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Reviewed Article:

Enhancing the Accuracy of Use Interpretation: The Discovery of a New Wear Formation with the Complementary Methods of Experimental Archaeology and Use-Wear Analysis

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Experimental archaeology and use-wear analysis are methods used together to understand aspects of an object's life, such as manufacture and use. This paper demonstrates the

benefits of analysing use-wear through experiments. It presents the results of experiments which were carried out to test the use of battle-axes and axe-hammers. Most notably, the paper presents the new discovery of a previously unknown use-wear formation, the 'three-group-arrangement'. This is a formation of wear on bladed implements which forms in the early stages of use – in contact with wood using chopping motions. Its discovery was only possible through the analysis of wear development throughout experiments. This use-wear formation was analysed on stone battle-axes and axe-hammers from the northern British Isles, c. 2200 - 1500 BC and allowed an interpretation of their use which was not previously possible for several artefacts in this assemblage. The discovery of this wear pattern significantly adds to the knowledge of use-wear formation on bladed and perforated, ground and polished stone implements which have previously been overlooked. It allows the previously unfeasible interpretation of less developed wear, formed during the early stages of use in contact with wood. The results demonstrate the importance of analysing the changing use-wear formations throughout experiments to understand the formation of use-wear patterns on implements in the archaeological record.

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Introduction

A battle-axe (See Figure 1) is a stone implement that is less than 190mm long and 80mm broad with a perforation, butt and a blade (Roe, 1966). The highly polished nature and small perforations of British Early Bronze Age (EBA) battle-axes have resulted in interpretations of their non-functional nature. The presence of many in funerary contexts has led to understandings that they are purely ceremonial, perhaps associated with an elite (for example Saville & Roe 1984; Smith, 1926; Mortimer, 1905; Greenwell, 1877; for the Continental studies of elite see: Brumfield & Earle 1987; Lekberg, 2002, p. 68). These stereotypical interpretations were often influenced by an awareness of the battle-axe and single grave cultures in Europe, which saw the placement of battle-axes in burials as an indication of their elite nature.

Axe-hammers (See Figure 2) are differentiated from battle-axes by size, they are stone implements with a blade, butt and perforation and are greater than 190mm long and 80mm broad. Axe-hammers have been thought of as neither functional nor prestigious, being too large and crude (Leahy, 1986; Pegge, 1773). Suggestions for the use of axe-hammers in woodworking, agricultural, and metal ore preparation roles also exist (Roe, 1967, p. 69; Bradley, 1978, p. 13). Yet, prior to the author's PhD research (Roy, 2019, 2020), an accurate scientific assessment of use of both battle-axes and axe-hammers in northern Britain and the Isle of Man had not occurred (Roe, 1966, 1968, 1979; Fenton, 1984, 1988).

This article uses the results of experiments conducted using replica battle-axes, as part of the authors PhD research, to demonstrate the importance of analysing use-wear throughout experiments, rather than only at the end of the experiment. It presents the discovery of a new use-wear formation, the 'three-group-arrangement', which forms in the early stages of use of a bladed stone tool in contact with wood using chopping motions. This discovery significantly enhances the understanding of use-wear development on bladed, ground and polished stone which have received less attention than grinding stones and flaked stone (Adams, 1993, 2003, 2010, 2014; Wright, 1992; Dubreuil, 2004; Hamon, 2008; Adams et al., 2009).

Method

Today, experimental archaeology is a common and fundamental method used by archaeologists to test their hypotheses and understand processes in the life history of artefacts (Dolfini and Collins, 2018, p.36; Mathieu & Meyer, 2002). These include the effectiveness of tools and objects at performing specific tasks, the manufacture of materials and artefacts, and processes of construction and farming. The labour investment, organisational requirement and social implications behind a labour force can also be better understood experimentally (Comendador et al., 2018; Martinón-Torres, 2002; Carrell, 1992, pp. 4-5).

Six experiments used replica stone battle-axes and axe-hammers to assess the formation of wear on ground and polished bladed stone implements and their effectiveness during use. Never had the uses of British battle-axes and axe-hammers been tested scientifically. The experiments aimed to establish the effectiveness of these implements and to understand if their form follows their presumed non-functionality (Saville & Roe, 1984, p. 20). A further aim was to understand the development of use-wear during use, which was then compared with the battle-axes and axe-hammers in the archaeological record to further understand their possible uses (see Roy, 2019, 2020 for more information on use-wear analysis results).

This paper will focus on the two experiments conducted using replica battle-axes, both in contact with wood – splitting logs into smaller pieces ideal for firewood and felling tree branches – to demonstrate the benefits of analysing use-wear formation throughout experiments. The use and effectiveness of British battle-axes and axe-hammers have not previously been assessed experimentally or by using use-wear analysis. However, non-perforated bladed stone implements, such as Neolithic stone axes and adzes, have been tested numerously over the past 100 years. More recently, Mathieu and Meyer demonstrated that wood type affected the time it took for stone axes to fell trees, with hardwoods taking longer than softwoods (Mathieu & Meyer, 1997, 2002). The use of a replica Neolithic stone adze to fell an oak tree, 42 cm in diameter, by cutting notches around the trunk (Elburg et al., 2015) concluded that it was feasible to use this type of stone implement to fell hardwood trees with large diameters successfully. The recent Huize Horsterwold and Vlaardingen Neolithic house experiments by Leiden University used Neolithic polished stone axes to chop

tree branches for the construction of a Neolithic longhouse attributed to the Vlaardingen Culture. They found that stone axes were effective and fast tools when used to chop trees, although implements of other material were also effective, such as bone and antler axes and adzes (Wijnen et al., 2018; Van Gijn & Pomstra, 2016). Moreover, microwear analysis of stone axes from across the globe has suggested that many of these implements were used as tree chopping (Mills, 1993; Yerkes et al., 2003; Yerkes and Berkai, 2013; Masclans Latorre et al., 2017) and earth working tools (Macdonald et al., 2019).

The project applied the established and combined method of experimental archaeology and use-wear analysis, commonly used to understand tool function (Keeley, 1980; Van Gijn, 1989; Adams, 1993, 2010, 2014; Lemorini and Nunziante Cesaro, 2012; Marreiros et al 2015). The experiments aimed to assess the development of wear throughout use to better understand the use-wear marks analysed on those implements in the archaeological record. Pauses were taken at specific points (table 1) throughout the experiments to analyse the use-wear at different stages during use. The replicas were analysed in the field under low magnifications using a stereomicroscope and casts of the blade tip and edges were also taken using cellulose acetate (Roy, 2019, 2020) for analysis under high magnifications with a metallographic microscope in the Wolfson Laboratory, Newcastle University. The combination of low and high-power approaches allows for a broader range of use-wear to be analysed and therefore the accuracy of the interpretation is increased (Dubreuil et al., 2015, p. 124). The use-wear was later compared with the use-wear analysed on the battle-axes and axe-hammers in the archaeological record to aid the interpretation of their use.

Pauses taken during experimental tests	
Analysis Stages	Strokes/hits of the implement
1	50
2	100
3	200
4	500
5	1000
6	1500
7	2000

TABLE 1: A TABLE TO SHOW THE PAUSES TAKEN DURING THE EXPERIMENTS

Faithful replicas of battle-axes and axe-hammers were made using dolerite from Poortown Quarry, Isle of Man. They were made by David Horan using modern tools: an angle grinder with a cutting disc was used to cut the stone into shape; a combination of a grinder with sanding discs of various grades and a Dremel, a rotary grinding tool, was used to finish the surface; and the perforation was drilled using a pillar drill with a hole corer. This choice was made due to resource and time constraints. The experiments were not affected by this choice

as the stone was not weakened by the power tools used, and the replicas were analysed microscopically before each experiment to understand the production wear caused by this manufacturing process. The hafts of the replicas were based on examples of axe-hammer and battle-axes found with their hafts remaining; the battle-axe haft was 700mm in length, and the axe-hammer haft was 760mm in length (Harding and Young, 1979). The wood used for the hafts and the experiments represented trees species present in EBA northern Britain (Dumayne-Peaty, 1999, p. 124; Dark, 2005, p. 608). The experiments used pine (felling tree branches) and birch (splitting wood for firewood) to manufacture the replica hafts. Due to the limited accessibility to wood, haft wood type could not be homogenous. Mathieu and Meyer (1997, 2002) found that the performance of stone axes was different on different tree types, therefore, the effectiveness of each experiment was assessed to understand if this variable affected the experiment. It is not within the scope of this paper to discuss the methods of the experiments further, all of which are discussed in Roy 2019; n. d. and Roy, 2020.

