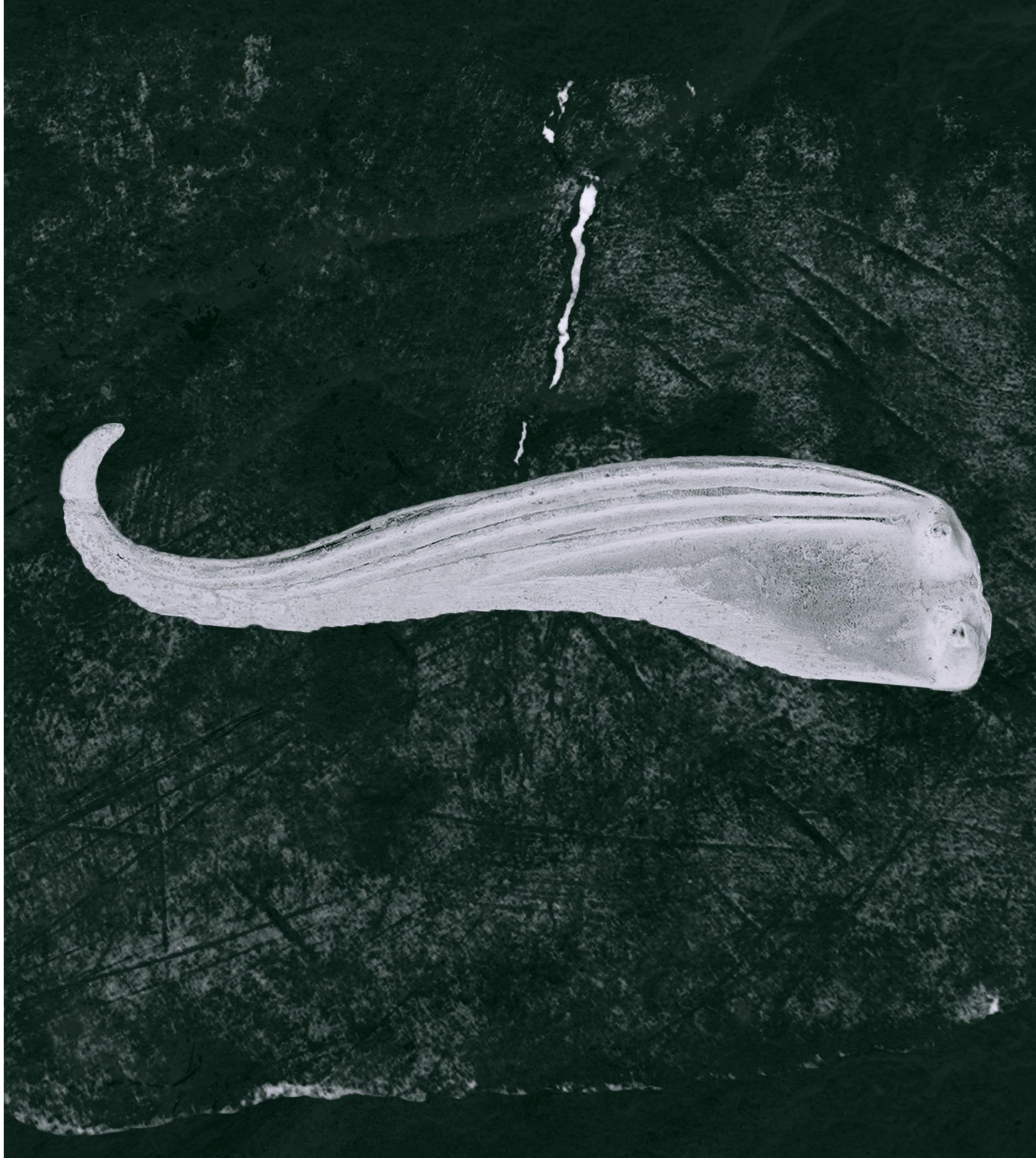
NOTCHES, SCRATCHES AND BREAKS.

Life and death of bronze age sickles in the Low Countries



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Photograph cover: sickle (WE 7) on a sickle (1/33) by Alexandre Wimlot

Cover design: Guillaume Wimlot

Notches, scratches, and breaks.

Life and death of Bronze Age sickles in the Low Countries

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Acknowledgements

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1. Introduction

1.1. Research questions

Bronze Age societies in Europe have long been associated with key concepts - agriculture, metallurgy, trade, and rituals being some of them. Through the traces they display, bronze sickles could make it possible to tackle all of these at the same time. Firstly, they are important tools for a society that practices agriculture (Anderson 2014, 126; Anderson & Sigaut 2014, 85-92; Anderson & Whittaker 2014, 106-108; Gibaja *et al.* 2014, 112-117). Secondly, they necessitated the development of activities related to metallurgy as they are made of bronze (Kuijpers 2008; 2017; 2018). Since copper and tin are the main components of this kind of alloy, and as they are never found together in the Low Countries, the manufacture of these sickles required exchanges (De Vries 2016; Radivojevic *et al.* 2018). These latter could be further confirmed by the foreign characteristics sometimes identified through morphological studies (Butler 1990, 91-92). Finally, since they most often ended up in depositions, it is fair to assume that they occupied a prominent place in activities with ritual significance (Bradley 1990; Fontijn 2002; Warmenbol 1985).

After typological research showed its limits (Palincas 2005, 222-231; Pollock & Bernbeck 2010, 45), a growing interest in the tools, their use and the technology needed to produce them has gradually grown. Thus, at the same time as experimental archaeology and ethnology, the concept of the *chaîne opératoire* and use-wear studies evolved to reach a role of prime importance for the prehistoric and protohistoric periods (Delage 2017; Marreiros *et al.* 2015; Martinon-Torres 2002). For the Netherlands, cultural biographies of object and the *chaîne opératoire* are particularly popular, which is illustrated by the work of Fontijn, Van Gijn, Kuijpers and Gentile, to name but a few. They respectively dealt with the phenomenon of deposition (Fontijn 2002; 2013; 2020), the lithic and bone industry (Little & Van Gijn 2017; Van Gijn 2010; Van Gijn et al. 2014; Van Gijn & Little 2016), bronze tools and their manufacture (Kuijpers 2008; 2012; 2017a; 2018), and weaponry along with combat techniques during the Bronze Age (Gentile & Van Gijn 2019).

By fitting into a tradition that focuses on the tool and its meaning, this research inevitably raises the question of technological innovation, as bronze tools developed in societies relying on flint (Van Gijn 2010a) and on archaeologically invisible techniques (Anderson and Pena-Chocarro; Bakels & Van Gijn 2014, 109-111). Nevertheless, the consequences of bronze introduction and its craftsmanship are not always easy to identify. In addition, the replacement of tools formerly produced in flint by their bronze counterpart is not always obvious as this alloy does not always bring improvement (Van Gijn 2010, a; b). The discovery of less than 50 bronze sickles for the Netherlands to date illustrate this issue very well (Arnoldussen & Steegstra 2016, 66-67).

This thesis is thus structured around one main issue and two secondary questions. Firstly, the suitability of use-wear studies for bronze tools that are sometimes damaged and were often discovered in the distant past will be evaluated. Consequently, the identification of limitations and the distinction between the different stages of sickles' life will play an important role (fig. 1.1).

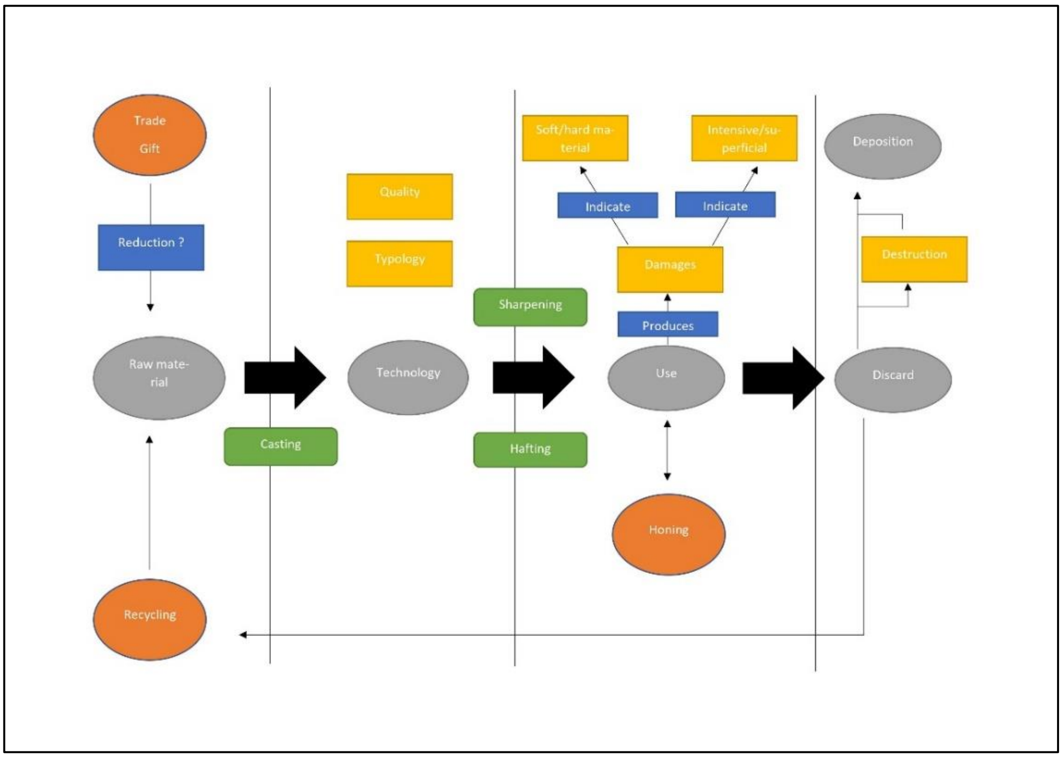

Figure 1.1: hypothetical chaîne opératoire *of the sickle, enhanced by biographical events that are not related to manufacture*

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The following reconstruction of the cultural biography of a selection of bronze sickles from the Low Countries will then provide an opportunity to address the other two research questions. On the one hand, it will allow us to explore the phenomenon of deposition through four different situations, with the sickles of Epe, Ede, Heiloo, and Petigny (fig. 1.2). On the other hand, it will make it possible to assess the role of bronze sickles in a world that preferred flint to metal for a long time (Van Gijn 2010a; b).

Figure 1.2: distribution of Dutch sickles (blue) and sickles studied in this thesis (red)

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1.2. Geographical framework

To begin with the contextualisation of this study, it is important to define the geographical area that will be investigated. Although bronze sickles have been found all over Europe, they are nevertheless present in different contexts and quantities (Arnoldussen & Steegstra 2016, 65-66). For practical reasons, which however follow a specific scientific coherence as we shall see, the corpus of sickles chosen for this research corresponds to the geographical area of the Low Countries. On the one hand, the relations maintained by the department of Material Culture of the University of Leiden with the nearby Rijksmuseum van Oudheden allowed access to three sickles found in Heiloo, Epe and Ede. In the other hand, the affinities of the present author with the Université Libre de Bruxelles as well as the kind collaboration of Eugène Warmenbol made it possible to add the nine fragments of sickles recently recovered in Petigny to the corpus of this thesis.

This geographical unit is also most often treated as such in the characterisation of the different geographical areas of the Bronze Age, since there seems to be no consistency in focusing on the Netherlands and neglecting Belgium, and vice versa

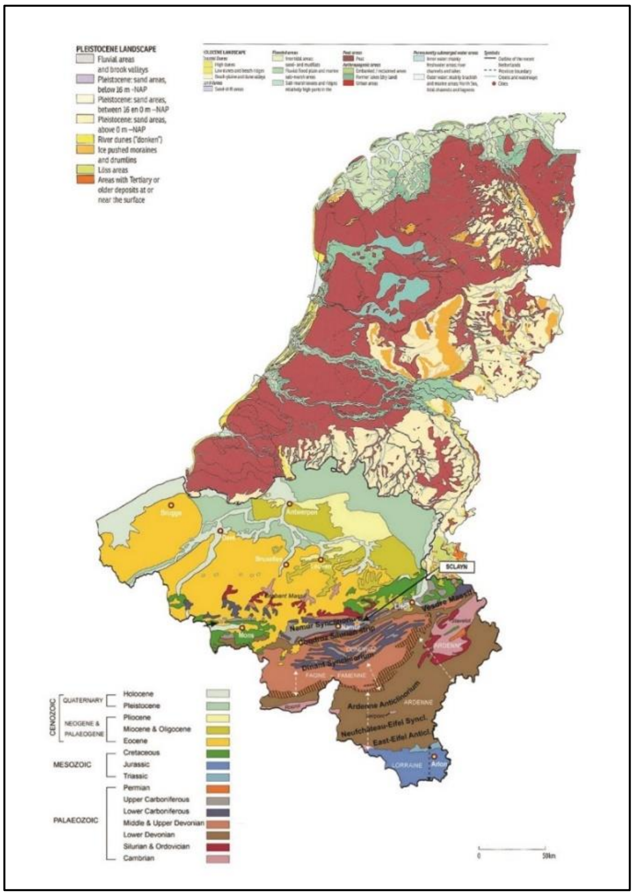

Figure 1.3: geological map of the Low Countries - being the result of the merging of a map of the Netherlands around 1500 BC (legend above), and a contemporary map of Belgium (legend below), after Pirson et al. 2008, 6, fig. 2; Vos 2015, 73, fig. 2.8

(Fontijn 2002, 7-9; Fokkens & Fontijn 2013, 551-552). This ensemble presents both a composite aspect and characteristics that make it a coherent entity. On the one hand, it is possible to divide the area geologically into three fairly different zones - Holocene coastal and river areas, Pleistocene sandy uplands and loess plateaux, and finally Tertiary limestone - which corresponded to cultural facies considered to be distinct throughout the Neolithic and the Bronze Age (fig. 1.4).

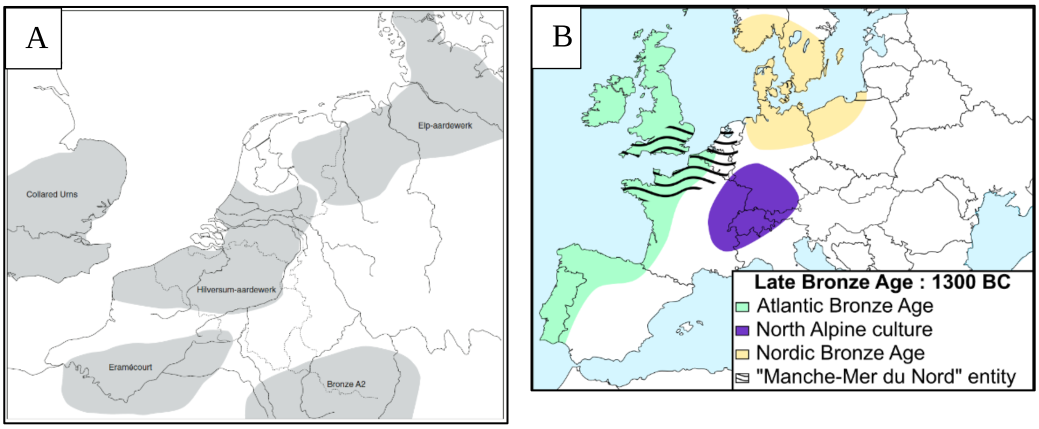

Figure 1.4: on A, theorised distribution of material cultures after 1850 BC (after Theunissen 2009, 210, fig. 5.4); on B, theorised distribution of material cultures after 1300 BC (after Fischer et al. 2018, fig. 5)

From 1850 BC onwards, the culture of Elp may be found to the north and east of the Ijssel, and the culture of Hilversum to the south, probably connected with north-western France and England (Fokkens 2005). After 1250 BC, so-called urnfield pottery can be found almost everywhere in the Low Countries, but again divided in different subgroups. One is located to the north and east of the Ijssel, another to the south with influences coming from the Lower Rhine, and finally, in the south of Belgium, lived a group integrated in the *Rhin-Suisse-France orientale* tradition. On the other hand, this geographical area has a unity due to its buffer-zone role since it constitutes the interface between various spheres of relations. During the Late Neolithic and the Bronze Age, these are identified as the northern sphere, the Atlantic sphere, and the continental sphere (Fokkens & Fontijn 2013, 552-553).

