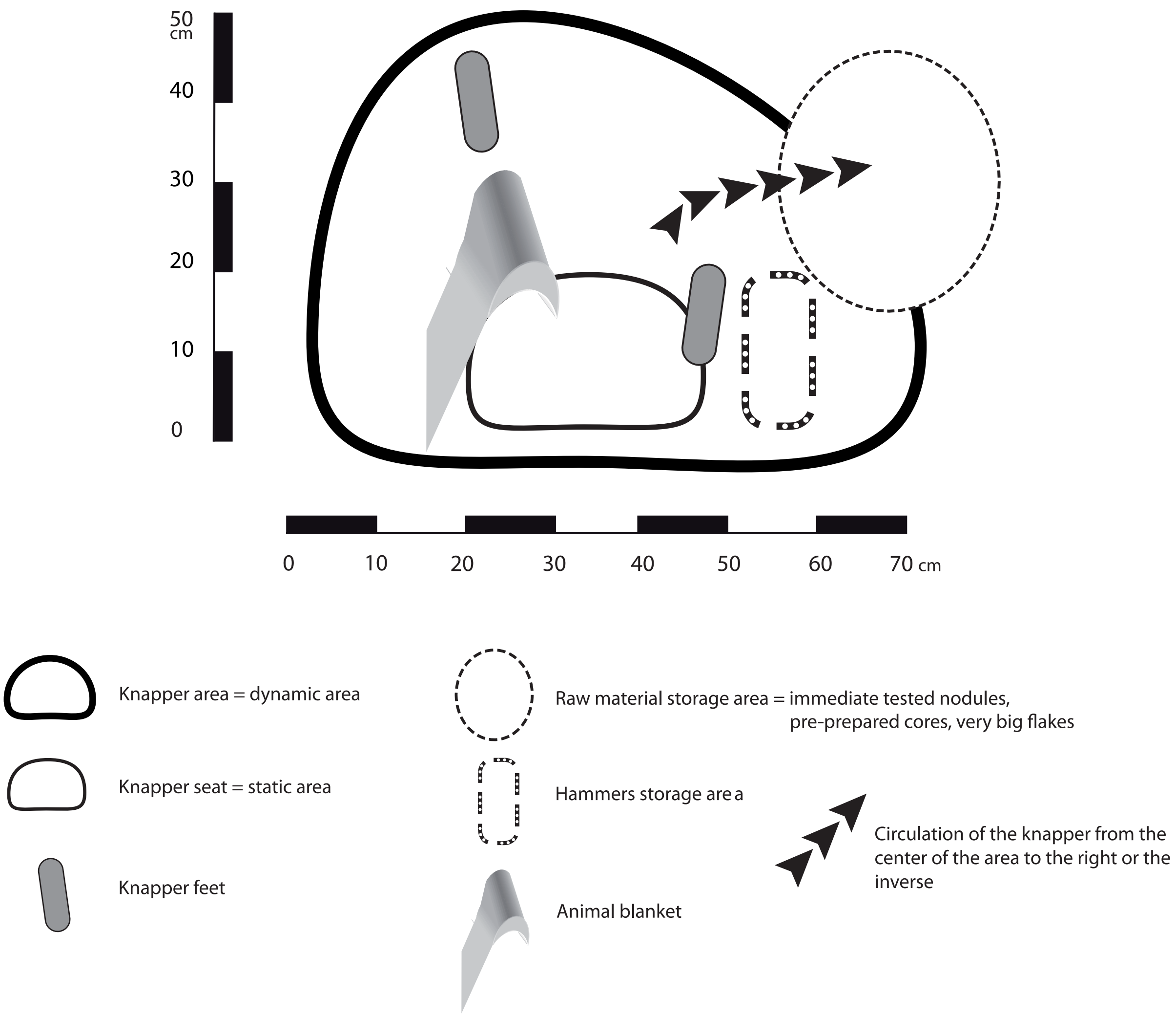


Fig. 1 – Characteristics of the knapper areas.

in this area, we have also pre-prepared nodules or big flakes depending on the aim of the realization. Another bigger storage area should be drawn somewhere else in the site. It could be described as non-tested nodules storage. Until a great number of experiments, the place of both feet of the knapper is still visible to the naked eye. With time, the heap of biggest flakes, by gravity, covers the area empty of feet. Identifying the place of each foot is somewhat an illusion if the site is too perturbed or if the knapping place has been used for a long time. A short time occupation could allow us to see this. In these experiments, the total area of the knapper is 80 cm x 60 cm.

3. Experiment 1

3.1. Constraints for the knapper

In the first experiment, the knapper should have to encounter no constraints. In that region where we made the experiment, the raw material available is constituted by quartzite of different colors, quality, quartz, sandstones, flints from the Mesozoic Era (different Jurassic flints and cherts), flint form the Tertiary era (Lamotte *et al.*, 2015 in press). Finally, the nature of the raw material was targetted on flint from the Tertiary period because in that region, from the Palaeolithic to the Neolithic, it's the most researched flint because of its quality and beauty. Unfortunately, the size of the raw material was a constraint for the knapper. We couldn't guess that the size of our greatest nodule in the landscape, that we jugged as big in size, was considered as a medium for a modern knapper. Greatest dimensions of the raw material would have permitted him to knap big flakes, the favourite blank for modern knapper but for knappers during the Palaeolithic too.

So for this first experiment, among the constraints (Tab. 1), we underline the nature of the raw material (Tertiary flint) and the quality (the knapper can't make any test before its realization).

3.2. Knapper choices and realization

The knapper took the biggest slab (30 x 25 cm), with a rectangular morphology. One face shows a cortical aspect much more homogenous than the other one. Length, width and thickness of this slab are regular.

Free of all other parameters, the knapper decided to produce a cordiform handaxe (he confirmed later that it's his favourite form when he is totally free to choose). The final result shows a cordiform handaxe without any cortical residue on one face and very few on the other. The handaxe is 15.2 cm length, the width is 10.3 cm. It weighs 280 gr. Face A counts 37 final flakes, face B 58. The handaxe is symmetrical (face and section).

The handaxe is smaller by half than the slab origin. In the dustpan, a total of 1232 whole and broken flakes have been recorded.

Parameters	*Constraints*	*Decisions of the knapper*
Raw material		
Nature	Flint	
Size	No	The biggest (30 x 25 cm)
Morphology	No	Rectangular slab, regular thickness
Quality	No test beforehand	
The handaxe		*Realization*
Blank	No	Slab
Morphology	No	Cordiform
Size	No	15.2 x 10.3 cm
Time of the realization	No	45 min

Tab. 1 – Experiment 1. Constraints and decisions of the knapper.

It took 45 min to realize the cordiform handaxe for one main reason: without a test of the raw material, the knapper had to erase the hindrance of flint cracks, a sublevel of silicification under the main cortex for one of the both faces, thus creating an imbalance of treatment between the two faces.

3.3. Flakes: size class distribution and characteristics

All flakes are splitted as follow (Tab. 2): more than 85 % of the flakes are without cortex, less than 9 % are few cortical flakes (Fig. 2), less than 6 % are with cortical residue on their dorsal face. If we comment the dimension of those flakes, less than 10 % are up to 20 mm. The longest flakes find their length around 84 mm (cortical or without cortex), the width is around 52 mm and thickness is around 12 mm. Those longest flakes are non-cortical and in contact with the handaxe (Fig. 3) or cortical and located in the external part of the flint nodule.

