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Reviewed Article:

Trampling Experiments – A Contribution to the Pseudo-Retouch Issue

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Stone tools can, apart from human-made retouch, exhibit traces of damage due to post depositional processes. As a result of post depositional factors, whether animal, human or natural in origin, this damage can sometimes be interpreted as human-made retouch, even

though it is actually the so called *pseudo-retouch*. Due to the problems arising in differentiating these two wholly opposite things, the last few decades have shown an increase in trampling experiments, the goal of which was to separate and recognize real retouch from pseudo-retouch. This article is going to show three such experiments executed by the authors, their methodology and results, as well the comparison to the results of the pseudo-retouch analysis done on lithic finds from a Middle Palaeolithic site of Mujina pećina in Croatia. The third experiment also consisted of taking a sample for soil micromorphological analysis which provided even more insights into this complex topic.

“ Inspiration for our trampling experiments came from the identification, through lithic analysis, of the presence of edge damage and pseudo-retouch on finds from Mujina pećina, a Middle Palaeolithic cave site in Dalmatia, Croatia, which showed presence of edge damage and pseudo-retouch (...) We devised three experiments to better understand the role of trampling in the making of edge damage.

Introduction

Apart from human-made retouch, stone tools can also exhibit traces of damage caused by several post depositional processes, one of which is trampling. Edge damage provoked by trampling, be it of animal or human origin, is sometimes interpreted as human-made retouch, although it ought to actually be interpreted as *pseudo-retouch*. Due to the difficulties involved in visually recognizing trampling damage, an increase in trampling experiments seeking to separate and recognize human-made retouch from pseudo-retouch have appeared in the last few decades. Some of these experiments resulted in the creation of *pseudo-tools* that could have been easily classified according to Bordes typology as notched and denticulated pieces (McBrearty, *et al.*, 1998, p.124). Shea and Klenck's experiment showed that trampling can obscure use-wear traces and make this kind of analysis difficult (Shea and Klenck, 1993, p.191). While Tringham and colleagues suggest that damage from trampling is random and appears only on one side of the artifacts (Tringham, *et al.*, 1974), Pryor (1988) and Nielsen (1991) state that trampling damage appears on both surfaces. These differing results only point to the need for more trampling experiments.

Inspiration for our trampling experiments came from the identification, through lithic analysis, of the presence of edge damage and pseudo-retouch on finds from Mujina pećina, a Middle Palaeolithic cave site in Dalmatia, Croatia, which showed presence of edge damage and pseudo-retouch. The cave is located north of Trogir on the right side of a deep karstic gorge (Boschian, *et al.*, 2017, p.2). Profile A has an eight-layered stratigraphic sequence which was dated to the Mousterian (Rink, *et al.*, 2002; Karavanić, *et al.*, 2008a). The sediments consist of large fragments of carbonate rock, small sand grains, silt, and some clay (Karavanić, *et al.*, 2008b, p.260). Typological analysis showed that the most common type of tool in layers B through to D2 are retouched flakes, while side-scrapers are the most common type in layers E1 and E3. Notched and denticulated pieces are the predominant tool types in layer E2 (Šprem, *et al.*, in press). It is important to note that according to Basler the significant presence of denticulates and notched pieces represents a universal characteristic of late Mousterian in the Eastern Adriatic (Basler, 1983). AMS dating places the interface between layers E1 and E2 to around 45,000 BP, while the AMS age of the overlying layers is about 39,000 BP (Rink *et al.*, 2002, p.261). Other examples of Middle Palaeolithic sites with elevated numbers of denticulate pieces are Bois Roche in France (Villa and Soressi, 2000) and Kulbulak in Uzbekistan (Kolobova, *et al.*, 2012). Villa and Soressi stated that bioturbation inside the Bois Roche den (trampling and digging by hyenas) might be the cause of edge damage on the artifacts (Villa and Soressi, 2000, p.205), whereas Kolobova and colleagues argue that the denticulate tools, or more correctly the pseudo-tools, at Kulbulak are the result of transportation by mudflow (Kolobova, *et al.*, 2012, p.22). It is difficult to tell whether the denticulate and notched nature of the late Mousterian pieces at Mujina pećina is human-made or natural in origin. We devised three experiments to better understand the role of trampling in the making of edge damage.

Materials and methods

Experiments

The first experiment (short: ET 1) involved 40 artifacts experimentally knapped from five different types of raw material. Two types of flint were collected near Lasinja at the site of Crna Draga-Kremešnica, two types came from the vicinity of Mujina pećina and Provaluša respectively (Dalmatia), and one type was collected from Vižula, Istria (See Figure 1). Kremešnica flint (*kremen* in Croatian – flint) has two varieties: one is of a dark colour, almost black, and the other is light green. Both are rich in cracks which often result in irregular flakes. Mujina pećina and Provaluša flint are very similar in appearance; they are of a light brown colour, have translucent edges, and are of a high quality. The Istrian raw material consists of a fine grey chert, with white and grey inclusions. Different raw material from different regions of Croatia were used so that we may observe differences in the trampling damage. Twenty of the experimentally knapped artifacts were retouched so that we could observe edge damage on both retouched and unretouched edges. Every artifact was photographed and signed. We decided to bury the artifacts 15 cm deep on a well-trodden path and to leave them in the soil for several months.

Two 1x1 meter quadrants were dug, with the help of colleagues, in November 2015 in the vicinity of the Faculty of Humanities and Social Sciences in Zagreb. We left one quadrant with its natural, dry sediment and we filled the other with debris taken from the Kličevica canyon near Zadar (See Figure 2a-d). The Kličevica canyon is located in the same karst environment as Mujina pećina and the debris was more easily available than that from Mujina pećina. Next, the artifacts were carefully placed in the ground and their position was taken with a total station. Each quadrant had ten unretouched and ten retouched pieces to better assess trampling damage caused by different sediments; sediment is what McBrearty and colleagues thought plays the most decisive role in damage (McBrearty, *et al.*, 1998, p.122). Everything was photographed and documented. The quadrants were then refilled, and their surfaces were trampled to look natural to passers-by. The artifacts were left in the sediment for seven months. They were carefully excavated and retrieved in June 2016, then washed and dried.

The second experiment (short: ET 2) began in 2017. In May 2017 we experimentally knapped 80 artifacts from six different types of raw material (See Figure 3). This time we used two types of Crna Draga-Kremešnica flint, chert collected from Vižula, in Istria, flint collected from near Trogir, flint collected in Slavonia, and obsidian from Melos island, in Greece. Trogir flint is of a dark colour, almost black, and presents a white cortex. It is very similar to the Provaluša and Mujina pećina flint used in experiment 1, and was collected nearby. The Slavonian raw material is a coarse flint of a deep red colour, gathered from a gravel exploitation site. It presumably originated from northern Bosnia, and was brought down to the Slavonian plains in pebble form by the rivers Bosna and Vrbas. The obsidian is interesting because of its brittle nature, so we hypothesised that obsidian artifacts would display the biggest amount of edge damage. Thirty six out of 80 artifacts were retouched, and the rest were left with unretouched edges. Every artifact was photographed and signed. In September 2018, while on an excavation on Korčula island, we were given permission to conduct the experiment in the Vela spila cave. We prepared a 1x1 meter quadrant filled with debris and then filled the empty spaces between rocks with sediment (See Figure 4). In the light of McPherron, *et al.*'s (2014) suggestions on footwear, we wore soft-soled shoes to avoid further damage. Duration of trampling was 30 minutes.

Trampling experiment 3 (short: ET 3) also involved 80 experimentally knapped artifacts, but made from six different types of raw material – Crna Draga-Kremešnica flint (two types), Istrian, Trogirian, and Slavonian flint/chert, and Melian obsidian. We also included pottery shards and bone to be trampled in this experiment (See Figure 5) so as to note whether density of finds affects the amount of edge damage. Thirty two out of 80 artifacts were retouched and the rest left with unretouched edges. The experiment was designed for trampling on soil, as opposed to trampling on debris carried out in experiment 2. The experiment was carried out in December 2018, when the ground was covered with slight vegetation and some vegetal remains (See Figure 6). We also wore soft-soled shoes "to avoid flake initiation from the shoes themselves" (McPherron, *et al.*, 2014, p.74). The duration of the trampling was 60 minutes, with breaks taken every 15 minutes during which photographs documenting the state and position of the trampled artifacts were taken.

An overview of the variables for all three experiments can be seen in Table 1. In all three experiments, we were careful to place the artifacts in both a face up and face down position.

Experiment	Depth	Substrate	Material	Sample size	Duration
ET 1	15cm	dry soil, debris	5 different types of siliceous rock	40	~ 7 months
ET 2	-	debris	6 different types of siliceous rock	80	30 minutes
ET 3	-	soil/soil, pottery shards and bones	6 different types of siliceous rock	80	60 minutes

TABLE 1. AN OVERVIEW OF ALL THREE EXPERIMENT VARIABLES.