Experiment: Felling tree branches

HOW TO CHOP BRANCHES WITH A STONE BATTLE AXE (AMBER ROY)

Four branches of a pine tree were felled during this experiment. Due to accessibility issues, a tree could not be sourced to fell in its entirety; however, the same horizontal chopping motions were used to fell branches, 300-400 mm in diameter (See Figure 3). Battle-axe replica 2 (See Figure 4), type 2 of Roe's typology (1966) with a slightly expanded straight blade (See Figure 5), was used for this experiment. The axe was hafted onto a pine haft, 700mm in length, made from a fresh branch of an appropriate slightly curved shape. Horizontal chopping motions were used to chop through branches to remove them from the tree. The branches were just below shoulder height and therefore were easily accessible.

Experiment: Splitting wood

HOW TO SPLIT WOOD WITH A STONE BATTLE AXE (AMBER ROY)

This experiment used battle-axe replica 1 (See Figure 6), type 1 of Roe's typology (1966), to split logs of semi-dried birch into smaller pieces ideal for use as firewood. The logs were cut into 300mm lengths using a modern saw before they were split with a vertical chopping action into four to six pieces, dependant on the diameter of the log (See Figure 7). The diameters ranged between 100 and 250mm. The semi-dried wood, which had been stored outside and uncovered for two months, was used for this experiment due to the difficulties in sourcing a large quantity of fresh wood of the same species.

Results

Despite the past interpretations that British battle-axes and axe-hammers were non-functional, the experiments determined that battle-axes and axe-hammers can be used effectively without breakage; they remained effective throughout the experiments. The experiments also determined that the effectiveness will be increased if the axehead is hafted correctly and that the efficiency did not differ between chopping pine and birch. Shaping the top of the haft to the same diameter of the perforation and gently forcing the axe onto it followed by soaking the haft in water in between use, ideally overnight, created the maximum possible pressure to hold the axehead in place, an effect known as hysteresis of wood (Foliente 1995). Doing this meant that the axehead did not spin on the haft during use. For a more detailed discussion of the findings of the experiments and use-wear analysis, see Roy, 2019; n. d.

Use-wear development throughout use

The analysis of use-wear development throughout experiments provides essential information about how use-wear attributes change, thus providing more comparative data for the interpretation of use-wear on archaeological objects. For example, the ongoing Huize Hosterwold house experiment carefully documents the house construction, including the development of wear (Project Horsterwold, 2020). The experiment demonstrated the effectiveness of using stone axes and adzes for wood chopping trees and wood (Wijnen et al., 2018); however, the project's current focus on its research questions means the wear attributes and its development have not been published.

While there have been experiments using replica stone axes to chop wood (Wijnen et al., 2018; Mathieu & Meyer, 2002, 1997), before this project, the use of British perforated ground stone implements had not been tested in this way. Moreover, the wear development through use had not been documented on this implement type; therefore, the results of the experiments provide new data for use-wear formation overtime on perforated bladed stone implements. The benefits of this data were demonstrated during the author's doctoral research when the experimental use-wear was compared with the wear analysed on battle-axes and axe-hammers from the archaeological record. These implements were deposited at various stages of use (Roy, 2020, n. d) which meant that they had differing degrees of wear development. By analysing use-wear development throughout the experiments, an understanding of how long it took for different degrees of wear to develop was possible and knowledge of the processes which led to these use-wear patterns considerably aided the interpretation of the use of the archaeological axeheads.

Several of the battle-axes and axe-hammers from the archaeological record had less developed wear; that is, wear that is sparse in density and quantity. Analysis of these examples under a metallographic microscope revealed that these implements had been in contact with wood during their use, as indicated by the wood polish on their blades. However, the sparse nature of the use-wear meant that interpretations of the motions of these implements during use were uncertain, as such, the specific uses were also unknown. The experimentally tested tools used in contact with wood provided much-needed data to interpret less developed wear on bladed implements in contact with wood; analysis of the use-wear during the early stages of the experiments revealed that wear developed in a specific pattern. This pattern matched those examples in the archaeological record with less developed wear, four axe-hammers and six battle-axes (axe-hammers - NMS AH 16: Leith, Edinburgh; NMS AH 249: Ballavullin; ShM J.93.3: Sherburn; Carlisle 2015.76.7 EF3667: Woodend / battle-axes - NMS EP 57: Nith Lodge; NMS EP 2: Broomend of Crichie; NMS AH 93: Cobbinshaw Lock; BM Sturge 471: Holystone; NMS AH 221: Balnagown; Yks Mus 1090.1948: Cawthorn, Stackyard).

This specific use-wear pattern has been named the 'three-group-arrangement'. The arrangement consists of a pattern of three groups of pits on the blade tip, in the centre of the

blade and one towards each corner bifacially. Figure 8 demonstrates this use-wear arrangement, the black lines indicate the striations on the blade edges, these are bifacial on both blade edges, and the white dots represent the grain removal pits on the blade tip, associated with the striations. The pits are sparse in quantity and density and have equally sparse associated striations, numbering two to four in each striation group, on the bifacial blade edges. This use-wear pattern developed between 50 and 200 strikes and was visible on both battle-axe replicas used during both experiments in contact with wood using chopping motions; felling tree branches used a horizontal chopping motion and splitting wood for firewood used a vertical motion. For instance, Figure 10a shows two groups of use-wear on the blade tip and edge, in the centre and towards one corner. The black circles show the sparse pits and associated striations, the white oval shows use-wear caused by the manufacture of the replica. Figure 10b displays small patches of superficial grain removal pits in the centre of the tip with a small patch of shallow striations running from them, see black circle and lines. This occurs bifacially and in two other groups towards the blade corners, the white oval shows striations caused by manufacture. Figure 10c shows a central group of superficial edge damage, pits on the blade tip with a small number of associated striations on the blade edge, these are bifacial, see black circle; see white circle for manufacture wear. Contact with pine and birch wood both caused the wear pattern which indicates that this pattern forms when a blade is used to chop wood between 420 and 1260 lbf hardness; pine (420-550 lbf) is softer than birch (1260 lbf) on the Janka hardness scale. The Janka hardness scale rates the wood hardness based on the resistant measures of a sample of wood to denting and wear, the softest being 22 lbf and the hardest 5,060 lbf. Continued use past 500 strikes increased the density and quantity of the use-wear, creating more numerous groups of pits and striations and eventually filling the gaps on the blade tip and edge so that there is a continuous spread of use-wear.

This use-wear pattern was analysed on four axe-hammers and six battle-axes in the archaeological record. For example, Figure 9a shows limited, undeveloped wear on a battle-axe from Seghill, BM Sturge 470; sparse pits in a group on the blade tip towards one corner with associated bifacial striations, 2-3 in number, see circle and lines. The use-wear has developed in three groups on the blade edge and tip. Figure 9b displays a central group of close grain removal pits with associated striations running from them on a battle-axe from Portpatrick, NMS AH 45. The pits are limited to the blade tip. Similar groups of use-wear are located towards each corner of the blade, bifacially. Previously, only the contact material of these implements was known, and no further information could be obtained to assess their past uses due to lack of analogies, which severely limited the interpretations of their past functions. The discovery of the ‘three-group-arrangement’ found on these examples enabled the interpretation of the motion used, a chopping motion, and that, due to their comparability with the replicas, they may have been used to split wood or fell trees. This discovery enhances the wear analyst’s ability to interpret of the use of bladed ground and polished stone implements.

Moreover, analysis of use-wear development also aided the interpretation of battle-axes and axe-hammers in the archaeological record that were used for longer periods and had moderate and well-developed wear. The experiments involving felling tree branches and splitting logs revealed that by 1000 strikes the use-wear became moderately developed. This moderately developed wear was comparable to eleven battle-axes and ten axe-hammers in the archaeological record. At 1000 strikes, the use-wear visible on the replicas used to split wood and fell tree branches were remarkably similar and therefore a distinction between the two wear patterns analysed in the archaeological record was difficult. This is because both experiments used a chopping motion. The use-wear on the replicas used for both experiments was significantly more developed than the use-wear analysed at 500 strikes. The groups of pits and associated striations no longer existed as separate patches since the gaps between them were filled with pits and striations with similar density and quantity characteristics. The increased quantity of pits on the blade tip caused some pits to join to form larger, wider pits and larger areas of edge damage than previously analysed. These denser patches of pits on the blade tip caused shallow dips that were macroscopically visible on the blade tip. At this stage, the striations were also greater in number, seeming to seamlessly spread along the blade edges with a close density. Some striations developed within the larger pits. They were short, u-shaped in profile and were arranged parallel to one another and perpendicular to the blade edge. The corners of the blade had begun to round at 500 strikes, this increased at 1000 strikes to cover a greater area of the blade corners.