Cortex	*Cortical*	*Half-cortical*	*Without cortex*	*Total*
Flakes dimensions	*Nb - %*	*Nb - %*	*Nb - %*	*Nb - %*
> to 20 mm	38 – 3.1	26 – 2.1	57 – 4.6	121 – 9.7
10 – 20 mm	19 – 1.5	52 – 4.2	467 – 37.9	538 – 43.7
< to 10 mm	14 – 1.1	29 – 2.3	530 – 43.1	573 – 46.6
Total	*71 – 5.7*	*107 – 8.6*	*1054 – 85.7*	*1232*

Tab. 2 – Experiment 1. Cordiform handaxe: cortical and metrical data of shaping flakes.

3.4. Surface trend analysis of flakes from experiment 1

Flakes are scattered in an area quite long from the seat of the knapper up to 1 meter distance in front him. Flakes up to 20 mm are numerous and located in front and left to the knapper who is righthanded, it represents 80 % of flakes (Fig. 4A). Those flakes are present on an area of 0.83 m x 1.08 m. The maximum distance between flakes up to 20 mm and the knapper is 90 cm. The minimum of distance is around 3 cm.

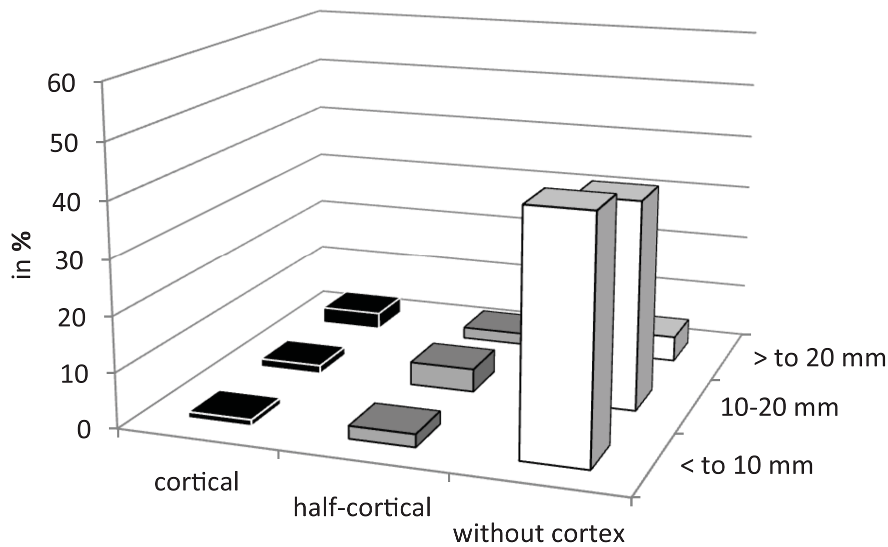


Fig. 2 – Experiment 1. Class distribution of flakes correlated to their metric analysis.

Flakes under 20 mm length are located everywhere right to left and in front to the knapper with a slightly higher density on the right of him (Fig. 4B). Distance between flakes from right to left and the knapper of are very homogenous. Flakes are present around the first 60 cm and rare over 1.10 m.

The area of flakes all together which do reflect the reality of this experiment is 1.10 x 1.62 m (Fig. 4C).

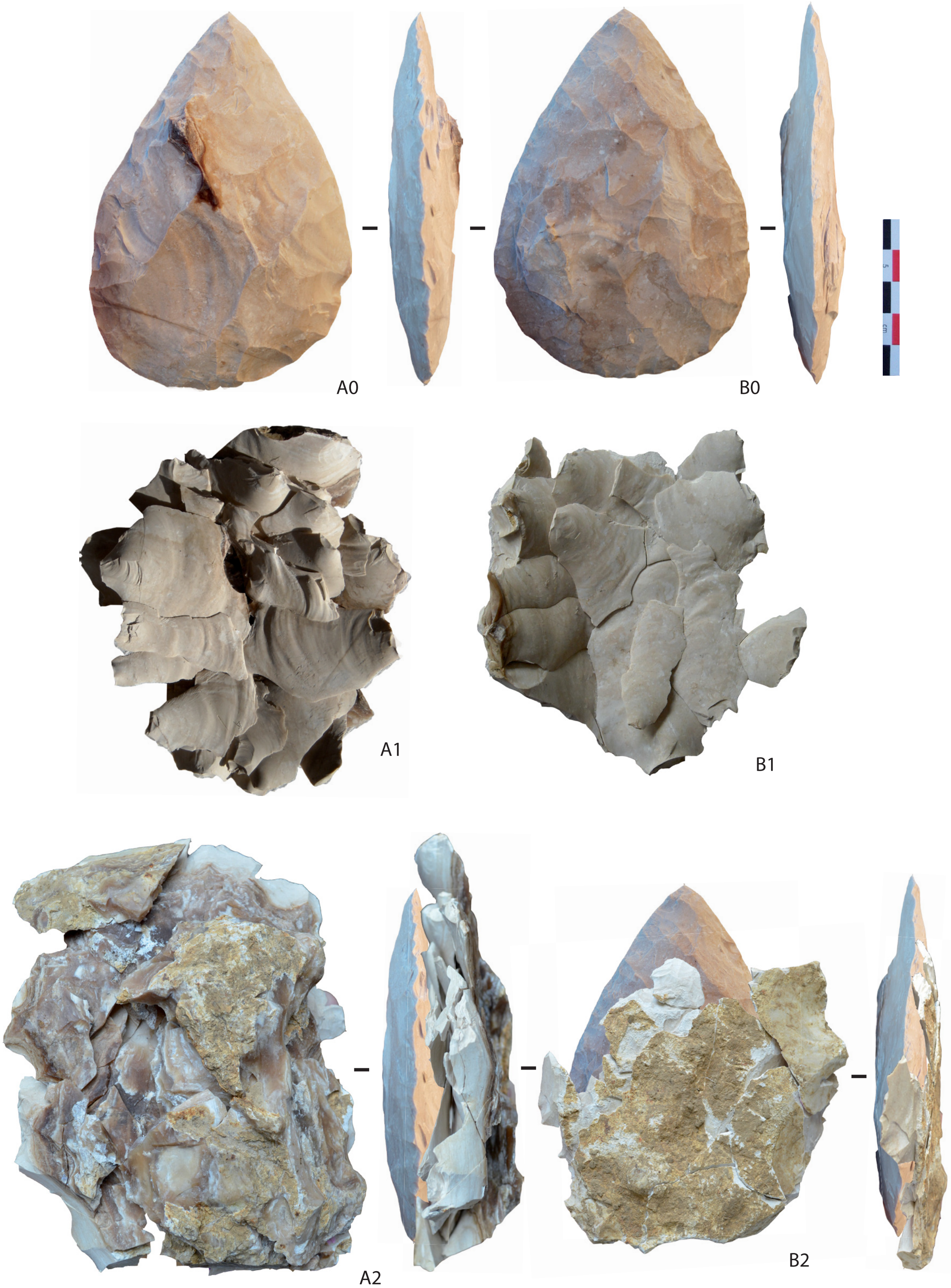


Fig. 3 – Experiment 1. The cordiform handaxe. A0: face A, BO: face B, A1: refitted face A (ventral view of the flakes), B1: refitted face B (ventral view of the flakes), A2: face refitted, B2: face B refitted.

