Flint vs. limestone: A first comparative analysis of the development of macro-wear traces and implications for the analysis of ancient lithic toolkits

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Abstract:

Particularly in the case of the Lower Palaeolithic, traceological analysis is very difficult to carry out due to poor preservation. Often the most tenuous clues have disappeared and only the macro-traces of use can allow a functional interpretation. Moreover, the diversity of raw materials used for the production of stone tools in the Early Palaeolithic requires specific experimental references. The development of experiments dedicated to the understanding of the development of macro-traces of use on different raw materials can therefore reinforce the robustness of functional interpretations. By extension, these results benefit the understanding of Early Palaeolithic toolkits.

We propose thus to present the results of a large experiment (over 300 experimental tools), conducted with limestone and flint flakes. Controlled parameters were established to provide replicative criteria for comparison. Three movements were performed systematically (longitudinal translation, and transversal translation both unidirectional and bidirectional), across two durations. In the first stage, actions were realised on the same worked material: dry wood. Each raw material for each action was represented by 48 experimental tools (288 in total). In the second stage (63 experimental tools), the same actions were realised on different worked materials, such as fresh and dry wood, and skin, bone and meat. The scars produced were described relative to their position on the edge and to one another, as well as to their morphology.

The comparison between the two raw materials was made using a statistical approach. The results were discussed under the influence of different parameters: morphology of the cutting edge, duration of use and edge angle of the active part. These results confirm, firstly, that macro-wear is reliable in determining the tool movement. Moreover, as assessed by the chosen criteria, only a few differences exist in macro-wear development between flint and limestone. Finally, it is concluded that the scars provide relevant information and should be used more frequently for functional analysis of ancient and poorly preserved material.

Keywords: traceological analysis; Lower Palaeolithic; comparative study; macro-wear traces

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1. Introduction and background

Traceological analysis provides functional information about tools outside of our technical memory. For these data to make sense, it is necessary to couple the results with a techno-morpho-functional approach, as shown by recent academic work (Bonilauri 2010: 369-380; Claud 2008: 461-482; Deschamps 2014: 103-177; Pedergnana 2017: 369-386; Viallet 2016: 316-357). The use of techno-morpho-functional data (as defined in particular by Airvaux (1987), as the morpho-potential unit; (Boëda 2013: 47-48; Lepot 1993: 28-41) is all the more important for early Palaeolithic periods, in which the artefacts most often show poor preservation (Beyries 1993). Very often in these cases, the results of the traceological analysis are limited to a small number of pieces and observation is carried out at low magnification.

Several years have been taken up with methodological debates concerning the scale of magnification to be favoured within the framework of a functional approach based on the analysis of traces of use (for a review: Claud 2008: 109-111). Henceforth, it has been understood that the analysis must be based on the majority of available traces and therefore include all observation scales. It is accepted that low magnification analysis allows the observation of scars, edge rounding and striations, which make it possible to determine the motion of tool use (Claud 2008: 109-111; Odell & Odell-Vereecken 1980; Prost 1989: 439-460; Semenov 1964: 16-22; Tringham *et al*. 1974). Analysis at high magnification makes it possible to observe polishes and striations, enabling inferences to be made about the material being worked (*e.g.*, Anderson-Gerfaud *et al.* 1987; Beyries 1987: 16-18).

Nevertheless, the vast majority of these conclusions are based on analysis of flint artefacts. Precursory work has shown that traceological analysis could be carried out on other raw materials, but those studies noted that in this case it was necessary to produce new experimental comparative collections (Beyries 1982; Bradley & Clayton 1987; Clemente Conte & Gibaja Bao 2009; Greiser & Sheets 1979). This work has been developing since the 1980s, on raw materials such as quartz (Knutsson 1986; 1988b; Knutsson *et al*. 2015; Ollé *et al*. 2016), obsidian (Mansur-Franchomme 1988; Vaughan 1981), basalt (Asryan *et al*. 2014; Bello-Alonso *et al*. 2021; Plisson 1982; 1985; Viallet *et al*. 2018), quartzite (Beyries 1982; Pedergnana & Ollé 2017) and limestone (Carbonell *et al*. 1999; Marquez *et al*. 2001).

In these works, the emphasis is often placed on the criteria for determining the material worked, with experimental collections that couple worked materials and modes of action. For example, they consist of cutting meat and cutting wood with the aim of finding the criteria for distinguishing between meat and wood; but they do so without highlighting the similarities between the traces, possibly linked to the common mode of action: cutting. According to known data (Bertouille 1991; Odell 1981; Prost 1989: 439-460) the diagnostic use-wear of the mode of action depend on strictly mechanical constraints and may therefore present similar characteristics on different lithic materials if these are isotropic solids.

The objective of this article is to highlight the criteria for diagnosing the mode of action, common to different raw materials. For this purpose, an extensive experiment has been conducted with an investment in experimental pieces in flint and limestone. In keeping with the archaeological sites for which the experimental collection has been created, the flint comes from the Narbonne-Sigean basin in southern France and is used in particular in the Arago Cave (Lower Palaeolithic, Pyrénées-Orientales), while the limestone comes from the alluvial deposits of the Paillon River, sources of supply for the hominids of Terra Amata and Lazaret Cave (Lower Palaeolithic, Alpes-Maritimes) (Grégoire 2012: 100-113).

2. Material and methods

2.1 Experimental protocol

The analysis of the experimental collection combines a controlled parameter approach, dedicated to the identification of wear formation processes (Unger-Hamilton 1989), and an approach in which tools are used in a non-mechanical way, making it possible to discuss the reproducibility of the first analytical phase.

The first stage is made up of experiments carried out by controlling as many parameters as possible (material worked, duration, angle of the cutting edge, gesture), making it possible to analyse and describe the use-wear and its link with the mechanical processes that caused it. This experiment comprises three modes of action implemented using the same raw material: the gestures of unidirectional transverse translation (UTT), bidirectional transverse translation (BTT) and bidirectional longitudinal translation (BLT), carried out on the same material: dry wood with a diameter of 18 mm (Figure 1).

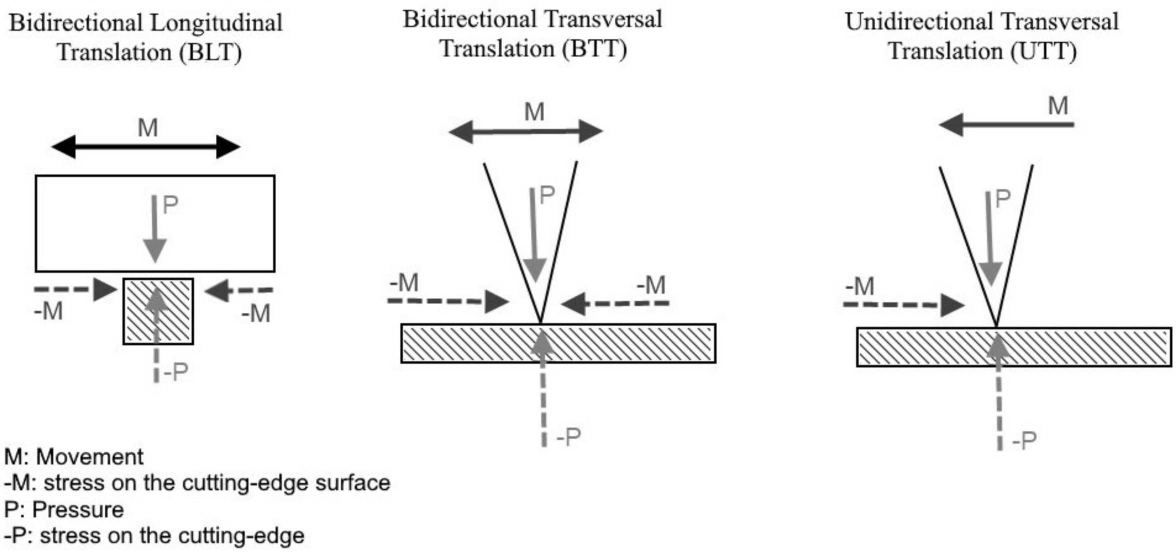

Figure 1. Schematic representation of the three types of motion tested experimentally.

The experimental pieces are made of flint from the Narbonne-Sigean basin and limestone from the alluvial deposits of the Paillon River. In order to control the impact of the angle of the cutting edge on the development of the traces, three angular classes are defined, where ‘A’ is ‘angle’: <30°; 30°<A<60°; and 60°<A<90°. For each class of angle, 16 experimental pieces are produced, in order to be able to compare the results via statistical tests based on a quantitatively viable comparative collection. Thus, each mode of action for each raw material is tested via 48 experimental pieces. Taking into account the two raw materials and the three modes of action, this experimental phase comprises 288 experimental pieces (Table 1). Half of the experimental pieces are used for 3 to 5 minutes (3 minutes when the cutting edge has completely lost its effectiveness), while the other half is used for 10 minutes. The Fisher’s exact test is used because it allows for nominal variables and a sample lower than 30, in which some data are not represented or are equal to zero.

Table 1. Summary of the experimental pieces and action of the first stage of the experiment.

	Tool motion					
	UTT		BTT		BLT	
Raw material	**Flint**	**Limestone**	**Flint**	**Limestone**	**Flint**	**Limestone**
A<30°	16	16	16	16	16	16
30°<A<60°	16	16	16	16	16	16
60°<A<90°	16	16	16	16	16	16
Total (raw material)	48	48	48	48	48	48
Total (tool motion)	96		96		96	
Total	**288**					

The second stage consists of testing the observations of the first stage in a context of use adapted to our knowledge of human behaviour in the Lower Palaeolithic and the various fundamental biological constraints involving technical interactions with the environment. This stage makes it possible to specify the reproducibility of the criteria used to determine the action tested, identified with controlled parameters. This second stage tests the same modes of action and the same raw materials. The gesture of bidirectional longitudinal translation is carried out on fresh and dry skin, on fresh and dry wood, on meat and on bones with meat, by 28 experimental pieces. The unidirectional transverse translation is performed on fresh and dry skin, on fresh and dry wood and on bone with meat (total of 19 pieces). The bidirectional transverse translation is performed on dry and fresh skin and dry wood (total of 16 pieces). In total, this second phase comprises 63 experimental pieces (Table 2) and allowed the activities of spear-making on fresh and dry wood and butchery (skin cutting, preparation for tanning, softening; meat cutting, recovery of bone and preparation before fracturing) to be carried out.