The experiments revealed that use at 2000 strikes (the maximum strikes of each experiment) increased the density of the use-wear patterns that were analysed at 1000 and 1500 strikes. The grain removal pits became denser and more numerous, extending across the tip and the blade edges bifacially and extending further onto the blade edges, 10 – 20mm. The pits became larger and their increased density created a rougher, abraded stone surface on the blade edges. Fractures, flake removals and edge damage such as micro fractured stone grains were also more likely to occur. Due to time limits, the experiments ended at 2000 strikes but the development of use-wear throughout the experiments indicated that continued, extensive use would develop the density and quantity of use-wear on the blade tips and edges, thus increasing the abrasion on the stone surface and the chances of fractures and edge damage. Comparable use-wear at 2000 strikes was visible on battle-axes and axe-hammers in the archaeological record with moderate-well developed wear, five battle-axes and five axe-hammers (battle-axes - NMS EQ 322: Hagg Wood, Foulden; Yks Mus 1090.1948: Cawthorn, Stackyard; NMS AH 44: Mugdrum Island; NMS AH 108: Longniddry; ShM J.93.10: nr Scarborough / axe-hammers - Carlisle 118.1977.2: no provenance; Carlisle A 11 210: Grinsdale; Carlisle R.41: Aspatria; Stranraer 2002.15: Blairbuy; Yks Mus 1036.1948: Hutton Cranswick). As is evident in Figure 11, these implements had dense striations covering both blade edges. They are u-shaped in profile, 10mm long and in a parallel arrangement, running perpendicular to the blade edge. Associated superficial grain removal pits interrupt the striations and surround them. Denser groups of pits containing micro fractured stone grains

are present along the blade tips, with the larger denser groups in the centre and towards the edges of the blade. Increased use resulted in the presence of flake negatives and fractures, occurring most frequently in the centre and towards the corners of the blades. Rounded stone grains along blade tip, at corners and the edges of the pits of the blade tip and the high topography and edges of the flake negatives.

Three battle-axes and eight axe-hammers from the archaeological record (battle-axe - Carlisle 41.1932: Stanger Farm, Embleton; NMS EQ 916: Barns Farm; Newcastle 1904.6: Newcastle, Barras Bridge / axe-hammers - NMS AH 14: Preston, Colmonell; NMS AH 147: Colmonell; Manchester 25939: Chelford; Carlisle 119.1961: Brougham; Carlisle 83.1962: Gilgarran; Carlisle R.1: nr Wigton; Stranraer 1945.01: Culmore; Yks Mus 1037.1948: Strensall) that were used with chopping motions in contact with wood had well-developed wear indicating extensive use beyond the use length of the experiments.

The similarities in experimental use-wear development, less, moderate and well-developed, with archaeological battle-axes and axe-hammers significantly enhanced the accuracy of their interpretation. Knowledge of use-wear development also gave information about use through time. Certainly, the variation in the amount of use on implements in the archaeological record would not be fully appreciated or understood if the analysis of use-wear only occurred at the end of experiments. This would only reveal data for the artefacts used for the same amount of time as the length of the experiment, but not all were used for the same length of time.

Conclusion

The paper demonstrates the significant breakthroughs – the three-group arrangement – that can be achieved when applying experimental and use-wear methods to increase the accuracy of our research. By assessing the development of wear throughout experiments, more comparable data is made available to interpret wear on artefacts in the archaeological record. After all, these artefacts were not all used for the same amount of time, or in the same way. Analysis of northern British EBA battle-axes and axe-hammers revealed that they were used for varying amounts of time, therefore the wear patterns were highly variable. Could these variable wear patterns suggest that these artefacts were polyfunctional tools? The overall findings of the project (see Roy, 2020, n. d.) revealed that the assemblage of battle-axes and axe-hammers analysed were used in contact with wood, bone and earth and roots as well as having episodes of re-use and multiple uses. This paper demonstrates that an assessment of wear through experiments increases the information about these varying wear patterns and enhances the accuracy of the interpretation of artefacts in the archaeological record.

Through analysis of wear throughout experiments, a new wear pattern was discovered: the ‘three-group-arrangement’, a wear pattern which develops in the early stages, 50 to 200 strikes, of use of ground and polished bladed stone tools. The experiments suggest that chopping wood or felling trees using chopping motions cause this wear pattern. Previously,

understandings of wear formation throughout use on blade stone implements was minimal, which severely limited the interpretation of those with less developed wear. This paper has demonstrated the comparability of this wear formation with implements in the archaeological record, which allowed the use of several EBA battle-axes and axe-hammers to be determined. This was not previously possible due to the lack of analogous data and limited understanding of wear formations in the early stages of use on bladed tools. Therefore, the potential that the discovery of the 'three-group-arrangement' has to aid wear analysis on ground stone bladed artefacts is considerable. It also demonstrates the importance of analysing the development of wear throughout experiments rather than just at the end. Overall, the finding significantly adds to the knowledge of wear formation on ground and polished bladed stone.

Keywords axe
stone working
use wear analysis

Country United Kingdom

Bibliography

Adams, J. L. 1993. Mechanisms of wear on ground stone surfaces. *Pacific Coast Archaeology Society Quarterly* 29, pp. 60-73.

Adams, J. L., 2003. *Ground Stone Tool Analysis; A Technological Approach*. Portland: University of Utah Press.

Adams, J. L., 2010. Understanding grinding technology through experimentation, In J. Ferguson, ed. *Designing Experimental Research in Archaeology: Examining Technology through Production and Use*. pp. 129-151.

Adams, J. L., 2014. Ground stone use- wear analysis: a review of terminology and experimental methods. *Journal of Archaeological Science* 48, pp. 12-138.

Adams, J.L., Delgado, J.S., Dubreuil, L., Hamon, C., Plisson, H., and Risch, R., 2009. Functional analysis of macro-lithic artefacts: a focus on working surfaces. In: F. Sternke, L. Costa, and L. Eigeland, eds. *Non-flint Raw Material Use in Prehistory. Old Prejudices and New Directions. Proceedings of the XV. Congress of the U.I.S.P.P.* pp. 43-66.

Bowden, M., 1991. *Pitt Rivers: The Life and Archaeological Work of Lieutenant-General Augustus Henry Lane Fox Pitt Rivers*. Cambridge: Cambridge University Press.

Bradley, R., 1978. *The Prehistoric Settlement of Britain*. Henley-on-Thames: Routledge & Kegan Paul.

Brumfield, E and Earle, T., 1987. *Specialization, Exchange, and Complex Societies*. Cambridge: Cambridge University Press.

Carrell, T., 1992. Replication and Experimental Archaeology, *Historical Archaeology* 26(4), pp. 4-13.

Comendador, B; Lackinger, A and Figueiredo, E., 2018. Learning to Recreate, Recreating to Learn. *EXARC Journal 2018-2* [online] Available from: < https://exarc.net/issue-2018-2/ea/learning-recreate-recreating-learn-ex... > [Accessed 11 August 2020]

Dark, P., 2005. Mid- to late-Holocene vegetational and land-use change in the Hadrian's Wall region: a radiocarbon-dated pollen sequence from Crag Lough, Northumberland, England. *Journal of Archaeological Science* 32(4), pp. 601-618.

Dolfini, A., and Collins, R., 2018. Modelling Physical and Digital Replication: Bridging the Gap Between Experimentation and Experience. *Open Archaeology* 4, pp. 36-49.

Dubreuil, L., 2004. Long-term trends in Natufian subsistence: a use-wear analysis of ground stone tools. *Journal of Archaeological Science* 31(6), pp. 1613-1629.

Dubreuil, L., Savage, D., Delgado-Raack, S., Plisson, H., Stephenson, B., and de la Torre, I., 2015. Current analytical frameworks for studies of use-wear on ground stone tools, In J. M. Marreiros, J. F. Gibaja Bao, and N. F. Bicho, eds. *Use-wear and Residue Analysis in Archaeology*. Cham: Springer International Publishing. pp. 105-158.

Dumayne-Peaty, L., and Barber, K. E., 1999. Late Holocene vegetational history, human impact and pollen representativity variations in northern Cumbria, England. *Journal of Quaternary Science* 13, pp. 147-164.

Elburg R., Hein, W., Probst, A., and Walter, P., 2015. Field Trials in Neolithic Woodworking: (Re)Learning to use Early Neolithic stone adzes. In. R. Kelm, ed. *Archaeology and Crafts: Experiences and Experiments on traditional Skills and Handicrafts in Archaeological Open-Air Museums in Europe.* Husum: Husum Druck- und Verlagsgesellschaft. pp. 62-77

Evans, J., 1897. *Ancient Stone Implements, Weapons and Ornaments of Great Britain.* 2nd ed. London: Longmans, Green and Co.

Fenton, M.B., 1984. The nature of the source and the manufacture of Scottish battle-axes and axe-hammers. *Proceedings of the Prehistoric Society* 50, pp. 217-243.