1.3. Chronological framework

To tackle the phenomena of deposition and innovation at the same time, it appeared that the Bronze Age was the best period to consider, since they both gained a new impetus back then. While the development of metallurgic technologies was mainly progressive, covering several hundred years, it was also specific to each region. In consequence, the particular chronology of bronze craft, especially sickles, in the

Low Countries has to be defined. Despite their limitations, typochronology and periodisation provided a necessary framework for this research (Fokkens 2001). Hence, the Bronze Age is divided in four periods and starts with the Early Bronze Age, (2000-1800 BC) and the appearance of barbed-wire pottery. The Middle Bronze Age A (1800-1500 BC) corresponds to the ceramic traditions of Hilversum and Drakenstein. During the Middle Bronze B (1500-1100 BC), the so-called Kümmerkeramik developed while the Drakenstein pottery subsided. Finally, the Late Bronze Age (1100-700 BC) concludes this period, and sees the development of urnfield traditions (Fokkens, 2000, 13, tab. 1; 2001, 242, fig. 1). If the phenomenon of deposition took place both during both Neolithic and Bronze Age (Fontijn 2002; Wentink 2006), the first bronze sickles in the Low Countries cannot be dated before the Middle Bronze Age B while the last ones are dated from the Early Iron Age (800-600 BC) (Arnoldussen & Steegstra 2016, 63). Regarding the corpus gathered here, the three sickles from the RMO may be dated from the Middle Bronze Age B to Late Bronze Age[1], and the sickles from Petigny were dated from the *Bronze final atlantique II*, which corresponds to 1250-1050 BC in absolute dates (Genvier *et al.* 2019, 69; Warmenbol 2019, 18-21).

1.4. Archaeological context

A sickle lost near a field certainly does not have the same significance for a Bronze Age society as a tool voluntarily buried, alone or along with others, fragmented or not. For the 43 sickles found in the Netherlands, there are several possible scenarios. They may have an unknown provenance, they may come from settlement sites, and finally they may have been found in intentional depositions. If some sickles seem to come from settlements for the Middle Bronze Age B, most of them have been found in remote depositions for the Late Bronze Age (Fontijn 2002, 137).

Bronze sickles were rarely found during professional excavations, as they were often located away from any archaeologically recognisable structures. As a result, most discoveries are chance finds, often made by metal detectors. The finding of sickles and their recording are therefore dependant on the legislation in place, as well as on the good will of the detectors. In both countries, metal detection is legal

[1] E2010 (Ede) and WE 7 (Epe) are dated to the transition between both periods and there are discussions about G1947 (Heiloo) that attribute it either to the Middle Bronze Age B or to the end of the Late Bronze Age.

but subject to conditions which can change according to the municipality for the Dutch side, or according to the region, for the Belgian side. Finally, most of the sickles in Dutch and Belgian museums today are mostly the result of ancient discoveries, lacking a proper control excavation or a good documentation of their context.

1.5. Research problem

This study has been motivated by the lack of rigorous use-wear study on the bronze sickles from the Low Countries. Indeed, while flint sickles and bronze weapons have been the subject of intense publication in recent years (Gentile & Van Gijn 2019; Unger-Hamilton 1985; Van Gijn 1988; Van Gijn 2010a), bronze sickles have only been investigated through the typological angle (Arnoldussen & Steegstra 2016; Butler 1990). In addition, traceological studies concerning metal tools are partially missing everywhere, even though the discipline is slowly getting organised (Dolfini & Crellin 2016; Gutiérrez Saez & Martin Lerma 2015). The lack of references, and above all of large databases that bring them together, as well as a need for a reproducible methodology are the main causes of this precarious situation. It thus seemed judicious to contribute to this development by addressing the particular case of the bronze sickle in the Low Countries. Although fewer in number than the other items deposited in the Netherlands and in Belgium, as well as fewer than the number of sickles delivered in other European countries, the Low Countries sickles constitute an assemblage worthy of investigation. Finally, the subsequent question of innovation in Bronze Age tools has only been tackled from the lithic perspective (Van Gijn 2010b). Indeed, the actual research fails to interrogate why bronze sickles are so few in a society that is supposed to rely partly on agriculture, and what their deposition may have signified for ancient people from the Low Countries.

1.6. Archaeological sample and research objectives

The access to three sickles coming from the RMO in Leiden, which are typologically very different, will make it possible to get some preliminary insight into the relationship between morphology and use. These sickles which stem from three different kinds of deposition, selected on the basis of the relative knowledge of their archaeological context, will be studied alongside with fragments of sickles coming from the two depositions of Petigny, near Couvin in Belgium. These delivered nine fragments, four of which were reassembled to reconstitute an almost entire sickle. These artefacts have only been the subject of preliminary publications because of their recent discovery and may display traces that could have suffered less post-excavation damage. They will also provide valuable parallels for the identification of use traces, as well as insights into the evolution of sickle deposition practices across time and space.

Indeed, this study based on use-wear analyses proposes to first distinguish ancient and modern traces, and then to assess which ones are relevant to manufacture, sharpening, destruction and use. The study of striations, notches, and polish, identified on experimental tools, could therefore constitute an important step in the reconstruction of sickles' cultural biography. Subsequently, these lives and deaths of objects will provide valuable information on the conception of the deposition process, but also on the value of such artefacts for ancient societies in the Low Countries. Indeed, using an object for getting food, heating material or for covering houses and tombs certainly did not refer to the same concepts for Bronze Age people (Van Gijn 2010, 173-174).

1.7. Organisation of the thesis

Chapter 2 addresses the characteristics and limitations of use-wear analyses and analogies, which are crucial to keep in mind for a good understanding of the results obtained during the research. They are followed by a description of the method and tools used for traceological analyses of experimental and archaeological sickles. Then, chapter 3 starts with a section dedicated to a literature review. General research concerning sickles, use-wear studies related to metal and specifically to sickles made of bronze, and finally a brief overview of the debate concerning Bronze Age depositions are presented there. The second part focuses on the archaeological contexts and post-excavation treatments undergone by the sickles. In short, this chapter provides the general context for the thesis. Chapter 4 describes the results obtained through the microwear study of the sickles. The objective here is to determine the different types of traces recorded for each tool. These traces are then discussed in Chapter 5, where they are attributed to one specific stage in the life of the sickle through the comparison with experimentally produced traces. This identification allows the hypothetical reconstruction of the biography of objects, and therefore to get a grasp on their significance for Bronze Age societies. Finally, in the concluding Chapter 7 I will recapitulate the various lessons that can be drawn from this study.

2. Biography of bronze sickles: methodology and limitations

2.1. Introduction

A total of 43 bronze sickles were known in the Netherlands for the period extending from the Middle Bronze Age B to the Early Iron Age when Arnoldussen and Steegstra published their exhaustive study, whereas no recent inventory has been made for Belgium (Arnoldussen & Steegstra 2016, 74). In the framework of this thesis, the collections of the Rijksmuseum van Oudheden in Leiden as well as the hoards of Petigny, in Belgium, were made accessible. In consequence, three bronze sickles and nine fragments, all coming from a known context, were selected . They display interesting typological characteristics and seem to be suitable for a micro-wear analysis. The fragmentation of some of the artefacts may be seen as a hindrance for their study, but as it seems ancient and deliberate it may prove interesting in the study of the deposition phenomenon. The total of twelve elements constituting the core of the present thesis are listed in the table below (tab. 1).

Table 1: Sampling of the sickles

ID	Location	Typology (after Arnoldussen & Steegstra 2016)	Fragmentation	Recovery context	Comment
E2010	Ede	Knobbed with elongated knob	No	Single deposition	Ribs with impressions
WE 7	Epe	Without knobs	Partial	Composite deposition (burial?)	Sinuous and broken nose
G1947	Heiloo	Double knobbed with three ribs	No	Composite deposition (along with flint sickles)	Hafting through perforation
1/31	Petigny	Knobbed with two ribs	Yes	Composite deposition	Reconstituted sickle
1/23	Petigny	Knobbed with two ribs	Yes	Composite deposition	Reconstituted sickle
1/15	Petigny	Knobbed with two ribs	Yes	Composite deposition	Reconstituted sickle
1/14	Petigny	Knobbed with two ribs	Yes	Composite deposition	Reconstituted sickle
1/18	Petigny	Two ribs	Yes	Composite deposition	Nose preserved
2/55	Petigny	Two ribs	Yes	Composite deposition	Nose partially preserved
2/57	Petigny	Two ribs	Yes	Composite deposition	Middle portion preserved, ribs with impressions
1/33	Petigny	One rib	Yes	Composite deposition	Distal portion preserved
1/21	Petigny	Two ribs	Yes	Composite deposition	Arched portion preserved

The choice has been made to analyse the sickles from the Low Countries by comparing them to the experimental sickle and knives, used on reeds, birch branches and celery (tab. 2). These latter were selected from the reference collection of the Laboratory of Material Culture Studies in Leiden. It would obviously be interesting to multiplicate the replicas, but it was impossible in the framework of this master's research because of the Corona crisis. The experimental results obtained by Barbara Ellen McClendon for her master thesis will be used as well to fill the lack of references (McClendon 2015). In addition, the traces observed through former use-wear analyses on archaeological sickles will allow us to get a better grasp on the wear and tear displayed by Belgian and Dutch sickles (McClendon 2015; Nowak *et al.* 2019; Sych 2015). Finally, in order to distinguish particular features, such as sharpening marks, research on other types of tools, as well as modern evidence will be consulted.

Table 2: Experimental sickles

ID	Typology	Date	Duration	Material	Comment
Exp1569	Bronze knife	2008	50 min	Birch branches	Very effective
Exp2431	Bronze knife	2008	?	Celery	
Exp1568	Bronze sickle with two ribs	2008	10 min	Reeds	Too blunt quickly

2.2. Microwear analysis

2.2.1. Introduction

Microwear analysis has been considered as particularly relevant for this study since its aim is to reach the complex biography of a special tool made of bronze. Were they used on wood, peat or gramineous plants, how intensively, how were they hafted? These many questions can only find an answer by performing such analysis. Its non-invasive nature, the basic equipment needed and the possibility to bring the artefacts to the laboratories of the Université Libre de Bruxelles and the University of Leiden made it a perfectly relevant method for the objectives of this thesis. The combined use of analogies makes it possible to go beyond the simple description of traces observed in use-wear studies. Hence, interpretation occupies a fundamental place in this thesis.

Traceological analyses have a long tradition for tools made of bone, stone, or flint, which is detailed in the literature review. However, their application to metals is still recent and in development. In consequence, researchers do not yet have large databases to refine the results (Dolfini & Crellin 2016). Though it is not one of the main objectives of this thesis, the constitution of variables and attributes allowing the distinction between observed traces is a first step towards the creation of a common database for the different types of bronze artefacts. These will be discussed in the section dedicated to the process.

2.2.2. Limitations

There are some important limitations to the application of microwear analysis to metal tools. Indeed, when they have not been particularly well preserved, it is merely impossible to tell anything about wear and tear. As it is the thinnest part of the sickle, the cutting edge - where the most interesting traces are located - is commonly the first area to decay (Grace 1990; Sych 2015, 119-123). This situation prevents from identifying striations, notches, dents and polish, which are fundamental in the understanding of the use of the tool.

Even when the cutting edge is preserved, some traces remain difficult to interpret. Hence, although it is one of the traces that give most clues about the use of flint artefacts (Clemente & Gibaja 1998, 457; D'Errico 2017; Vardi *et al.* 2010 ; Van Gijn 1988 ; 1999 ; 2010), polish is not the most commonly investigated trace for metalwork (Dolfini & Crellin 2016, 83). The brilliance of the material and the particular reflection of the light under the microscope due to the physico-chemical composition of bronze make it difficult to detect. On archaeological artefacts, patina or corrosion sometimes cover any traces of polish or manufacture polishing. On experimental tools, these traces are even more difficult to identify since the brightness of the surface may be confusing.

However, their study is made possible by the use of a metallographic microscope. It then takes on a shape quite similar to the polish usually observed for flint tools, which directionality is linked with the type of action performed. For instance, with flint implements, scraping gramineous plants seems to produce a rather transversal polish, whereas cutting reeds, generates a polish that develops in a longitudinal direction (fig. 2.1). If bronze tools were used with the same type of movement as flint implements, which is conditioned in particular by the hafting and curvature of the blade, it should be possible to draw the same conclusions about polish directionality.

Modern transformations are another problem encountered. Indeed, the collection of samples, conservation and restoration treatments, as well as damage during or after excavations can obscure traces of use (Sych *et al.* 2020). In order to avoid this pitfall, it is essential to identify them as well as possible. This can be done by researching previous literature, by contacting the hosting institutions or the individuals that are in charge, or by apprehending these modern traces directly through microscopy.

Finally, microwear in general analysis is evidently not flawless as subjectivity plays a great role, as always (Van Gijn 2014b). While everything possible will be done to document all the operations and observations by registering the significant traces with pictures and drawings, plenty of space is left for personal biases. In this regard, all the conclusions that could be drawn in the present thesis have to be questioned further, and a considerable work should be dedicated to the enlargement of the reference collection. This would allow to reach higher levels of precision and objectivity. Hence in this context, the research that is developed here should be considered as another step towards the development of traceology in bronze studies, where a lot still has to be made.

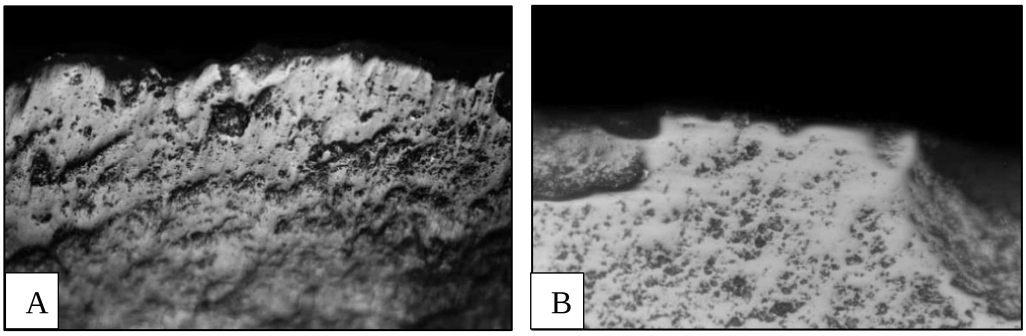

Figure 2.1: transversal polish (A) and longitudinal polish (B) observed on flint blades (Van Gijn 2010, 64, fig. 4.4b; 68, fig. 4.6a)

2.2.3. Methods

No special preparation was needed before the microscopical analysis of these archaeological and experimental sickles and knives, other than removing what may be residues from conservation treatments when they made the reading of the traces difficult. This process involved the use of cotton-buds and an ethanol-based solution to avoid the degradation of the objects as well as any production of new traces. Experimental specimens were manipulated bare hands, while latex gloves were worn for the archaeological tools. The previous operations carried on these objects will be detailed in a dedicated chapter, in order to allow the distinction between proper use-wear and post-excavation traces.

The analysis was conducted in two different places, as observations were carried on sickles from both Belgium and the Netherlands. For the latter, all the operations occurred at the Laboratory for Artefact Studies, at the University of Leiden, where a large experimental reference collection is available. The laboratory, comprising a section for experiments, one for residue analysis and one for microscopy, is dedicated to the reconstruction of artefact cultural biographies. Within the framework of the analysis performed on Belgian sickles, an access was granted to the CReA-Patrimoine laboratory, located at the Université Libre de Bruxelles. In Leiden, the stereoscopic analyses were carried on a Leica M80, with a zoom range of 0.75X to 6X. The metallographic analyses were carried out on a Leica DM1750 allowing magnification up to 20X. Both were equipped with a Leica MC120HD camera. In Brussels, the stereoscopic observations were made on a STEMI 508 Zeiss, with a zoom range of 0.63X to 5X. The several relevant traces for this study were annotated on vectorised drawings of the sickles, using the vector graphics editor Inkscape, an open access substitute to Adobe Illustrator. This technique allowed to avoid contacts with the archaeological tools as it relies on scaled pictures that were taken for both sides of each sickle.

2.2.4. Terminology

The general terminology is borrowed from the one used in use-wear analyses of other materials, while some particular damages, such as dents and notches, are terms specific to traceology on metal (Dolfini & Crellin 2016; Gentile & Van Gijn

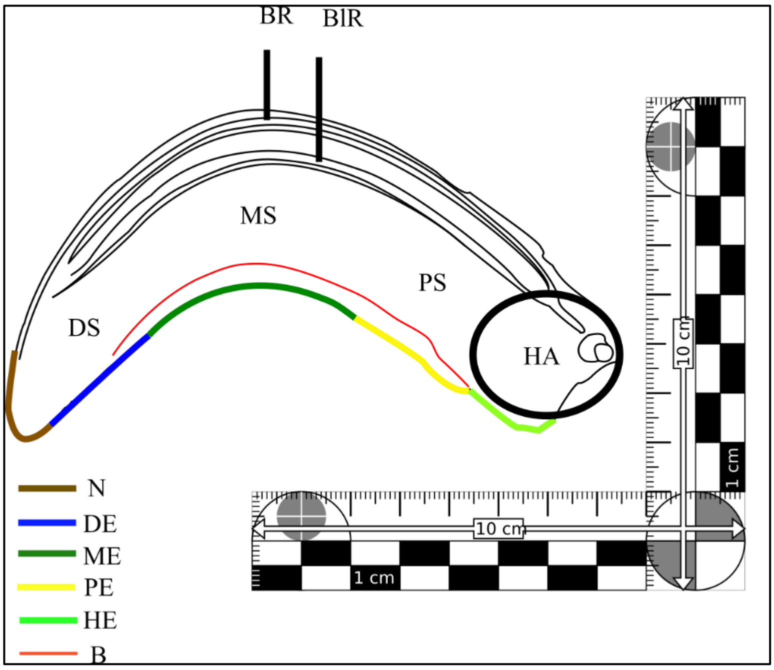

Figure 2.2: sketch detailing the denomination of sickle's various parts

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2019; Gutiérrez Saez & Martin Lerma 2015). For more clarity through the reading of the results, the different parts of the sickle have been divided into several sections, and subsequently abbreviated (fig. 2.2). Thus, the cutting edge was divided into distal (DE), mid- (ME), proximal (PE) and hafted edge (HE), and the rest of the sickle was split between the different ribs (BR and BlR), the distal (DS), mid- (MS) and proximal surface (PS), the hafted area (HA), the bevel (B) and the nose (N).