Definitions

During the analysis, we used a system developed by Villa and Soressi (2000, p.202). They described three different edge damage categories according to size: marginal (scars 1.5 mm), medium (scars 1.5 – 4.5 mm), and microfractures (edge break without a bulbar scar). We also recorded breakages and damages bigger than 4.5 mm (*chipped*).

For pseudo-tools, we used a definition put forward by McBrearty, *et al.* (1998, p.114): "Pseudo-tools show one or more large scars (>3mm); in most cases these scars are contiguous*.*" Therefore, we defined pseudo-tools as artifacts that show one or more contiguous scars.

Thiébaut (2010) undertook an experiment with artifacts trampled by large bovids as well as those damaged by streaming. She argues that a comparison can be made between trampled pseudo-notches and archaeological notches based on several characteristics (Thiébaut, 2010, p.353). Using Prost's terminology (Prost, 1993), we recorded four different types of negatives: alpha, beta, gamma, and delta (Thiébaut, 2010, p.353). We also measured the opening of the notch, as well as the extent of the negatives. Moreover, we recorded the angle of the notch removal: low, low entering, abrupt, and abrupt entering (See Figure 7, Thiébaut, 2010, p.356). Since Thiébaut devised criteria that can only be applied to notches and denticulates, we only analysed experimental pseudo-tools which mimic notches. We then compared them to Thiébaut's bovid-trampled artifacts, as well as archaeological notches from several archaeological sites.

Soil micromorphology

The last two decades have produced several experimental studies on different materials through micromorphological analyses (e.g. Goldberg and Whitbread, 1993; Mallol, *et al.*, 2007; Miller, *et al.*, 2010; Driscoll, *et al.*, 2015), and a few review papers on their main micromorphological characteristics, particularly on the results of trampling experiments (Miller, 2017; Rentzel, *et al.*, 2017). Each experiment presented different trampling durations, different materials (chert, quartz, burnt or unburnt bone), and different conditions (some were buried before trampling and others were trampled on the surface of the sediment).

In the third experiment described in this paper we provide results of "surface trampling" effects on chert, pottery, and unburnt bone identifiable also at microscopic scale. We collected three undisturbed and oriented samples. Two of the samples were collected from the trampled area, and one control sample was collected from outside the trampled area, approximately 1.5 m away. Sample EXP 1 was collected after the removal of larger pottery fragments from the surface, while sample EXP 2 was collected from the area where a concentration of trampled flint could be observed at the surface. Sample EXP 3 is the control sample.

The monoliths were oven-dried at 30°C. Thin sections were then made in the Servizi per la Geologia laboratory (Piombino, Italy). The samples were impregnated with low-viscosity acetone-diluted polyester resin under moderate suction and polymerisation took place under atmospheric pressure for about 90 days. The thin sections were cut with a diamond disk and ground to 30 μm with corundum abrasive powders, using petroleum for cooling. They were then covered by a standard optic glass slide. The size of the slides is 90 x 55 mm. The thin sections were examined with a petrographic microscope at magnifications ranging from 4x to 40x under plane-polarised light (PPL), cross-polarised light (XPL), and oblique incident light (OIL). The descriptions of the thin sections follow the guidelines proposed by Stoops (2003), Bullock, *et al.* (1985), and Courty, *et al.* (1989).

Results and discussion

Edge damage and pseudo-retouch

Out of 40 artifacts from the first experiment, 23 presented edge-damage (57.5%). Experiment 2 produced 56.1% of edge-damaged pieces, whereas experiment 3 produced 49,4%, which means that trampling on soil in this instance produced the smallest percentage of edge-damaged artifacts. Regarding edge damage types (marginal, medium or microfractures), artifacts trampled on debris (experiment 2) presented 40.7% of medium edge damage (1.5 – 4.5 mm in size), whereas experiment 1 and 2 presented 21.2% and 25.5% respectively. All three groups of experimental artifacts exhibited marginal damage (1.5 mm) as the predominant type. Experiment 2 also produced the biggest number of pseudo-tools – 13 (15.9%), compared to six pseudo-tools from experiment 1 (15%) and 9 pseudo-tools (11.1%) produced during experiment 3. However, experiment 1 only involved 40 artifacts, whereas experiments 2 and 3 involved double the amount (80 pieces).

The results of edge damage analysis for the Mujina pećina artifacts are somewhat similar (See Graph 1); artifacts from layer E1 present the largest amount of edge damage (97%) and artifacts from layer D1 and D2 present the smallest amount (75.5%). Also, the predominant type of damage on artifacts from all the Mujina pećina layers is marginal; however, it appears that artifacts from the cave's upper layer present higher amounts of medium edge damage (See Graph 2). The sediment in Mujina pećina is rich with stone debris, layer E1 of Mujina pećina even more so; it is described as "reddish brown sandy sediment with *a great amount* of rock debris and an abundance of organic material" (Karavanić, *et al.*, 2008b, p.260; emphasis by authors). Even though the Mujina pećina assemblage was not subjected to the same natural processes as those at Kulbulak or Bois Roche mentioned earlier, the amount of debris present in the sediment could have triggered taphonomic processes which may have in turn affected artifact morphology. McBrearty, *et al.* (1998) stated that the substrate was the most important factor influencing edge damage, followed by raw material, and artifact density.

When considering the extent of edge damage, whether artifacts display one or more types of damage, the results are telling (See Graph 3). Artifacts from experiment 2 show a greater number of damage types: 45.7% display two different types of damage on their edges, and 39.1% display only one edge damage type. 47.8% and 65% of artifacts from experiment 1 and 3 respectively, display only one type of edge damage. These percentages again indicate that trampling lithic artifacts on debris for 30 minutes produces more edge damage than trampling buried artifacts for seven months or trampling on soil for 60 minutes does, as was done in experiments 1 and 3. The extent of edge damage on the artifacts from Mujina pećina is shown in Graph 4. Again, the upper layers of the site (B, C, D1, D2 and E1) exhibit the largest amount of edge damage on artifacts. This could be due to the upper layers being closer to the walking surface or it may be a result of larger amount of stone debris in these sediments, since several analyses show the upper layers were deposited rapidly (Rink, *et al.*, 2002, p.944).

Regarding the raw material, all three experiments showed that chert from Istria and Kremešnica, and obsidian from Melos, suffered the highest degree of edge damage (See Graph 5). Raw material from Provaluša and from the vicinity of Mujina pećina were collected close to the "Trogir" used in experiments 2 and 3, but the former ones have more brittle edges.

Comparison with other sites using Thiébaut's methodology

Out of the 28 pseudo-tools produced in all three experiments, only 13 displayed pseudo-retouch mimicking notches (See Figure 10). As was mentioned earlier, we analysed these pseudo-tools using criteria and characteristics established by Thiébaut (2010, p.353). She compared notches made by trampling with those found in archaeological contexts from four sites: Grotte de l'Hyène, Grotte du Bison, Mauran, and Les Bosses. We compared our pseudo-notches to Thiébaut's bovid trampled notches (34 pieces).

Type of negatives

Thiébaut demonstrated that the notches on the human-made tools from the four sites she analysed are almost exclusively made of alpha type negatives, whereas the pseudo-notches show diversified morphologies. That is also true for our pseudo-notches, which show diverse types of removals (See Graph 6).

The angle of the notch removal

The angle of the notch removal of our trampled notches shows similar results to Thiébaut's pseudo-notches (See Graph 7): low angle entering is predominant. Archaeologically isolated notches and denticulate notches also mainly present a low angle, particularly a low entering one. However, among the artifacts excavated from the Middle Palaeolithic site of Les Bosses, Thiébaut was able to separate pieces that had been damaged by streaming, and which bore pseudo-notched features, from those which present almost exclusively abrupt angles of removal (Thiébaut, 2010, pp.351 – 356). Also, pseudo-denticulates created by trampling show generally abrupt angles (Thiébaut, 2010, p.356). This one characteristic ought to be investigated further since its use in distinguishing pseudo-tools remains unclear.

Dimensions of negatives

Regarding the length and the extent of the opening of the notch, both groups of pseudo-notches again show similarities, and stand out when compared to Thiébaut's analyses of archaeological material (See Graph 8). The average dimension of the openings and the extent of the negatives from the pseudo-tools are lower than those of the notched artifacts from archaeological sites. The negatives on Thiébaut's pseudo-tools and those on our assemblage are therefore also smaller.

Soil micromorphology

Both samples from the trampled area (EXP 1 and EXP 2) show microstructural modifications which include compaction and lack of voids caused by trampling. This contrasts with the soil in the control sample of EXP 3 which is much more porous and presents frequent packing voids and chambers (See Figure 8). Furthermore, effects on coarse components in the two trampled samples were also visible. These include the vertical downwards movement of coarse fragments (up to 5 cm) due to soil pressure and compaction (See Figure 9a and b). Some of the bones and pottery fragments appear to be crushed.