Fenton, M.B., 1988. The petrological identification of stone battle-axes and axe-hammers from Scotland. In T.H. Mck Clough and W.A. Cummins, eds. *Stone Axe Studies vol. II: The*

Petrology of Prehistoric Stone Implements from the British Isles. London: Council for British Archaeology. pp. 92-132.

Foliente, G., 1995. Hysteresis Modeling of Wood Joints and Structural Systems. *Journal of Structural Engineering* 121(6), pp. 1013-1022.

Gijn, A. L. van., 1989. The Wear and Tear of Flint. Principles of Functional Analysis Applied to Dutch Neolithic Assemblages. *Analecta Praehistorica Leidensia* 22. Leiden: University of Leiden (1990, PhD Thesis: Leiden University)

Gijn A.L. van., and Pomstra D., 2016. "Huize Horsterwold" The reconstruction of a Neolithic house plan using Stone Age equipment, In. L. Hurcombe & P. Cunningham, eds. *The life cycle of structures in experimental archaeology an object biography approach*. Leiden: Sidestone Press. pp. 177-186.

Greenwell, W. and Rolleston, G., 1877. *British barrows: a record of the examination of sepulchral mounds in various parts of England*. Oxford. Clarendon Press.

Harding, A., and Young, R., 1979. Reconstruction of Hafting Methods and Function of Stone Implements. In: T.H. Mck Clough and W.A. Cummins, eds. *Stone Axe Studies*. Council for British Archaeology Research Report 23, pp. 102-105.

Hamon, C., 2008. Functional analysis of stone grinding and polishing tools from the earliest Neolithic of north-western Europe. *Journal of Archaeological Science* 35(6), pp. 1502-1520.

Keeley, L., 1980. *Experimental Determination of Stone Tool Uses: Microwear Analysis*. University of Chicago Press: Chicago.

Leahy, K., 1986. A Dated Stone Axe-hammer from Cleethorpes, South Humberside. *Proceedings of the Prehistoric Society* 52, pp. 143-152.

Lekberg, P., 2002. *Lives of Axes, Landscapes of People: A Study of Landscape and Society in the Late Neolithic of Central Sweden* (English). Uppsale: Institutionen för arkeologi och antik historia.

Lemorini, C. N. and Nunziante Cesaro, S., 2014. *An integration of the use-wear and residue analysis for the identification of the function of archaeological stone tools : proceedings of the international workshop, Rome, March 5th-7th, 2012.* Oxford, BAR publishing.

Macdonald, D. A., Xie, L., and Gallo, T., 2019. Here's the dirt: First applications of confocal microscopy for quantifying microwear on experimental ground stone earth working tools. *Journal of Archaeological Science: Reports* 26, pp. 1-10.

Masclans Latorre, A., Palomo Pérez, A., Gibaja-Bao. J. F., Remolins Zamora. G., and Gómez-Gras, D., 2017. Use-wear analysis of Neolithic polished axes and adzes: The site of "Bobila Madurell-Can Gambús-1-2" (Northeast Iberian Peninsula). *Quaternary International* 427, pp. 158-174.

Mathieu, J. R. and Meyer, D. A., 1997. Comparing Axe Heads of Stone, Bronze, and Steel: Studies in Experimental Archaeology. *Journal of Field Archaeology* 24(3), pp.333-351.

Mathieu, J. R. and Meyer, D. A., 2002. Reconceptualizing experimental archaeology: Assessing the process of experimentation. In J. R. Mathieu, ed. *Experimental Archaeology: Replicating past objects, behaviors, and processes*. Oxford: Archaeopress. 73-82.

Marreiros J, Gibaja Bao JF, Bicho N., 2015. *Use-Wear and Residue Analysis in Archaeology*. Manuals in Archaeological Method, Theory and Technique 10. Cham: Springer International Publishing.

Martinón-Torres, M., 2002. Chaîne opératoire: the concept and its applications within the study of technology. *Gallaecia* 21, pp. 29-43.

Mill, P. R., 1993. An axe to grind: a functional analysis of Anasazi stone axes from Sand Canyon Pueblo Ruin (5mt765), southwestern Colorado. *Kiva* 53(3), pp. 393-413.

Mortimer, J. R., 1905. *Forty years' researches in British and Saxon burial mounds of East Yorkshire*. London: A. Brown and Sons LTD.

Pegge, S., 1773. Observations on stone axe-hammers. *Archaeologia* 2, pp. 124-128.

Project Horsterwold, 2020. Project Horsterwold: Experimentele archeologie. [online] Available at: < https://experiment-horsterwold.nl > [Accessed 17 July 2020].

Roe, F., 1966. The battle-axe series in Britain. *Proceeding of the Prehistoric Society* 32, pp. 199-245.

Roe, F., 1967. The battle-axes, mace-heads and axe-hammers from south-west Scotland, *Transactions of the Dumfriesshire and Galloway Natural History Antiquaries Society* 44, pp. 57-80.

Roe, F., 1968. Stone mace-heads and the latest Neolithic cultures of the British Isles, In J.M. Coles and D.D.A. Simpson, eds. *Studies in Ancient Europe: Essays Presented to Stuart Piggott.* Leicester: Leicester University Press. pp. 145-172.

Roe, F., 1979. Typology of stone implements with shaftholes, in T. H. Mck Clough and W.A. Cummins, eds. *Stone Axe Studies: Archaeological, Petrological, Experimental and*

Ethnographic. London: Council for British Archaeology. pp, 23-48.

Roy, A.S., 2019. *The Use and Significance of Early Bronze Age Stone Battle-Axe and Axe-hammers*. Ph.D. thesis. Newcastle University.

Roy, A.S., 2020. The use and significance of Early Bronze Age perforated stone battle-axes and axe-hammers. *Proceedings of the Prehistoric Society.* pp, 1-24.

Roy, A.S. n.d. *The utilitarian use of ground and polished Early Bronze Age stone battle-axes and axe-hammers from Northern Britain and the Isle of Man: a use-wear and experimental approach.* [unpublished item].

Saville, A and Roe, F., 1984. A stone battle-axe from Wotton-under-Edge, and a review of battle-axe and mace-head finds from Gloucestershire. *Transactions of the Bristol and Gloucestershire Archaeological Society* 102, pp. 17-22.

Smith, R.A., 1926. The perforated axe-hammers of Britain. *The Antiquaries Journal* 75, pp. 77-108.

Tringham, R., Copper, G., Odell, G., Voytek, B., and Whitham, A., 1974. Experimentation in the formation of edge damage: a new approach to lithic analysis. *Journal of Field Archaeology* 1, pp. 171-196.

Wijnen J., Verbaas A., and Van Gijn A., 2018. 'Mimicking the Neolithic: long-term experiments with polished stone axes and adzes.' *Association of Archaeological Wear and Residue Analysts Conference*. Nice, 29-31/05/18. Viewed 29/05/18.

Wright, K., 1992. A classification system for ground stone tools from the Prehistoric Levant. *Paléorien*t 18(2), pp. 53-81.

Yerkes, R. W., Barkai, R., Gopher, A., and Bar Yosef, O., 2003. Microwear analysis of early Neolithic (PPNA) axes and bifacial tools from Netiv Hagdud in the Jordan Valley, Israel. *Journal of Archaeological Science* 30(8), pp. 1051-1066.

Yerkes, R. W., and Barkai, R., 2013. Tree-Felling, Woodworking, and Changing Perceptions of the Landscape during the Neolithic and Chalcolithic Periods in the Southern Levant. *Current Anthropology* 54(2), pp. 222-231.