The results presented in a dedicated section, summed up in a table and accompanied by pictures of the most important features, are further detailed in the appendix. There, they are associated with drawings showing the location of the observations - **x** for notches and numbers for other traces. For the sake of simplicity in creating the table, the tool has been divided into the cutting edge, the hafting zone, the rib zone and finally the more common surface, which is not supposed to be damaged by regular use. Some of the traces relate to the use itself, others to manufacture, and others to destruction and deposition. The first category includes striations -considered according to their directionality, regularity and shape-, dents, notches, and polish. The second includes mainly casting flash and residues from hafting. The third category consists of corrosion and patina, and the last one is made up of blows, bending and folding, and finally fragmentation. As it was made possible by a comparison with the reference collection, the interpretation is proposed in the discussion chapter. The exhaustive description of the results, often lacking in past use-wear studies of bronze artefacts (Dolfini & Crellin 2016; Gutiérrez Saez & Martin Lerma 2015), is another step towards a better understanding of the proposed interpretations.

2.3. Analogies and comparisons

To progress within the reconstruction of past populations' everyday life, and overall, of non-writing societies, archaeologists started to rely on analogies and comparisons (Gould & Watson 1982; Van Gijn & Raemakers 1999; Wylie 1982). Experimental archaeology and ethnoarchaeology are the two main disciplines that grew from this new approach that allows to go further than description (David & Kramer, 2001; Reeves Flores & Paardekooper 2014, 7-14; Vukovic 2016). On the one hand, ethnoarchaeology will not be used here longer than to understand the possible ways of using or sharpening the sickle. On the other hand, experimentally reproduced traces will definitely bring some determinant arguments for the issues that were introduced above. Indeed, analogies will provide this work with a solid basis for distinguishing the observed traces. This is why the elaboration of a vast database is very much needed (Dolfini & Crellin 2016, 85). The University of Leiden understood it well and produced one of the biggest reference collections for shells, bones, stone, and flints[2]. They also recently launched a database for use-wear on metal at the same time as they multiplicated the replication of weapons and tools made of bronze.

Experimental archaeology, however, has its share of criticisms, divided into several categories that Reich and Linder summed up (2014, 67-84). Firstly, it has been argued that the mental structures of modern man, as well as his environment are different from these of the man of the Past (Fortin 1991; Frère-Sautot 2003; Otte 1991; Tixier 1980). His ethics and mental barriers are also diverse, leading to biased considerations in the way of imagining things and making them (Mohen 1988). In the field of technology, it is often stated that the craftsman of ancient societies, having arguably spent his life specialising, delivers work that the inexperienced researcher will never be able to reproduce (Andrieux 1991; Frère-Sautot 2001). However, recent studies on specialisation during Bronze Age tend to contest this view (Kuijpers 2019). Another critique addressed to experimental archaeology considers that the archaeologists performing this kind of experiments regularly lock themselves into a circular reasoning, by trying to match their results with their observations (Otte 1991). This point may also be contested, as the growing care brought to methodology progressively prevents these kinds of pitfalls.

However, while it is possible to overcome these criticisms, certain limitations emanate from the particular context of experimenting with metal tools. First, there is a big discrepancy between the duration of the experiment and the use of archaeological sickles. Indeed, the first rarely lasts more than one day, while an archaeological tool could have been used a long period and resharpened several times. Then, typology could influence the traces left by the action of cutting. The shape of the blade or the way it has been hafted are factors that change the angle and the power

[2] See the description on the website of Leiden Universiteit: https://www.universiteitleiden.nl/en/research/research-facilities/archaeology/laboratory-for-artefact-studies.

with which the sickle would have attacked the material. This has also to be borne in mind when analysing the microwear traces located on experimental sickles. Finally, the logistical aspects and the lack of means considerably limit the possibility of carrying out enough experiments to be able to draw solid conclusions (Frère-Sautot 2001). This criticism is particularly relevant for the reproduction of bronze objects, which require special installations and a substantial financial investment. This, for instance, along with the Covid crisis, prevented us from producing more replicas of sickles.

2.4. Conclusion

Experimental archaeology and more generally analogies are necessary to carry out a consistent use-wear analysis despite their limitations since they can provide the necessary reference base. Although the experiments were few in number, and whereas I did not take part actively in their realisation, important results have been produced. Their confrontation to other metal tools experiments in Leiden, as well as to McClendon and Sych's researches, allowed to be confident that this thesis constitutes a valid first step towards a better understanding of sickles biographies. However, in the perspective of future research, further experiments should be carried out in order to broaden the spectrum of produced traces and thus allow better comparison for archaeological specimens, as advocated by Dolfini and Crellin (fig. 3.3). Together with the latest results of archaeometallurgical research in the Netherlands, analogies and use-wear analyses make it possible to reconstruct the cultural biographies of these bronze sickles, and to better understand their place in Bronze Age societies in the Low Countries.

3. General context

3.1. The Bronze Age of the Low Countries: current debates

3.1.1. Bronze Age sickles and technology

Sickles have been found all over Europe. As a result, they have been the subject of numerous studies, which can be divided into two categories. The first comprises typological studies which are the most frequent, mainly concerning the NW-SE axis which extends from the British Isles to Romania and Serbia. Arnoldussen and Steegstra made an exhaustive inventory, listing the publications related to sickles by country (Arnoldussen & Steegstra 2016, 65-66). In consequence, I will limit the discussion here to the studies published in the direct vicinity of the sickles studied in this thesis.

For the United Kingdom, two early studies by O'Connor and Fox constitute the bulk of the literature about sickles (Fox 1941; O'Connor 1980). Some more recent publications dealt with isolated cases, such as the discovery of the Shinewater Park sickle, which was treated from a conservation perspective (Brysbaert 1998). Regarding France, there is unfortunately no publication covering the entire territory, the North being the only part correctly studied (Blanchet 1984). Other papers linked with specific museums and regions, give some more details as well as illustrations of sickles (Breuil 1901; Opitresco-Dodd *et al.* 1978), but are rather anecdotic. While sickles from Austria, Switzerland and Southern Germany have been extensively published thanks to the excellent work of Primas in the framework of the *Prähistorische Bronzefunde* (Primas 1986), some other parts of Germany remain insufficiently documented. The west particularly suffers from this lack of publications, and the area bordering the Netherlands, for instance, has only been tackled by Weber (2007). The eastern and northern parts of Germany, on the other hand, are rather well documented (Brunn 1957; Kleeman 1941-1942; Sommerfeld 1994). To conclude this outline of the research bordering the Low Countries, a series of ten publications spanning 20 years covers the sickles found in Denmark (Aner & Kersten 1973-1993; Aner *et al.* 2001).

For the Netherlands, Butler's monumental work laid the foundations for Arnoldussen and Steegstra's research, as for more than ten years he was engaged in the publication of Bronze Age artefacts (Butler 1990; Butler & Steegstra

2007/2008). In contrast, the publication of Belgian sickles suffered the effects of the division of the country as well as of its heritage policy. Warmenbol took care of the sickles of the south of the country (Warmenbol 1985), while Van Impe and Creemers published the sickles found in the north (Van Impe & Creemers 1993). However, these works, which are getting old, do not present the more recent discoveries. We will therefore have to wait for the next publication of Warmenbol to obtain the complete study of Petigny's sickles, which are included in this thesis (Warmenbol *et al.* 2019; to be published).

Most Western and Central European countries lack a general publication that would include all the sickles found. The decentralised, or at least regionalised, nature of these countries is perhaps one of the causes of this deficiency, and research would most likely be improved by overcoming this situation. But if inventory work still needs to be done, technological research has a long and solid tradition. Indeed, researchers investigated harvesting techniques as early as the 1940's. The works of Steensberg and Gaudron thus laid the foundations for future research about the *chaîne opératoire* of the sickle (Steensberg 1943; Gaudron 1944). By dwelling on the hafting process, they went beyond a simple typological study. This work was later taken up by Clark and Sommerfeld (Clark 1952; Sommerfeld 1994).

More broadly, Steensberg has also made a major contribution to the study of agricultural technology, popularising the subject in the middle of the 20th century. Nevertheless, we had to wait several decades before the new notable impact on this field, with the works of Anderson, Clemente and Sigaut (Anderson 1998; 1999; 2000; Clemente 1998; Sigaut 1978; 1988). More recently, Van Gijn, Whittaker and Anderson carried out a considerable project, that has brought the understanding of agricultural technologies to a new level (Van Gijn *et al.* 2014a). However, these studies have historically focused more on flint tools, which have been the first subject to traceological analyses (Van Gijn 2010a; Van Gijn *et al.* 2014b, 9). Finally, the recent work of Kuijpers has made an important contribution to the understanding of the archaeometallurgical *chaîne opératoire.* In particular, he explored thoroughly the notion of specialists and workshops for metalwork in general, and in the Netherlands in particular (Kuijpers 2008; 2012; 2017a; 2017b; 2018). In this last publication, he critically summarised the previous literature, and broke away from it with his innovative approach (Kuijpers 2018, 1-35). Since the demonstration of

Kuijpers seemed convincing to us, we will not go into more detail about these older publications here.

3.1.2. Use-wear, experimental archaeology and biographies of objects

As presented in the introduction, microwear analysis is a fundamental approach in this thesis. Developed in the second half of the 20th Century (Marreiros, Bicho, & Gibaja 2012; 2015; Van Gijn 1990; 2012; 2014b, 168), the study of microwear traces has revolutionised material culture studies. The discipline started mainly with flint and was initiated by Semenov (1964). A good review of further developments of use-wear analyses can be found in Van Gijn *et al.* (2014b, 9), already mentioned in a previous section. Setting apart from the formerly prevailing typological tradition that confined archaeology to descriptive studies, microwear specialists have reconsidered archaeological artefacts and tried to go beyond to reconstruct human lives that lie behind. They quickly integrated the *chaîne opératoire* concept as they were developing in parallel with the archaeology of technology (Delage 2017; Martinon-Torres 2002), that led in consequence to the development of cultural biographies of objects (Fontijn 2013; Gosden & Marshall 1999; Kopytoff 1986).

For this purpose, experimental archaeology is pivotal. Traceological analyses cannot go beyond simple description when experimental archaeology is not involved in the research. Indeed, it is the only discipline capable of producing a reference base for comparison. It is also the overcoming of observation for interpretation that allows the reconstruction of the cultural biographies of objects. Indeed, experimental archaeology allows to find the gesture and the aim behind the trace. This discipline has existed for more than a century now and mingles with most fields of archaeology. Recently, Reeves Flores and Paardekooper published a book that gathers the history of experimental archaeology and its developments in the different regions of Europe (Reeves Flores & Paardekooper 2014). It would therefore be inappropriate to reproduce their review here. For archaeometallurgy, which directly concerns this thesis, an essential volume has been edited recently, which has redefined the methodology and the prospects of the discipline, while tackling every aspects of the manufacture (Verly *et al.* 2019)

Use-wear analyses applied to metal, on the other hand, developed rather late, and still lack a common methodology. It has grown in importance over the last two decades, and Soriano, Gutiérrez, Dolfini and Crellin have brilliantly established the discipline's flaws and perspectives (Dolfini & Crellin 2016; Gutiérrez Saez & Martin Lerma 2015; Soriano Llopis & Gutiérrez Saez 2009). Up to now, research has mainly focused on use-wear applied to weaponry (Gentile & Van Gijn 2019; Molloy 2017; Uckelmann *et al.* 2011), especially swords, and the traces left on tools such as axes (Crellin 2018; Roberts & Ottaway 2003). As the study of wear traces for metal is still in its early stages of development, scholars are still focusing on the limitations and constraints related to phenomena such as conservation treatments (Sych *et al.* 2020).

Bronze sickles that have been subjected to microwear analysis are too few. Actually, if the superficial macro-observations that concern tools like the sickle of Epe are let aside (Arnoldussen & Steegstra 2016, 84; Butler 1990, 91-92), there are only three noticeable recent works concerning bronze sickles. First of all, McClendon, who has already been cited, elaborated a method to work on sickles, basing her research on several European tools from the Bronze Age (McClendon 2015). She crafted four experimental sickles herself and had the control over every step in the *chaîne opératoire.* The approach she proposes is promising and inspired the methodology of this thesis on some aspects, notably the use of pictures associated to vector graphics. Unfortunately, the results are a little disappointing, mainly because of the corrosion present on the sickles chosen. McClendon also remains overly descriptive, and does not really link observations to use, intensity of use, hafting or sharpening, despite an experimental part which is one of the major focus of her thesis. Finally, the realisation of these experimental sickles by the author seems to have affected quite considerably their quality, which could weaken the quality of the traces produced. However, her experimental approach is relevant and shows a good understanding of the whole *chaîne opératoire.*

Secondly, Sych conducted a great work on bronze sickles and knives from South-Western Poland (Sych 2015). As he aimed to reconstruct cultural biographies, his research has also largely inspired the present thesis. The identification of production related, use related and post-excavation traces also led us to articulate our observations around the different steps of sickles' *chaîne opératoire*. One of the only criticisms that could be addressed is the lack of photographic documentation considering the number of sickles analysed, as he relied on five replicas and 80 archaeological sickles. However, this does not affect the quality of the author's work, which has been able to balance archaeological context, experimental archaeology and microwear analyses to reconstruct the life of the sickles.

Finally, Nowak *et al.* investigated sickles from the same area, in a more holistic approach which is maybe less worthy of interest for this thesis (Nowak *et al.* 2019). Indeed, even if one part of this research concerns traces of use and manufacture, the authors do not focus on microwear. Most of their traceological results are mainly based on macroscopic observations. Nevertheless, the use of physico-chemical analysis tools such as the SEM provides inspiring results for the future, as it allows an in-depth analysis of the fabrication process. Dolfini and Crellin also recommend a more systematic use of this tool in the context of micro-wear research for metal (Dolfini & Crellin 2016, 83-84).

3.1.3. The phenomenon of deposition during the Bronze Age

The nature of bronze alloy makes it necessary to take the act of deposition into consideration as it is possible to recycle bronze objects more or less endlessly. Integrating them in the blend of metals intended for remelting, in order to craft new implements, marks a strong difference with flint artefacts for instance (Delfino 2014; Radivojevic *et al.* 2018). In fact, although these latter may be used during a considerable period of time through resharpening, transformation or fragmentation (Van Gijn 2010, 161-197), they will consecutively reach a state in which they can no longer be reshaped and turned into a fresh tool.

In this regard, it may seem pretty odd from a 21st century perspective not to recycle bronze and to discard such a rare and valuable material. The Homo Oeconomicus who the modern human is supposed to be in the capitalistic world cannot help but consider the abandonment of well-made bronze objects to be irrational (Fontijn 2002, 19-22; 2020, 1-21). This is the main reason why many scholars have been inclined to consider most of Bronze Age depositions as stockpiles of metal for artisans, awaiting to be remelted, rather than as conscious actions to discard the precious metal in the form of a deposition (Fontijn 2002, 13-15; Kubach 1985; Von Brum 1968, 231; Geißlinger 1984).

This perspective, besides being irrelevant for evident chronological reasons, neglects several aspects of bronze casting and its importance for ancient societies. Indeed, depending on the level of use of the implement, various possibilities seem to emerge. Firstly, if the tool was not used at all, the reason of the deposition may be metonymic; the bronze implement was intended to represent the idea surrounding a functional artefact within the practice of deposition into the ground, while mundane tools continued to be used - sometimes shifting later as well to a ritual function (Van Gijn 2014, 311-318) - or entered the recycling loop.

Secondly, if the traces indicate that it was slightly used, the tool could have been part of a special ceremony or series of actions linked to a structure, people, or a particular event. It would have been used to perform a special role linked to the "normal" use of the implement or not, and then discarded once its ritual participation was accomplished.

When it was deposited after being heavily used, the tool may have been discarded for technical reasons. It could have become impossible to make it efficient again through sharpening, or maybe was it damaged in such a way that it prevented the tool from working properly. Its deposition would have been the consequence of either an impossibility for the community that was using it to control the process of bronze casting or sharpening[3], or of a will to set it apart from the community (Fontijn 2002, 33-37; 2020, 22-43).