4. Experiment 2

4.1. Constraints for the knapper

In the second experiment, the knapper should have met the same constraints (best regional flint). At the contrary of experiment 1 where the knapper made a choice on the

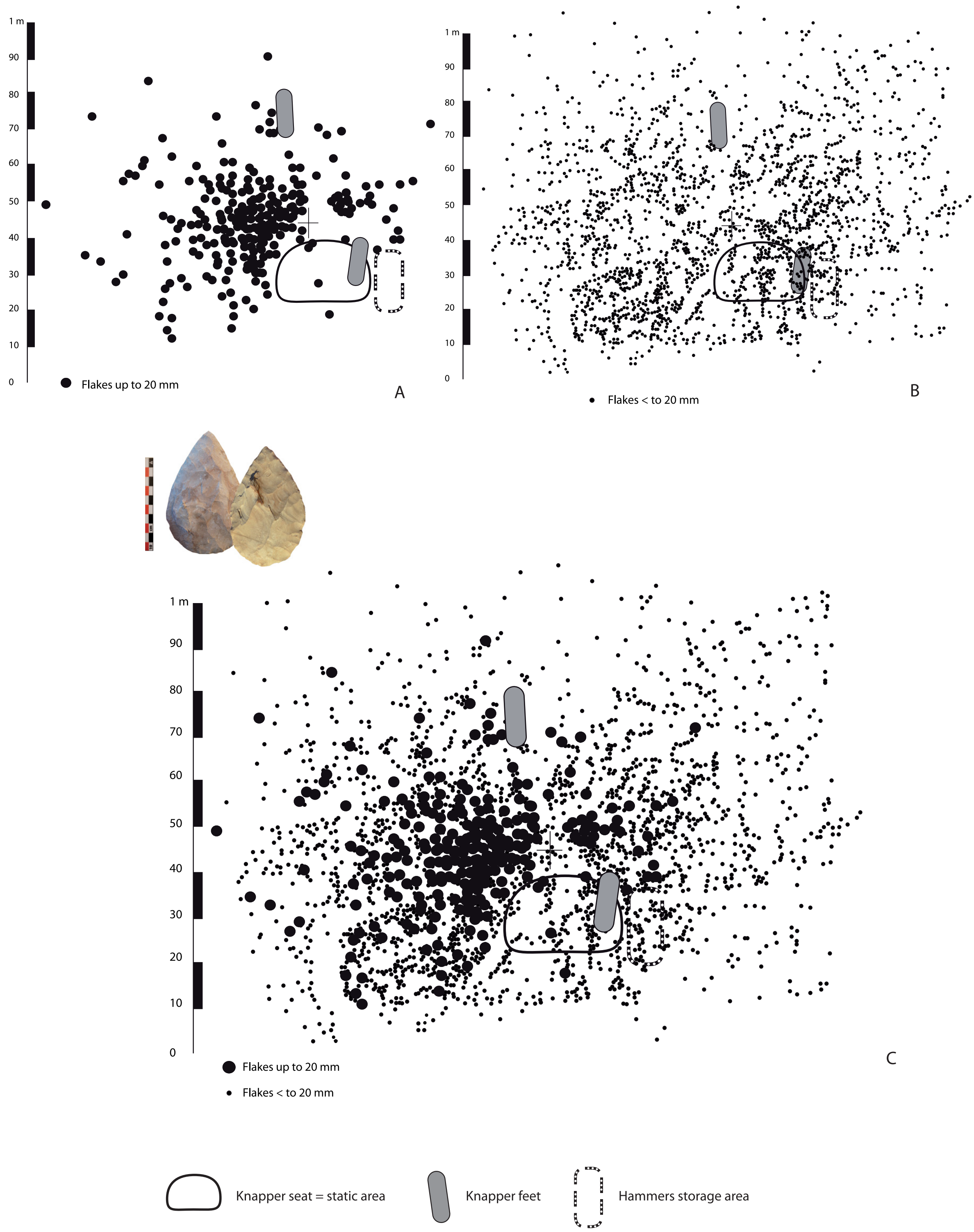


Fig. 4 – Experiment 1. Cordiform handaxe. A: scatter of flakes > to 20 mm, B: scatter of flakes < to 20 mm, C: scatter of all flakes.

bigger nodule, he has, for new constraint, the obligation to knap on the smaller nodule (11 x 8 cm), but was free as to the realization of the handaxe morphology.

The nodule selected was bi-convexe and very regular in his morphology and thickness. The knapper had another constraint that he didn't know: we stopped the experiment after 5 minutes of action in order to observe a roughout handaxe (Tab. 3) and its consequences in flakes (metric) and also spatial layout.

4.2. Knapper choices and realization

The knapper made his choice on a bi-convex nodule with its maximum width located near the future basis of the handaxe. On that nodule, the width decreased uniformly from this maximum near the basis throughout the nodule towards the tip, which can be mentally imagined as the handaxe-tip. The knapper quickly engages a series of flakes which contribute to reduce the triangular base of the nodule in a rounded one.

Parameters	*Constraints*	*Decisions of the knapper*
Raw material		
Nature	Flint	
Size	The smaller nodule (11.2 x 7.3)	
Morphology	No	Sub-triangular, bi-convex, flat and regular thickness
Quality	No test beforehand	
The handaxe		
Blank	Nodule	Nodule
Morphology	Cordiform roughout	Ovate roughout
Size	No	9.1 x 6.6 cm
Time of the realization	5 min	6 min

Tab. 3 – Experiment 2 - Constraints and decisions of the knapper.

Cortex	*Cortical*	*Half-cortical*	*Without cortex*	*Total*
Flakes dimensions	*Nb - %*	*Nb - %*	*Nb - %*	*Nb - %*
> to 20 mm	37 – 11.3	3 – 0.9	59 – 18	99 – 30.2
10–20 mm	4 – 1.2	8 – 2.4	5 – 1.5	17 – 5.1
< to 10 mm	12 – 3.6	27 – 8.2	173 – 52.9	212 – 64.7
Total	*53 – 16.1*	*38 – 11.5*	*237 – 72.4*	*328*

Tab. 4 – Experiment 2. Roughout of handaxe: cortical and metrical data of shaping flakes.

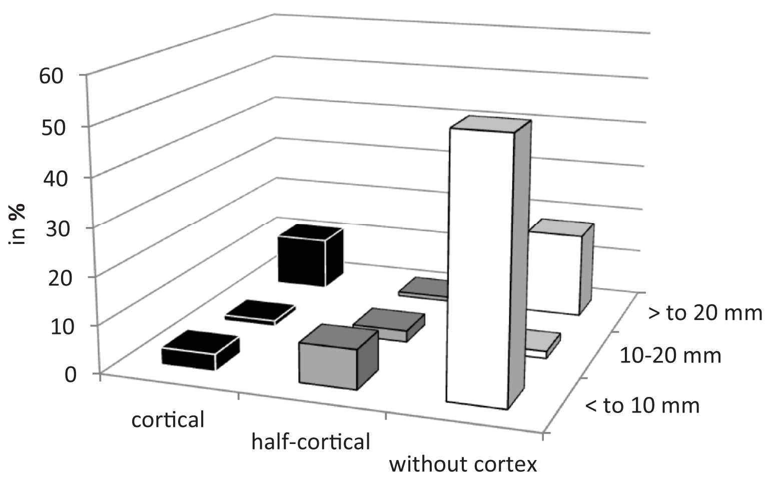


Fig. 5 – Experiment 2. Class distribution of flakes correlated to their metric analysis.