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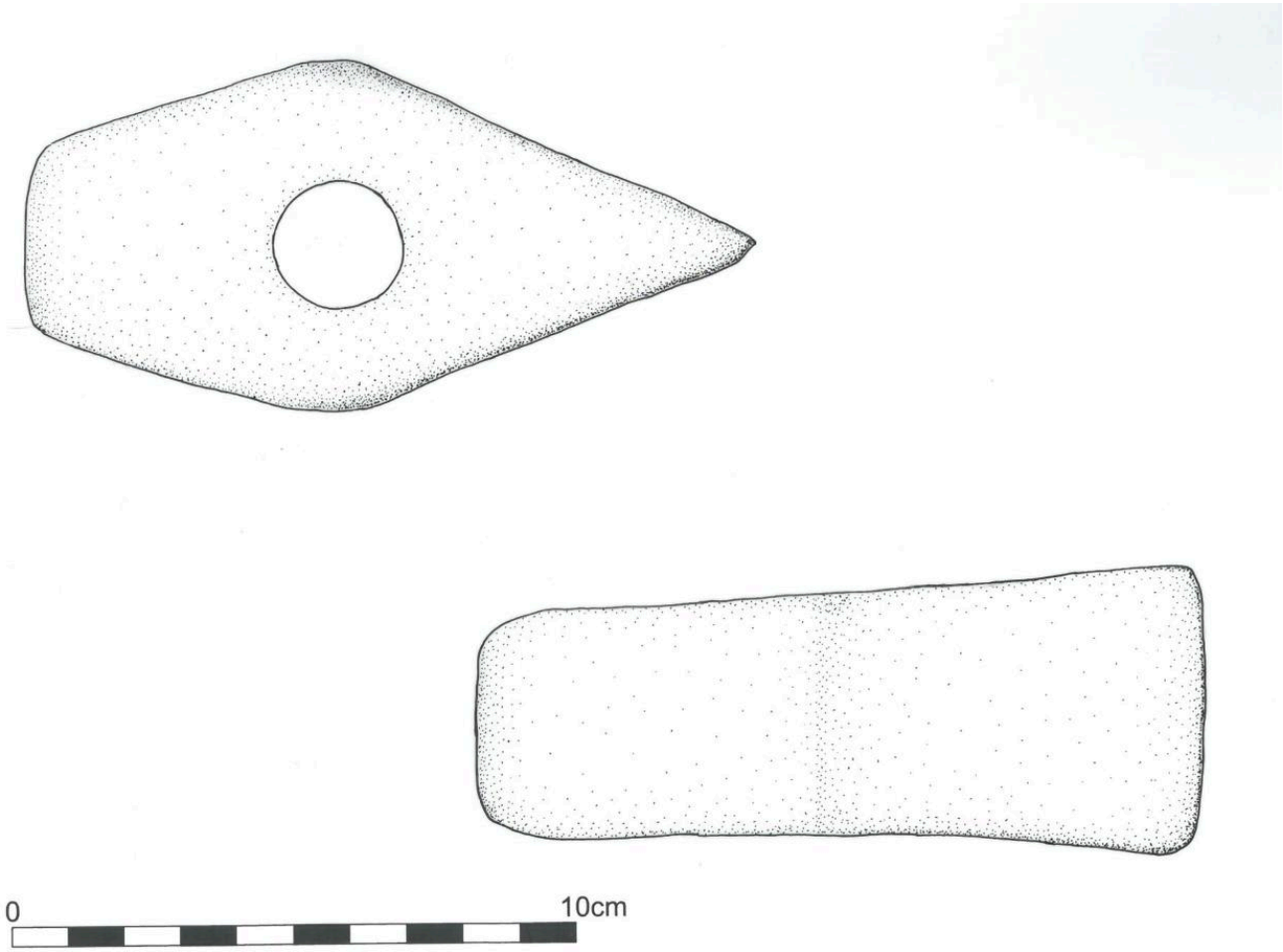

FIG 1. AN ILLUSTRATION OF A BATTLE-AXE, STAGE II. IMAGE BY AMBER ROY (FOR TYPOLOGY SEE: ROE, 1966, PP. 202-212)