Table 2. Summary of the counts, actions and worked material of the experimental pieces during the second step of the experiment.

	BLT		UTT		BTT		
	Flint	**Limestone**	**Flint**	**Limestone**	**Flint**	**Limestone**	**Total**
Fresh skin	2	2	3	3	0	0	10
Dry skin	2	2	2	2	2	2	12
Dry wood	2	2	1	1	3	3	12
Fresh wood	2	2	1	1	3	3	12
Meat	3	3	0	0	0	0	6
Meat and bones	3	3	1	4	0	0	11
Total	14	14	8	11	8	8	63
Total	**28**		**19**		**16**		

The experiments are carried out by 9 different people (6 men and 3 women), all with academic backgrounds in prehistory. However, only 4 individuals have experience in experimental practice. It is certain that carrying out the experiment with several experimenters can create additional variability that is difficult to quantify. Nevertheless, in the case of this experimentation, this influence is negligible for two reasons: firstly, the quantity of experimental pieces tested tends to erase idiosyncratic variability; and secondly, the very principle of the experimentation, which aims at systematically producing strictly the same movement so as not to create an additional variation parameter, must lead to erasing individual particularities.

2.2. Definition, descriptive criteria and techniques for observing traces

Micro-flakes scars are negatives of the bursting of matter. They are the result of the solid fracture and result from the meeting of external (pressure, percussion, friction) and internal (compression and tension) forces (Bertouille 1991; Prost 1989: 51-71). The morphology and arrangement of use-wear marks on a cutting edge depend on the mode of force application (Bertouille 1991) and the type of contact (Prost 1989: 386-414). In theory, each type of fracture, characteristic of given mechanical parameters, produces a micro-flake with a specific morphology.

A mode of action can be further characterised by a specific arrangement of several scars on the edge of a tool (Claud 2008: 126-210; Odell 1981; Tringham *et al*. 1974; Viallet 2016: 163-165). Thus, the latter can be described according to criteria aimed at transcribing their intrinsic and extrinsic characteristics (Claud 2008: 126-210; Prost 1989: 386-414).

The arrangement of the scars on the edge is described in this experiment according to four criteria (Figure 2):

- Position: percentage of scars on one side in relation to the other;
- Continuity: continuity of scars on one face;
- Facial pattern: relative arrangement of the scars across the two faces;
- Overlap: superposition of the scars.

At the same time, the morphology of the scars is described according to two criteria (Figure 2):

- Initiation: in cone for an elastic contact or in flexion for an inelastic contact;
- Termination: morphology of the rib at the cessation point of the fracture.

The scars are observed using an Optika SZM-SMD stereomicroscope combined with a Nikon Digital Sight DS-Fi2 camera. The pieces have not been specifically cleaned; where necessary, alcohol has been used to remove grease accrued during the different manipulations.

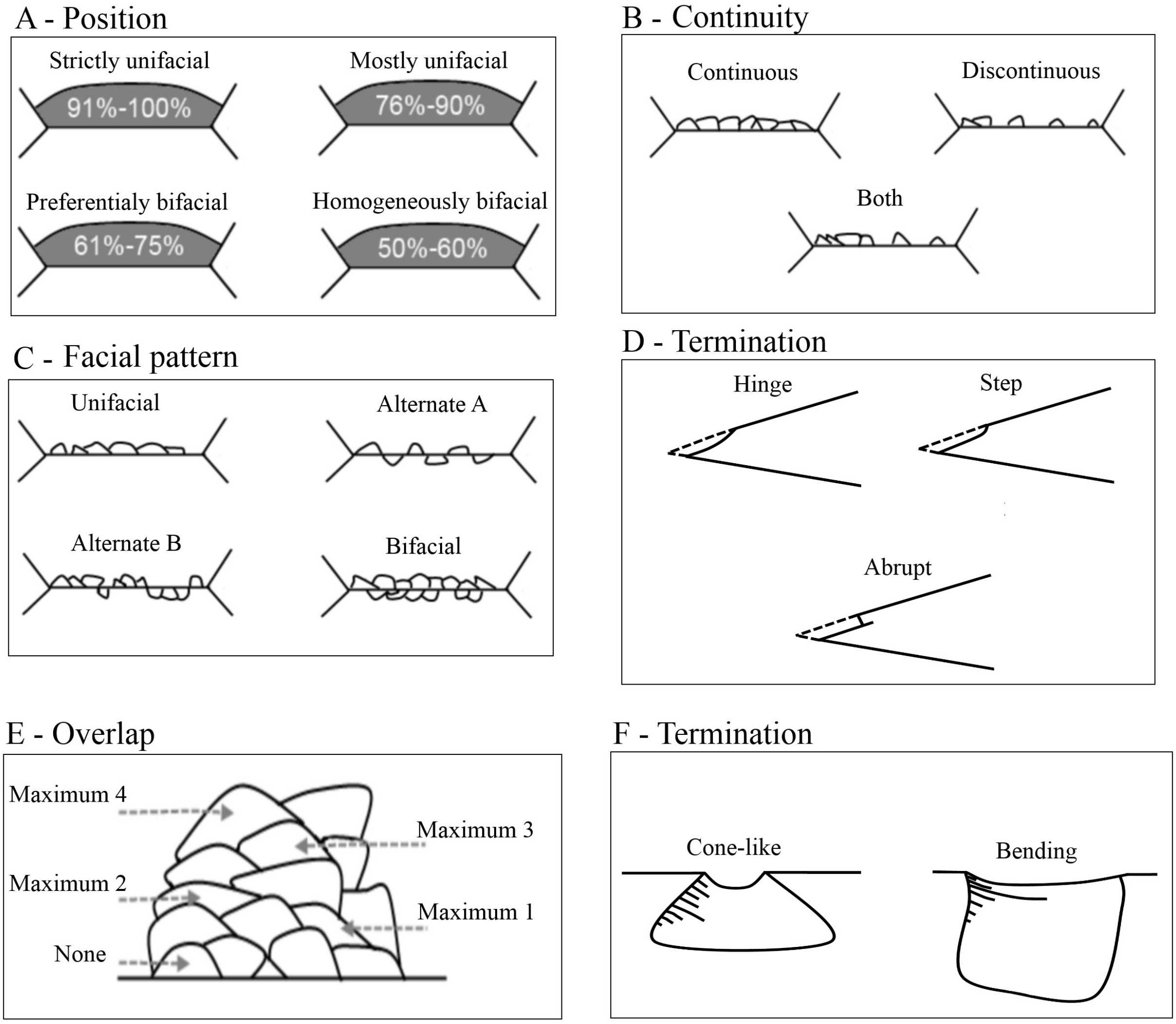

Figure 2. Outline of the criteria used to describe the arrangement and form of the micro-flake scars.

3. Data results

3.1. Experimentation - Stage 1

3.1.1. Position criterion

In the case of UTT, the most common position of the scars is strictly unifacial, followed by mostly unifacial. The results are nearly the same for flint and limestone (Figure 3). By contrast, for BLT, the position of scars is homogeneously bifacial or preferentially bifacial. The results show a greater contrast of position criteria in BTT, but the behaviour of the flint and of the limestone are the same; the most represented position is preferentially bifacial, followed by homogeneously bifacial and mostly unifacial. For the three actions, no significant differences are found with the Fisher exact test. It is noteworthy that UTT is clearly differentiable from BLT.