Conclusion and further considerations

The three trampling experiments demonstrate how easily artifacts trampled directly or through a layer of sediment can sustain edge damage and pseudo-retouch; 30 minutes of trampling on debris produced 13 pseudo-tools and 60 minutes of trampling on soil produced nine, whereas burial in sediment for seven months produced six pseudo-tools. Half of all the trampled artifacts in every experiment sustained edge damage. The upper layers at Mujina pećina (layers B, C, D1, D2, and E1) display the greatest amount of edge damaged artifacts. This may have been caused by the stone debris in the sediment of the cave. However, where matters of time are concerned, we cannot exactly compare the archaeological artifacts from Mujina pećina which spent a lot of time in sediment, with the experimental artifacts which were trampled over short time period. We nevertheless believe that one of the aspects we can compare is the morphology of the negatives on the experimental pseudo-tools and morphology of negatives from archaeological contexts. When looking at the results of Thiébaut's methodological approach, it seems that pseudo-tools show various characteristics – very diverse types of negatives of small sizes, and mostly low entering angle of removals, as opposed to human-made tools. This very diverse morphology of negatives could by itself be a characteristic of pseudo-tools, or at least pseudo-notches. Our next step would be to repeat the experiments with a larger number of experimental pieces in order to gather further data.

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Country Croatia

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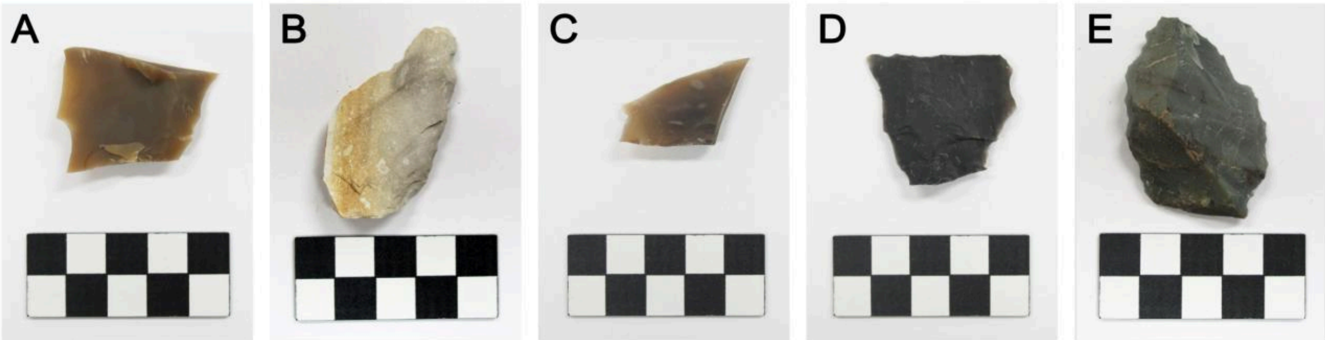


FIG 1. DIFFERENT TYPES OF SILICEOUS ROCKS USED IN THE TRAMPLING EXPERIMENT 1. A - PROVALUŠA, B - ISTRIA, C - MUJINA PEĆINA, D - CRNA DRAGA KREMEŠNICA (DARKER), E - CRNA DRAGA KREMEŠNICA (LIGHTER).

FIG 2A. EXPERIMENTALLY MADE LITHIC ARTIFACTS PLACED IN TWO DIFFERENT QUADRANTS, EXPERIMENT 1.

FIG 2B. EXPERIMENTALLY MADE LITHIC ARTIFACTS PLACED IN TWO DIFFERENT QUADRANTS, EXPERIMENT 1.

FIG 2C. EXPERIMENTALLY MADE LITHIC ARTIFACTS PLACED IN TWO DIFFERENT QUADRANTS, EXPERIMENT 1.

FIG 2D. EXPERIMENTALLY MADE LITHIC ARTIFACTS PLACED IN TWO DIFFERENT QUADRANTS, EXPERIMENT 1.

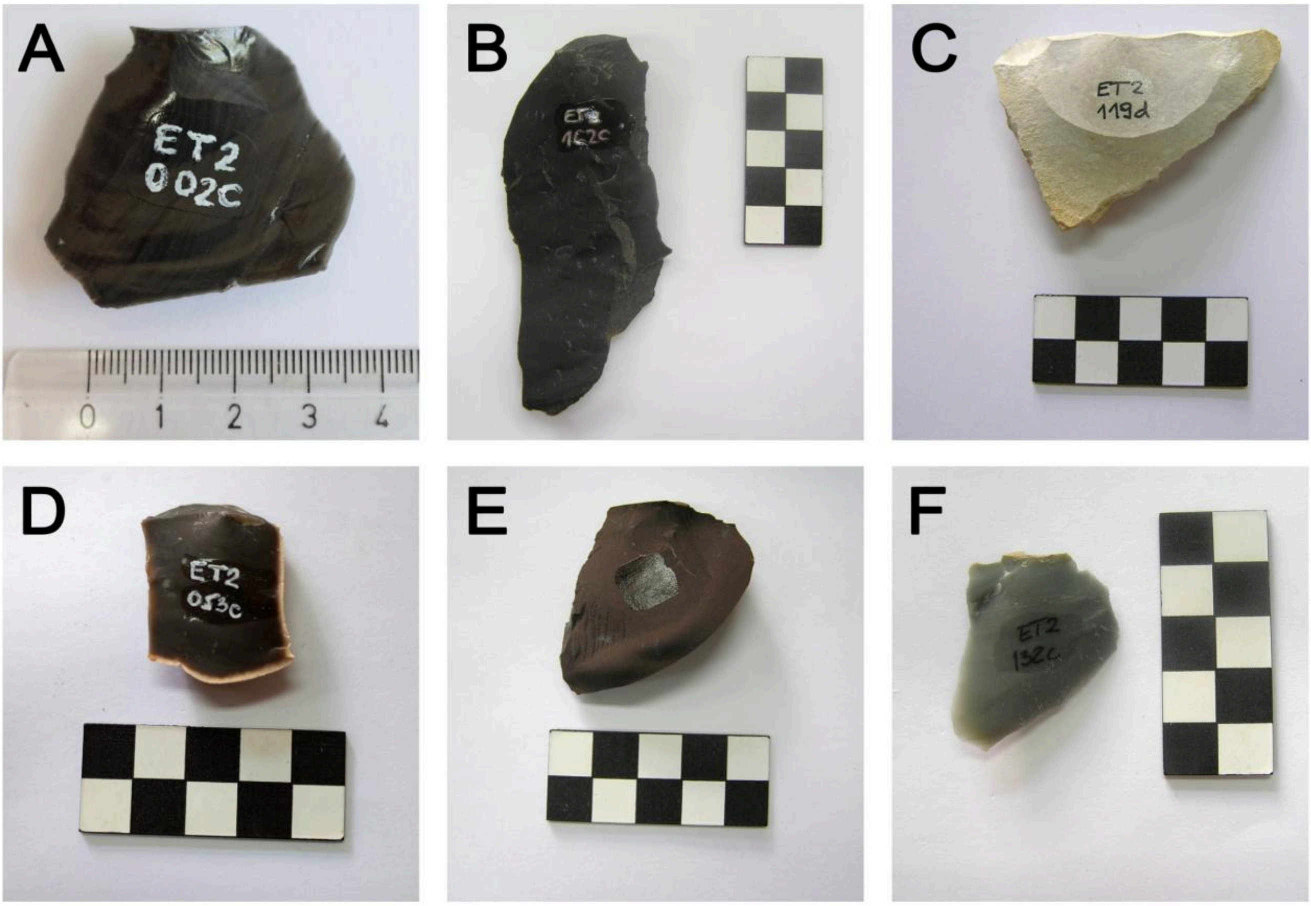


FIG 3. DIFFERENT TYPES OF SILICEOUS ROCKS USED IN THE TRAMPLING EXPERIMENT 2. A - MELOS, B - CRNA DRAGA KREMEŠNICA (DARKER), C - ISTRIA, D - TROGIR, E - SLAVONIJA, F - CRNA DRAGA KREMEŠNICA (LIGHTER).

FIG 4. QUADRANT PREPARED FOR TRAMPLING EXPERIMENT 2.

FIG 5. A BONE, POTTERY AND LITHIC ACCUMULATION SET UP FOR TRAMPLING, EXPERIMENT 3.