The roughout dimension (9.1 cm x 6.6 cm) is close to the size of the raw material (11 x 8 cm). It weighs 180 gr. 14 final flakes are counted for face A, 23 for face B. In the dustpan, around 328 flakes are recorded.

After 5 min of knapping, the knapper is angry that we stop the experiment. He explains that no one can leave a partial handaxe except if they are internal reasons (quality). Even bored, you'll find a "finished" biface on the floor. The reflex of the knapper then, was to knap again the handaxe in order to perfect it, but experiment 2 stopped there in spite of his attempt.

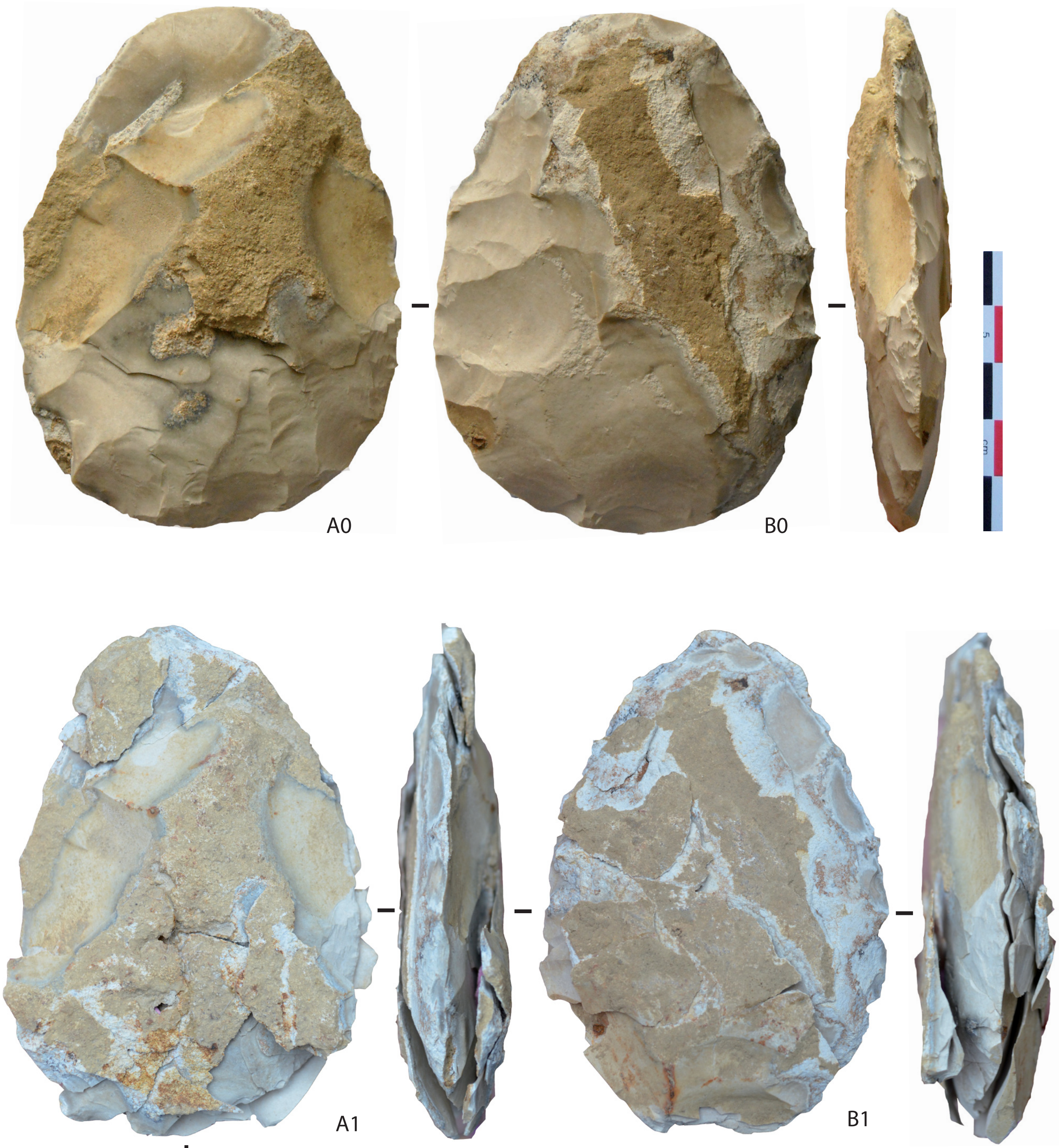
On that biface, one face is more engaged by gestures and flakes than the other. The handaxe rim is cleared off cortical residue excepted for the tip of the duty-tool. One face is rough-hewed at the base, the rest of the artifact is composed and benefits of natural flint removals characterized also by another patina (yellow) than the fresh flint.

The other face doesn't show the same way of treatment between the right edge and the left. Removals of the left edge are non invasive in comparison to the right edge and these coming from the basis.

4.3. Flakes: size class distribution and characteristics

The best representation of size class in link with the manufacture is the small flakes under 10 mm length which represents more than 50 % of the flakes (Tab. 4 ; Fig. 5). 30 % of the flakes find their length up to 20 mm, 5,1 % between 10 and 20 mm. Generally speaking, in 72 % of the cases, flakes are without cortex (even for a roughout), 16 % are cortical, 11 % are half-cortical. The poorest size class is the cortical flakes from 10-20 mm length, flakes without cortex from the same size class and the half-cortical flake up to 20 mm length.

The longest flake is 42 mm, its width is 32 mm and thickness 5 mm. It's a flake coming from the basis, a flat back-knife. Another one of 42 mm length, 16 mm width and 2 mm thick is coming also from the base of the other face (Fig 6).



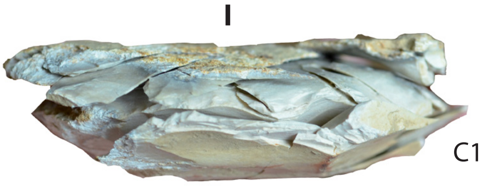


Fig. 6 – Experiment 2. The cordiform roughout. A0: face A, BO: face B, A1: refitted face A, B1: refitted face B, C1: refitted base.

4.4. Surface trend analysis of flakes from experiment 2

In experiment 2, flakes are scattered in the same area than in experiment 1. Most of the flake up to 20 mm are preferentially located in front and left from the knapper (Fig. 7A).