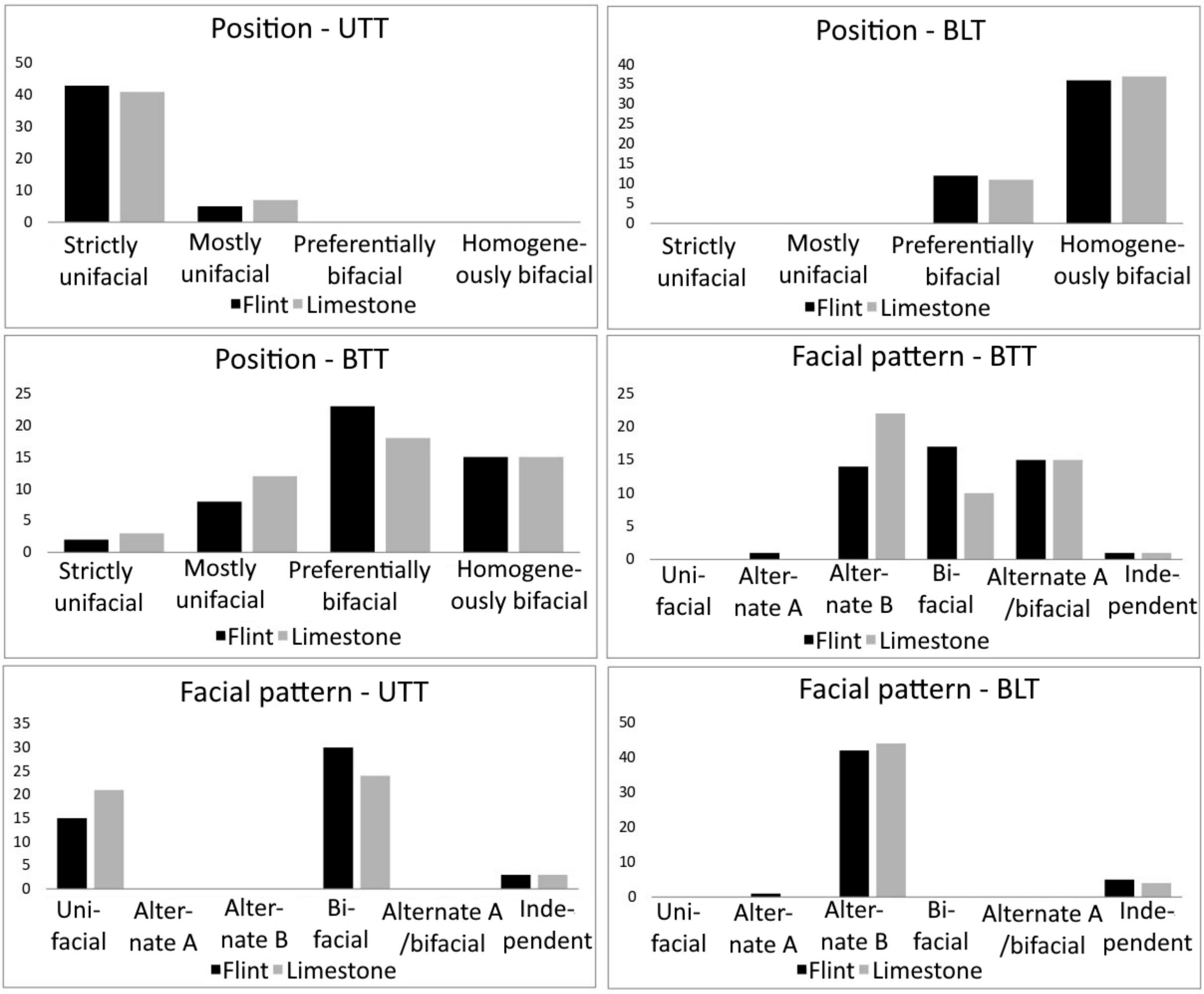

Figure 3. Facial pattern criterion.

For UTT, the most frequent finding for the criterion of facial pattern is mostly bifacial, followed by unifacial. The results are nearly the same for the two raw materials. LBA leads to different results, with the predominance of alternate B pattern. But here again, the behaviour of flint and limestone are very similar. Alternate B distribution is also most frequently represented for BTT, particularly for the limestone, followed by the bifacial and alternate A and bifacial patterns. The behaviour of the two raw materials seems to be very similar, however, and the Fisher exact test does not reveal significant differences.

3.1.2. Continuity criterion

The description of the (dis)continuous distribution of scars needs to make the distinction between the two sides of the cutting edge. For the BLT, the two sides received the same strain. But for unidirectional transverse action one side is more heavily employed in the movement - named side A - and the other side less so - named side B - and it is side A that registered a more significant amount of damage.

On side A, the most represented distribution, whatever the cutting action, is discontinuous (Figure 4). In some cases, for UTT, the micro-flakes scars are absent on this side. For BTT, the Fisher exact test is positive. This outcome seems to be linked with the proportion of the continuous distribution for the limestone by contrast with flint.

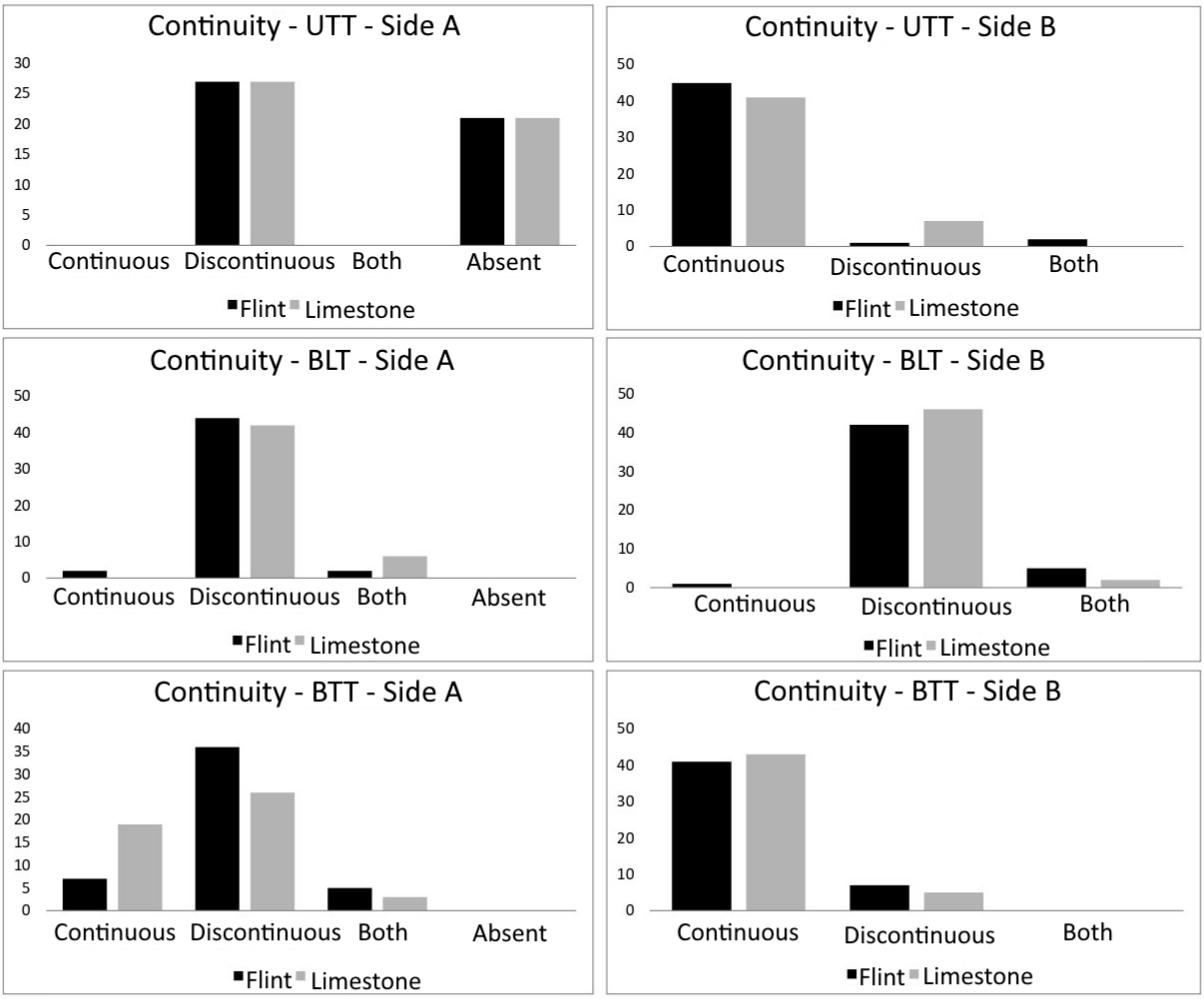

Figure 4. Histograms of distribution criteria for UTT, BLT and BTT.

On side B, the BLT result is logically the same as that for side A. The transverse bidirectional action presents an almost similar result, the most represented distribution being continuous. But for UTT the Fisher exact test is positive. This outcome may be linked to the proportion of discontinuous distribution on the limestone.

3.1. Overlaps and terminations criteria

BLT produces micro-flakes scars with very few overlaps. The maximum number of overlaps found on any one piece is one and concerns a few limestone pieces (Figure 5). UTT does not produce overlaps on side A, except for one piece in limestone. The results are very different for side B because most of the pieces have a minimum of one or two overlaps. For BTT, on side A the overlaps are mostly absent, followed by at most one overlap. On side B, the result was similar to that of transverse unidirectional action, with a high proportion of overlaps.

It appears that the overlapping phenomena are more developed on limestone for all tested actions. For transverse action, the maximum of three or four overlaps is mainly represented by limestone cutting edges.

For BLT, the terminations are only hinge, for flint and limestone. For transverse action, except on side A with unidirectional movement, flint and limestone present inverse results: where the flint terminations are dominated by hinge morphology, the limestone terminations are step. The abrupt terminations are mainly present on side B for the transverse unidirectional action.