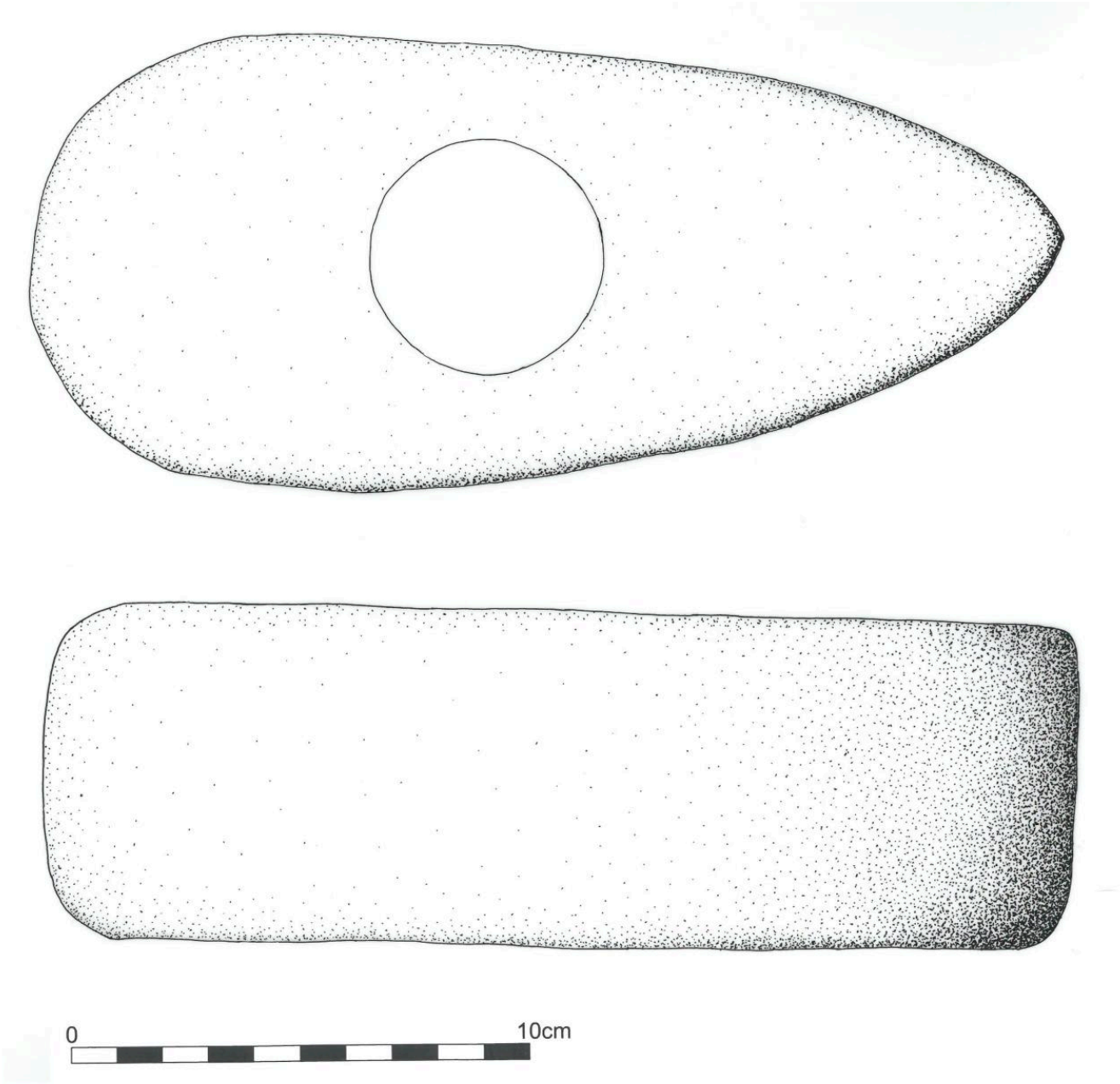

FIG 2. AN ILLUSTRATION OF AN AXE-HAMMER. IMAGE BY AMBER ROY

FIG 3. IMAGE OF THE EXPERIMENT CHOPPING PINE TREE BRANCHES WITH A REPLICA BATTLE-AXE. PHOTO BY AMBER ROY

FIG 4. AN IMAGE OF BATTLE-AXE REPLICA 2 USED TO FELL TREE BRANCHES. PHOTO BY AMBER ROY

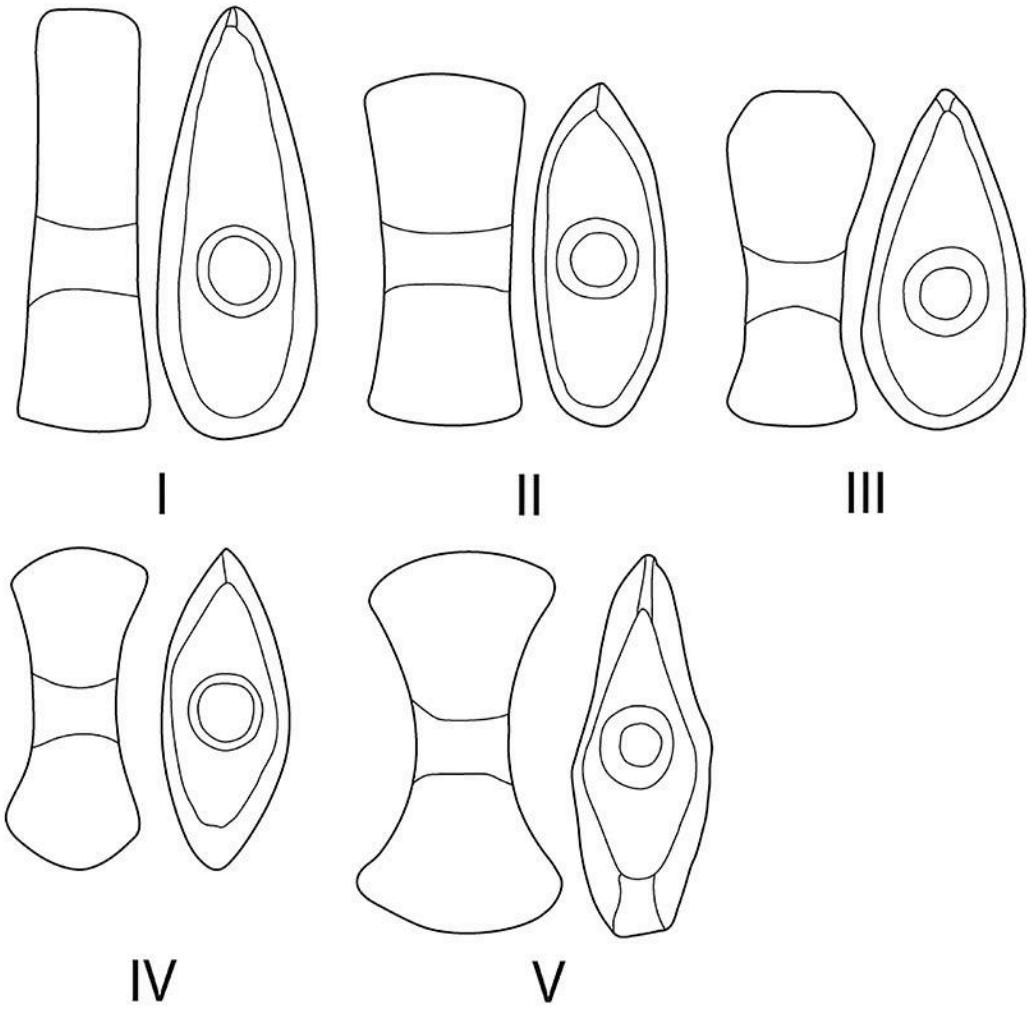

FIG 5. ROE'S 1966 TYPOLOGY OF BATTLE-AXES. IMAGE BY AMBER ROY, BASED ON ROE (1966, PP.202-212)