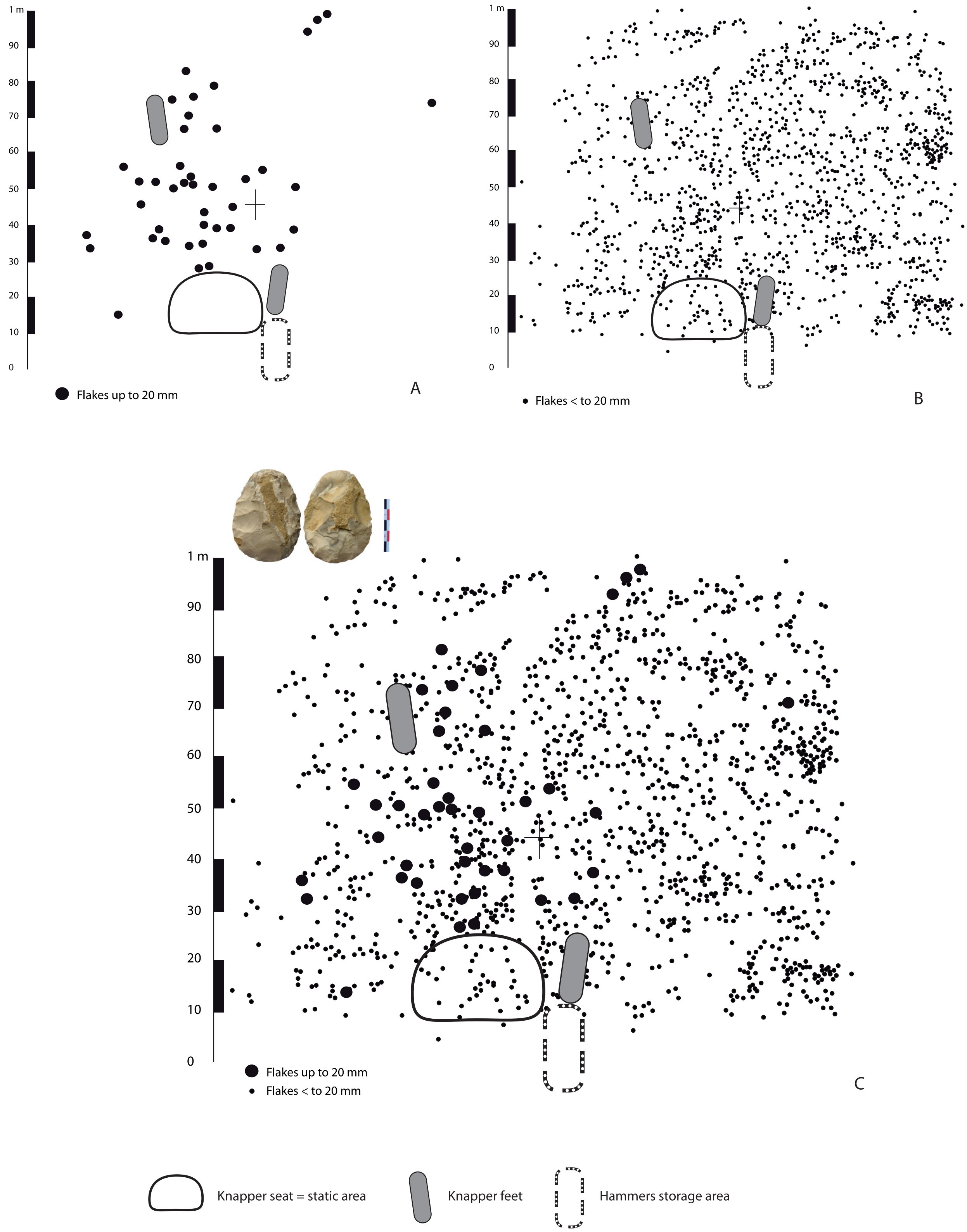


Fig. 7 – Experiment 2. Roughout handaxe. A: scatter of flakes > to 20 mm, B: scatter of flakes < to 20 mm, C: scatter of all flakes.

A series of flakes is also visible in front and right of him. The distance maximum between those flakes and the knapper is 80 cm, and generally they are not far right and left from the knapper: 52 cm left and less for right side (21 cm) except for 1 flake (52 cm). The minimum of distance between flakes up to 20 mm is 15 cm on the left and 30 cm in front of the knapper.

The area of such flakes is 0.97 m x 0.98 m, if we integrate the flake alone on the right (Fig. 7A), but the main area is around 0.97 m x 0.72 m.

Flakes under 20 mm length scatter everywhere right to left and in front to the knapper (Fig. 7B), with a shiny higher density on the right of him. Both flakes (total of flakes; Fig. 7C) give an area of 1.03 m distance in the axis of the knapper and a total of 1.28 m on both side from him. The total of the area involved by the knapper is 1.03 m x 1.28 m = 1.31 m^2.

5. Experiment 3

5.1. Constraints for the knapper

In the third experiment, the knapper had a new constraint: making a replication of a local handaxe, rare in eastern France, but very common in Central Europe. The knapper had 5 minutes to observe the handaxe type "Pont-de-Planches" (Tab. 5). The typology and the technology of this handaxe find many common points with the handaxes founded in Central Europe especially in Southern Germany (Bosinski, 1967, 2004, 2006; Richter, 1997, 2006) more than the one described in the Bordes list (Bordes, 1950, 1961).

This handaxe looks like a Mousterian point, but it's realized on nodule or thin slab. It's a plano-convex handaxe. The first face shaped is the plano one, the last face shaped is the convex one obtained by a huge quantity of small flakes on both edges, finishing in a convergent tool. Except the retouched flakes, this face can be very cortical. This handaxe is very often lopsided.

Parameters	*Constraints*	*Decisions of the knapper*
Raw material		
Nature	Flint	
Size	No	10.3 x 7.2 cm
Morphology	No	Sub-triangular, plano-convex nodule
Quality	No test beforehand	
The handaxe		
Blank	Nodule	
Morphology	Plano-convex and pointed handaxe	9.3 x 5.6 cm
Size	No	Cordiform then after twice time the handaxe wanted
Time of the realization	No	25 min

Tab. 5 - Experiment 3 (Keilmesser handaxe). Constraints and decisions of the knapper.

5.2. Knapper choices and realization

After these 5 minutes of observation towards the biface type "Pont-de-Planches", the knapper makes its choice for a sub-triangular and plano-convex nodule so that he gets the maximum of equivalence between the departure situation and the realization to make.

The shaping of the plano-face is very quick. This face is obtained by flakes of diverse morphology and metric aspect. Near the base, flakes come from a strict bilateral way perpendicular to the length axis of the handaxe (Lamotte *et al.*, 2015). The rest of the body of the tool is obtained by flakes coming in slanting way from the both edges or from the tip of the handaxe. The convex face is more longer worked with a strict bilateral shaping method; flakes are coming from both edges in an axis perpendicular to the lenght axis of the tool. Only the tip of the handaxe is shaped with flakes coming from the tip.

After 10 min of working, the knapper gives us in hand a cordiform handaxe.

Four things are not respected compared to the original: the handaxe is not lopsided, both edges are not convergent and pointed enough, both edges are too convex and the size is too high. The knapper admits that the handaxe is too close from what he is used to shape: a cordifom handaxe.

A possibility to re-shape the tool is given to him after a small watch to the original once again. During 3 minutes, only the morphology of both edges was re-engaged in order to make a lopsided handaxe, but the handaxe is not reduced, not pointed, not enough convex for the most convex of the two faces.

When one of us explain the technology of those central Europe technology, then in the last 7 minutes the reply looks like the original as for prove the doubt reading on face of students looking for the original and the reply. The knapper has understood the technology.

Analysing every parameter of the construction of the biface, face by face, he finally recognizes that this type of handaxe is very quick to obtain (in reality, less than 10 minutes) and do not need a lot of engagement. It's clearly a lopsided Mousterian point on a plano-convex slab or nodule. The plano-convex handaxe measurements (9.3 cm x 5.6 cm) are close to the size of the raw material (11 cm x 8 cm). It weighs 200 gr. 21 final flakes are counted for face A, 35 for face B. In the duspan, around 406 flakes are recorded.

Cortex	*Cortical*	*Half-cortical*	*Without cortex*	*Total*
Flakes dimensions	*Nb - %*	*Nb - %*	*Nb - %*	*Nb - %*
> to 20 mm	5 – 1.2	14 – 3.5	4 – 0.9	23 – 5.7
10–20 mm	10 – 2.4	9 – 2.2	23 – 5.7	42 – 10.3
< to 10 mm	17 – 4.1	82 – 20.2	242 – 59.6	341 – 84
Total	*32 – 7.7*	*105 – 25.9*	*269 – 65.3*	*406*

Tab. 6 – Experiment 3. Plano-convex handaxe type « Pont-de-Planches »: cortical and metrical datasof shaping flakes.