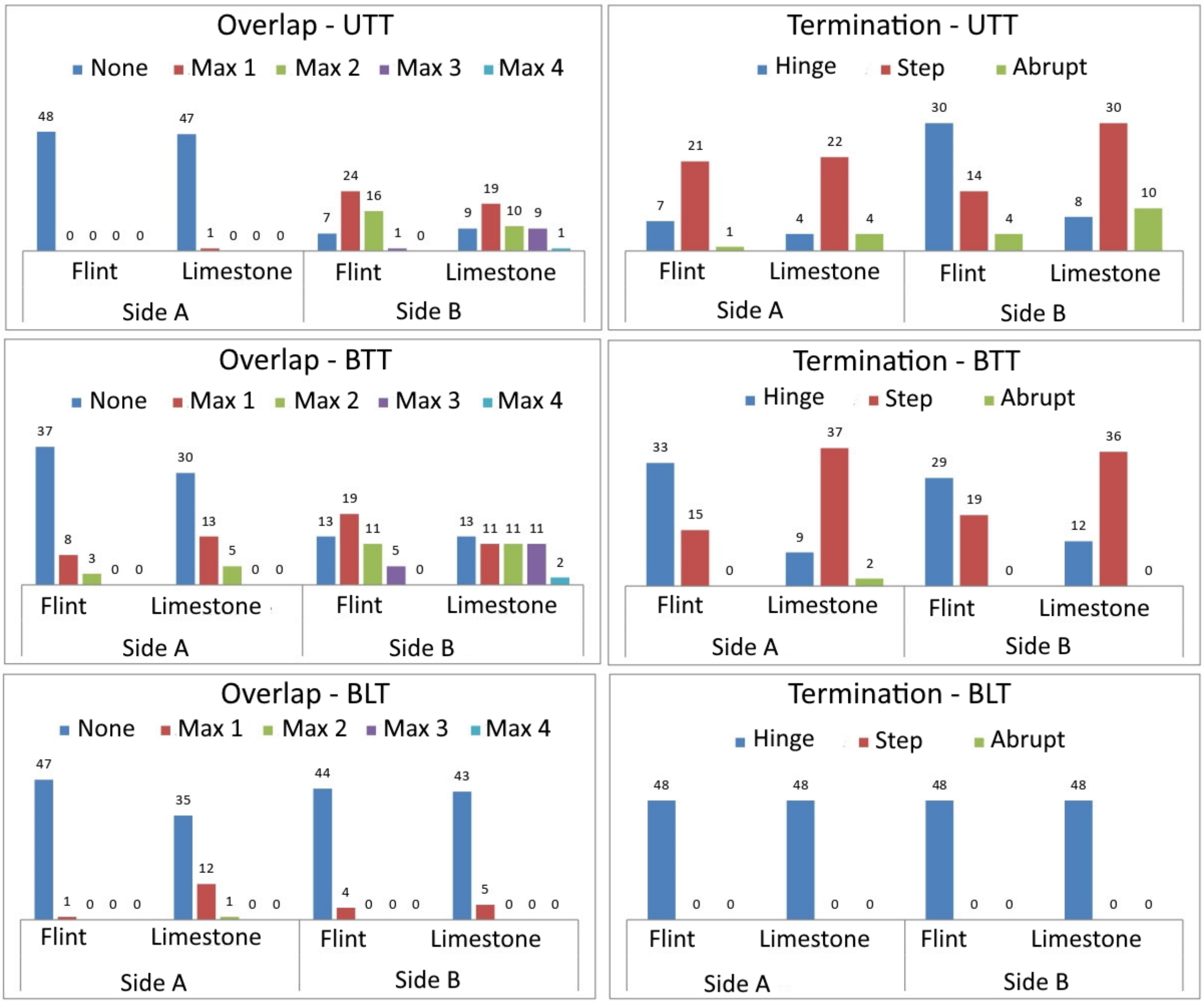

Figure 5. Histograms of overlapping and termination of micro-flake scars, for UTT, BTT and BLT.

3.1.5. Impact of time and angulation on the development of use-wear

The angulation of the cutting edge influences the development of the use-wear. The higher the angle, the less the scars develop. Angular differences generate other effects, too - for example, in an increase in the discontinuous distribution of traces on the B side in the case of UTT. Likewise, the duration of use is a factor in the increase in the number of traces, as shown by the fact that test pieces used for 10 minutes bear more damage than those used for 3 to 5 minutes. (Figure 6). The bifacial position or, in a majority of cases, the preferred single-sided position is more often represented finding for the position criterion when the operating time is 10 min, with the distribution more often continuous on the B side for UTT and BTT (Figure 6).

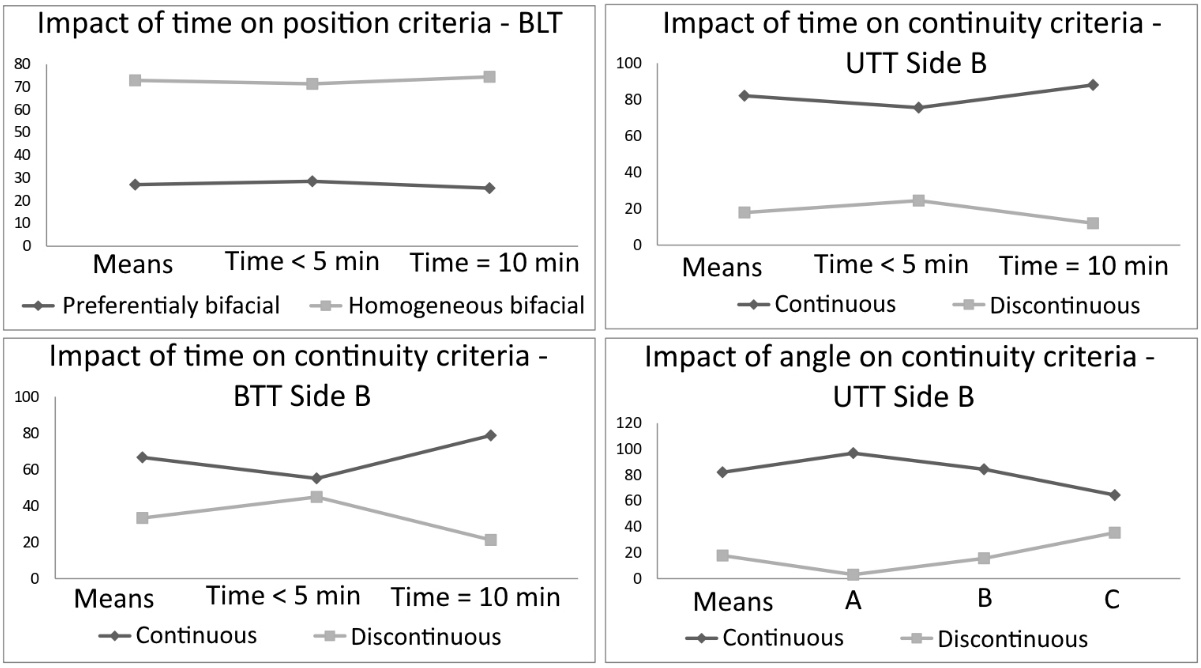

Figure 6. Impact of the duration of use and angle on distribution criteria for different actions.

However, other parameters can create variability in the arrangement of the micro-flake scars on the edge. For example, in the case of UTT, the criterion of scars' continuity follows an illogical evolution according to the angle. Thus, between angles less than 30° and those between 30° and 60°, there is an increase in the unifacial distribution for continuity criterion (Figure 7), logically correlated to the increase in the edge angle, which creates a more robust dihedral on which the traces develop less easily and are therefore fewer in number. However, between angles ranging from 30° to 60° and those greater than 60°, the phenomenon is not the same, and it is the bifacial distribution that increases (Figure 7). The analysis shows that it is the morphology of the cutting edge - an uncontrolled parameter for this experimental phase - which is the origin of this particular arrangement of scars. Thus, a convex edge morphology in plan view favours a bifacial distribution (Figure 7), and this morphology is twice as frequently represented in edges with an angle greater than 60° than in those with an angle between 30° and 60°. Furthermore, a convex-concave morphology in section favours a bifacial distribution (Figure 6) and is six times more prevalent in cutting edges greater than 60° than in those between 30° and 60°. Conversely, a concave-plane cross-sectional morphology favours a unifacial distribution (Figure 7) and is represented twice as much by cutting edges between 30° and 60° as by those greater than 60°.It therefore appears that, beyond the cutting edge angle and the duration of use, the morphology of the cutting edge has an impact on the process of damage development and its arrangement. In fact, interpretations must take into account the morphology of the cutting edge, and this parameter should be monitored in future experiments.

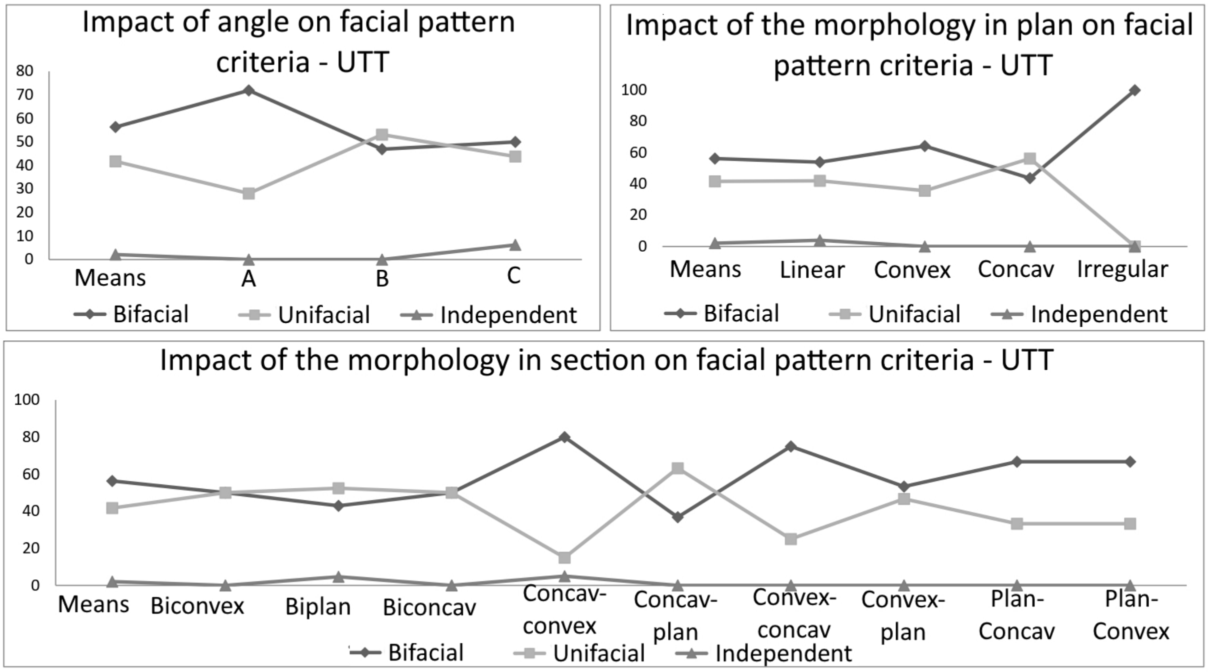

Figure 7. Impact of the cutting edge morphology on the repartition criteria.

3.1.6. Synthesis of the first experimental stage

To conclude this first step of the experiment, we can say that limestone and flint present few differences (Figures 8, 9 and 10).

The differences concerning the continuity criterion for the transverse action may be linked to a lesser development of micro-flakes scars on the limestone cutting edges. It seems that the development of use-wear is faster for the limestone, and the equilibrium profile - that is, the step at which the scars could no longer develop - is more quickly reached. This data was obtained following direct observations during the experiment and needs to be confirmed by an objective quantification of use-wear and analysis of its development in the specified time (Ollé & Vergès 2014).

The differences concerning the termination and overlaps may be linked to the structure of the raw material. The limestone pebbles used are less homogeneous than flints and present beddings. These characteristics must favour the development of step termination and overlaps.