Finally, fragmenting a tool may either be intended for scrap storage with the aim of being recast, or the result of a ritual violence exercised against the object as documented by ethnoarchaeological studies (Fontijn 2020, 120, citing Burkert 1983 and Lambek 2008, 150; Nebelsick 2000). In general, and regardless of the level of wear and tear or fragmentation, it is possible that the exclusion of bronze objects was part of an elitist desire to create value by reducing the amount of available metal (Earle 2002; Earle *et al.* 2015; Kristiansen 1998). It could also be a way for ancient societies to mark their landscape and to signal their independence from a globalising world, as recently suggested by David Fontijn (2002; 2020, 153-176).

The hypothesis of lost metal stocks of ancient craftsmen seems to prove unable to explain why bronze artefacts would be deposited alongside with other materials

[3] Craftsman skills discussed in Kuijpers 2008, 107-109; 2018, 1-18.

such as flints (Van Gijn 2010, 209-212). In this case, discarding bronze tools for utilitarian reasons may in no way be raised as an answer to the complex hoard issue in Bronze Age societies. On the contrary, should these tools of bronze be found in settlement context, the loss would either be accidental or intentionally planned for melting it down in a workshop nearby. This finally raises the question of the proximity of the depositions to any dwelling or artisanal area in order to be able to consider the constitution of a stock for casting purposes (Fontijn 2020, 1-7).

3.2. Archaeological context

3.2.1. Diverse types of deposition

After the review of the research context and before diving in the use-wear analysis, it is necessary to explore both the archaeological context of the different sickles, and the results obtained by the first typological studies. First of all, the lack of context would make it impossible to fully understand the biography of these implements made of bronze as their presence in a hoard, a deposition of discarded materials or a settlement constitutes an important step in their life. Indeed, their deposition could be seen as the moment of their death for the society which had a use for them, in the event that the tools were deliberately abandoned, buried, or isolated (Lee 2019, 26-31). Then, morphological characteristics are important as they allow a first dating of the tools and provide an insight into exchange relations in Bronze Age Europe.

The sickles that are under investigation for this thesis received at least two identification codes, one coming from the museum, the other created by Arnoldussen and Steegstra in the framework of their fundamental study (Arnoldussen & Steegstra 2016). Here, both will be mentioned once, while a simplification of the museum code will be used afterwards in order to avoid confusion.

3.2.2. E2010 and the spoil dump (Ede, Netherlands)

E2010/2.QHG, or **DB 2104**, was found in 1971 in the area of Maanen, located in the town of Ede. The sickle was lying in the spoil dump of a sand extraction site in what seemed to be the remains of a settlement, since two flint arrowheads and sherds of Hilversum-type pottery were recovered together (Arnoldussen & Steegstra 2016, 89). It was discovered by P. Balster and E. Zuuurdeeg, the latter being an amateur archaeologist active since the 60’s and corresponding with the

RCE, on whose advice control excavations were carried out (Hulst 1971, 77). These latter confirmed an Early and Middle Bronze Age presence but mainly highlighted the intensification of the occupation during the Iron Age and the Roman period (Taayke *et al.* 2012, 21; 57; 258-259). Nonetheless, there might be a chronological disparity between the sickle and the settlement, the latter being attributed to the Early Bronze Age – Middle Bronze Age A (Arnoldussen 2015, 22), while the tool was given a dating of 1325 to 1000 cal. BC at the latest through typochronology (Primas 1986, 141), which corresponds to the Middle Bronze Age B – Late Bronze Age (Fokkens 2001; Lanting & Mook 1977, 6-8).

3.2.3. G1947, a bronze tool amongst flint implements (Heiloo, Netherlands)

G1947/12.14, or **DB 508**, was first mentioned in 1932 as being part of a composite hoard from Bollendorp, in the vicinity of Heiloo. This discovery was made during levelling work in a dune landscape at a depth of 3.5 metres. The ensemble was not acquired by the RMO before 1947 from the finder-owner, as it was previously on display in the collection of the Provincial Water Board for North Holland at the House Foghteloo in Bakkum. W. Harms, the discoverer, testified that this blade was located in the middle of four flint sickles (fig. 3.1) arranged in a row, all standing vertically and pointing upwards.

Figure 3.1: G1947 in the composite hoard from Heiloo (photograph of the RMO in Van Gijn 2010, 210, fig. 8.5)

Butler expressed some doubts about the nature of this blade, which he said could have been either a sickle or a knife (Butler 1990, 92-94). The lack of typological parallels effectively makes it a unique tool, which finds a match only in a tool from Graubünden (Primas 1986, 191-192), roughly datable from the 13th century. Arnoldussen and Steegstra ruled out this date on the basis of the common dating attributed to the typology of the four flint implements accompanying the sickle made of bronze, in Northern Holland (Arnoldussen & Steegstra 2016, 91-92, citing Boersma 1988, 31; Schinning 2012). In addition, the recent discovery of a composite hoard dated to the 9th century (Fontijn & Knippenberg 2015, 7) led them to attribute the sickle of Heiloo to the transition between the Bronze Age and the Iron Age, which could be confirmed by the high percentage of iron contained in the alloy of the bronze sickle (Arnoldussen & Steegstra 2016, 94-96, tab. 1)[4].

For G1947, the studies were thus limited to the typo-chronological aspect, despite rather detailed descriptions (Arnoldussen & Steegstra 2016, 91-92; Brunsting 1962, 107-115; Butler 1990, 92-94). However, if the bronze sickle has never been subject to a use-wear analysis, the four flint sickles were studied for traces of use (Van Gijn 1992; 2010, 212-213; 229; 240). Firstly, these flint sickles appear to have been used at different levels of intensity, as well as in contact with various materials. Van Gijn proposed that the first and second ones (G1947/12-10 and G1947/12-11) were used to cut turves, the third (G1947/12-12) was not used or at least bears no traces of use, and the last one (G1947/12-13) was used on siliceous plants (Van Gijn 2010a, 240). Secondly, the low number of whole flint sickles found in settlements could indicate the voluntary and meaningful nature of such deposition. These use-wear analyses possibly highlight the ritualisation of essential activities, through the staging of tools presumed to be common, but which have special features (Van Gijn 2010a, 228-230). Finally, this combination of bronze sickles and flint sickles, although unique in the Low Countries, has a parallel in the hoard of Renz, on the island of Rügen, where a bronze knobbed sickle was found along with three flint

[4] It is necessary to ask the question of this strange composition (approximatively 22% Cu, 30% Sn, 28% Pb and 18% Fe) as the physico-chemical analyse was carried out by means of a portable XRF. Indeed, because of the low penetration of the analysis that makes it difficult to overlook corrosion, the heterogeneity of the material, the air space present between the analytical tool and the measured object and finally the lack of proper description of the methodology employed by Arnoldussen & Steegstra in 2015, the results are imprecise and inaccurate, and therefore highly questionable. The resulting anormal composition only reinforces the present author's doubts about the validity of the analysis.

implements (Keiling 1989, pl. 34), which could further confirm the special character of this type of deposition, particularly in coastal contexts.

3.2.4. WE7, the sickle on the hill (Epe, Netherlands)

WE 7, identified as **DB 346** by Arnoldussen & Steegstra is the oldest discovery among the corpus studied in this dissertation. Indeed, this sickle was accidentally recovered around the middle of the 19th century by workmen in Epe and presented to the RMO in February 1865 (Butler 1990, 91[5]), rather than in 1875 as Arnoldussen and Steegstra may have erroneously indicated it (Arnoldussen & Steegstra 2016, 84). At that time, such discoveries were obviously not recorded according to a scientific methodology, and only a brief note reported by Butler gave us information about the context of the find. According to the letter, it would appear that the sickle was part of a hoard wrapped in a linen that was found on the slopes of a hill, containing also a stopridge axe (WE 5) and a palstave (WE 6). It is rather difficult to determine whether this mound was natural or man-made, since the aforementioned letter only specifies that the tool was found under a layer of gravel and iron pan at a depth of about 2 meters (Butler 1990, 91). However, the presence of iron pan could well confirm the funerary nature of the hoard, since these formations have already been identified as marking the presence of a burial mound in other contexts (Breuning-Madsen 1998, 1103-1110; Breuning-Madsen & Holst 1996, 80-86). Unfortunately, apart from this evidence, no other elements that could link the hoard to a funerary context have been recovered. Furthermore, the possibility of such a deposition in a tomb before the transition between the Bronze Age and the Iron Age remains to be established (Fontijn 2002, 137).

In order to better identify the dating of this deposit, its nature as well as its significance, it is necessary to tackle the typology of the elements constituting the hoard. The sickle of Epe, which finds parallels in England (O'Connor 1980) and Central Europe (Butler 1990, 91) has no equivalent in terms of the sinuosity of its blade[6]. It was found together with a flanged stopridge axe of the Vlagtwedde-style (Buttler

[5] Butler citing the letter of the donor which accompanied the objects, 8th February 1865, RMO archives.
[6] Arnoldussen & Steegstra 2016, 84, citing Butler 1990, 91, propose that this particular sinuous blade is rather the consequence of numerous re-sharpening and re-working than a typological feature. The present author is fairly sceptical about this unsupported strong assumption and will extensively discuss it later in this thesis.

1995/1996, 233) - which is mainly distributed in the region of Ijssel -, and a palstave whose characteristics classify as an Oxford type - often found in British Islands (O'Connor 1980; Schmidt & Burgess 1981, 131). In consequence, the latter proposed an English origin for the sickle (O'Connor 1980). Butler instead linked it to series from Central Europe, without neglecting the possibility of a local production or an origin from the Somerset (Butler 1990, 91). Regarding the palstave, he did not deny the proposals of Schmidt and Burgess (Schmidt and Burgess 1981, 132) as well as O'Connor's, who placed its production in England. Finally, he more formally attributed a Dutch origin to the stopridge axe. He dated the assemblage of the Taunton phase, whose Dutch equivalent is the Middle Bronze B, on the basis of the palstave and the British equivalents of the sickle (Butler 1990, 91), which Arnoldussen & Steegstra did not deny (Arnoldussen & Steegstra 2016, 84).

These dates and provenances should be treated with caution, since physico-chemical analytical techniques, albeit under development[7], do not yet offer a strict identification method for material made of a copper-based alloy (Artioli *et al.* 2016; Klein *et al.* 2010; Pollard 2009; Radivojevic *et al.* 2018; Stos-Gale & Gale 2009). Nonetheless, while contextual data are practically absent given the age of the discovery, some conclusions may nevertheless be drawn. The deposition has more than likely a composite nature, already suggested by Butler (Butler 1990, 92), to which the local, British, and Central European characters of the tools that compose it contribute. Moreover, if dating the hoard to the Middle Bronze Age B is accurate, it would be difficult to identify it as grave goods in respect to indigenous traditions (Fontijn 2002, 137). On the other hand, it would be unwise to reject this hypothesis completely as coeval findings from other parts in Europe, as well as the sickles from Holset, in the Netherlands (**DB 1872** and **DB1873**), do indeed come from funerary contexts.

Consequently, the re-evaluation of these data could lead to raising the dates of development of the phaenomenon of depositing tools in burials in the Netherlands by a few hundred years, or similarly lowering the probable dating of the Epe hoard.

[7] The improvement of analytical techniques such as MC-IP-MS and the build up of databases on the model of OXALID for other elements than lead shall allow archaeologists to get a better grasp on ancient metals provenance

Another possibility, if the funerary nature of the hill were confirmed by other elements additional to the layer of iron pan, could be the allochthonous origin of the dead. This would not be the only occurrence of an individual travelling and dying outside his native land during the Bronze Age (Frei *et al.* 2015). In addition, the lack of workshop traces found in association with the bronze artefacts recovered in hoards indubitably questions the possibility of any bronze craft in the Netherlands for the Middle Bronze Age B[8]. If it cannot be taken *per se* as a proof of a foreign origin for the sickle and the stopridge axe of Epe, it remains the most probable hypothesis. Unfortunately, it is impossible to bring these conclusions to another level on the simple basis of typology and a context painfully reconstructed through a letter more than 150 years old.

3.2.5. Two exceptional depositions (Petigny, Belgium)

In 2016, two assemblages were discovered in Petigny, near Couvin. The detectorists who were behind the find handed it over quickly to the municipality of Couvin, but no control excavation has been carried out. Christian Frébutte has since been in charge of its archaeometallurgical study, notably through the non-destructive composition analyses of the elements of this hoard made up exclusively of metal. According to the discoverers, these two assemblages, one comprising 49 fragments and the other comprising 34 of them, were found in two neighbouring faults in the terrain. Eugène Warmenbol proposed to study these two sets together, as a whole (Warmenbol 2018, 35), and the recent identification of two joint fragments from the first and the second hoard by Alexandre Duriau (Warmenbol to be published) could confirm the relevance of such a treatment.

This deposition, in addition to containing fragments of sickles (**1/14**, **1/15**, **1/18**, **1/21**, **1/23**, **1/31**, **1/33**, **2/55**, **2/57**) is also composed of other tools, weapons and ornaments from various types. These two sets are, for the moment, in the process of being studied and edited, but some conclusions have already been reached, particularly in terms of typology. Eugène Warmenbol, together with his collaborators, was able to publish an overview of the Final Bronze Age in the region of Sambre and Meuse (Warmenbol 2019), integrating the hoards of Petigny which may be

[8] Kuijpers discusses further the issue about metalworking and smiths in his thesis and proposes new paths for research, after a critical review of the conclusions of Butler and Childe: Kuijpers 2008.

dated to the Final Bronze Age II[9] (Genvier *et al.* 2019; Warmenbol 2018; Warmenbol to be published), as well as a preliminary inventory (Genvier *et al.* 2019). The complete catalogue is currently being edited and will be published in the proceedings of "Les Journées d'Actualité de la Recherche Archéologique en Ardenne-Eifel (17-18 octobre 2019)", and Eugène Warmenbol has kindly allowed the present author to consult it. A detailed account of these two hoards' content is therefore beyond the scope of this thesis. However, I will have to dwell on some important elements to allow a better understanding of the depositions' nature.

First and foremost, these hoards have indeed delivered different types of goods. The first set contained seven fragments of sickles, four of which could belong to a single knobbed specimen (1/14, 1/15, 1/23, 1/31). The second deposition contained two of them. Axe fragments are also present in both depositions, with winged axes and archaic socketed axes, including some of the Niedermaas type being complete (Butler 1973; Warmenbol 1987; Van Impe & Creemers 1993). The first deposition also delivered fragments of knives.

Weaponry forms the second category and is represented by fragments of swords, among others of the Wilburton (Quilliec 2007; Milcent 2012, 107-109; Warmenbol 2009) and Grossauheim types (Schauer 1971, 545), sword sheaths elements, probably of the so-called "evolved" type and characterised as Wilburton (Milcent 2012, 109-111). Finally spearheads, perhaps of the Parisian type, complete the arsenal (Van Strydonck & Warmenbol 2012, 7; Warmenbol 2010).

Ornaments were present as well, presumably Rhenish, including bracelets of the Pfeddersheim type (Eluère 1975; Richter 1970, 146-149) and a Wollmesheim (Eluère 1974; Richter 1970, 64-67) leg piece. In addition, several pieces of chariot, which is unique in Belgium, and fragments of bandage that could indicate a miniature chariot or a shield were also recorded (Genvier *et al.* 2019, 69-72).

In conclusion, regional trends seem to emerge from both depositions, while the first contains more armaments and the second more ornaments (Genvier *et al.* 2019, 69). Thus, it would seem that the tools were more likely to be made in Belgium, the

[9] Corresponding to 1250-1050 BC (Milcent 2012, 107-117)

weapons could come from France, the ornaments from Germany and finally the chariot elements from Central Europe (Warmenbol to be published).

3.3. Conclusion

The first section of this chapter has shown that this thesis is situated at the intersection of disciplines that have their own traditions. The review of the previous literature, far from being exhaustive, has however made it possible to assess the most recent developments and conclusions concerning the phenomenon of deposition, agricultural technologies, archaeometallurgy, use-wear studies and experimental archaeology. The most striking observation is the lack of studies on use-wear focused on bronze tools, and more specially on sickles. Non-ferrous experimental archaeology has also been used mainly to reconstruct the techniques linked to the manufacture of bronze artefacts, neglecting their use. Consequently, researchers invested in use-wear studies are left without a suitable reference base. As a proper background is therefore lacking for the kind of the present study, the exploration of a broader horizon was necessary to enable this thesis to achieve its objectives.

In the second section, it has been established that the twelve sickles and fragments of sickles studied in this thesis stem from different types of deposition involving artefacts of multiple origins. It was thus possible to establish with certainty that ten of them came from "regular" depositions, one sickle had been hypothetically linked to a settlement (E2010) and one to a possible burial context (WE 7). For the latter two, however, some doubts may be expressed. Indeed, E2010 is separated by several hundred years from the settlement it was linked to, on basis of its morphology. Regarding the possible funerary context of WE 7, this could not be formally established because of the age of the discovery and the lack of control excavations. Even if the funerary context were certified, it would still be necessary to link the deposition chronologically to it.