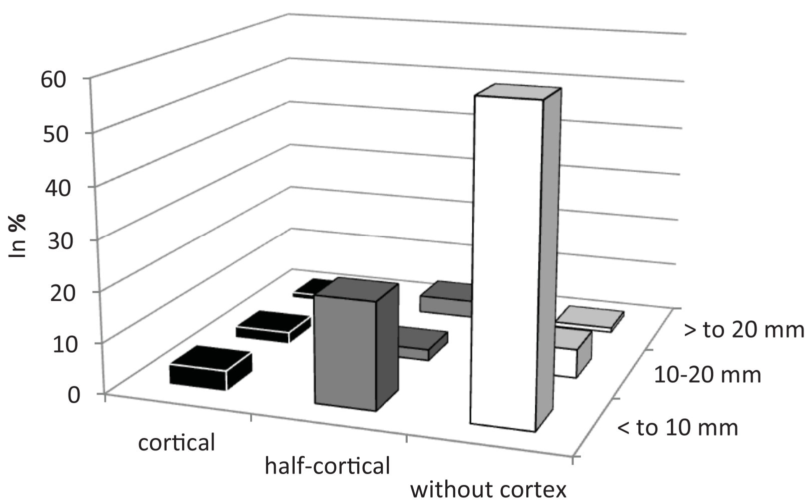


Fig. 8 – Experiment 3. Class distribution of flakes correlated to their metric analysis.

5.3. Flakes: size class distribution and characteristics

The best representation of size class in link with the debitage is, such as the other experiments, the small flakes under 10 mm length which represents more than 80 % of the flakes (Tab. 6 ; Fig. 8). Less than 6 % of the flakes find their length up to 20 mm, 10 % between 10 and 20 mm. Around 65 % of flakes are without cortex, less than 10 % are cortical, 26 % are half-cortical. The poorest size class is the cortical flakes us to 20 mm length, and flakes without cortex up to 20 mm length.

The longest flake is 48 mm, its wideness is 20 mm and thickness 3 mm. It's a flake with few cortical on the plano-face coming from tip of the handaxe (Fig. 9). Other flakes with size up to 40 mm are half-cortical and coming from the lateral edges of the tool. All flakes from the convexo-face are under 31 mm.

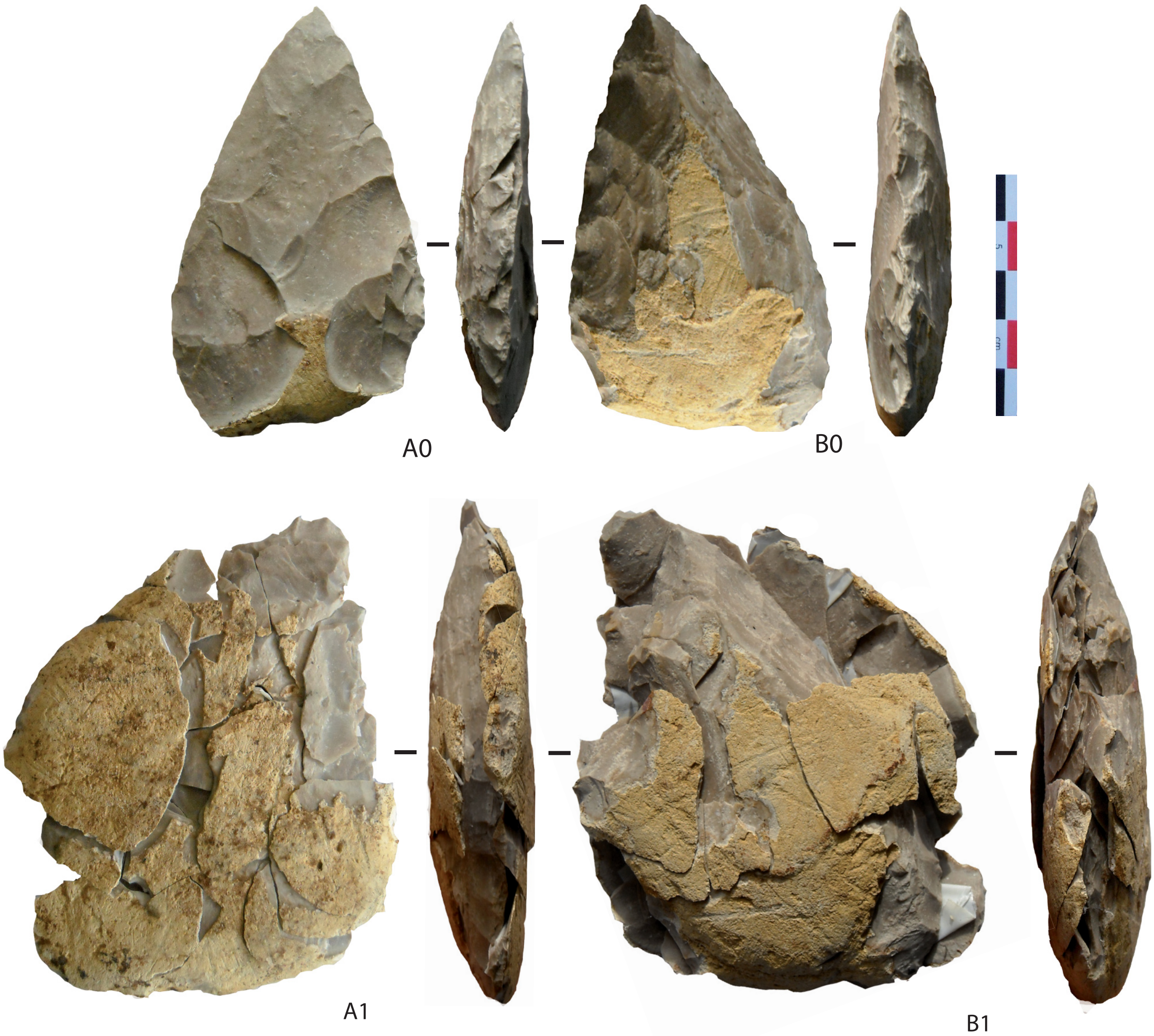


Fig. 9 – Experiment 3. The handaxe type "Pont-de-Planches"; A0: face A, BO: face B, A1: refitted face A, B1: refitted face B.

5.4. Surface trend analysis of flakes from experiment 3

Flakes are scattered in an area closer from the knapper compared to the both other experiments. Flakes up to 20 mm are located the same way right and left from the knapper with a relative higher quantity for the right side (Fig. 10A) on an area of 0.63 x 0.92 m^2. The maximum distance between those flakes and the knapper is 82 cm for the right part and 73 cm for the left part. The minimum of distance between flakes up to 20 mm is 21 cm on the left and right and a little more in front of the knapper to 35 cm. Flakes under 20 mm length scatter everywhere right to left and in front to the knapper (Fig. 10B) with a clear higher density on the right of him. All flakes together (Fig. 10C) give an area of 0.67 m distance in the axis of the knapper and a total of 1.12 m on both sides from him. The total area engaged for this third experiment is 0.67 m x 1.12 m = 0.75 m^2 (Tab. 7).