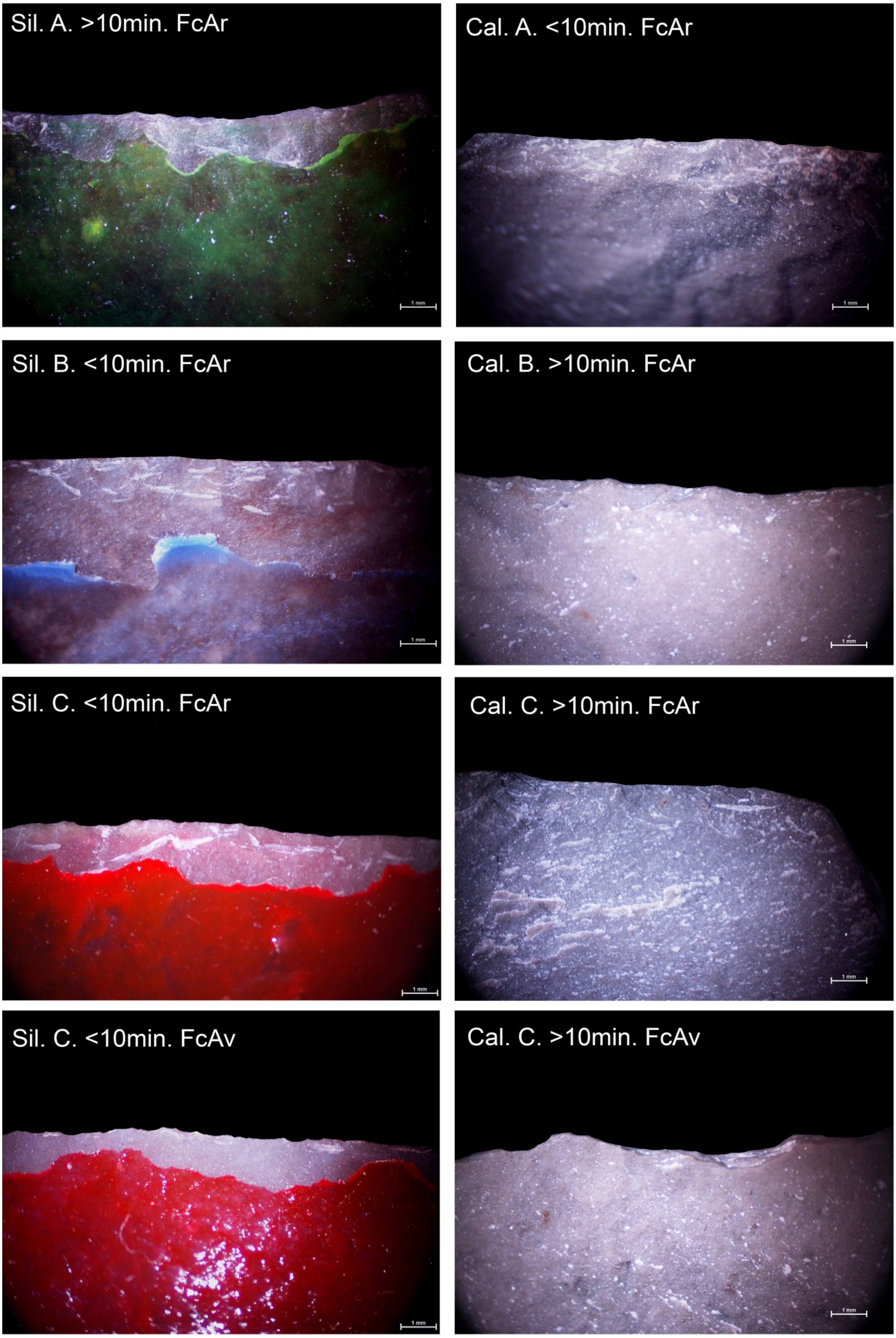

Figure 8. Photograph of micro-flakes scars, resulting of TUA (flint to the left and limestone to the right) (scale bar = 1 cm).

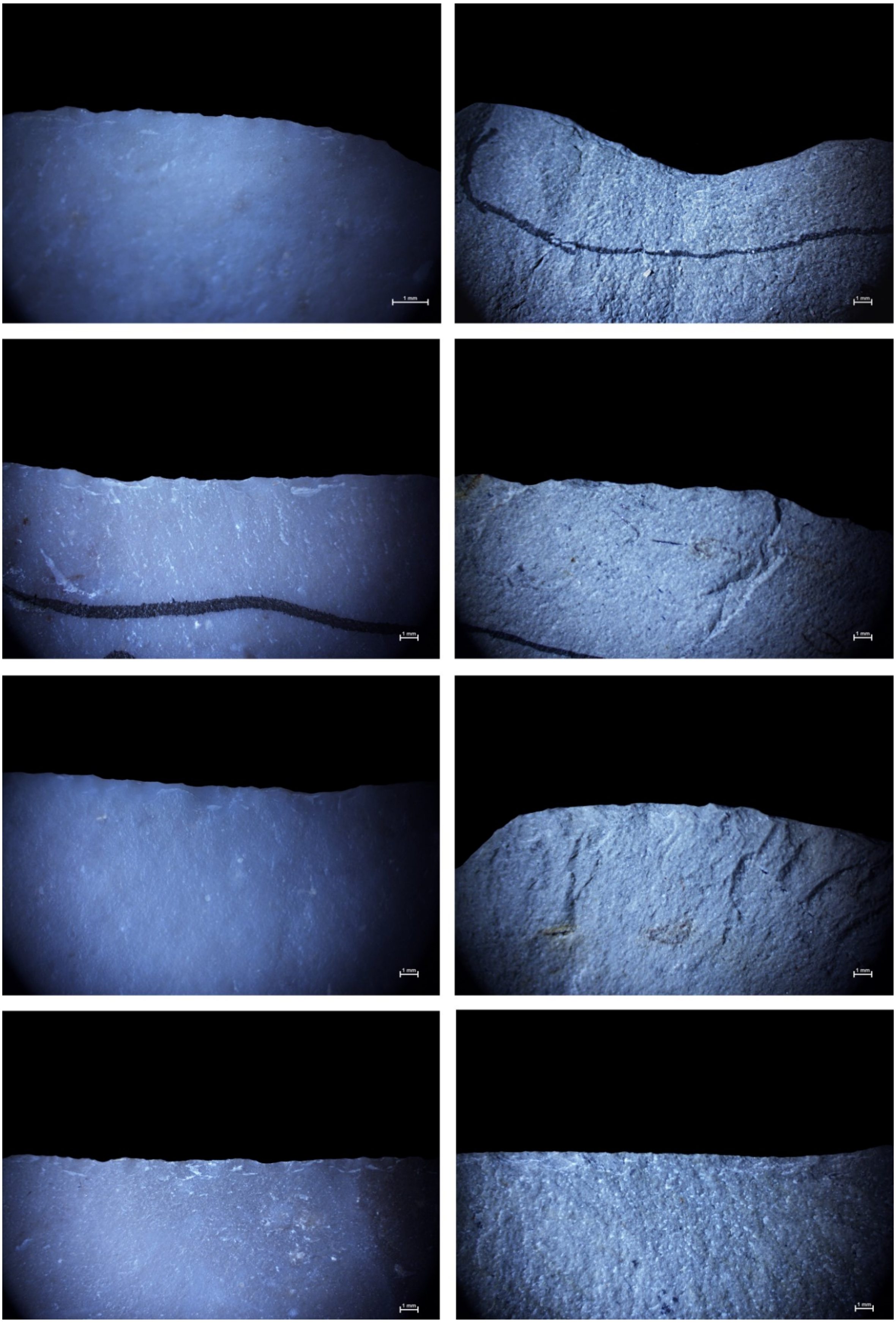

Figure 9. Photograph of micro-flakes scars, resulting of TBA (flint to the left and limestone to the right) (scale bar = 1 cm).