In any case, it should be mentioned that these two situations are also peculiar since E2010 was found alone, whereas WE 7 was part of a set of three objects of different nature and provenance. The hoards of Petigny and Heiloo present a similar situation to that of WE 7, being composite in their own way. Indeed, those of Petigny have yielded an impressive multiplicity of types, origins and preserved states[10], while

[10] From the small and hardly identifiable fragment to the complete or restorable specimen.

that of Heiloo distinguished itself by its multiple composition in terms of material, with its bronze and flint sickles. For all these situations, however, it is difficult to consider the functional hypothesis (Fontijn 2002, 13-17, citing Hodges 1957; Kubach 1985; Von Brunn 1968), which would give these depositions the status of stocks destined to be recast or traded and subsequently lost by their owners. This hypothesis does not make sense as one would expect this kind of stock in the vicinity of the workshop or the household (Brumfiel & Earle 1987; Kristiansen 1987; Kristiansen & Larsson 2005; Kuijpers 2008, 32-33; 108-109; Kuijpers 2017, 4-5). On the other hand, the link established between E2010 and the former settlement, as well as the possible presence of WE 7 in the vicinity of a burial mound could correspond to one of Fontijn's theories about depositions' nature (Fontijn 2002, 33-36). Indeed, their link with a structure or a special event corresponds well to the role of marker for a particular community. Following this idea, the depositions could thus be used to delimit a physical and memorial territory in non monumental landscapes (Fontijn 2020, 144-149), which fits well with situations encountered here.

4. Results

4.1. Introduction

Now that the preliminary studies have been carried out it is time to get into the heart of this thesis with the results obtained by the traceological analysis. These will then be discussed and compared with the data obtained from experimental archaeology in the next chapter. The traces can stem from different actions. Indeed, they can be linked to the very nature of the material, to the manufacture, the sharpening, the way of hafting the tool, its use, its destruction or even to post-excavation manipulations. Indeed, since the period of time that has elapsed since the discovery of the sickles sometimes exceeds a century, it is vital to reconstruct the series of manipulations undergone by the tools. This could allow to understand the extent to which they may have influenced the traces that could be seen during their study under the microscope, and how the conclusions could be affected. Then, the results concerning pre-deposition actions will be detailed, focusing on the characteristics that will allow, in the next chapter, to determine the origin of the traces.

These traces can be distinguished on the basis of their nature, directionality, regularity, length and depth. Hence, it has been possible to identify striations or scratches that can be multi-directional, transversal or longitudinal, long or small, deeper or shallower, often superimposed to form a complex stratigraphy. Dents and notches can also be observed on the cutting edge. They can display various shapes, as they may be more or less deep or extended, with a rounded or rather straight profile. These characteristics may indicate the nature of the damage (fig. 4.1A).

Under certain conditions of conservation, it was also possible to observe polish on the sickles, which is a feature that is commonly used in lithic use-wear analyses (D’Errico 2017; Little & Van Gijn 2017). Its degree of reliability has been established in a previous chapter (fig. 4.1B). During the casting of the bronze, it is possible that some undesirable and superfluous elements may remain, such as casting flash for example (fig. 4.1C). These, of various shapes, are present on several specimens, more or less retouched during the finishing process of the sickle.

Accidental or intentional, some other damages have profoundly affected the effectiveness of the tool. Blows with another instrument or weapon, as well as bending, could sometimes affect the tools to the point of partial or even complete fragmentation (Knight 2018, 155, tab. 5.2; Knight 2020). To conclude the review of the various traces found, it is now necessary to mention the perforation marks and residues that are difficult to identify. While the former are easy to spot and can provide valuable information on how the bronze blade was inserted in a wood shaft, the antiquity of the latter is more questionable. Indeed, it is normally unlikely that adhesive residues have survived the passage of time on bronze artefacts, and their presence will be discussed extensively in the next chapter, as they could also be evidence of particular hafting techniques (Steensberg 1943, 14, fig. 5; 16, fig. 7).

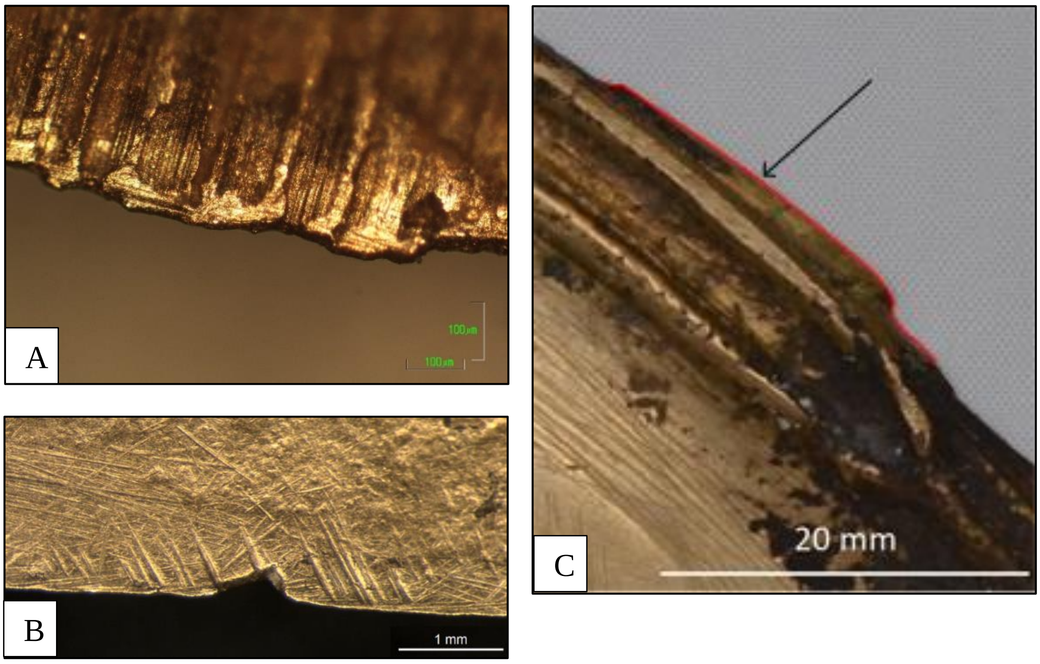

Figure 4.1: example of the striations stratigraphy associated to a notch, located on the cutting edge of Exp1568 (experimental sickle); polish in formation (B), located on the cutting edge of Exp1569 (experimental knife); remains of the bronze casting of Exp1568 (C) then folded by hammering (experimental sickle)

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4.2. Modern treatments and how to identify them

4.2.1. Introduction

Bronze sickles were manipulated a lot since their discovery, which could have produced traces that can complicate the reading of the actual traces of use. Some of them are detailed in the related publications, but others do require some in-depth investigations. Thus, while archaeologically recovered artefacts are quite easy to track, from their discovery to their exhibition or storage, private finds raise some issues that grow along with the antiquity of their finding.

In the first case, the information may be easily found in the publication of the artefacts or by asking directly to the institution hosting the latter. In the other situation, information received from museum may prove insufficient. Nonetheless, it is still feasible to get a good idea of the manipulations performed so far by addressing directly, whenever possible, the discoverer of the artefact. If this procedure still appears to be insufficient, it is therefore necessary to contact the institutions in charge of the restoration and conservation of archaeological objects. These institutions are generally an obligatory step in the process leading to the exhibition of such items. In the Netherlands, the *Rijksdienst voor het Cultureel Erfgoed* (RCE) is in charge. The *Institut royal du Patrimoine artistique* (IRPA) which is theoretically the Belgian equivalent, did not have to be contacted in the context of this research.

The causes of a potential obstruction for use-wear analyses on tools can be of various kinds. As early as the excavation process, archaeologists' tools can cause damage that may be mistaken for traces of use. Fragmentation and blow marks can occur at this stage, but are quite easy to identify, as the variations in corrosion may signal a modern deterioration (Bell 2019, 159, citing Crellin 2014, 182; Melheim & Horn 2014, 12; Moyler 2007; Roberts and Ottaway 2003). The way in which the artefact is stored before it is taken over by conservators and restorers is also likely to damage the artefact to a greater or lesser extent, but in a way that can still be identified. The conservation process referred to is normally the first stage that involves the use of chemical solutions such as paraloid treatments. They do not cause any harm to the object itself, but they may obscure its traceological reading (Graziano 2012, 539-540; Sych *et al.* 2020). Restorations are much more problematic since they involve grinding or other destructive interventions that erase use traces. After the conservation treatment stage, the artefacts are ready to be displayed in a museum and studied by archaeologists, which in turn can result in an irreversible but no less noticeable harm to an informed eye. Friction, blows, and breakage are thus made possible by the displacement of the artefact from an institution to another and its re-handling. In some extreme cases, archaeological objects may even end up missing because of negligence, as it is the case with the sickle H.1930/7.35 from Venenburg, lost after

Butler's studies in the 90's[11]. Finally, voluntary destructions may occur because of the sampling for physico-chemical analyses. Indeed, some techniques of analyse need special quantities of material coming from the artefact in order to get precise and accurate data, while others that are also less reliable do not require any sample collection (Tykot 2016). Physico-chemical analyses are always evolving and improving, but former composition studies may have left indelible marks on bronze tools. In the following sections the selected sickles or sickle fragments will be described in terms of their find history, context, and conservation treatments.

4.2.2. E2010 (Ede)

During the first macro-observation of the tool, it was noticed that a circular indentation was present at the rear of the sickle (fig. 4.2A), at a location that corresponds in part to the hafted part of the tool, the attachment system of the latter being based on the front knob. Observation with the stereoscopic microscope also confirmed this finding as will be detailed later in this thesis. As the modernity of this incomplete perforation could not be totally ruled out due to a corrosion that was difficult to differentiate, it was decided to contact the RMO to check whether any destructive treatment or physico-chemical analysis had been carried out beforehand. In fact, inquiry was necessary, since Arnoldussen and Steegstra's review of the analyses undergone by the sickles does not mention any for E2010 (Arnoldussen & Steegstra 2016, 94-96, tab. 1).

It was thus established by Luc Amkreutz, curator of the Prehistoric collections at the RMO, that no treatment was performed on it during its stay at the museum and that it was necessary to contact the finder. Subsequently, the latter certified that he had not handled the sickle during its stay at home, had not treated it, and that it was therefore necessary to contact the RCE - ROB at the time the sickle stayed there - where the sickle had remained for some time. As a result, it was finally understood from one of the institution's conservation experts that, given the active corrosion pattern of the tool, it had undergone only minimal treatment. At most, a combination of BTA with paraloid was used, which did not make the tool unsuitable for use-wear analysis. It appears, however, that a more concentrated paraloid solution was

[11] The present author was able to get this information through some correspondence with Dr Luc Amkreutz, Curator of the Prehistory of the Netherlands department at the *Rijksmuseum van Oudheden* in Leiden.

applied to the base in the form of strip to inscribe the inventory code (fig. 4.2B). Unfortunately, this latter could conceal some of the traces that could result from hafting. Finally, it is safe to conclude that no modern manipulation or physico-chemical analysis could be at the origin of this rather large perforation, which is of prime importance to analyse in order to understand the manufacture and hafting processes of this tool.

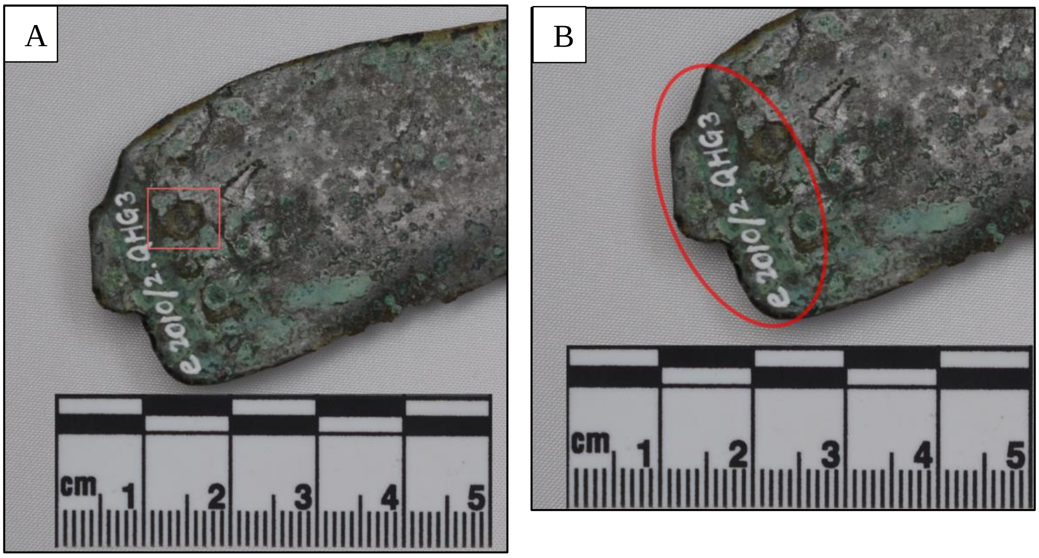

Figure 4.2: detail of the perforation (A) and the inscription on paraloid (B) on E2010/Ede

4.2.3. G1947 (Epe)

There is little information about the treatments received by this bronze sickle from Heiloo underwent. Indeed, the age of its discovery and the uncertainties regarding the first years following its discovery shed a dark veil on most of the possible manipulations. There is no evidence in the records that the tool was at the RCE for conservation purposes. Meanwhile, the latest studies make no mention of any mechanical or chemical intervention on the tool, and the only physico-chemical analysis seems to have been carried out in 2015 by Arnoldussen and Steegstra, using a portable XRF (Arnoldussen & Steegstra 2016, 94-96).

It seems that no heavy paraloid solutions were used on the sickle, which could also be explained by a corrosion pattern that is finally quite weak, or at least no longer active. To go further in this identification of the possible interventions, it might be necessary to employ other methods prescribed by conservators and restorers, such as UV lamps, which would make it possible to detect treatments with a very low concentration of paraloid (Ghistelinck 2019). Nevertheless, this would not necessarily be very useful in the context of this thesis, since there is no real, or at least visible, alteration of the traces of wear. Furthermore, it seems that the identification number was traced without prior protection in the area where the tool was hafted. This could explain its degradation, while it may cause some problems for a use-wear analysis of this particular process. It is possible, however, that a product was applied to certain areas of the tool, such as the cutting edge, or that it remained there only. Indeed, microscopic observations have revealed the presence of whitish residues (fig. 4.3). A first possibility would be that these are what remains of a wax applied to simplify the making of a sketch of the archaeological piece in previous studies, as suggested by Eric Mulder. The second option would be that this wax would have been applied to protect the object within the scope of conservation processes that are now obsolete (Jaeger 2008; Moffett 1996). However, even if they obstruct the traceological reading in some places, these residues are rather easy to remove locally by applying an ethanol-based solution, which seems to discard the possibility of them being part of some corrosion pattern.

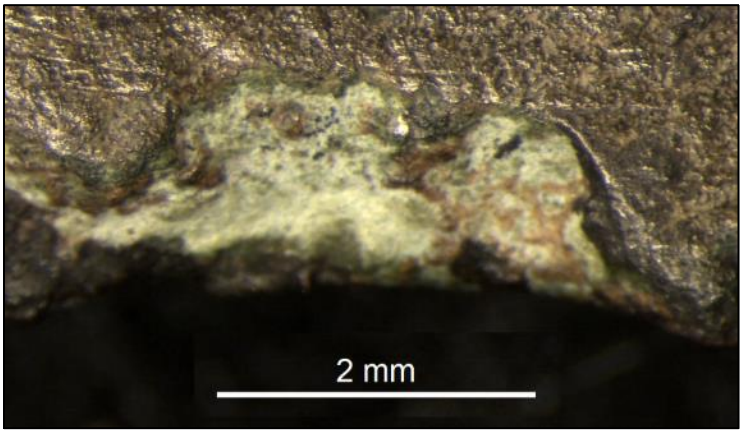

Figure 4.1: detail of the wax present on the cutting edge of G1947/Heiloo

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4.2.4. WE 7 (Epe)

The data concerning the treatments and manipulations WE 7 may have undergone during the century and a half that separates us from its finding are completely absent. In fact, the various publications concerning the hoard of Epe make no mention of it, and focus on the typological aspect of the tools that compose it (Arnoldussen & Steegstra 2016; Butler 1969; 1971; 1990; 1995/1996; Modderman, P. J. R. 1964; O'Connor 1980; Schmidt & Burgess 1981). Once again, the contact with Luc Amkreutz proved unsuccessful, as the antiquity of the acquisition of the Epe hoard by the RMO did not allow the recording of the oldest operations of conservation. Moreover, given the stable state of the corrosion and the quality of preservation of the tool, it is more than likely that it did not need to undergo any more intervention recently. Macroscopic and microscopic analyses did not allow the identification of any handling other than modern corrosion removals due to unintentional friction (fig. 4.4A), or a different pattern of corrosion in the hafted area which remains enigmatic (fig. 4.4B). In addition, it is also possible that the sickle may have undergone a wax treatment, already identified for G1947. Indeed, in some fissured areas, particularly in the fracture towards the tip of the sickle, whitish residues were found (fig. 4.4C).