From experiment 1 to 3, the areas of flakes up to 20 mm and under 20 mm are not exactly the same. The greatest area is obtained in the cordiform handaxe experience (1.78 m^2), the smallest is for the Keilmesser or handaxe type "Pont-de-Planches" with a

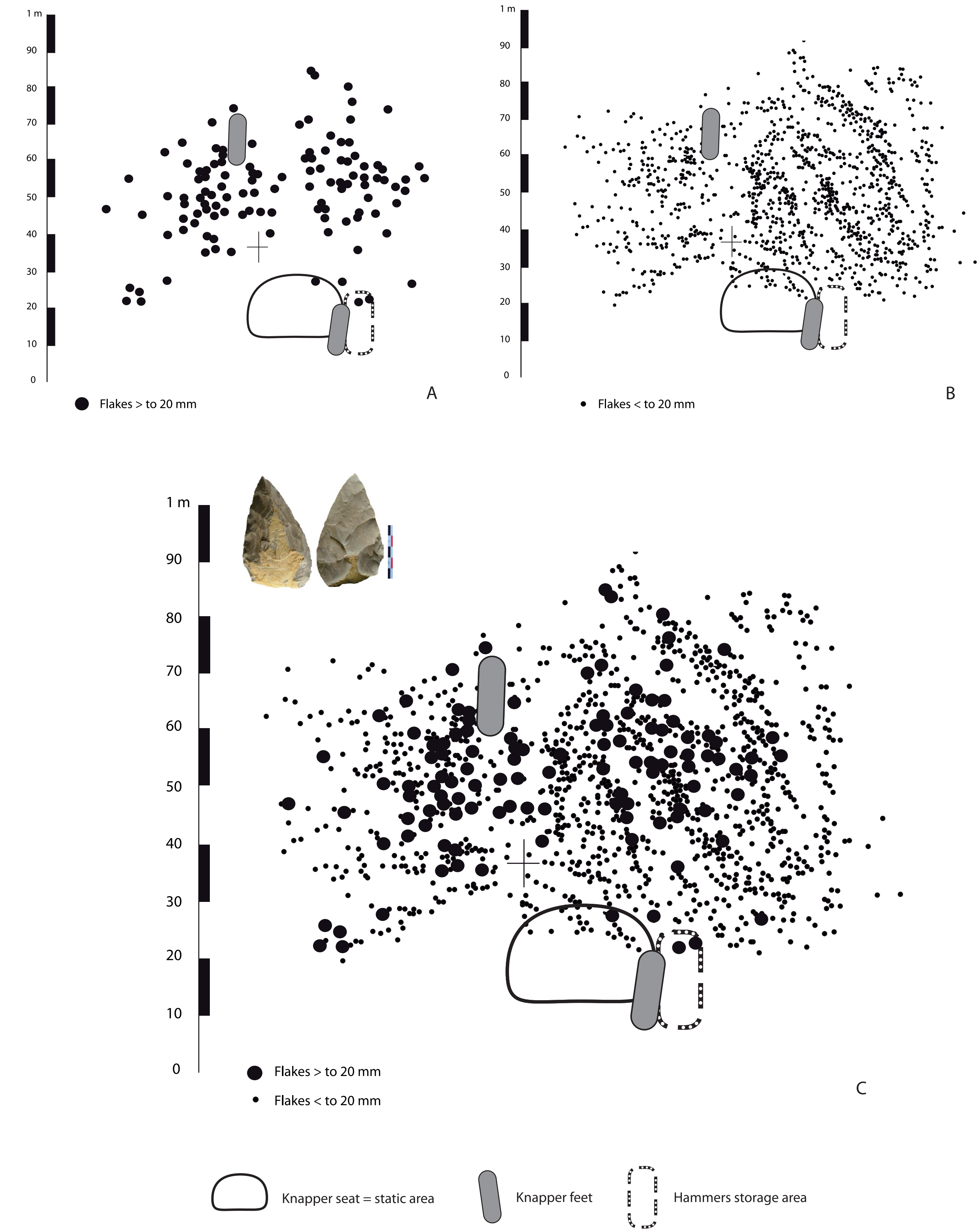


Fig. 10 – Experiment 3. Keilmesser handaxe.
A: scatter of flakes > to 20 mm, B: scatter of flakes < to 20 mm, C: scatter of all flakes.

maximum of 0.75 m^2. In literature, the smallest area never found is in Boxgrove (Newcomer & Mark, 1971; Bergman *et al.*, 1990; Austin, 1994; Robers & Parfitt, 1999) for an area of 0.30 x 0.30 m^2 and where they conclude for a knapper sitted on the floor (Bergmann & Roberts, 1988).

	Experiment 1 *cordiform handaxe*	*Experiment 2* *Rough out*	*Experiment 3* *Keilmesser*
Area of flakes up to 20 mm length	0.83 x 1.04 = 0.86 m^2	0.97 x 0.98 = 0.95 m^2	0.63 x 0.92 = 0.57 m^2
Area of flakes under 20 mm length	1.10 x 1.62 = 1.78 m^2	1.03 x 1.28 = 1.31 m^2	0.67 x 1.12 = 0.75 m^2
Total area of the experiments	*1.10 x 1.62 = 1.78 m^2*	*1.03 x 1.28m = 1.31 m^2*	*0.67 x 1.12 = 0.75 m^2*

Tab. 7 – Comparison of flakes areas between the three experiments.

6. Conclusion

One of the aim of this study shows that the knapper, as an individual agent of variability, has a great role for understanding our assemblages. The study and the synthesis of our enquiry of 124 questions (Bidault, 2014) to 8 knappers show that their environment, skill and practice are the main parameters of their realizations. Usually, knappers need calm, concentration and to be alone. Even if they need concentration, finally they admit that they need less concentration than for other main artefacts categories of artifacts such as Levallois method and laminar or bladelet production. They need light, space, warmth. They are considered as meticulous.

As an individual factor, it's very interesting to admit that for 87 % of them, some days they cannot knapp or they are bored after 2 or 3 hours. They also consider their activity as physical. Then, what is the reality of a common Palaeolithic day? Nobody has no tool? Users must resharpen themselves? Another knapper with less skill must replace the others?

In term of space, knappers make their realization very often at the same place and in elevated sitting. When then knap, they think that the biggest flakes (up to 10 cm) fall down the external part of the leg, medium flakes (2 to 10 cm) also down the external part, whereas the smallest flakes would fall down between the two legs or internal part. Quality of raw material is first requirement, then the morphology of raw materials and the nature (petrography) of raw materials. The lack of raw materials is a source of pressure. When raw materials is missing, knappers admit that they will work diligently and without hesitation in their gestures. The choice of the morphology of the raw material depends on the realization of artifacts or tools wanted. Generally, creating and knapping handaxes are a great source of satisfaction. On a scale to 1 (easy) to 10 (hard), handaxes are judged 4-6, laminar (8-10) for a comparison. For shaping handaxes, they prefer flakes and slabs and far from that, bi-convex nodules. The size of the blank influences the size of the flake production, but for this question we have a clear debate between the knappers.

The production of handaxes causes automatic gestures compared to laminar production. It could explain that handaxes are found since a long time and further in the recent periods. Knappers can produce 4 or 5 handaxes per day, 10 for a great knapper and spontaneously, knappers are producing cordiform handaxes and then triangular. To the question about and our interest for lopsided handaxes, they really think that it's not a natural to wish to produce such tools. Stopping shaping a handaxe, for any involuntary reason, means loss of concentration, sharp pain, loss of precision and suddenly irritation within the main parameters. In that case, what did our knapper produced?