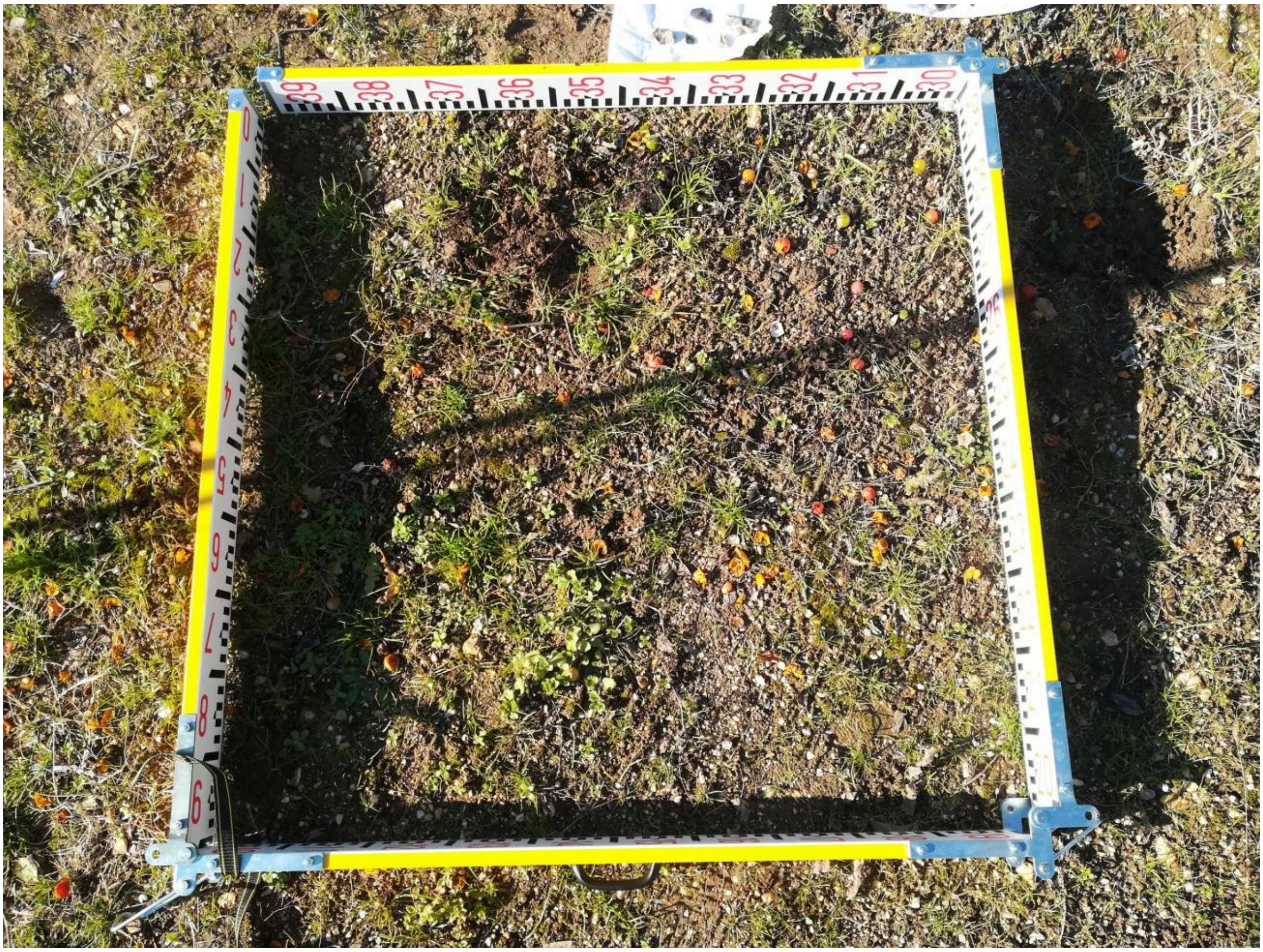


FIG 6. THE TRAMPLING QUADRANT PREPARED FOR EXPERIMENT 3.

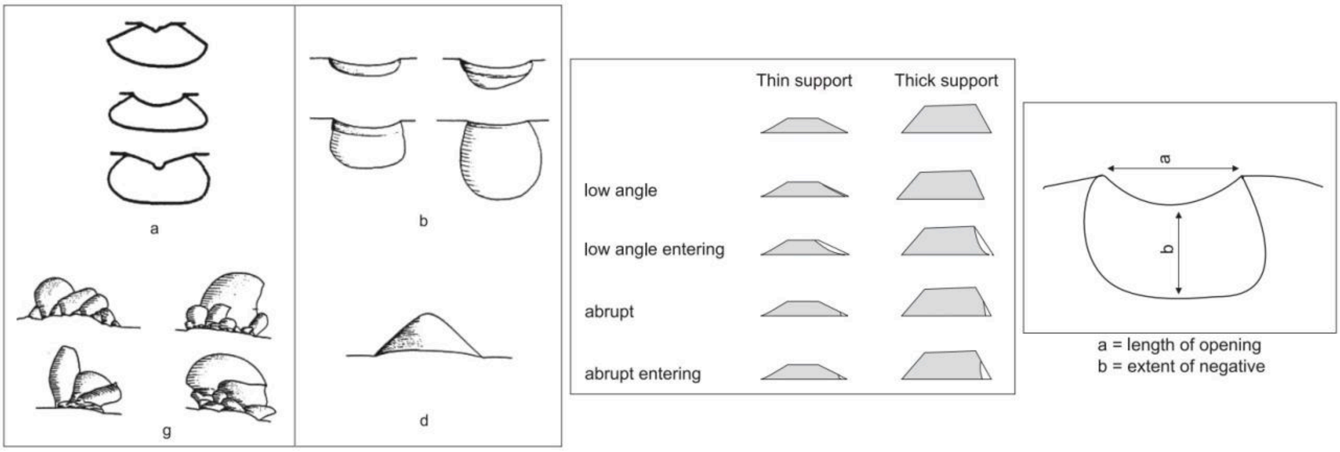


FIG 7. CHARACTERISTICS MEASURED ACCORDING TO THIÉBAUT METHODOLOGY: TYPE OF NEGATIVE, ANGLE OF THE NOTCH REMOVAL, LENGTH AND EXTENT OF THE REMOVAL (AFTER THIÉBAUT 2010, 354 – 356).

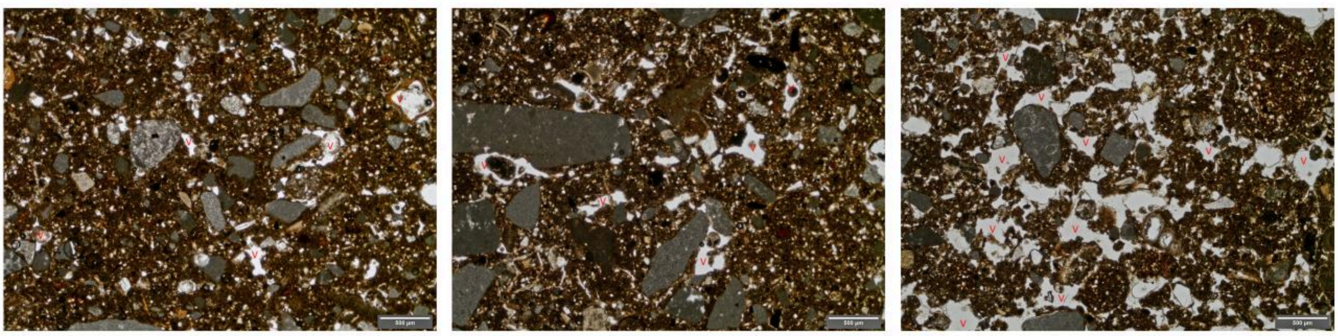


FIG 8. MICROPHOTOGRAPHS SHOWING SOIL COMPACTION IN TRAMPLED SAMPLES (EXP1 AND EXP2) VS. SOIL POROSITY IN THE CONTROL SAMPLE (EXP3). 1) EXP 1, PPL; 2) EXP 2, PPL, 3) EXP 3, PPL.