FIG 6. AN IMAGE OF BATTLE-AXE REPLICA 1 USED TO SPLIT WOOD. PHOTO BY AMBER ROY

FIG 7. AN IMAGE SHOWING A SPLIT LOG. PHOTO BY AMBER ROY

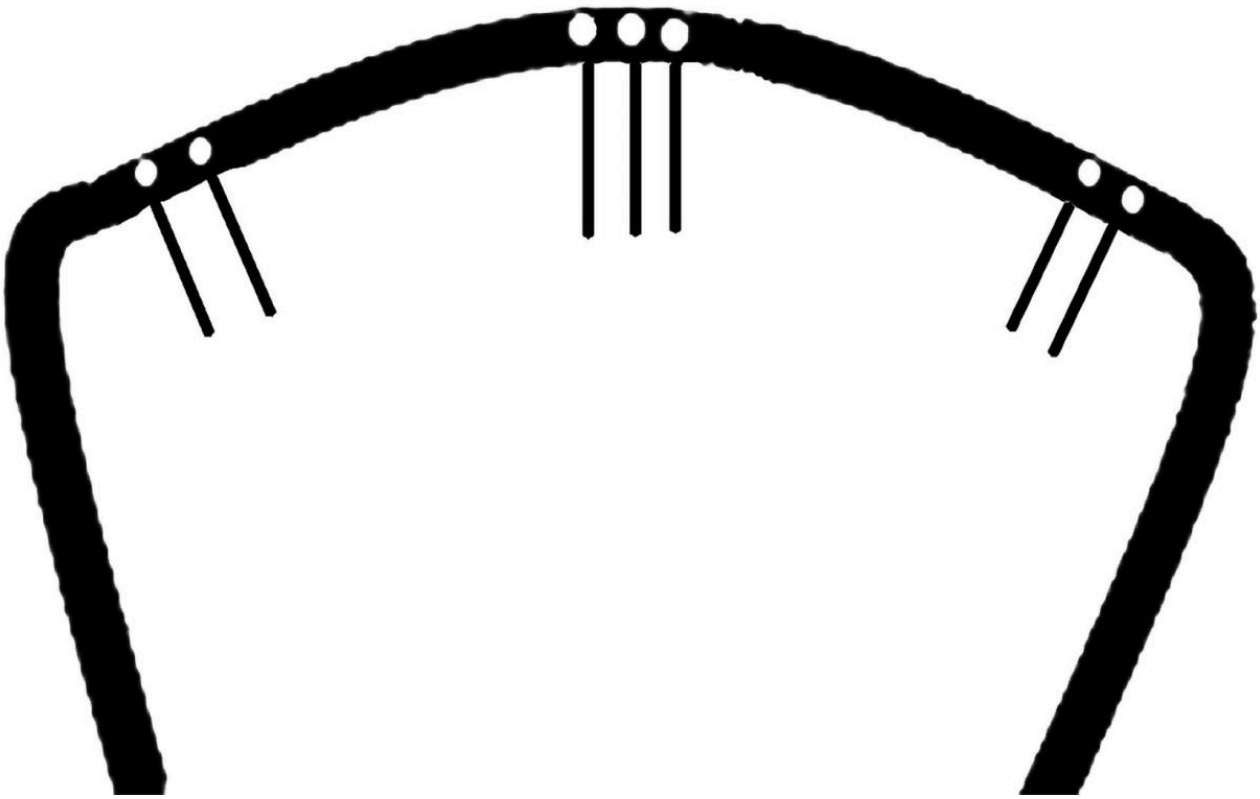

FIG 8. A DIAGRAM TO CLARIFY THE THREE-GROUP ARRANGEMENT. IMAGE BY AMBER ROY

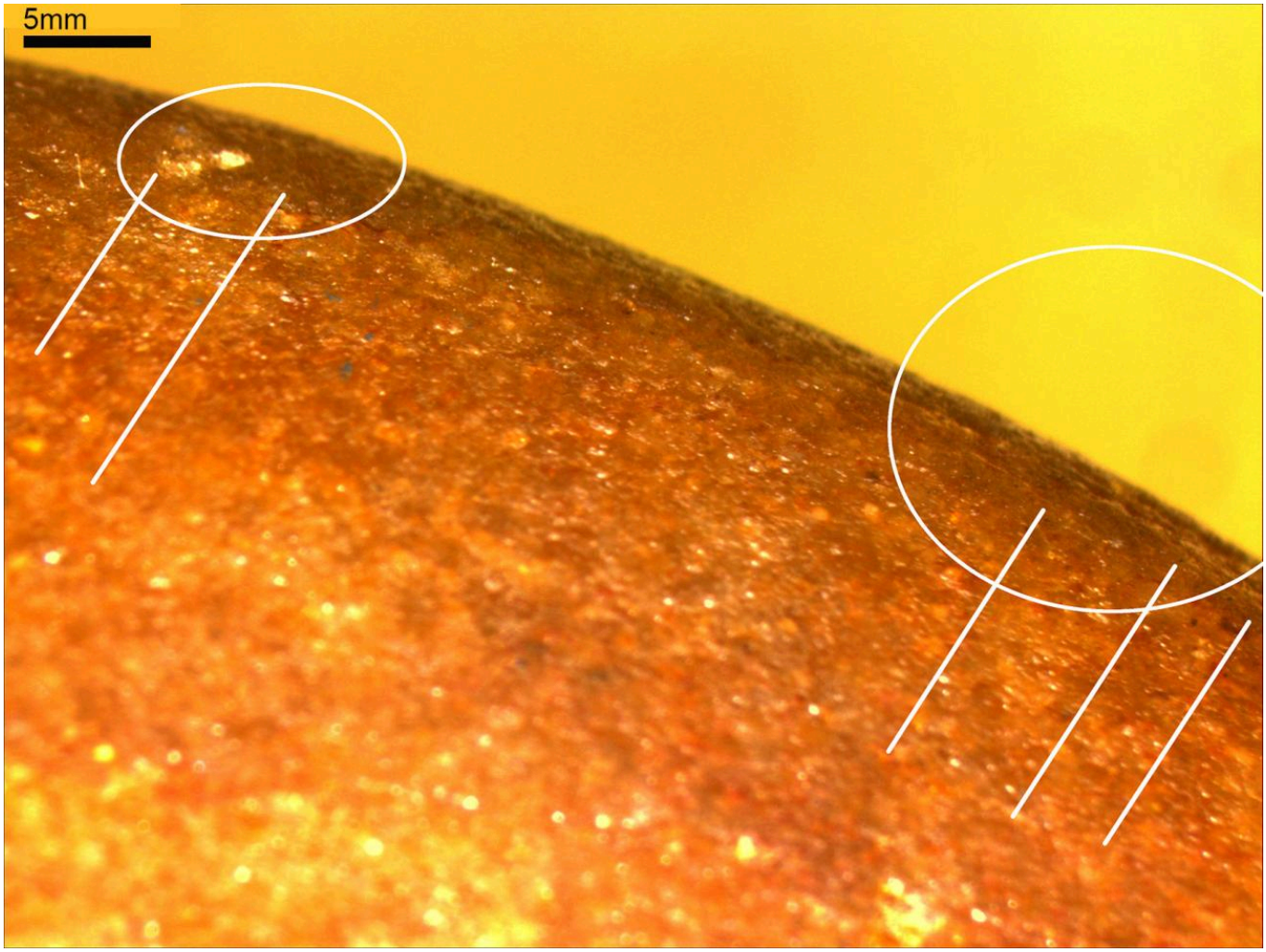

FIG 9A. EXAMPLES OF THE ‘THREE-GROUP-ARRANGEMENT’ ON ARCHAEOLOGICAL BATTLE-AXES. PHOTO BY AMBER ROY

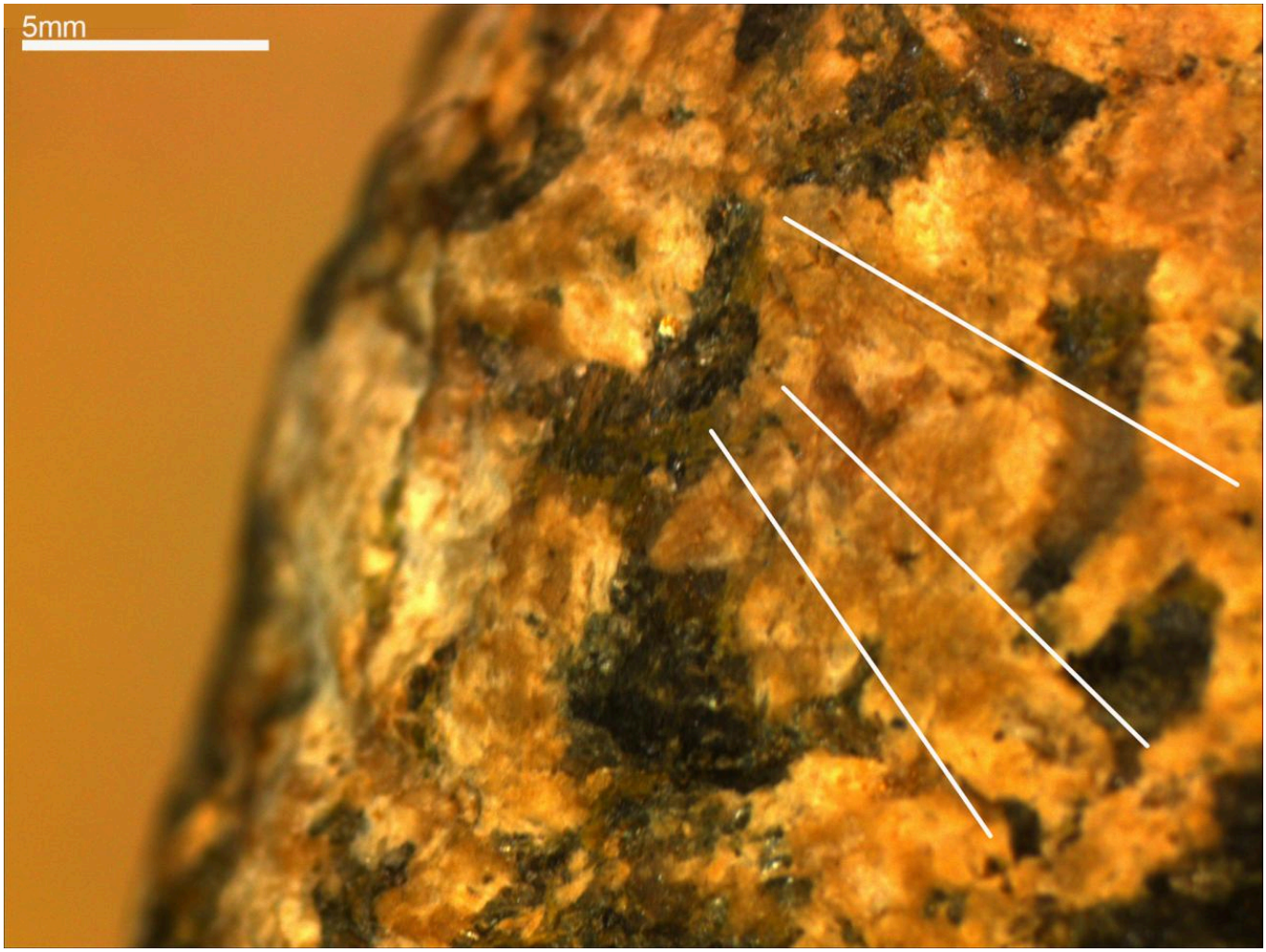

FIG 9B. EXAMPLES OF THE ‘THREE-GROUP-ARRANGEMENT’ ON ARCHAEOLOGICAL BATTLE-AXES. PHOTO BY AMBER ROY

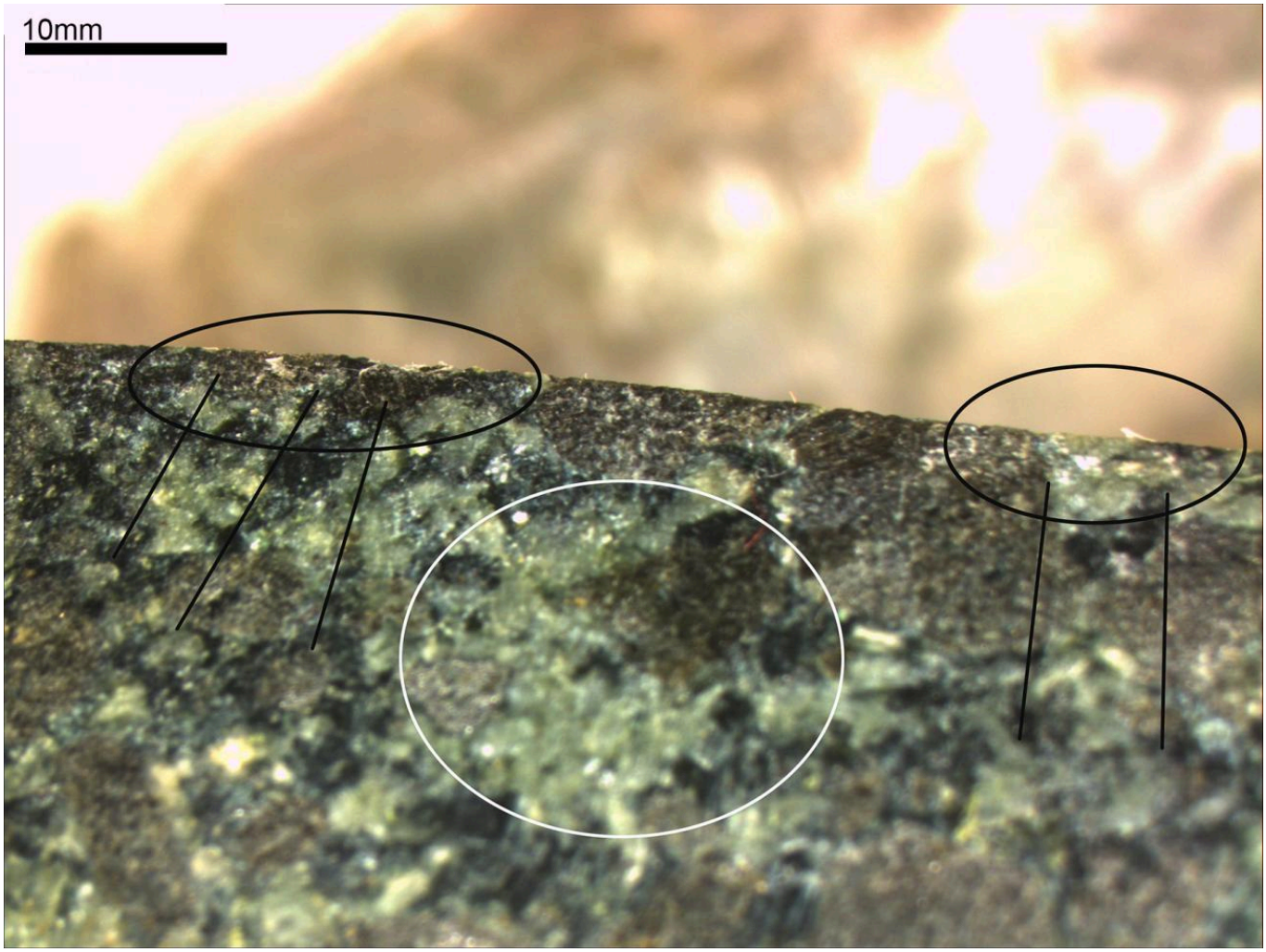