To conclude, the only operation that may have degraded the conditions for a use-wear analysis is the inscription of the inventory code on the tool, without precaution, directly on the surface. Its location, on the base of the blade, at the intersection of the "normal" corrosion zone and the "greenish" corrosion zone is problematic. As it is the case for G1947 and E2010, it could disrupt the analysis of the hafting process of the tool. Other possible manipulations, however, do not seem to be able to affect in any way the traceological study.

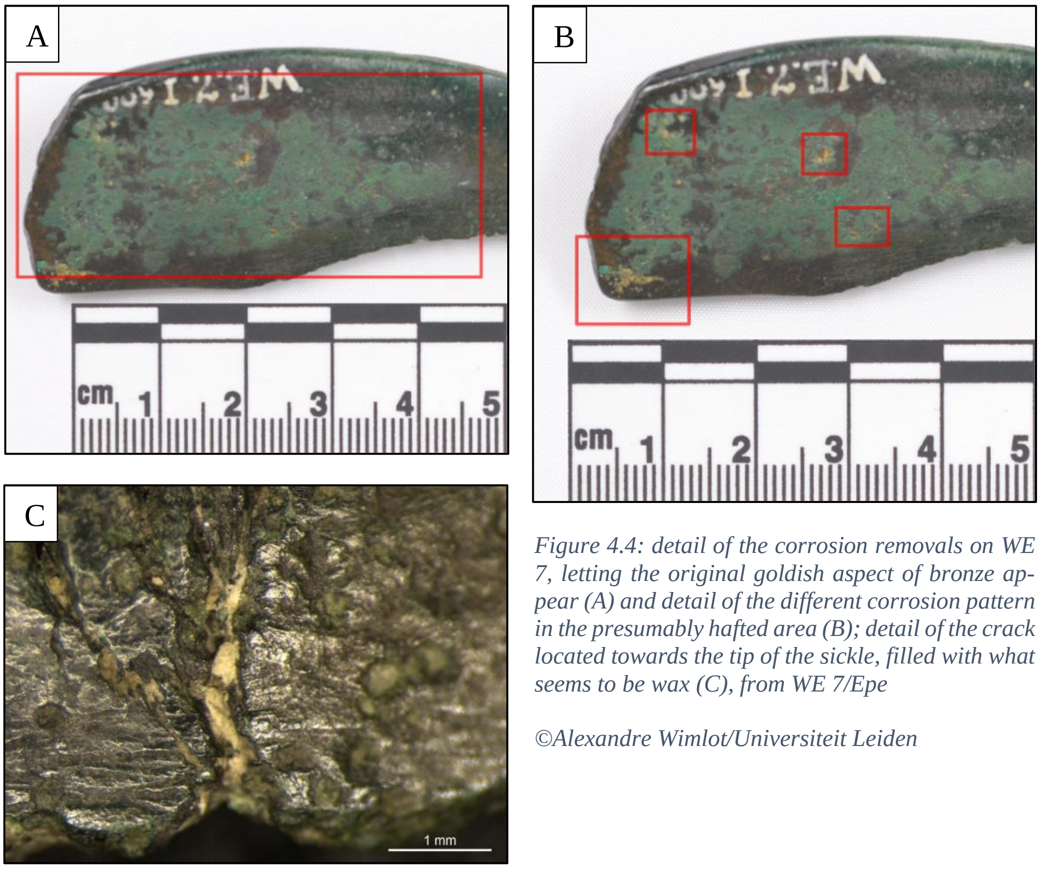

Figure 4.4: detail of the corrosion removals on WE 7, letting the original goldish aspect of bronze appear (A) and detail of the different corrosion pattern in the presumably hafted area (B); detail of the crack located towards the tip of the sickle, filled with what seems to be wax (C), from WE 7/Epe

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4.2.5. Petigny

Because of its recent discovery the material from Petigny has not been handled extensively. The archaeometallurgical analyses will be carried out using non-destructive techniques such as XRF, and no conservation or restoration treatment has been accomplished yet. According to Eugène Warmenbol, the discovery was made by experienced detectorists who are unlikely to have caused serious damage to the depositions during their excavation. Nonetheless, after analysis, two types of damage are suspicious and could be of modern origin. Indeed, blow marks have been identified on 1/33 (fig. 4.5A), and some of the fragments show removals of patina (fig. 4.5B). For this issue, colour is a good indicator of when the damage occurred. Indeed, while the blow marks seem to differentiate very little in terms of patina colour, the removals reveal the original golden lustre of the bronze. Thus, while no certainty can obviously be established, it would appear that the blows rather precede the deposition act, whereas the patina removals could be the result of unfortunate handling during or after the excavation, or of unintentional rubbing during storage. The fragmentation, however, is ancient, since the section displays a patina similar to the one covering the rest of the specimen.
To conclude, nothing seems to obstruct the traceological reading of the fragments. The blow traces with no real change in patina colour will be included in the use-wear analysis, and the absence of identification code allows access to all areas, and therefore does not complicate the understanding of the hafting area, as it is the case for the older sickles that we have had the opportunity to deal with in the context of this thesis.

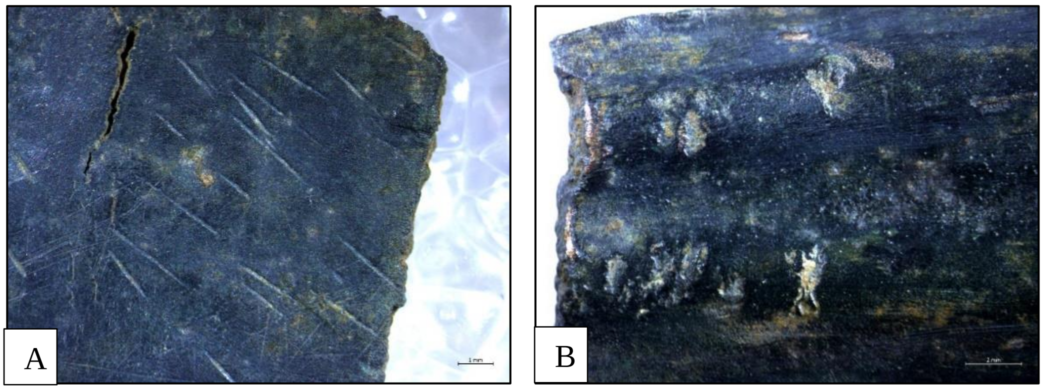

Figure 4.5: blow marks on the B-side of 1/33 (A), and blow marks on the A-side of 1/21 (B), from Petigny

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4.2.6. Conclusion

Thanks to the various methods of investigation used here, it has been possible to identify interventions of various kinds. These can be divided into conservation and restoration treatments, storage, study and exhibition manipulations, and finally analytical interventions, which here do not go beyond the non-destructive framework. In the first category, it is then possible to distinguish between potential wax-based treatments, which leave a whitish residue on the artefact, and more recent paraloid-based treatments which leave hardly any visible traces. The second category includes the inscription of the inventory code directly on the object, with or without prior paraloid treatment, but also modern damage due to unintentional rubbing and other careless handling, which mainly affect the patina or the corrosion. The last one, finally is of little importance for the coming use-wear analysis, as it does not influence the surface of the sickles at all, since it is the XRF analyses that have been carried out as a priority by previous researchers.

Thus, some limitations arising from these interventions are to be considered in the framework of the traceological analysis. The wax present in some depressions or on the cutting edge of the tool and paraloid treatments, for their part, do not present any problems for the use-wear study. The inventory numbers, on the contrary, significantly affect the analysis of the hafting area by obscuring parts of the base of the sickle, since it is there that they are systematically written. It might be possible to erase them in order to access the area covered, but this was not requested for this master’s degree work. Finally, damage resulting from modern handling does not really cause any problem in the identification of use and manufacture traces, such as striations and dents, but may on the other hand be confused with ancient damage deliberately caused.

4.3. Comparing the sickles from the Netherlands and those from the hoards of Petigny: establishing categories of traces

4.3.1. E2010, G1947 and WE 7

From the microscopic observations (app. 1), it appears that two distinct ensembles can be distinguished quite clearly in terms of traces. On the one hand, the sickles from the Netherlands constitute a homogeneous group that displays polish, notches, dents and transversal striations on the cutting edge, while on the other hand, the two hoards from Petigny delivered fragments that show principally long longitudinal striations and traces that may be associated to destruction.

Indeed, E2010, G1947 and WE7 present transversal striations that may be regular and shallow, or irregular and deep (fig. 4.6), as well as deep or shallow longitudinal striations (fig. 4.7). Edge damages are also abundantly present on these tools (fig. 4.8A-C), sometimes linked with polish (fig. 4.8D-F), while the hafting part shows some interesting traces as well (fig. 4.9A-C), as polish and striations. Some flashing, located either on the edges or on the hafted part, were conscientiously worked, to improve the efficiency and the finishing quality of the tool (fig. 4.9D-F).

These sickles also have special characteristics. E2010, for instance, displays some peculiar features such as a possible adhesive (fig. 4.10A) and an incompletely drilled hole, both on the B-Side (4.10B). G1947, meanwhile, shows traces of material deformation, a complete hole for hafting, whose irregularity and striations make it look like it was drilled mechanically, and a drop of resin-like material on the A-Side (fig. 4.10C-E). This latter could be a residue from a glue applied to the hafted part. Finally, a partial fragmentation was observed for WE 7, which seems to interrupt the continuity of the striations (fig. 4.10F), which is a detail that can be used to understand the succession of events.

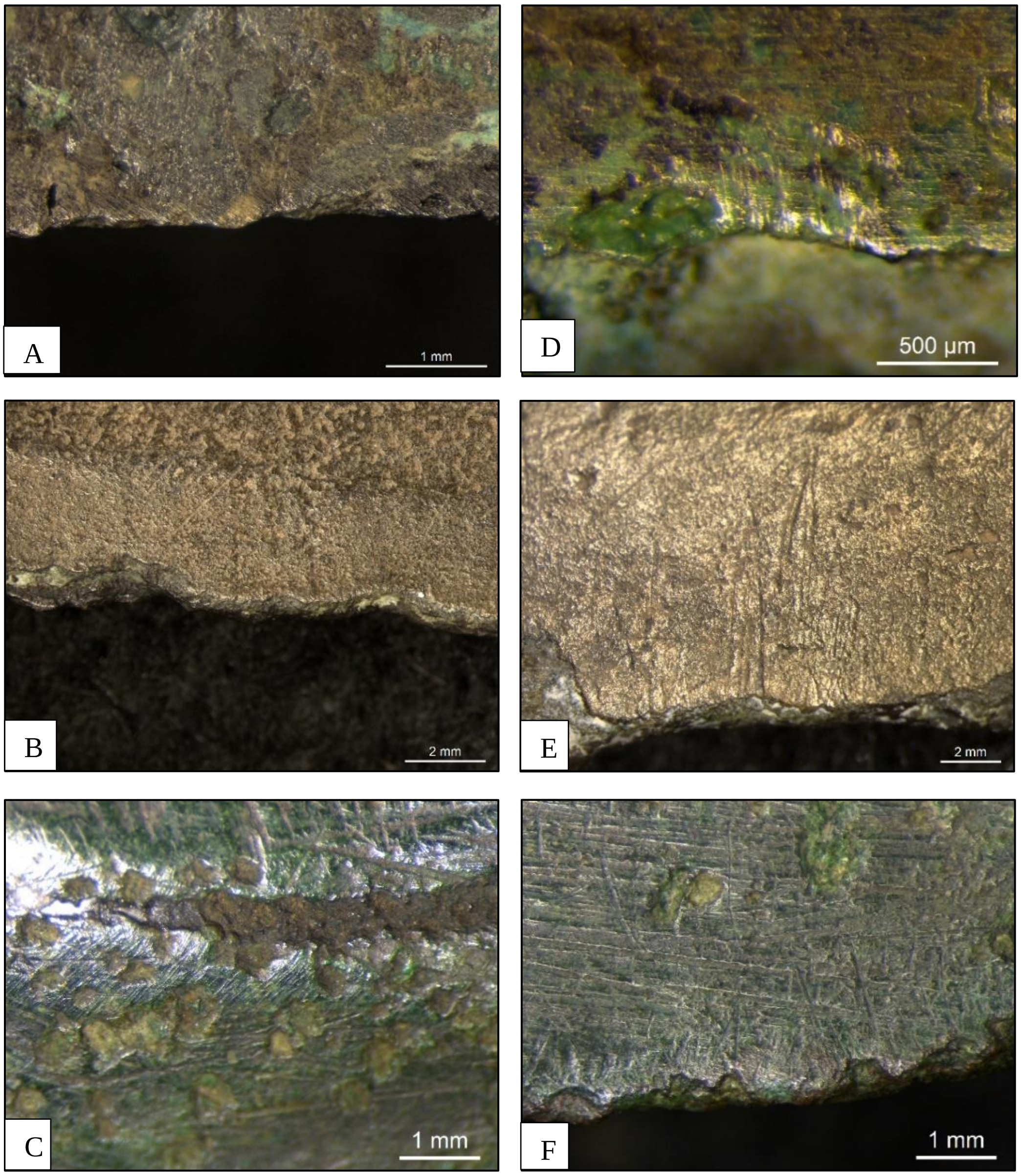

Figure 4.6: detail of light transversal striations respectively on E2010/Ede (A), G1947/Heiloo (B) and WE 7/Epe (C); detail of deeper transversal striations respectively on E2010/Ede (D), G1947/Heiloo (E) and WE 7/Epe (F)

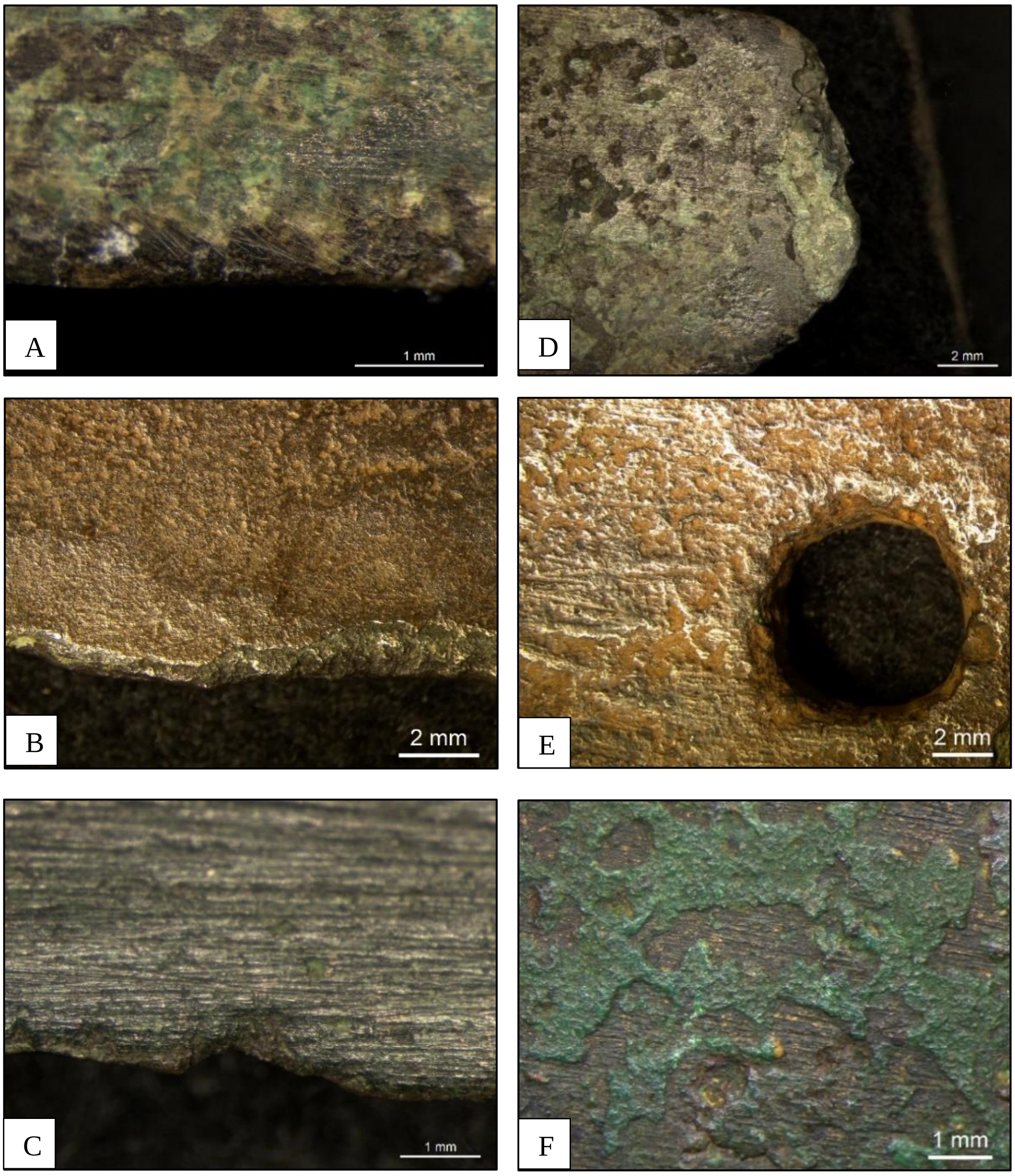

Figure 4.7: detail of longitudinal striations, probably associated with sharpening, respectively on E2010/Ede (A), G1947/Heiloo (B), WE 7/Epe (C), E2010/Ede (D), G1947/Heiloo (E) and WE 7/Epe (F).