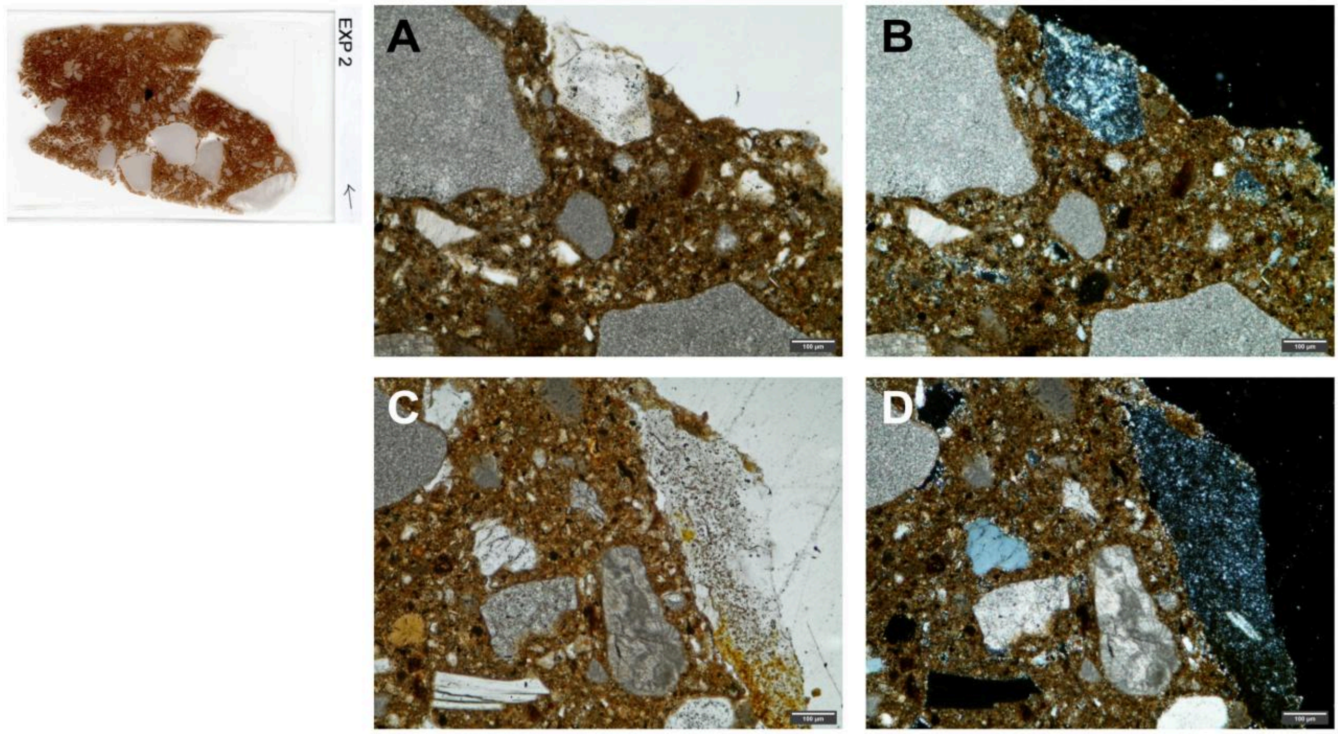


FIG 9A. FLATBED SCAN OF THIN SECTION EXP2; A. MICROPHOTOGRAPH OF TRAMPLED CHERT IN COMPACTED SOIL, PPL (EXP2); B. MICROPHOTOGRAPH OF TRAMPLED CHERT IN COMPACTED SOIL, XPL (EXP2); C. MICROPHOTOGRAPH OF TRAMPLED CHERT IN COMPACTED SOIL, PPL (EXP2); D. MICROPHOTOGRAPH OF TRAMPLED CHERT IN COMPACTED SOIL, XPL (EXP2)

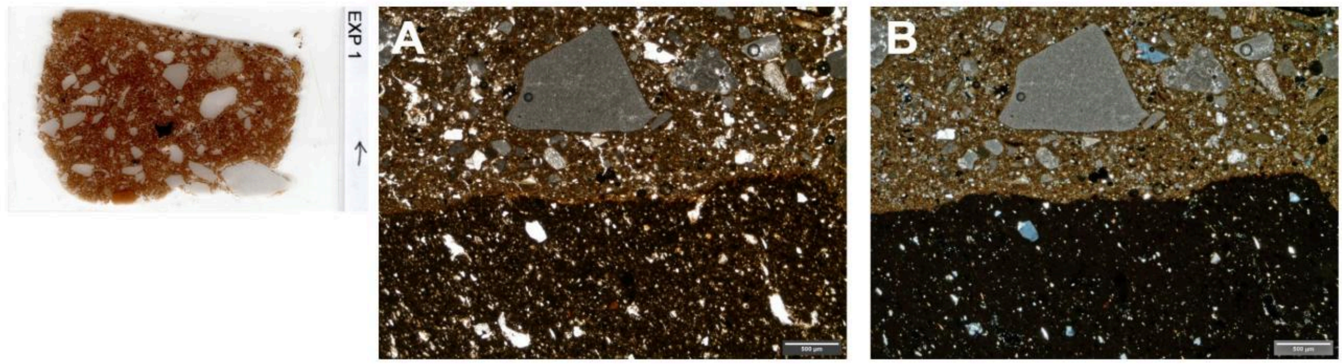
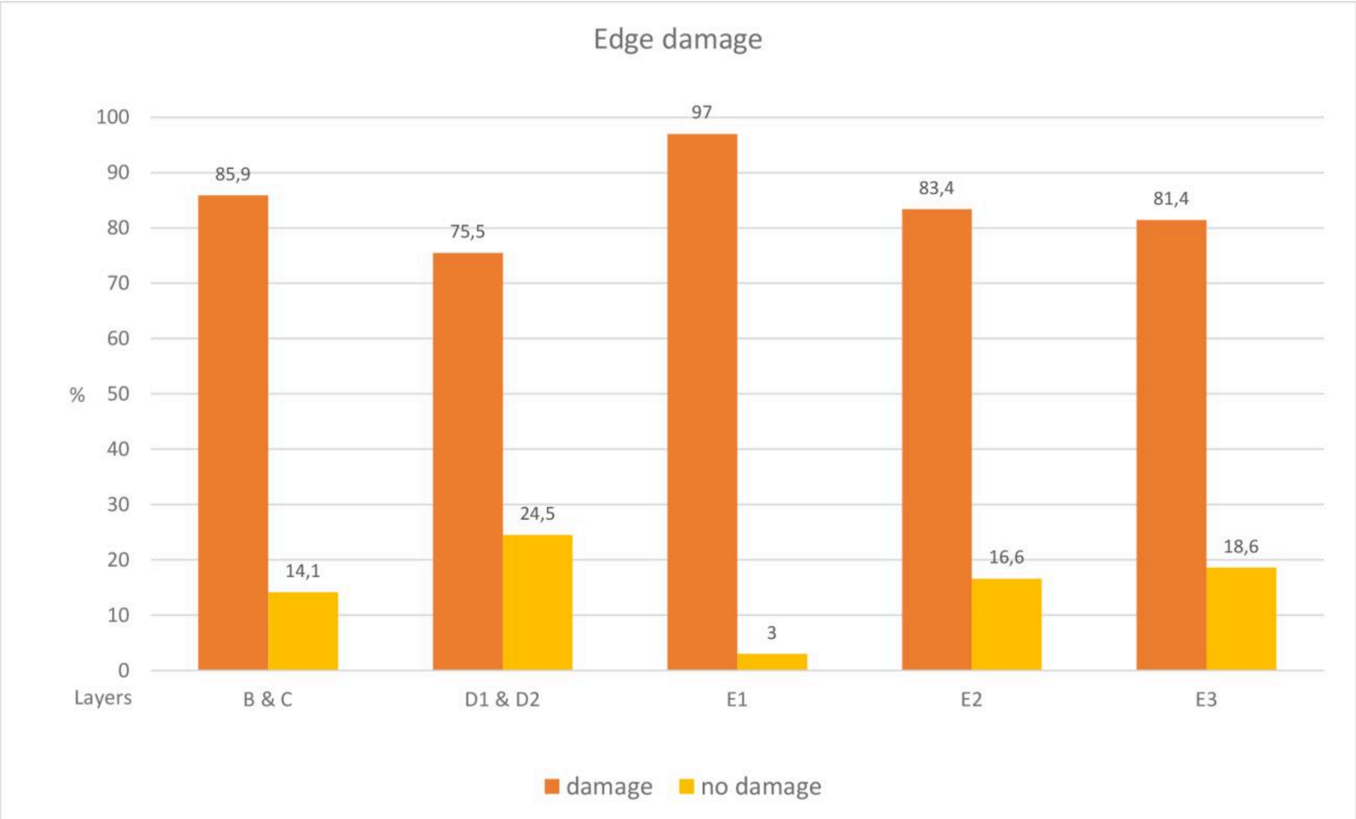
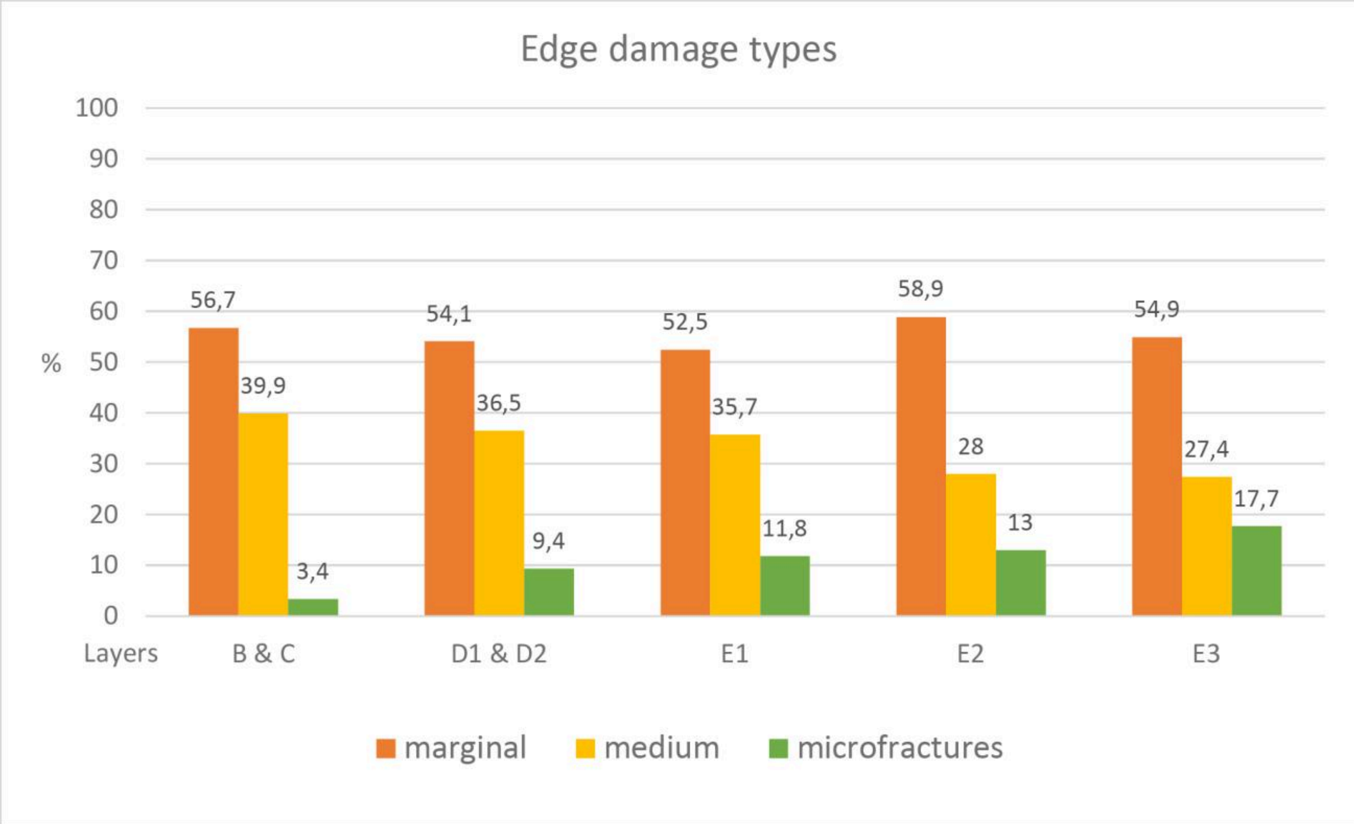