In our case, remarkable data are expected in both aspects of our demonstration: in the spatial analysis of the production of handaxes with 3 different experiments and in the analysis of gestures and the mood of the knapper when he has constraints from the beginning to the end of its realization. The knapper place and the knapper area cover less than 2 m^2 occupied. In our case, the knapper sat on a stool and artifacts could go under it. In the reality, and on an excavation, it's possible to record the sitting place of the knapper, with more or less a clear limit between an accumulation of artifacts against a tree trunk for example. Recording all artifacts during those experiments means testing the reality of the spatial organization of lithic production. The three experiments have shown that flakes under 20-40 mm are more numerous than those of upper dimensions. The excavations which do not record artifacts under 20 mm length can lose 70 % of the shaping production and information. Places occupied by seat, foot, hammers, stock of raw materials can take 20 x 50 cm^2 by 20 x 50 cm^2. Those places are without registration of anything or characterized as lost spaces. Compared to the result of the enquiry, flakes go everywhere all around the knapper and not between legs. In fact, each step of shaping produce a great quantity of flakes in front, to the left and right of the knapper.

Artefacts over 40 mm (or around) length fell down in a nearest area close the knapper. Their weight infers a fall, very quick in time, after the knapp and in space (less than 40 cm around the knapper). Artifacts of less than 20 mm length scatter everywhere right, left and in front of the knapper. Artifacts of less than 10 mm length scatter also everywhere. The maximum of distance between the flakes and the knapper, in front of the knapper, is never over 90 cm. Distances right and left to the knapper are widest. They can be over 1.23 m.

For all experiments, the vertical dispersion of flakes was 6 cm at the maximum of the concentration deposit immediately on the left of the knapper. Everywhere else and very quickly this vertical dispersion decreases and most of the time, flakes were alone with no other flakes stacked up.

One of our main observation is that flakes fell down on the floor in a dorsal position. The dorsal face with scars or cortex touch the floor, the ventral face is visible to the naked eye. Could it be an indication of *in situ* artifacts and by extension of *in situ* levels as it is described for Boxgrove for example (Pope & Roberts, 2005)? Between experiment 1 and 3, this percentage of flakes found in a dorsal face in contact with the floor can represent more than 80 % of the cases. A law says that when an object falls down, it falls down a half rotation compared to its departure position. For our flakes, it's the same observation: the dorsal face visible on the core or on the handaxe will fall down in dorsal position on the floor. For us, it would mean that the knapper is standing up and would be a tall knapper. There is, of course exceptions in this law: if the vertical distance is long enough, the object has time to turn once again and to fall in the same position than its departure one.

We also know that many other external factors can endomage this data like the knapper who pushes his target on his leg as consequence all flakes seen in a dorsal position change of orientation and also of position.

About the knapper: most of the results of the enquiry are efficient except the fact that the knapper never takes a flake as blank. He always worked with tabs or nodule and size of the nodule conditioned size of the flakes (experiment 1 to 3). The mood of the knapper often gives a signature to the handaxe. If two convergent edges are efficacious outwards morphology, then all our discussions about handaxes are questions about knapper signature and later functional or cultural aspects.

About technology: number of flakes scars recorded, on each face, is between 27 and

50 but from our experiments, 38 to 1232 were necessary to produce handaxes. The traditional plan (in three main stages) to obtain handaxes is not always active (Gamble & Marshall, 2001). It's much more the type of flake which is not commensurate with this traditional plan partially due to the morphology of raw materials (Callahan, 1979; Inizan *et al.*, 1992; Debenath & Dibble, 1993). When working on slabs, we noted the absence of long cortical flakes. The first generation of flakes produce short and cortical flakes: their aim is to break the 90 degrees angle in a convex approach. The second and third generation of flakes will produce long flakes which will be half cortical or poor cortical at the distal part of the flake. For ovate and bi-convex nodule, the theoretical approach of long/cortical opposed to smaller/non cortical is more active.

For the case of Le Pont-de-Planches, the production of lopsided handaxes, backnife handaxes, leafpoints and plano-convex handaxes finished like a Mousterian point are judged very quick to obtain with, on average, less than 18 minutes. All this typology and technology still ask the question of function of handaxes and cultural aspects of prehistoric societies.

Basically, knappers have a shaping concept in mind and a mental representation of their ideal realization. The strategy that they will exhibit is a cycle reproduction of actions, cycle which is not rigid, cycle which is amenable to internal or external changes. Let's authorize this parameter to be an indicator of our assemblage variability.

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Abstract

To explain technological and typological variability in Lower and Middle Palaeolithic assemblages, researchers most commonly use environmental factors, and human activities and behaviors are inferred from the available faunal, mineral or plant data. Also, the recurrent question among specialists and the public relates to "was it the work of one main knapper or more?' Because, in the end, what we are describing and interpreting from our lithic collections is the knapping skill and performance of one or more knappers, which reflect their mood, good will and persistence; these being important notions during its realization across a day's duration. Many knapping experiments in France have remained unpublished so far. In our experiments, knappers had several constraints which were not the same for each experiment. We aim to summarize and comment on, some of these experiments, relate and describe the gestures and duration of the principal steps of the handaxe production sequence, as well as perform a spatial analysis of the knapping waste.

Keywords: Experiments, handaxes, knapper, constraints, skill, flexibility.

Résumé

Pour expliquer la variabilité des industries lithiques au Paléolithique inférieur et moyen, la plupart du temps, les chercheurs utilisent des paramètres environnementaux, les activités des hommes induites ou dérivées des contextes fauniques, minéraux ou végétaux disponibles. L'ensemble se décline sous la notion de culture matérielle. Parmi les questions récurrentes des spécialistes, étudiants et du public se trouve l'interrogation d'un ou plusieurs tailleur ; car, finalement, que décrivons-nous et interprétons-nous dans nos séries lithiques: l'exercice de taille d'un ou plusieurs tailleurs qui se décrivent par une humeur, une volonté, une persévérance, une implication plus ou moins notoire dans sa réalisation tout au long d'une journée. Le tailleur-expérimentateur n'était certainement pas sans contraintes de temps, de matière première, de température et dans nos expérimentations, dans chacune d'elle-elle une contrainte a été imposée au tailleur afin de cerner la flexibilité et les aboutissants morphométriques de la réalisation aux vues de la contrainte. De nombreuses expérimentations de taille sont restées inédites. Nous nous proposons d'en relater diverses, elles concernent et décrivent les gestes et la durée des principaux temps de la chaîne opératoire de façonnage des bifaces, ainsi que la lecture spatiale des résidus lithiques des diverses expériences de taille.

Mots-clés : Expérimentation, biface, débitage, contraintes, compétence, flexibilité.

Agnès LAMOTTE
University of Lille 3, UMR 8164 CNRS Halma
University of Lille 1, Sciences and technologies
Bâtiment de Géographie, avenue Paul Langevin
FR – 59655 Villeneuve d'Ascq
agnes.lamotte@univ-lille1.fr

Florent LE MENÉ
UMR 7055 CNRS Préhistoire et Technologie
Maison Archéologie Ethnologie
21, Allée de l'Université
FR – 92023 Nanterre
lmflo@yahoo.fr

Léa BIDAULT
University of Burgundy
Maison de l'Université
Esplanade Erasme, BP 27877
FR – 21078 Dijon
lea.bidault.pro@gmail.com