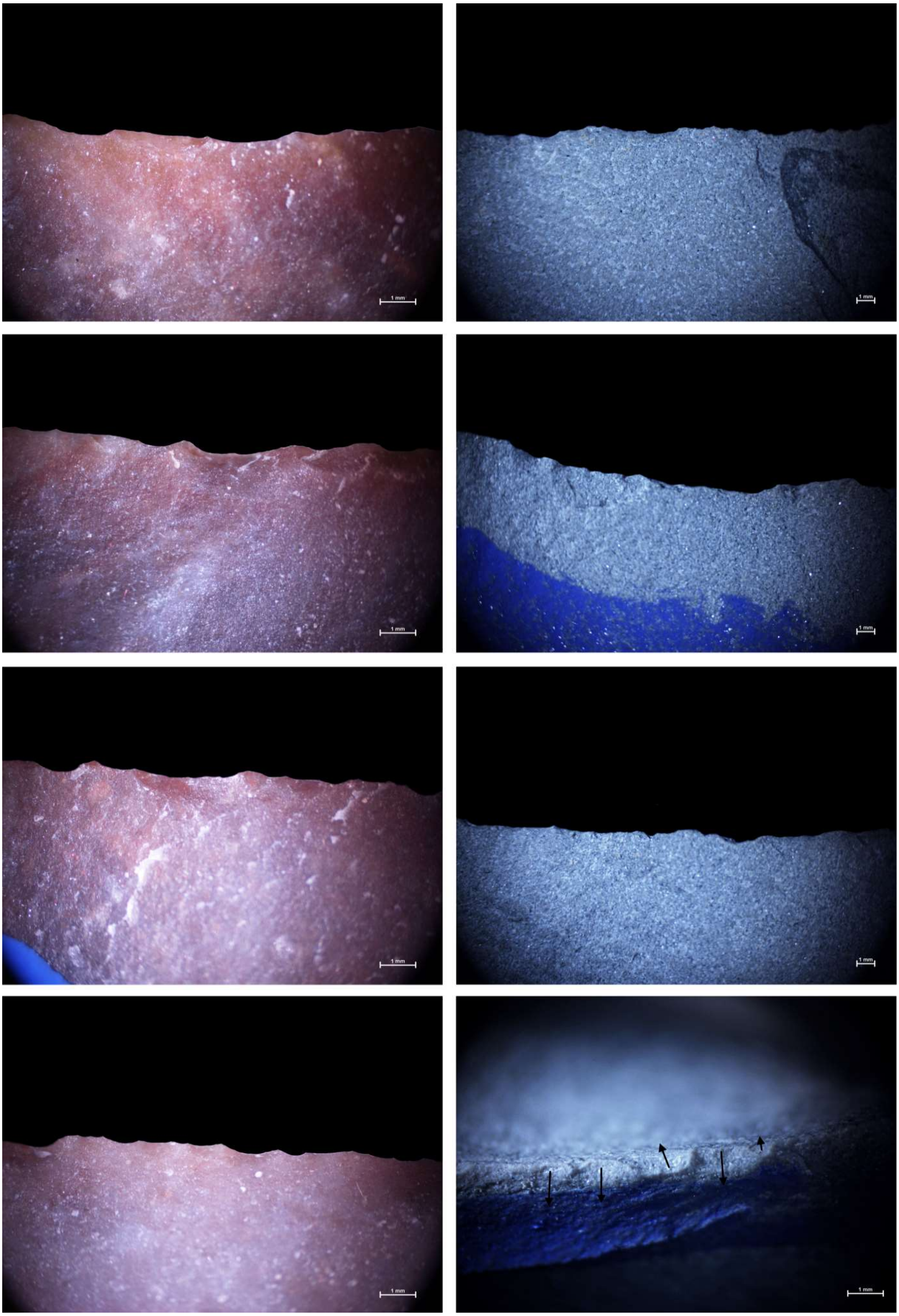

Figure 10. Photograph of micro-flakes scars, resulting of LBA (flint to the left and limestone to the right) (scale bar = 1 cm).

3.2. Experimental stage 2 results and comparison with stage 1

3.2.1. Position criterion

For UTT, the position of micro-flakes scars does not present major differences between the two stages of the experiment (Figure 11). The most represented finding is strictly unifacial, followed by mostly unifacial. This last result is more present in stage 2 than in stage 1.

For BLT, the most represented findings for the two stages are preferentially bifacial and homogeneously bifacial. It is important to note that there is an inversion between the two stages - in stage 2 the main finding of the criterion of position is preferentially bifacial, whereas in stage 1, it was homogeneously bifacial.

As with UTT, the second stage of the experiment for BLT leads to more variable results. The position of micro-flakes scars is less strictly linked to the action performed. These observations are confirmed by the results for BTT, where the finding mostly unifacial is the most represented in stage 2, in contrast to the preferentially bifacial finding in stage 1.

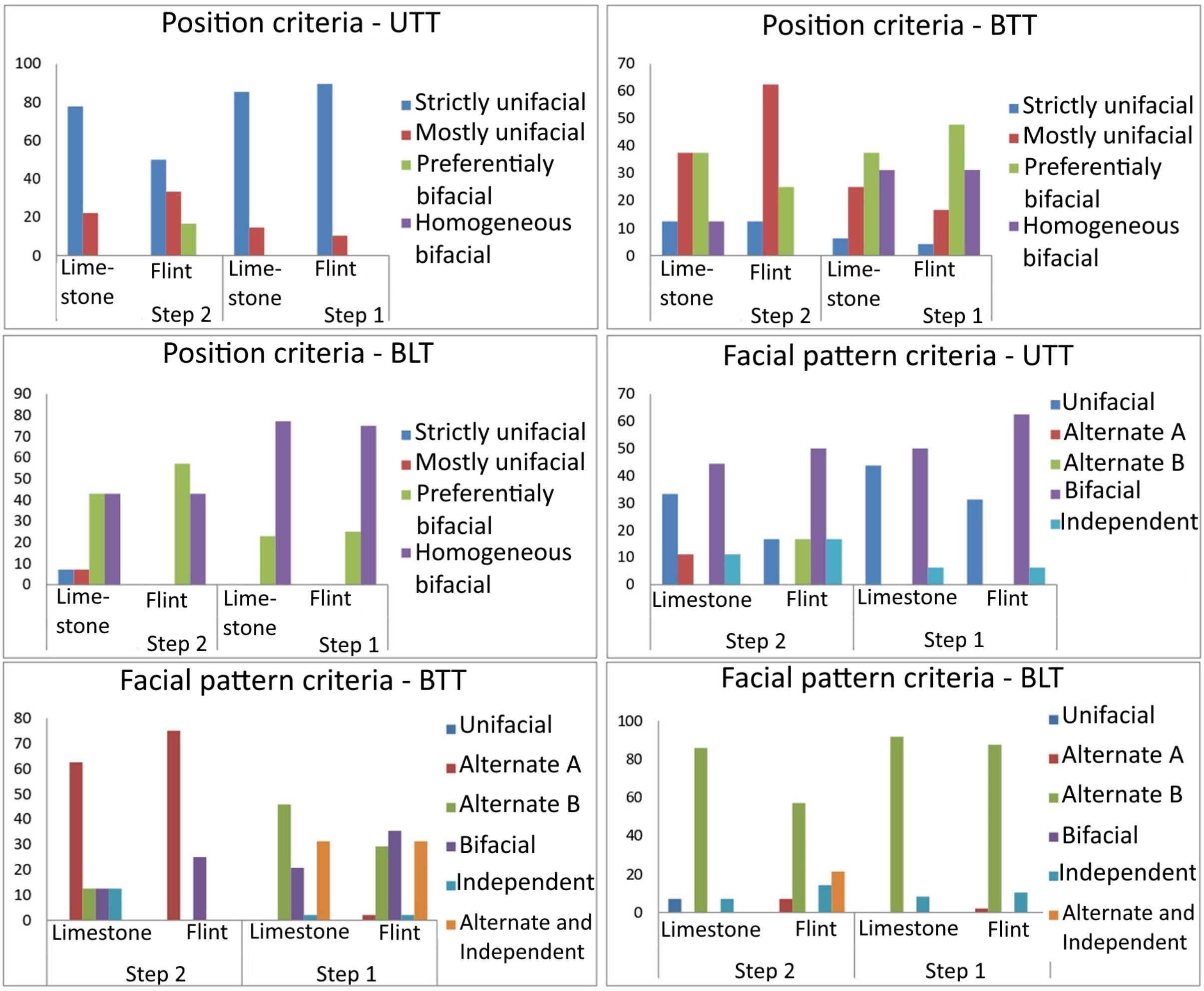

Figure 11. Comparison to experimental step 1 and 2, for the position and the repartition criteria.

3.2.2. Facial pattern criterion

As with the position criterion, there are no major differences between the facial pattern results of the first and second stage for UTT and BLT (Figure 11). It is possible, however, to note a more significant variability in the result of the second stage, perhaps induced by the lower quantities of experimental pieces in comparison to stage 1.

In stage 2 of the experiment for BTT, the main pattern represented is alternate A, whereas it is mostly alternate B or bifacial in stage 1. This difference concerns both flint and limestone and warrants the development of specific controlled experiments in the future to better understand these results.

3.2.3. Continuity criterion

For BLT, the most represented distribution on sides A and B in the second stage is discontinuous (Figure 12).

For UTT, on side A, there are no major differences between the two stages and the two raw materials. On side B, in stage 2, the discontinuous distribution or the absence of micro-flakes altogether are more commonly represented. This is directly linked to the work on fresh or dry skins, which produce very few scars but rather edge rounding.

For BTT, on side A, in stage 1 the most common distribution is discontinuous followed by continuous, and in stage 2 is either discontinuous or features a mixture of both continuous and discontinuous distribution. That is a product of the lesser development of scars in stage 2. The same observation could be made for side B, which demonstrates minor manifestations of continuous distribution in stage 2 alongside mainly discontinuous distribution.

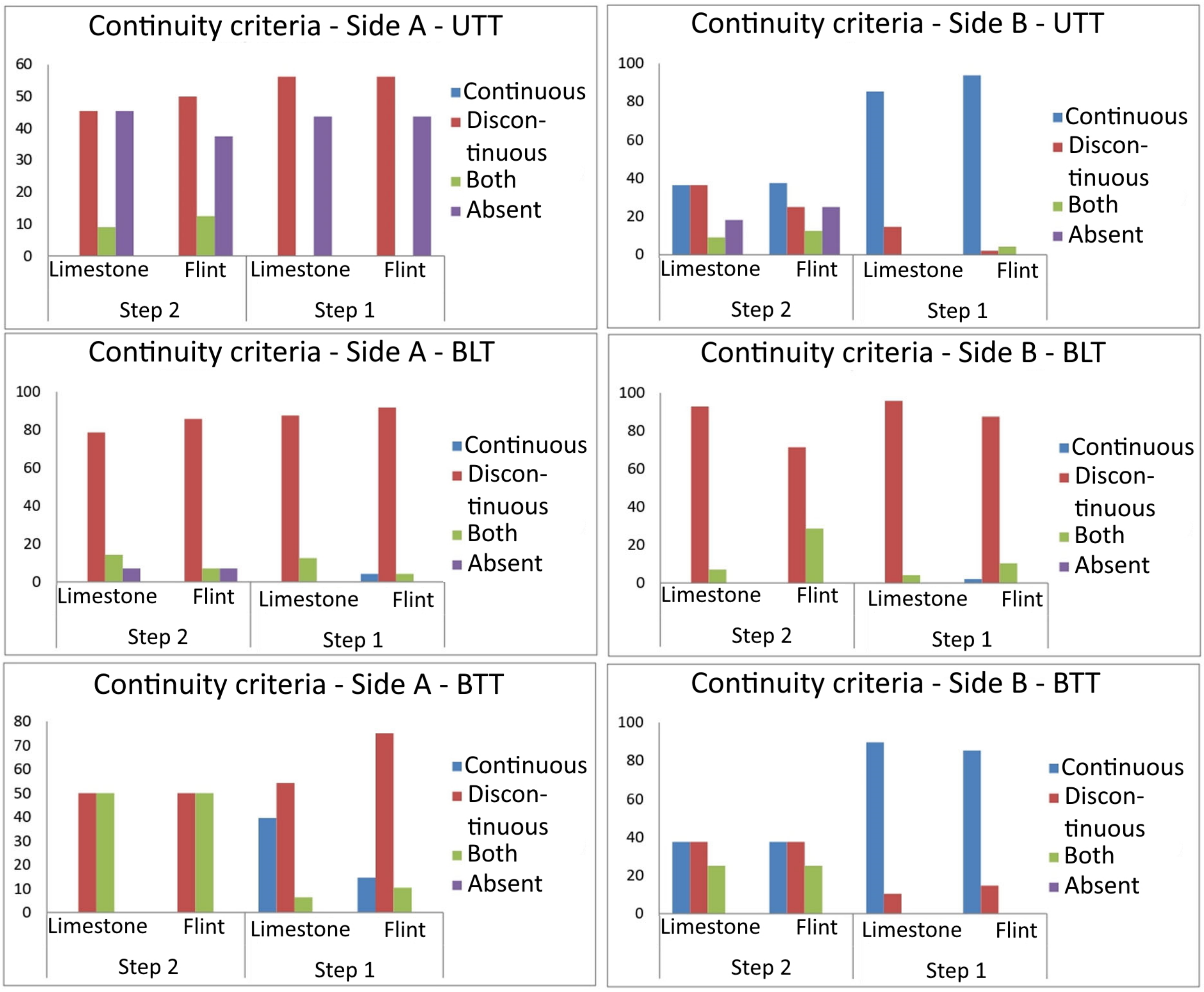

Figure12. Comparison to experimental step 1 and 2, for the distribution criteria.