FIG 9B. FLATBED SCAN OF THIN SECTION EXP1; A. MICROPHOTOGRAPH OF TRAMPLED POTTERY FRAGMENT, PPL (EXP1); B. MICROPHOTOGRAPH OF TRAMPLED POTTERY FRAGMENT, XPL (EXP1).

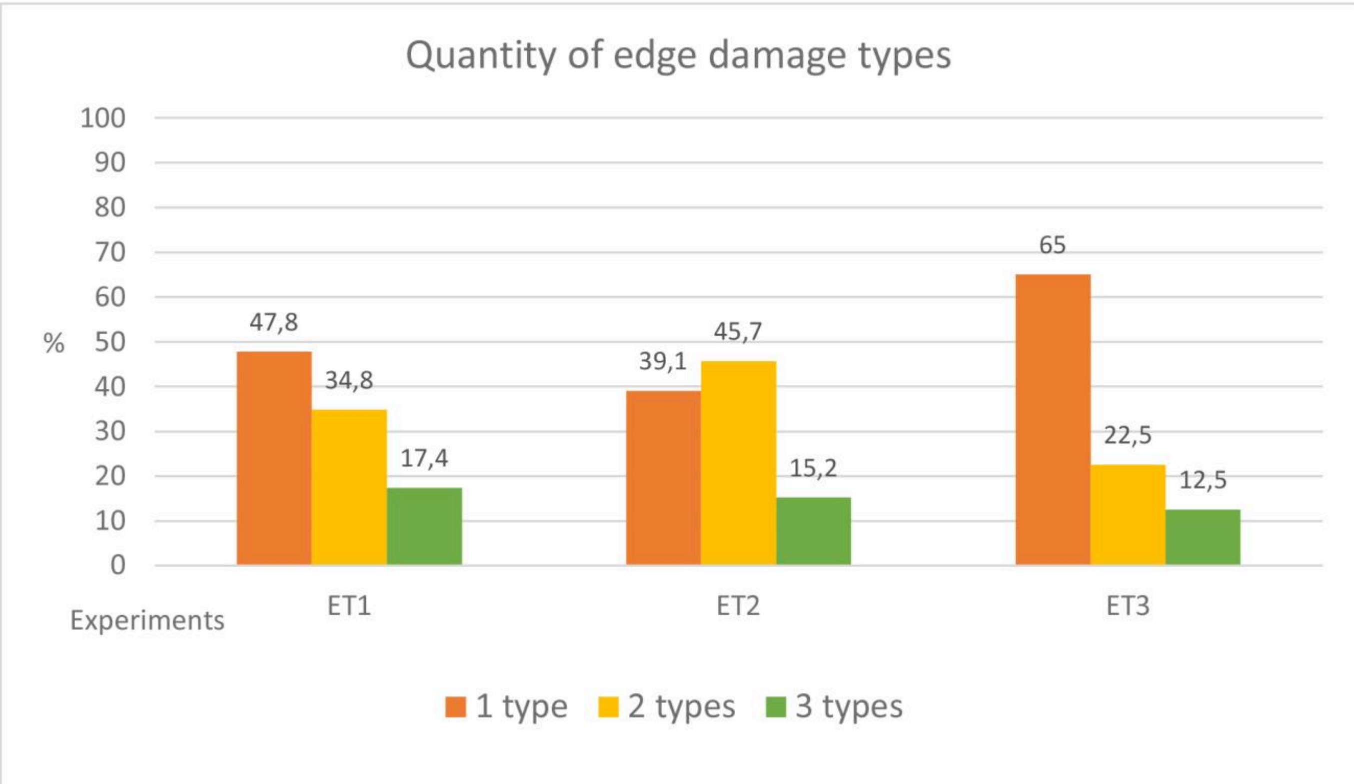
FIG 10. AN EXAMPLE OF A PSEUDO-NOTCH FROM ONE OF OUR EXPERIMENTS.



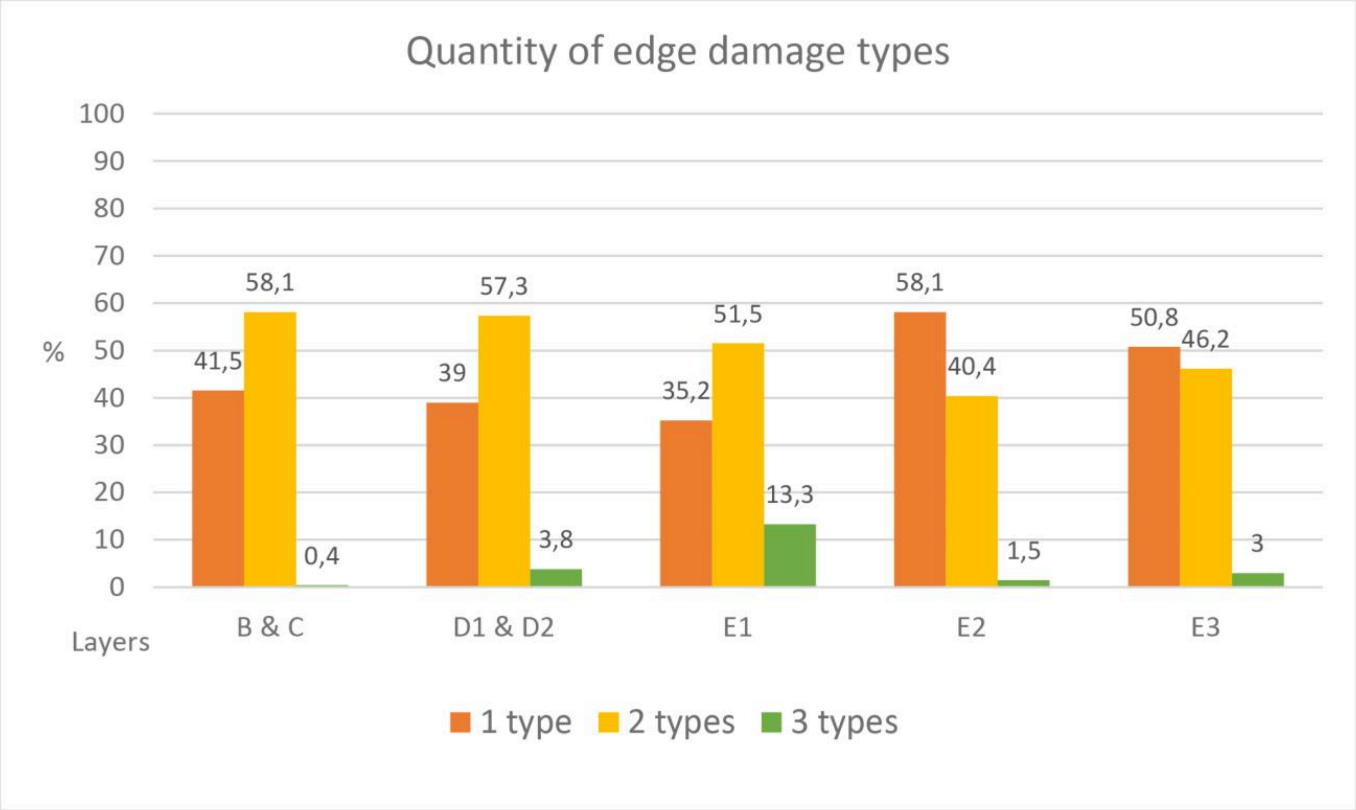
GRAPH 1. PRESENCE OF EDGE DAMAGE ON ARTIFACTS FROM MUJINA PEĆINA. SHOWING ALL LAYERS.