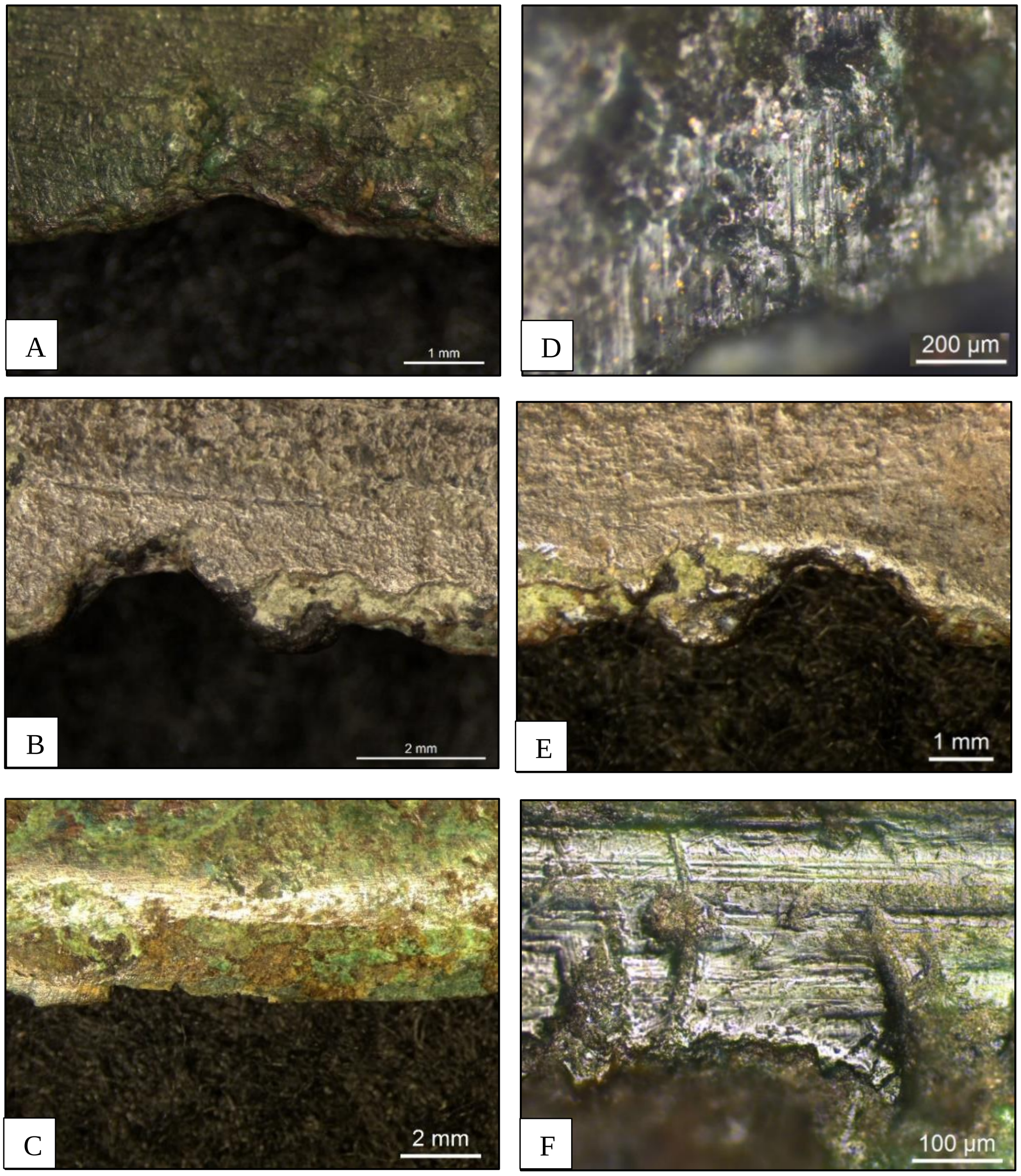

Figure 4.8: notches that may be associated with use, illustrating the several shapes and depths observed, from left to right to bottom, on WE 7/Epe (A), G1947/Heiloo (B) and E2010/Ede (C); different kinds of polish present on the cutting edge, respectively on E2010/Ede (D), G1947/Heiloo (E) and WE 7/Epe (F)

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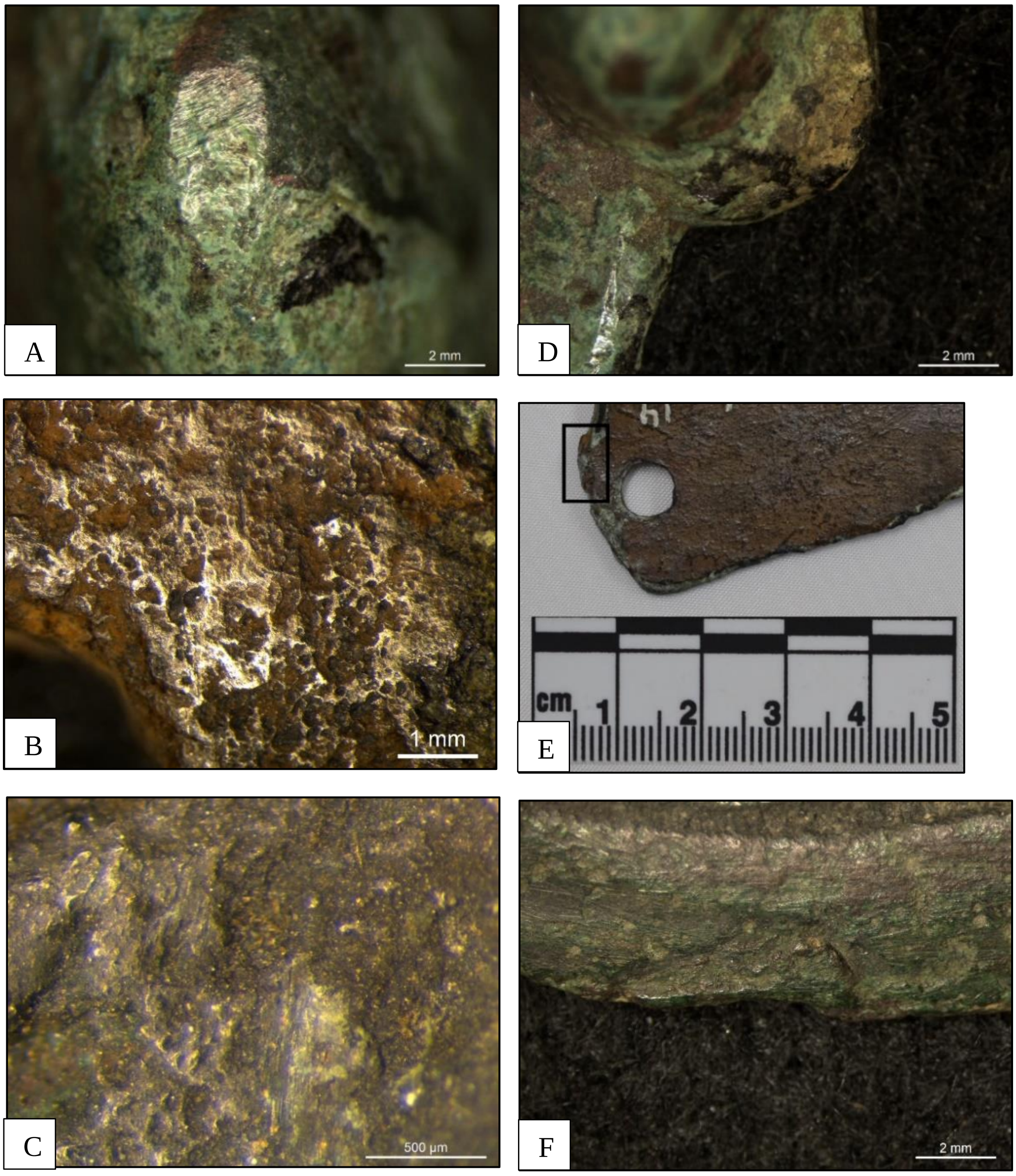

Figure 4.9: traces left after hafting, with a light polish on E2010/Ede's knob (A), a heavy polish on G1947/Heiloo (B) and an impression left in the corrosion that could be consistent with the decomposition of a wooden handle on WE 7/Epe (C); heavily polished casting flashes, on the HA on E2010/Ede (D) and G1947/Heiloo (E), and on the cutting edge on WE 7/Epe (F)

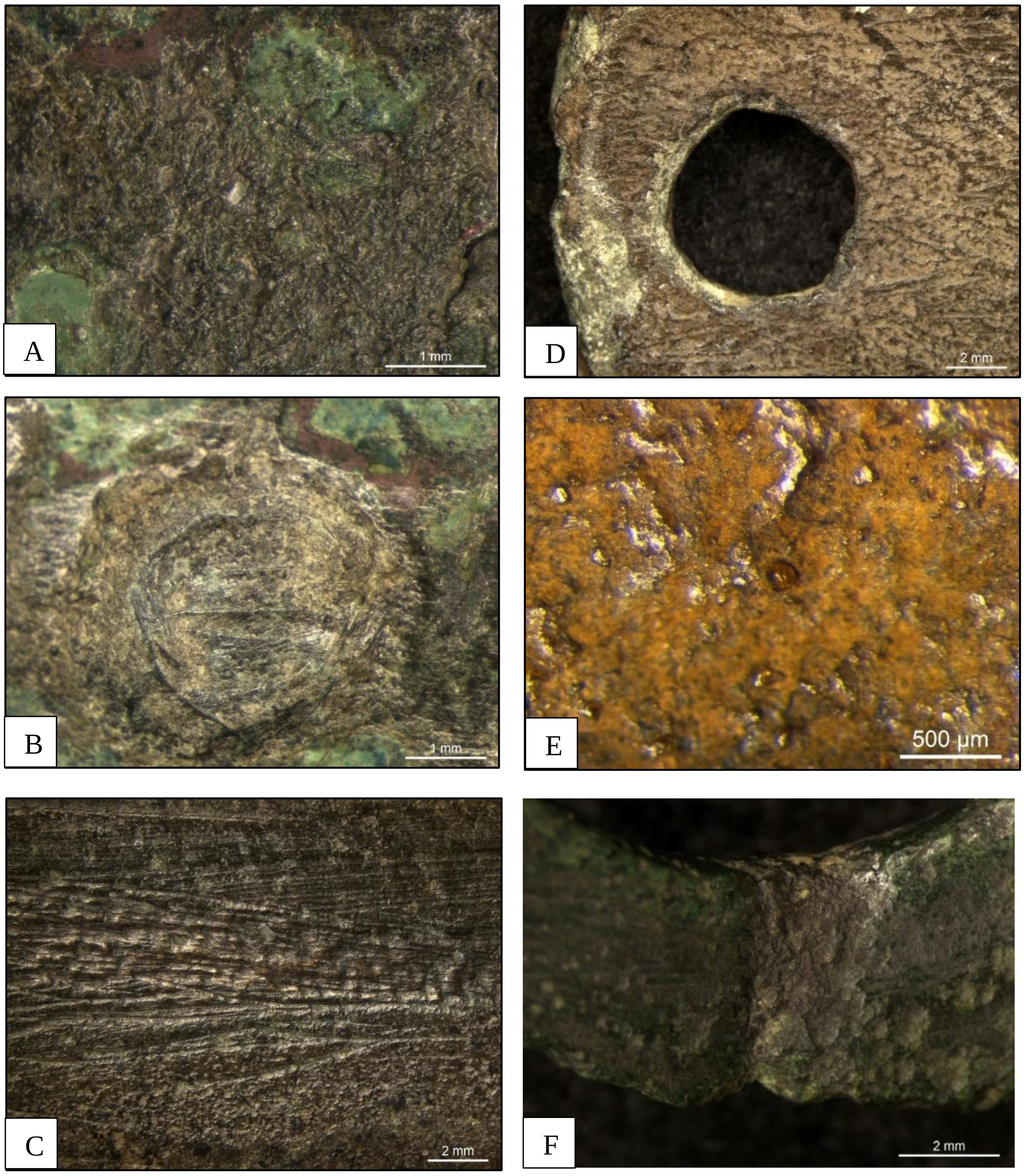

Figure 4.10: adhesive of uncertain origin on E2010/Ede (A); incomplete hole, mechanically drilled on E2010/Ede (B); material deformation associated with longitudinal striations (C), peg-hole mechanically drilled (D) and resin-like drop, perhaps a residue of an organic material or an adhesive (E) on G1947/Heiloo; bending of the blade that may be an accidental damage or linked to a voluntary destruction on WE 7/Epe (F)

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4.3.2. Sickles from Petigny

The fragments from Petigny, on the other hand, display several kinds of striations. Some grooves are multi-directional and are often linked to the fracture points observed on most of the fragments (fig. 4.11). They are shallower than the striations that were observed on the Dutch sickles. Longitudinal striations (fig. 4.12A-C), both regular and irregular, are also common, while transversal scratches are remarkably rare (fig. 4.12D-F), as are notches (fig. 4.12G-H). The multi-directional grooves, together with torsions (fig. 4.13A-C) and blow marks (fig. 4.13D-F), seem to be linked to sickles' end of life. Casting flash, roughly corrected, completes this panorama, showing a probable lack of attention to the finish of the product (fig. 4.14). Hence, the analysis of these traces provides important information for reconstructing the cultural biography of these sickles.

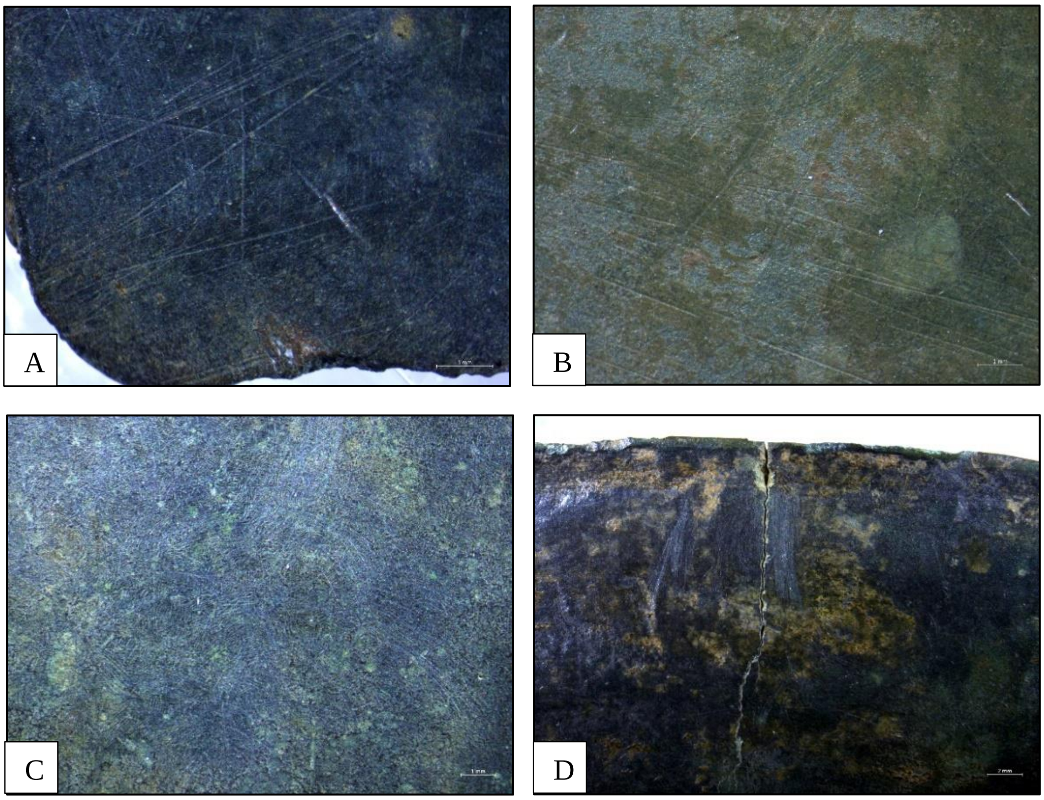

Figure 4.11: multi-directional grooves, of different depth and shape, quite enigmatic, but maybe accidental damages for 1/33 (A) and 1/18 (B), or linked with material deformation on 2/57 (C) and 1/31 (D) from Petigny