3.2.4. Overlaps and terminations criteria

The criteria of overlapping and of termination in stage 2 are not comparable to those in stage 1. In fact, the significant proportion of experimental pieces in stage 2 with very few micro-flakes scars leads to results that are not statistically comparable to the results of stage 1. To correctly make these comparisons, we need to upgrade the experiment of the second stage.

3.2.5. Synthesis of the second experimental step

As in the first experimental phase, the differences between flint and limestone are not very significant. This may be surprising because of the variation in the raw materials worked. The explanation lies in the chosen analysis grid, which focuses on the organization of traces on the support, which depends on mechanical constraints linked to the mode of action. For other criteria, such as the quantity or morphology of the scales, or their association with a blunt edge, the raw material is a variable parameter.

4. Synthesis and Conclusions

The development of quantitatively meaningful collections, in which a portion of the variation parameters is controlled, makes it possible to reinforce the robustness of the conclusions. These are expressed in the form of questions.

4.1. Did flint and limestone pieces present different characteristics of use-wear?

Concerning the micro-flakes scars positioning and patterning, the two raw materials present few differences. The differences for the continuity criterion in transverse action in the first stage of the experiment may be explained by the section morphology. Our data show that the presence of concave surfaces creates variations in the distribution of micro-flakes scars, but this observation is based on too tiny a quantity of experimental pieces to make a simple extrapolation. It is necessary to develop this hypothesis in future experiments.

The differences between stage 1 and 2 may be linked to cutting edge angles and to the duration of use, neither of which were controlled in the second stage of the experiment, but also to the specific morphology of the cutting edge. This hypothesis will be verified in future experimentations.

4.2. Is it possible to follow the same principle of analysis for both flint and limestone?

The results show that the same criteria can be used. But it is necessary to develop purpose-built experimental databases to discern and understand limestone specificities. For example, edge rounding is more often present in limestone than in flint, and this seems to be linked to the work on hide.

4.3. Is it possible to determine the action of tools only with micro-flakes scars analysis?

The results of the first stage were positive, but the second stage points to the need to continue the development of experimental databases to produce more robust conclusions. However, these results underline the link between organisation of the micro-flakes scars on the cutting edge and the movement of the tool.

Thus, macro-wear analysis, and specifically scars organisation, is an important research route for the functional analysis of lithic tools made from different raw materials. In order to provide a more robust diagnosis of tool movement from micro-flakes analysis, new experiments must be developed to assess the impact of the morphology of the cutting edge on the development of damage.

Obviously, where possible, all use-wear should be analysed. But when preservation conditions do not allow it, micro-flakes scars can be a relevant way of analysing the tool movement.

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Data accessibility statement

The data generated and analysed during this study are included in this article and Supplementary File 1.

List of supplementary files

Supplementary file 1
VIALLET - supplementary file 1 - database.xls”
Spreadsheet of lithic attributes recorded during experiments.

References

Airvaux, J. 1987, Les potentialités morphologiques. In: *Sistemes d'analisi en Prehistoria*, (Carbonell, E., Guilbaud, M. & Mora, R., eds.). Centre de Recerques Paléo-ecosocials (CRPES), Girona: p. 17-67. (in French) (“Morphological potential”)

Anderson-Gerfaud, P., Moss, E., Plisson, H. 1987, A quoi ont-ils servi ? *Bulletin de la Société Préhistorique française 84-8*: 226-237. (in French) (“What were they used for?”).

Asryan, L., Ollé, A. & Moloney N. 2014, Reality and confusion in the recognition of postdepositional alterations and use-wear: an experimental approach on basalt tools. *Journal of Lithic Studies,* 1(1): 9-32. doi:10.2218/jls.v1i1.815

Bello-Alonso, P., Rios-Garaizar, J., Panera, J., Rubio-Jara, S., Pérez-González, A., Rojas, R., Baquedano, E., Mabulla, A., Domínguez-Rodrigo, M. & Santonja, M. 2021, The first comprehensive micro use-wear analysis of an early Acheulean assemblage (Thiongo Korongo, Olduvai Gorge, Tanzania). *Quaternary Science Reviews*, 263: 22 p. doi:10.1016/j.quascirev.2021.106980

Bertouille, H. 1991, Réflexions à propos des traces d'utilisation présentées par les outils préhistoriques. *Paléo*, 3(1): 201-206. (in French) (“Reflections on the microwear of use presented by prehistoric tools”) URL: https://www.persee.fr/doc/pal_1145-3370_1991_num_3_1_1047

Beyries, S. 1982, Comparaison de traces d'utilisation sur différentes roches siliceuses. In: *Tailler! pour quoi faire: Préhistoire et technologie lithique, vol. II. Recent progress in Microwear studies*, (Cahen, D., Ed.). Studia Praehistorica Belgica Vol. 2, Notae Praestorica, Leuven: p. 235-240. (in French) (“Comparison of use patterns on different siliceous rocks”)

Beyries, S. 1987, *Variabilité de l'industrie lithique au Moustérien – Approche fonctionnelle sur quelques gisements français*. BAR International Series 328, B.A.R, Oxford, 203 p. (In French) ("Mousterian tool-kit variability - functional approach of some French site).

Beyries, S. 1993, Are we able to determine the function of the earliest Palaeolithic tools? In: *The Use of Tools by Human and Non-Human Primates*, (Berthelet, A., & Chavaillon, J. eds.). Oxford Clarendon Press, Oxford, p. 225-236.

Boëda, E. 2013, *Techno-logique & Technologie. Une Paléo-histoire des objets lithiques tranchants.* Archéoéditions, Préhistoire au Présent, online, 266 p. (in French) ("Techno-logic & Technology. A Paleo-history of lithic cutting-tools")

Bonilauri, S. 2010, *Les outils du Paléolithique moyen: une mémoire technique oubliée? Approche techno-fonctionnelle appliquée à un assemblage lithique de conception Levallois provenant du site d'Umm el Tlel (Syrie centrale).* Doctoral thesis at the UFR des Sciences Sociales et Administrative, Université de Paris Ouest Nanterre, Paris, 429 p. (in French) ("Middle Palaeolithic tools: a forgotten technical memory? A techno-functional approach applied to a Levallois-designed lithic assemblage from the Umm el Tlel site (Central Syria)")

Bradley, R. & Clayton, C. 1987, The influence of flint microstructure on the formation of micro-wear polishes. In: *The Human Uses of Flint and Chert*, (Sieveking G. & Newcomer M. eds.), Cambridge University Press, Cambridge: p. 81-89.

Carbonell, E., Garcia-Anton, M.-D., Mallol, C., Mosquera, M., Ollé, A., Rodriguez, X.-P., Sahnouni M., Sala R. & Vergès J.-M. 1999, The TD6 level lithic industry from Gran Dolina, Atapuerca (Burgos, Spain): production and use. *Journal of Human Evolution*, 37: 653-693. doi:10.1006/jhev.1999.0336

Claud, E. 2008, *Le statut fonctionnel des bifaces au Paléolithique moyen récent dans le Sud-Ouest de la France. Étude tracéologique intégrée des outillages des sites de La Graulet, La Conne de Bergerac, Combe Brune 2, Fonseigner et Chez-Pinaud / Jonzac*. Doctoral thesis at the école doctorale des Sciences du Vivant, Géosciences et Sciences de l'Environnement, Université de Bordeaux I, Bordeaux, 546 p. (in French) ("The functional status of bifaces in the late Middle Palaeolithic in southwestern France. An integrated traceological study of tools from the sites of La Graulet, La Conne de Bergerac, Combe Brune 2, Fonseigner and Chez-Pinaud / Jonzac")

Clemente Conte, I. & Gibaja Bao J.-F. 2009, Formation of use-wear traces in non-flint rocks: the case of quartzite and rhyolite - differences and similarities. In: *Non-Flint Raw Material Use in Prehistory. Old Prejudices and New Directions*, (Sternke, F., Eigeland, L. & Costa, L.-J. eds.), BAR International Series, 1939, Archaeopress, Oxford: p. 93-98.