FIG 10A. MICROGRAPHS OF THREE-GROUP ARRANGEMENT ON EXPERIMENTAL REPLICAS. PHOTO BY AMBER ROY

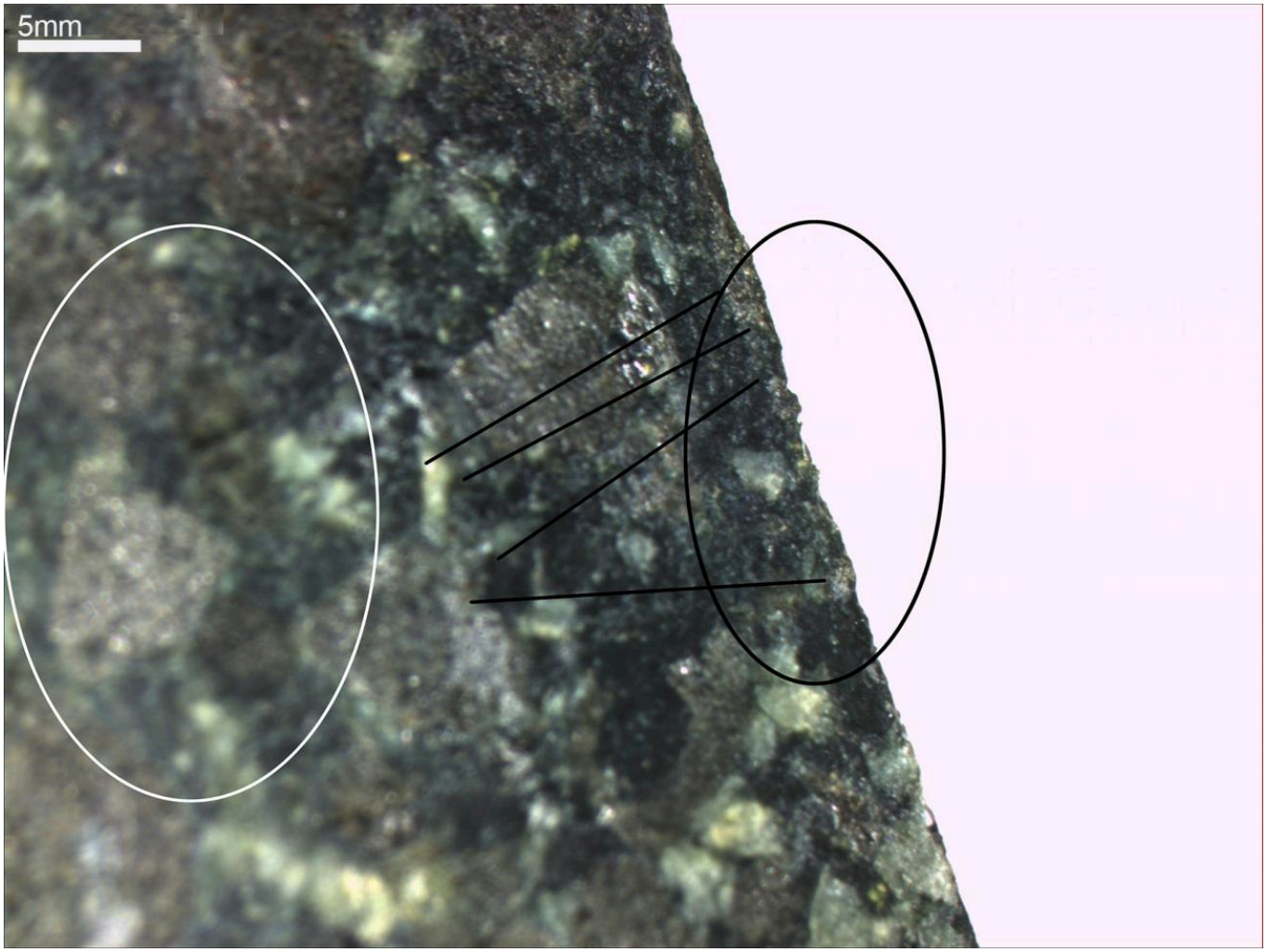

FIG 10B. MICROGRAPHS OF THREE-GROUP ARRANGEMENT ON EXPERIMENTAL REPLICAS. PHOTO BY AMBER ROY

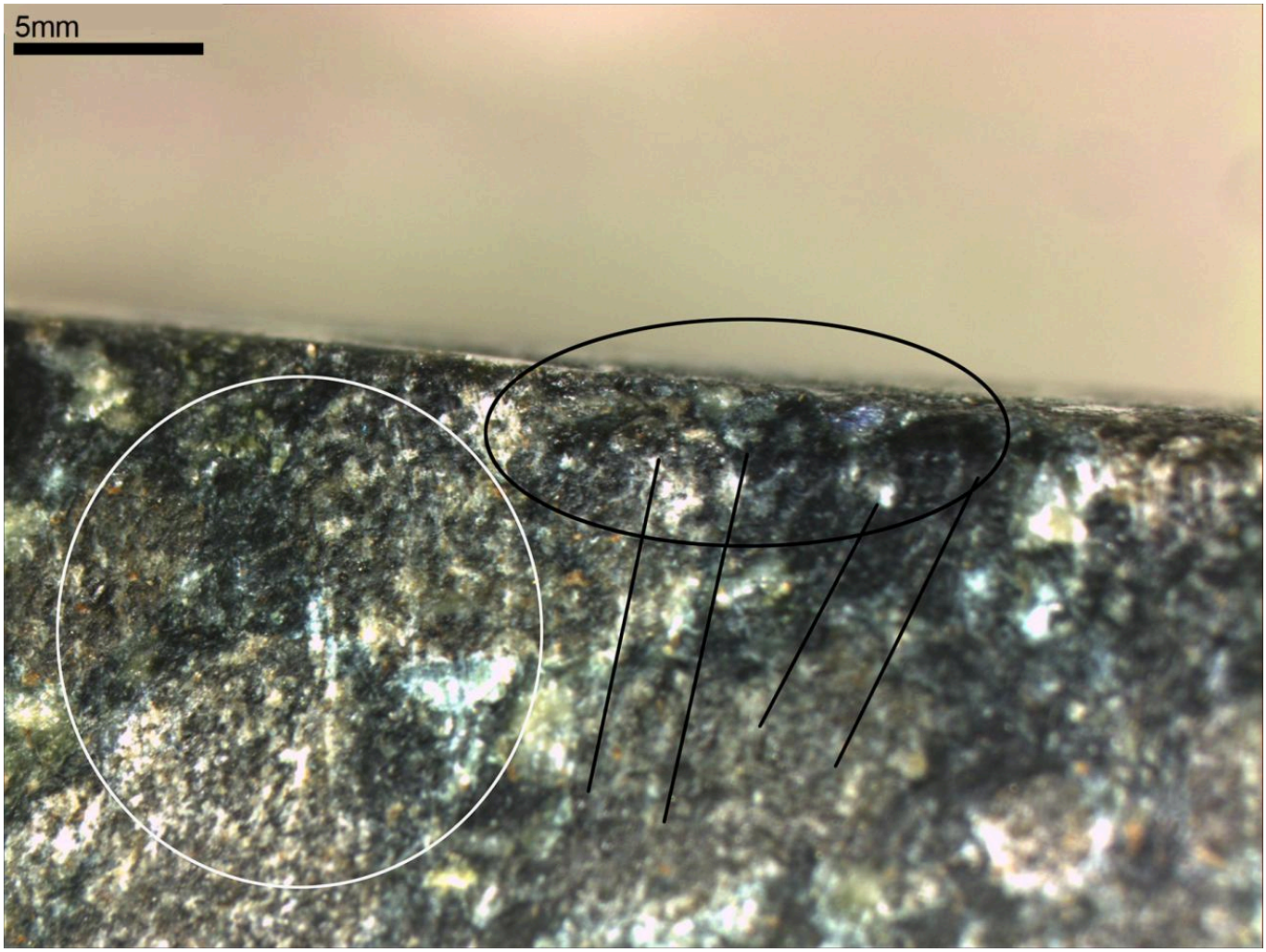

FIG 10C. MICROGRAPHS OF THREE-GROUP ARRANGEMENT ON EXPERIMENTAL REPLICAS. PHOTO BY AMBER ROY

FIG 11. A MICROGRAPH DEMONSTRATING THE USE-WEAR ON A BATTLE-AXE FROM THE ARCHAEOLOGICAL RECORD, NMS EQ 322 FROM HAGG WOOD, FOULDEN, WHICH IS COMPARABLE TO THE USE-WEAR ANALYSED ON THE REPLICA BATTLE-AXES USED TO CHOP AND SPLIT WOOD UP TO 2000 STRIKES (SEE FIG. 10). PHOTO BY AMBER ROY