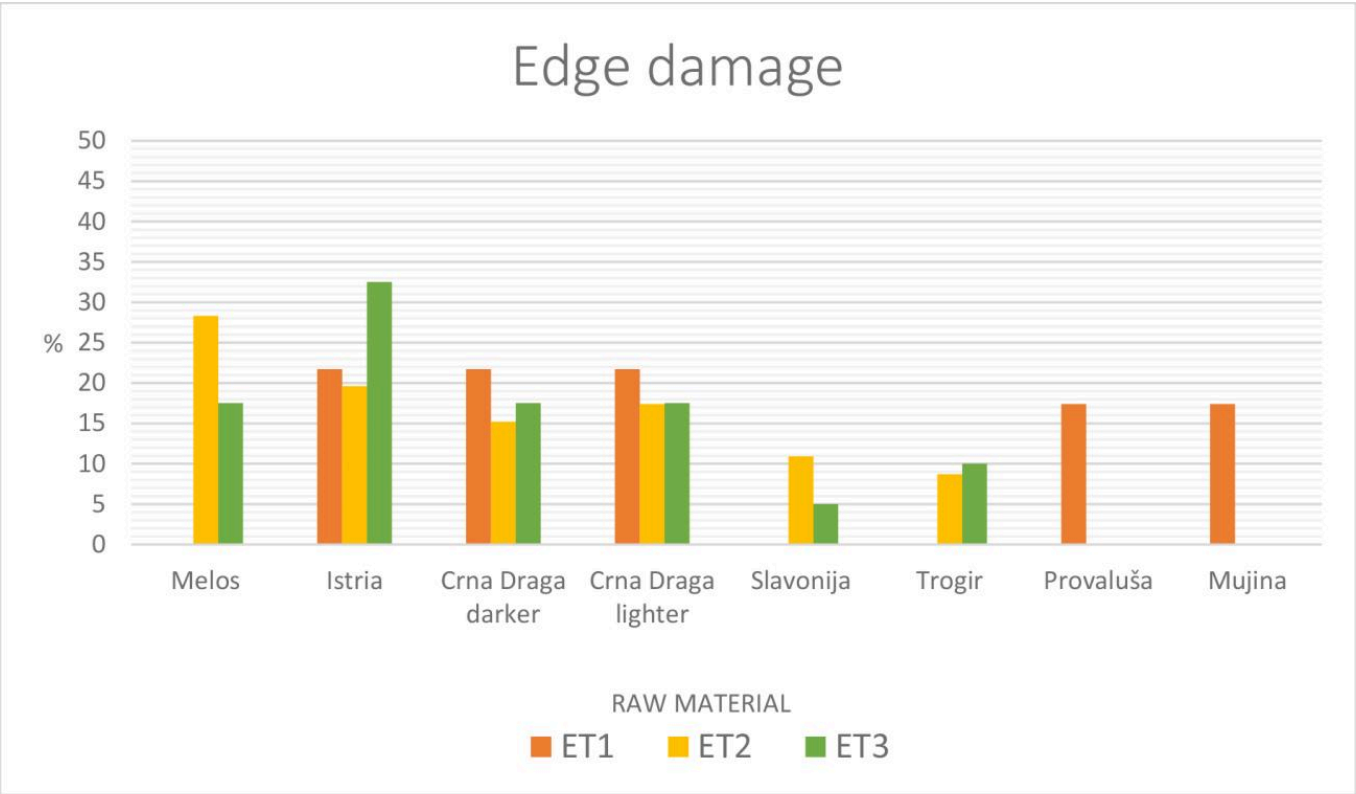
GRAPH 2. EDGE DAMAGE TYPES ON ARTIFACTS FROM MUJINA PEĆINA. SHOWING ALL LAYERS.



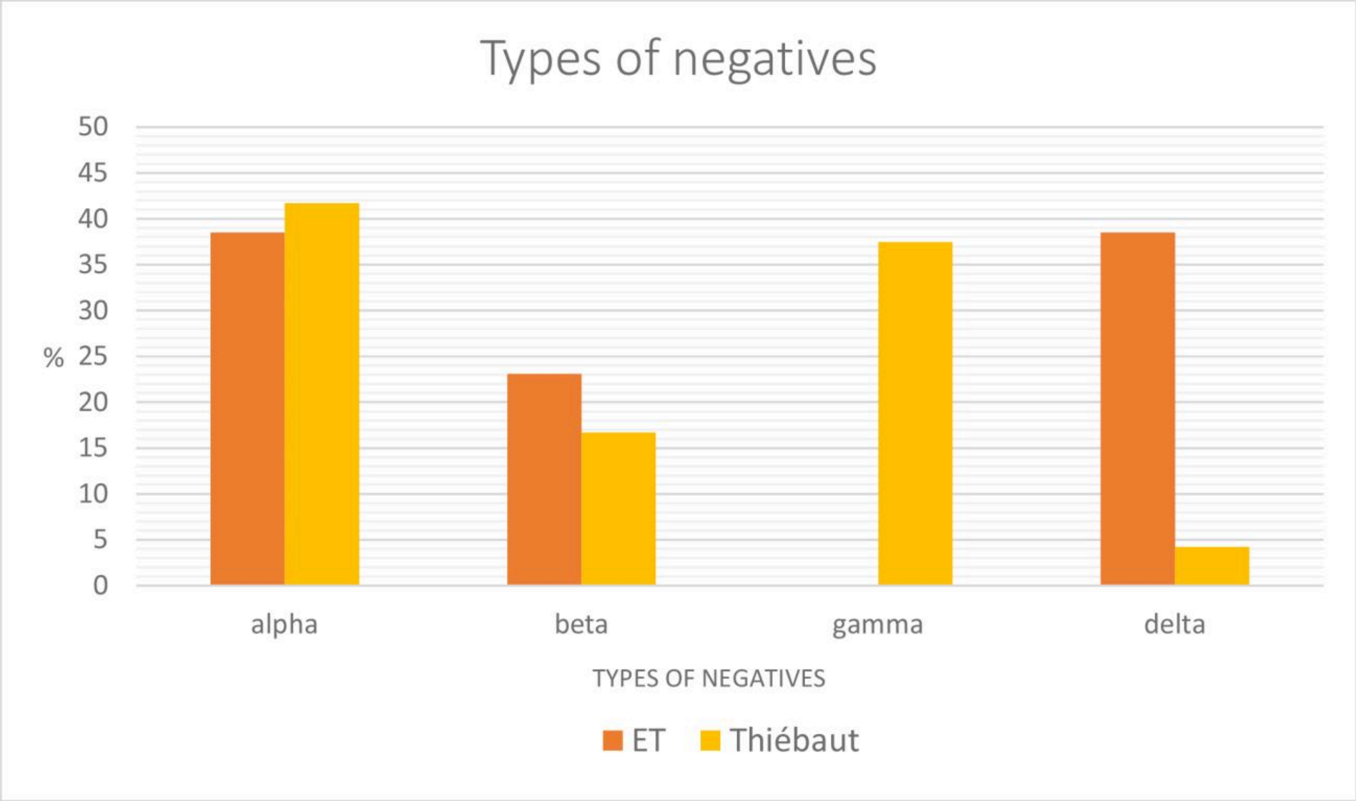
GRAPH 3. QUANTITY OF EDGE DAMAGE TYPES ON TRAMPLED ARTIFACTS.