Deschamps, M., 2014, *La diversité culturelle au Paléolithique moyen récent : le Vasconien et sa signification au sein des faciès moustériens*, Doctoral thesis at the école doctorale Temps, Espaces, Sociétés, Culture, Université de Toulouse 2, Toulouse, 582 p. (in French) ("Cultural diversity in the Late Middle Paleolithic: the Vasconian and its significance within the Mousterian facies")

Grégoire, S. 2012, *Des matières et des hommes. Nature et évolution de l'organisation territoriale des populations paléolithiques du bassin méditerranéen.* Mémoire d'habilitation à diriger des recherches at the école doctorale Inter-Méd, Université de Perpignan Via Domitia, Perpignan, 195 p. (in French) ("Materials and people. Nature and evolution of the territorial organisation of Paleolithic populations in the Mediterranean basin")

Greiser, S.-T. & Sheets, P.-D. 1979, Raw material as a functional variable in use-wear studies. In: *Lithic Use-Wear Analysis. Proceedings of the Conference held at Department of Archaeology, Burnaby, Canada 16-20 March 1977*, (Hayden, B., Ed.). Academic Press, New York: p. 289-296.

Knutsson, K. 1986, SEM-analysis of wear features on experimental quartz tools. In: *Technical Aspects of Microwear Studies on Stone Tools*, *Actes de la conférence de Tübingen février 1985*, (Owen, L.-R. & Unrath, G. eds.). Early Man News: Newsletter for Human Palaeoecology, 9/10/11, Archaeologica Venatoria, Institut Fur Urgeschichte, Tübingen, Germany: p. 35-46.

Knutsson, K. 1988, Chemical etching of wear feature features on experimental quartz tools. In: *Scanning Electron Microscopy in Archaeology*, (Olsen, S. L. Ed.). BAR International Series 452, B.A.R, Oxford: p. 117-153.

Knutsson, H., Knutsson, K., Taipale, N., Tallavaara, M. & Darmark, K. 2015, How shattered flakes were used: Micro-wear analysis of quartz flake fragments. *Journal of Archaeological Science: Reports*, 2: 517-531. doi:10.1016/j.jasrep.2015.04.008

Lepot, M. 1993, *Approche techno-fonctionnelle de l'outillage moustérien. Essai de classification des parties actives en termes d'efficacité technique. Application à la couche M2e sagittale du Grand Abri de la Ferrassie (fouille H. Delporte).* BA thesis at the département d'ethnologie, de sociologie comparative et de préhistoire, Université de Paris X, Nanterre, 159 p. (in French) ("Techno-functional approach to Mousterian tools. An attempt to classify the active parts in terms of technical efficiency. Application to the M2e sagittal layer of the Grand Abri de la Ferrassie (H. Delporte excavation)").

Mansur-Franchomme, M.-E. 1988, Tracéologie et technologie: quelques données sur l'obsidienne. In: *Industries lithiques: tracéologie et technologie. Actes de la table ronde, Centre de Recherches Archéologiques du CNRS, Valbonne 18-20 octobre 1986,* Vol. 2 (Beyries, S., Ed.), BAR International Series, 411, B.A.R, Oxford: p. 29-47. (in French) ("Traceology and technology: some data on obsidian")

Marquez, B., Ollé, A., Sala, R. & Verges, J.-M. 2001, Perspectives méthodologiques de l'analyse fonctionnelle des ensembles lithiques du Pléistocène inférieur et moyen d'Atapuerca (Burgos, Espagne). *L'Anthropologie,* 105: 281-299. (in French) ("Methodological perspectives on the functional analysis of Lower and Middle Pleistocene lithic assemblages from Atapuerca (Burgos, Spain)") doi:10.1016/S0003-5521(01)80017-0

Odell, G. H. 1981, The mechanism of use-breakage of stone tools: some testable hypotheses. *Journal of Field Archaeology,* 8(2): 197-209. doi:10.1179/009346981791505120

Odell, G. H. & Odell-Vereecken, F. 1980**,** Verifying the reliability of lithic use-wear assessments by "blind tests": the Low-Power approach. *Journal of Field Archaeology,* 7(1): 87-120. doi:10.1179/009346980791505545

Ollé, A., Pedergnana, A., Fernandez-Marchena, J.L., Martin, S., Borel, A. & Aranda, V. 2016, Microwear features on vein quartz, rock crystal and quartzite: a study combining Optical Light and Scanning Electron Microscopy. *Quaternary International*, 424: 154-170. doi:10.1016/j.quaint.2016.02.005

Ollé, A. & Vergès, J.M. 2014, The use of sequential experiments and SEM in documenting stone tool microwear. *Journal of Archaeological Science,* 48: 60-72. doi:10.1016/j.jas.2013.10.028

Pedergnana, A. 2017, *Microwear and residue analyses of quartzite stone tools. Experimental development of a method and its application to the assemblages from the Pleistocene sites of Gran Dolina-TD10 (Sierra de Atapuerca, Burgos, Spain) and Payre (Ardèche, France).* Doctoral thesis at the école doctorale Science de la Nature et de l'Homme, Muséum National d'Histoire Naturelle et Université de Rovira et Virgili, Paris, 803 p.

Pedergnana, A. & Ollé, A. 2016, Monitoring and interpreting the use-wear formation processes on quartzite flakes through sequential experiments. *Quaternary International*, 427: 35-65. doi:10.1016/j.quaint.2016.01.053

Plisson, H. 1982, Une analyse fonctionnelle des outillages basaltiques. In: *Tailler! pour quoi faire: Préhistoire et technologie lithique II. Recent progress in Microwear studies*, (Cahen, D., Ed.). Studia Praehistorica Belgica Vol. 2, Notae Praestorica, Leuven, p. 241-244. (in French) ("Functional analysis of basaltic tools")

Prost, D.-C. 1989, *Enlèvements accidentels, enlèvements d'utilisation et de retouche sur les outils de pierre taillée.* Doctoral thesis at the école doctorale Droit et Lettres, Université de Paris X, Nanterre, 552 p. (in French) ("Accidental, use and rework removals on shaped stone tools")

Semenov, S.-A. 1964, *Prehistoric Technology; An Experimental Study of the Oldest Tools and Artefacts from Traces of Manufacture and Wear*. Cory, Adams and Mackay, London, 211 p.

Tringham, R., Cooper, G., Odell, G., Voytek, B. & Whitman A. 1974, Experimentation in the formation of edge damage. A new approach to lithic analysis. *Journal of Field Archaeology*, 1: 171-196. doi:10.1179/jfa.1974.1.1-2.171

Unger-Hamilton, R. 1989, Analyse expérimentale des microtraces d'usure : quelques controverses actuelles. *L'Anthropologie,* 93(3): 659-672. (in French) ("Experimental analysis of wear micro-traces: some current controversies")

Vaughan, P. 1981, Microwear analysis of experimental flint and obsidian tools. *Staringia,* 6: 90-91. URL: https://natuurtijdschriften.nl/pub/568099

Viallet, C. 2016, *Potentiel fonctionnel des outils bifaciaux au Pléistocène moyen en contexte méditerranéen. Analyse de la structure et des macro-traces des séries bifaciales de la Caune de l'Arago, Terra Amata, Orgnac 3 et du Lazaret.* Doctoral thesis at the école doctorale Inter-Méd, Université de Perpignan, Perpignan, 398 p. (in French) ("Functional potential of bifacial tools in the Middle Pleistocene in a Mediterranean context. Analysis of the structure and macro-traces of the bifacial series of the Caune de l'Arago, Terra Amata, Orgnac 3 and Lazaret")

Viallet, C., Bourguignon, L., Mathias, C., Magniez, P., Ivorra, J. & Brugal, J.P. 2018, Identify the launched percussion use of lower Palaeolithic tools the case of shaped pieces in limestone and basalt. *Butlleti Arqueologic,* 40: 49-55. URL: https://halshs.archives-ouvertes.fr/halshs-02290467

Silex vs. Calcaire - Première analyse comparative du développement des macro-traces d'utilisation : implication pour l'analyse des ensembles lithiques anciens

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Résumé:

L'analyse tracéologique est parfois difficile à mettre en œuvre en raison d'une mauvaise préservation du matériel archéologique, ce qui est souvent le cas pour les séries lithiques du Paléolithique inférieur. Bien souvent les traces les plus ténues ont disparu, ou ne sont pas interprétables et seules les macro-traces d'utilisation sont à même d'apporter des informations fonctionnelles. Par ailleurs, la diversité des matières premières utilisées pour la production des outils nécessite de disposer de référentiels expérimentaux spécifiques. Ainsi, le développement d'expérimentations dédiées à la compréhension du développement des macro-traces d'usage sur différentes matières premières peut renforcer la robustesse des interprétations fonctionnelles. Ces données doivent permettre de disposer de nouvelles clés de compréhension concernant les séries lithiques du Paléolithique inférieur.

Nous présentons les résultats d'une large expérimentation (plus de 300 pièces expérimentales), menée avec des éclats de silex et de calcaire. Des paramètres contrôlés ont été mis en place afin de livrer des critères de comparaison réplicatifs. Trois gestes ont été systématiquement testés (translation longitudinale et translation transversale avec un mouvement unidirectionnel et bidirectionnel), avec deux durées d'utilisation. Dans un premier temps, l'expérimentation a été réalisée sur une même matière travaillée : du bois sec. Chaque matière première pour chaque geste a été éprouvée avec 48 outils (288 au total). Pour la deuxième expérimentation (comprenant 63 outils), les mêmes gestes ont été réalisés sur différentes matières premières : bois frais et sec, peau, os et viande. Les écailles d'utilisation produites sont décrites en fonction de leur position sur le bord tranchant, leur répartition ainsi que selon leurs morphologies.

La comparaison des résultats entre les deux matières premières est réalisée suivant une approche statistique. Les résultats sont discutés en fonction de l'influence de différents paramètres : forme et angle du tranchant et durée d'utilisation. Les résultats obtenus confirment, d'une part, que les macro-traces d'utilisation permettent de diagnostiquer le mode d'action de l'outil. Par ailleurs, concernant les critères de description choisis, il n'y a que peu de différences concernant le développement des macro-traces entre le silex et le calcaire. Finalement, nous concluons que les macro-traces d'usages, en particulier les écailles, livrent des informations fiables et pourraient être utilisées plus fréquemment pour l'analyse fonctionnelle du matériel ancien, souvent moins bien conservé.

Mots-clés: Analyse tracéologique; Paléolithique inférieur; Analyse comparative; macro-traces d'utilisation.