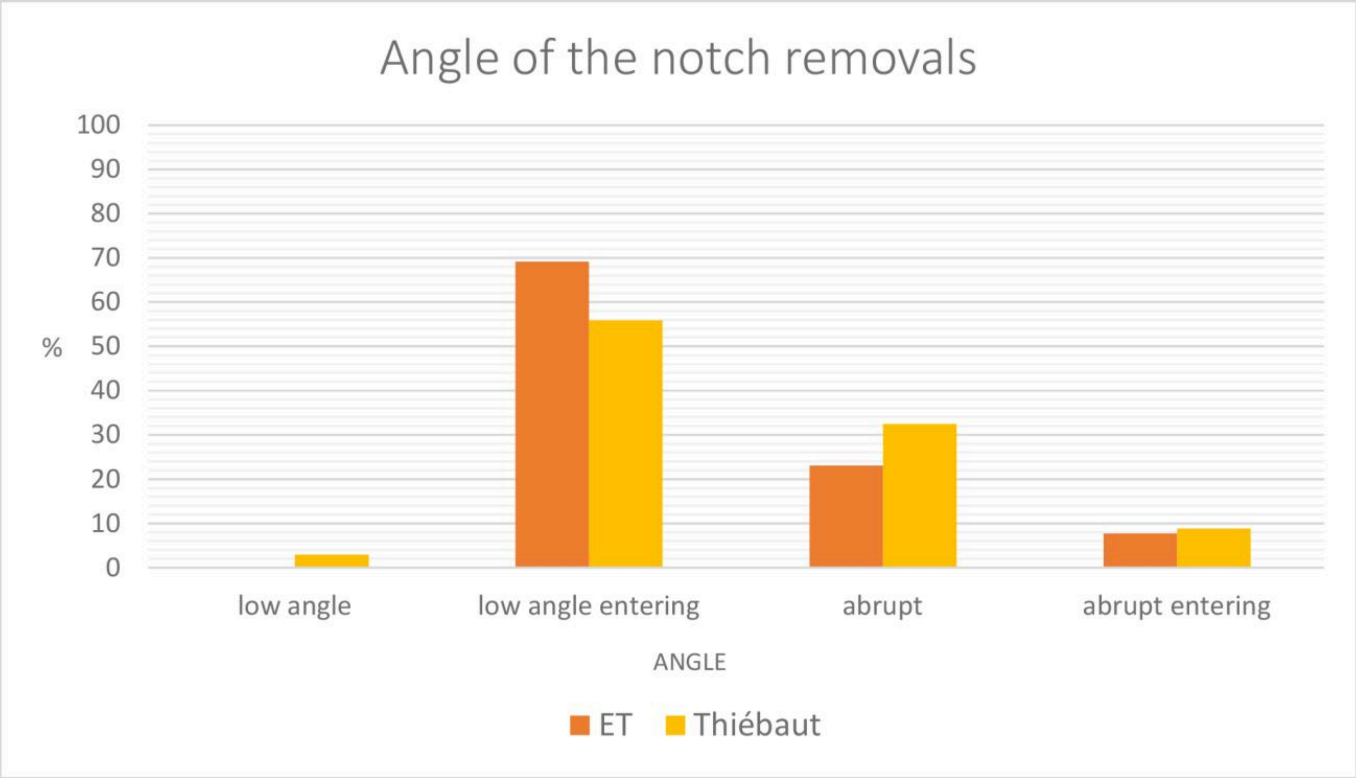
GRAPH 4. QUANTITY OF EDGE DAMAGE TYPES ON ARTIFACTS FROM MUJINA PEĆINA. SHOWING ALL LAYERS.



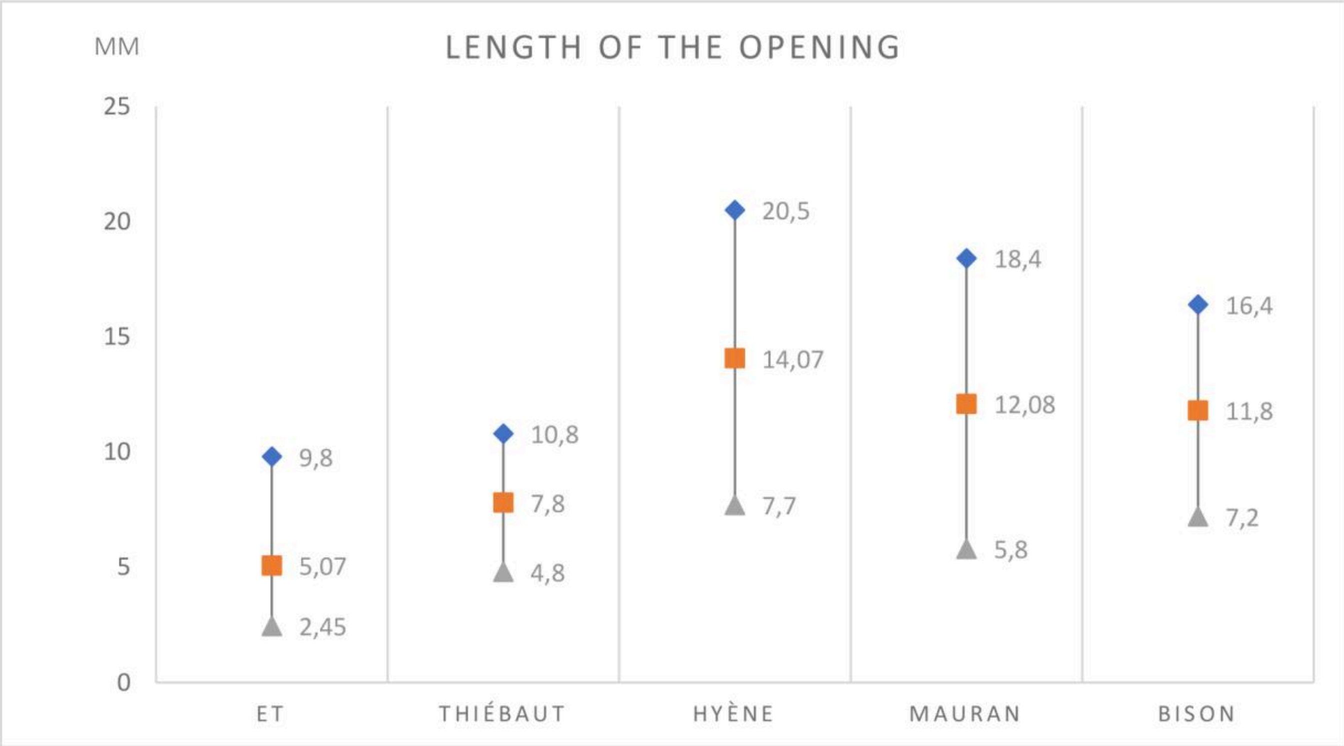
GRAPH 5. EDGE DAMAGE ACCORDING TO DIFFERENT RAW MATERIAL USED IN EXPERIMENTS.

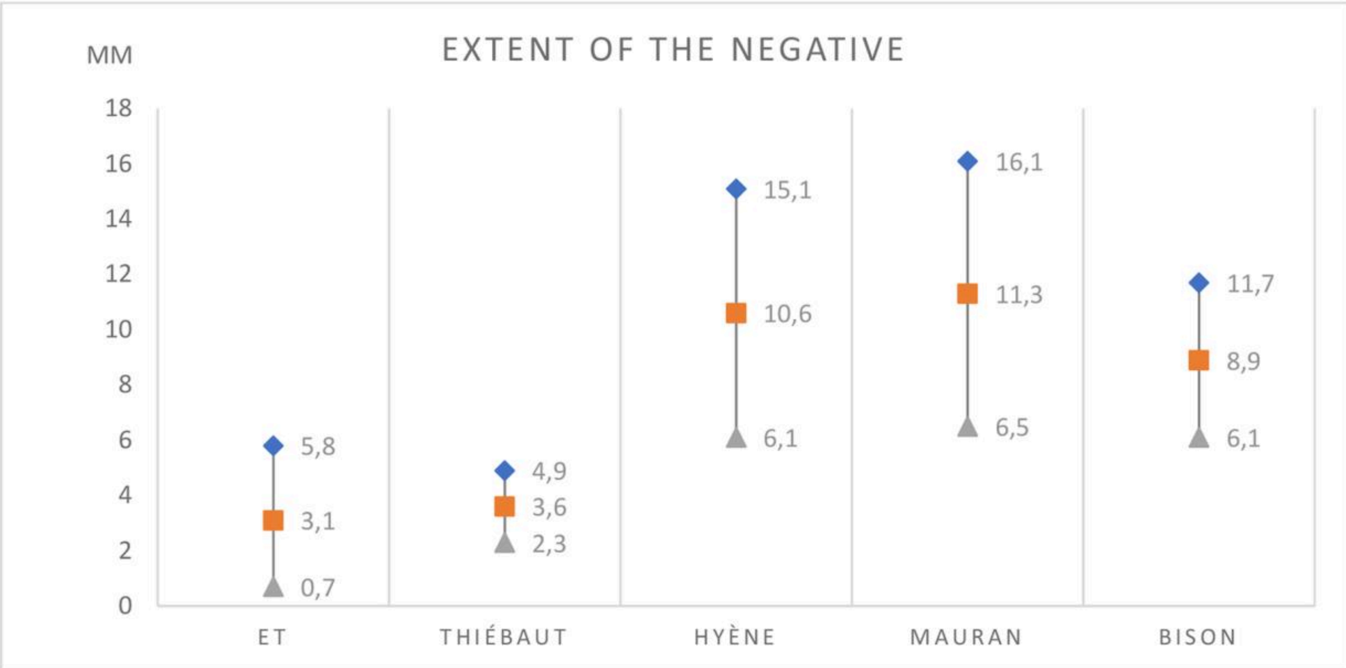


GRAPH 6. TYPES OF NEGATIVES ON PSEUDO-NOTCHES FROM OUR EXPERIMENTS AND THIÉBAUT'S (AFTER THIÉBAUT 2010, 354).



GRAPH 7. ANGLE OF THE NOTCH REMOVALS ON OUR PSEUDO-NOTCHES AND THIÉBAUT'S (AFTER THIÉBAUT 2010, 356).





GRAPH 8. LENGTH OF THE OPENING AND EXTENT OF THE NEGATIVE ON PSEUDO-NOTCHES FROM OUR EXPERIMENT, THIÉBAUT'S EXPERIMENT, AS WELL AS ON NOTCHES FROM ARCHAEOLOGICAL SITES HYÈNE, MAURAN, AND BISON, IN MM (AFTER THIÉBAUT 2010, 355).