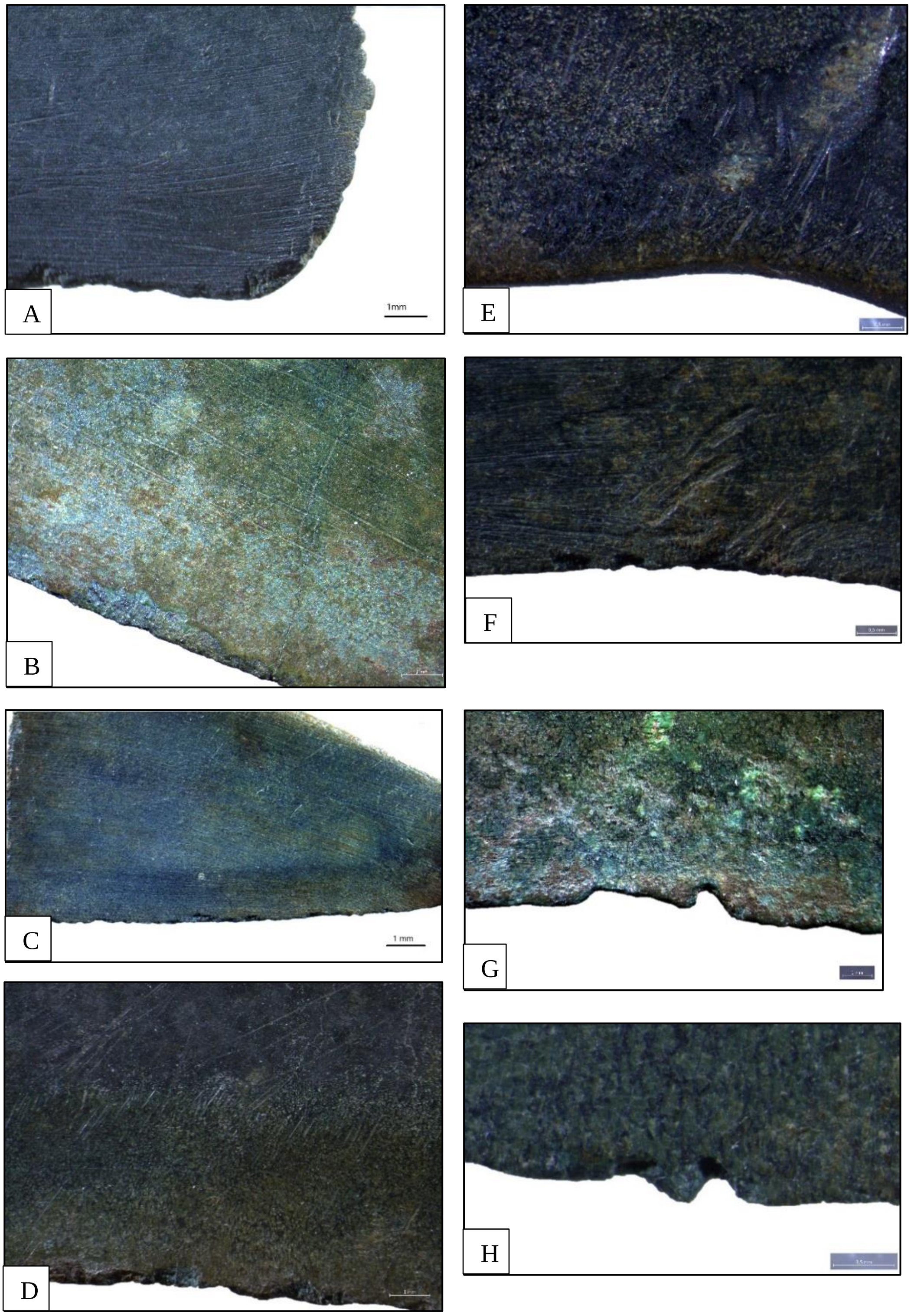

Figure 4.12: longitudinal striations on 1/18 (A), 1/33 (B) and 1/14 (C), transversal striations on A-Side (D) and B-Side (E) of 1/31, and on the A-Side of 1/21 (F); notches from 2/57 (G) and 1/15 (H), from Peti-gny

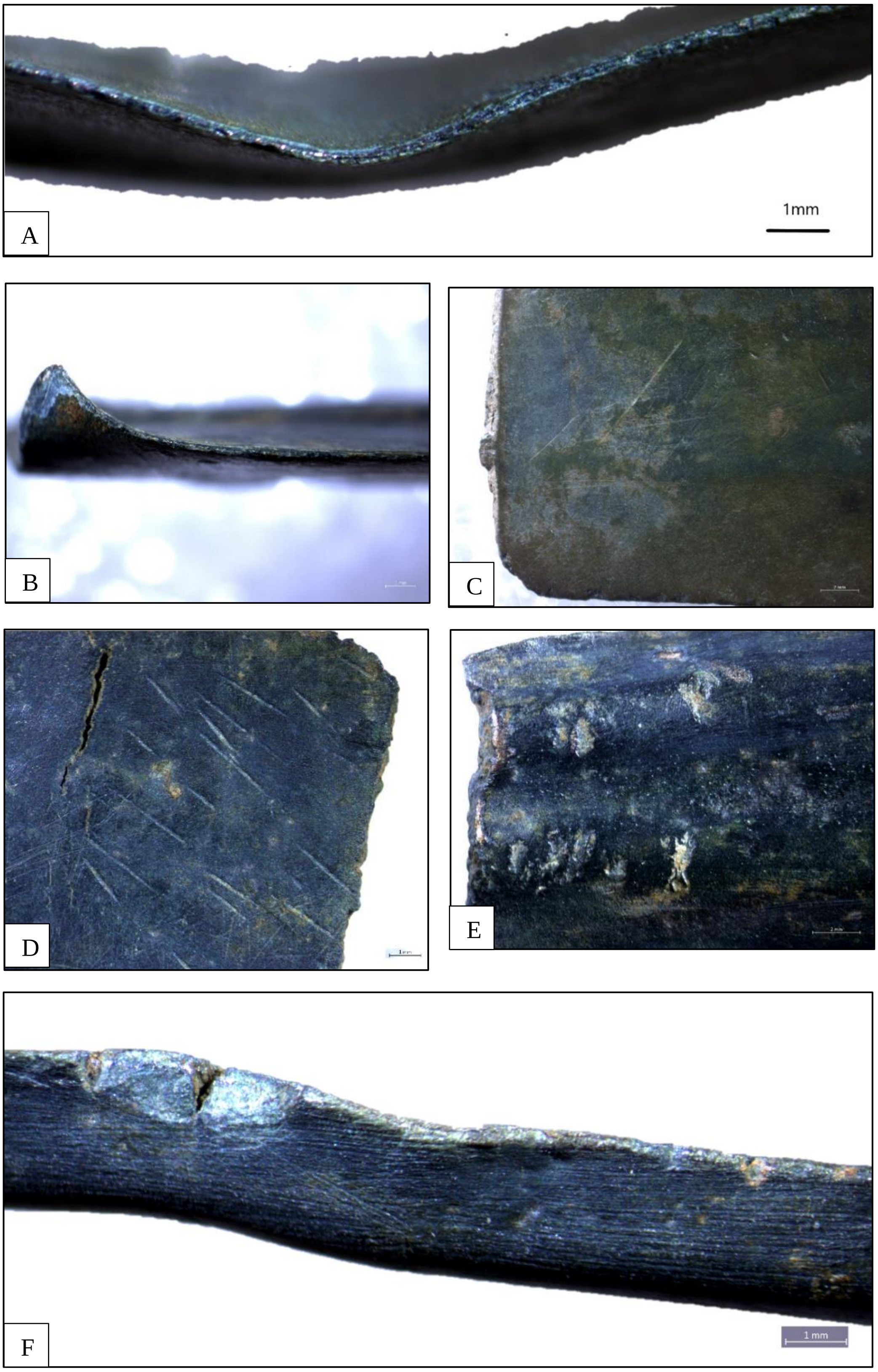

Figure 4.13: torsion of the blade from 2/55 (A) and 1/21 (B) and displacement of material caused by the torsion on 1/18 (C) from Petigny; blow marks on 1/33 (D; F) and 1/21 (E), from Petigny

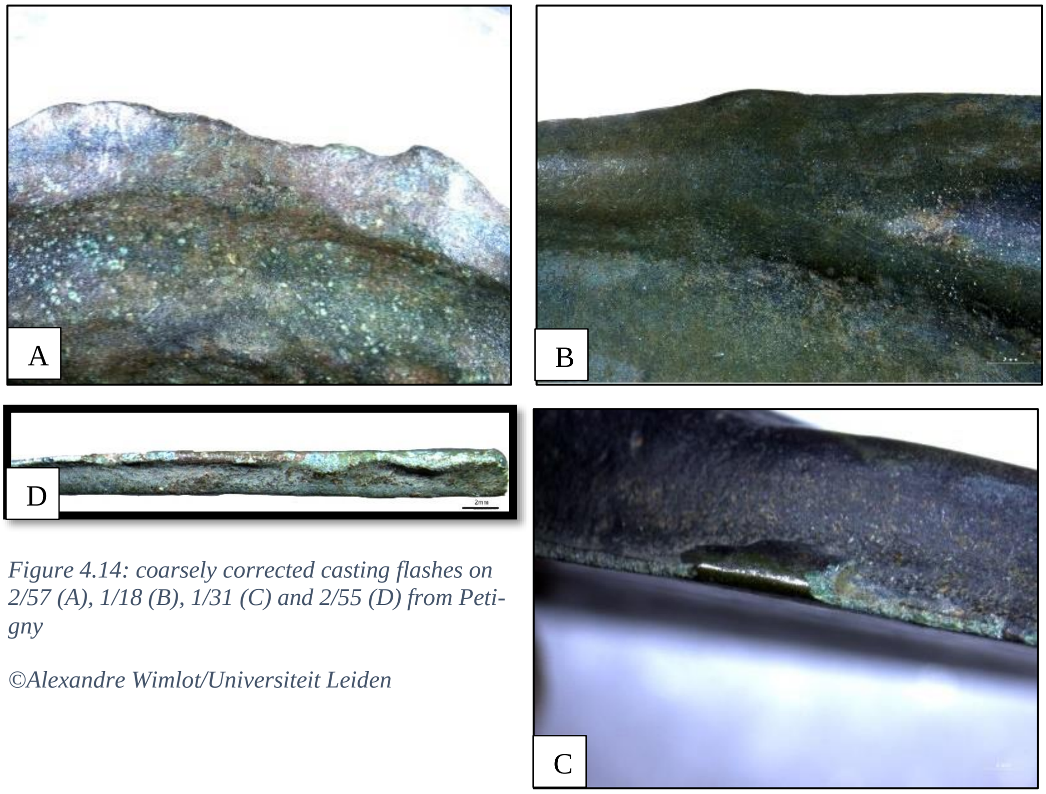

Figure 4.14: coarsely corrected casting flashes on 2/57 (A), 1/18 (B), 1/31 (C) and 2/55 (D) from Petigny

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To sum up the sickles selected for the present study that come from the Netherlands - which are also the oldest as the depositions were morphologically dated to the transition between the Middle Bronze Age and the Late Bronze Age (Arnolduseen & Steegstra 2016; Butler 1990) - show traces of intensive use and an end of life that is only indicated by their deposition or abandon. The sickles coming from Belgium - which are more recent since they are approximately dated from the end of the Late Bronze Age on the basis of the other elements of the depositions (Genvier *et al.* 2019; Warmenbol 2018; Warmenbol to be published) - show very few traces of use but a terminal phase which is characterized by systematic fragmentation. The characteristic elements of these two sets, outlined in the table (tab. 3), will thus serve as a basis for the following chapter, and thus for the discussion that will lead to the reconstruction of the cultural biography of the sickles.

Table 3: summary of the main observations made on archaeological and experimental sickles, as well as on experimental knives. The striations were described further when the feature was significant. The colours presented here are an interpretation of the patina (yellow stands for natural goldish patina)

E: edge / S: surface / H: hafting area / R: ribs zone / T: transversal / L: longitudinal / D: diagonal / M: multi-directional / R: regular / I: irregular / Lo: long / Sh: short / De: deep / S: shallow / X: present / 1-5: degradation level of corrosion

A		E2010				G1947				WE 7				1/14+1/15	+1/23+1/31		
		E	S	H	R	E	S	H	R	E	S	H	R	E	S	H	R
	Striations	TI / TR	LRLo		TR	TShS	LRLo	M		TSh / LRLo / TDe	TDe / LRLo		T	LRLo / T	TRLo		TShS
	Dents					X				X				X			
	Notches	X				X				X				X			
	Polish	X		X		X		X		X		X					
	Corrosion	X	2	2	2	2	2	2	2	2	2	2	2	1	1	1	1
	Patina																
	Residues							X				X?					
	Folding									X	X						
	Blows												X				
	Casting flashes			X						X						X	X
	Bending					X	X									X	
	Fragmentation													X			

A		1/18				1/21				1/33				2/55			
		E	S	H	R	E	S	H	R	E	S	H	R	E	S	H	R
	Striations	LR	TDe / MRS / LR		T / L	TDe / LS / DS				LRLo	LLoS						
	Dents																
	Notches					X							X				
	Polish																
	Corrosion	1	1	1	1	2	2	2	2	1	1	1	1	2	1	1	1
	Patina																
	Residues																
	Folding		X			X				X							
	Blows								X				X				
	Casting flashes				X				X								X
	Bending													X	X		X
	Fragmentation																

A		2/57				Exp 2008				Exp 1569				Exp 2431			
		E	S	H	R	E	S	H	R	E	S	H	R	E	S	H	R
	Striations	LIo	TS			TISD / LRLo	LRLo	LRLoDe		TRDe / TIDe / LI / D	TR / LR			M / LS / TRD	TR / LR		
	Dents																
	Notches	X				X				X							
	Polish							X		X							
	Corrosion	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
	Patina																
	Residues																
	Folding		X														
	Blows																
	Casting flashes				X				X								
	Bending																
	Fragmentation																

B		E2010				G1947				WE 7				1/14+1/15+1/23+1/31			
		E	S	H	R	E	S	H	R	E	S	H	R	E	S	H	R
	Striations	TRL / DS / TDe / Lde	LRLo	TRL		D / TS	LRLo			TISh / LRLoDe	LRLo			TISh	LLoDe / LLoS / MR	MR	
	Dents					X				X							
	Notches	X				X				X							
	Polish	X				X		X									
	Corrosion	3	3	3	3	2	2	2	2	3	2	3	2	1	1	1	1
	Patina																
	Residues			X													
	Folding									X	X						
	Blows																X
	Casting flashes			X		X				X							
	Bending					X	X									X	
	Fragmentation													X			

B		1/18				1/21				1/33				2/55			
		E	S	H	R	E	S	H	R	E	S	H	R	E	S	H	R
	Striations	LIDe / LISh	MI / MRS			MI	LRLo							LIo	MShS		
	Dents																
	Notches												X				
	Polish	X (N)															
	Corrosion	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
	Patina																
	Residues																
	Folding		X			X											
	Blows		X			X	X			X	X		X				
	Casting flashes				X												X
	Bending													X	X		X
	Fragmentation																

B		2/57				Exp 2008				Exp 1569				Exp 2431			
		E	S	H	R	E	S	H	R	E	S	H	R	E	S	H	R
	Striations	TS / LIo	MIShS / T			TISDe / DR		MI		TRDe / TIDe / LI / D	TR / LR			M / LS / TRDe	TR / LR		
	Dents																
	Notches	X				X				X							
	Polish					X				X							
	Corrosion	1	1	1	1	0	0	0	0	0	0	0	0	0	0	0	0
	Patina																
	Residues																
	Folding																
	Blows																
	Casting flashes																
	Bending				X												
	Fragmentation																

5. Discussion

5.1. Introduction

The analysis of the sickles has yielded interesting results. Striations, polish, traces of hafting and destruction, to name but a few, have been observed to different extents for each of the sickles studied in this thesis. It is now time to process these results in order to reconstruct the biography of the twelve sickles and fragments of sickles, or at least to get an overview of the different types of use and discard. The various phenomena observed will be discussed and related to what could be recorded for the specimens coming from experimental archaeology in this chapter. After the identification of potential modern traces in the fourth chapter, it will therefore be appropriate to focus here on what story the presumed ancient traces can tell. These latter will allow to reconstruct the biography of bronze sickles in the Low Countries.

5.2. Hafting strategies

5.2.1. Knobs, holes and semi-holes

The sickles can be hafted using several strategies, which are used, among other things, to define typologies (Arnoldussen & Steegstra 2016, 68-71). These include single or multiple knobs, which predominate in the prehistory of the Low Countries, and peg-holes, which are much less often found there. Since the selected sickles does not present other techniques such as socketing and tanging, which are, however, also attested either for sickles in Europe or for other bronze tools in the Low Countries, they will not be investigated here. The knobs generally show few traces, which are nonetheless rather easy to identify (fig. 5.1). Indeed, the presence of a light polish associated with shallow striations, most often displayed by a slightly flattened face, are traces that were also found on the knob of the experimental sickle (fig. 6.2), hafted according to Gaudron's proposal (fig. 6.3c). It testifies to a minimal use at least, which is necessary to produce these traces through the friction between the haft and the metal.

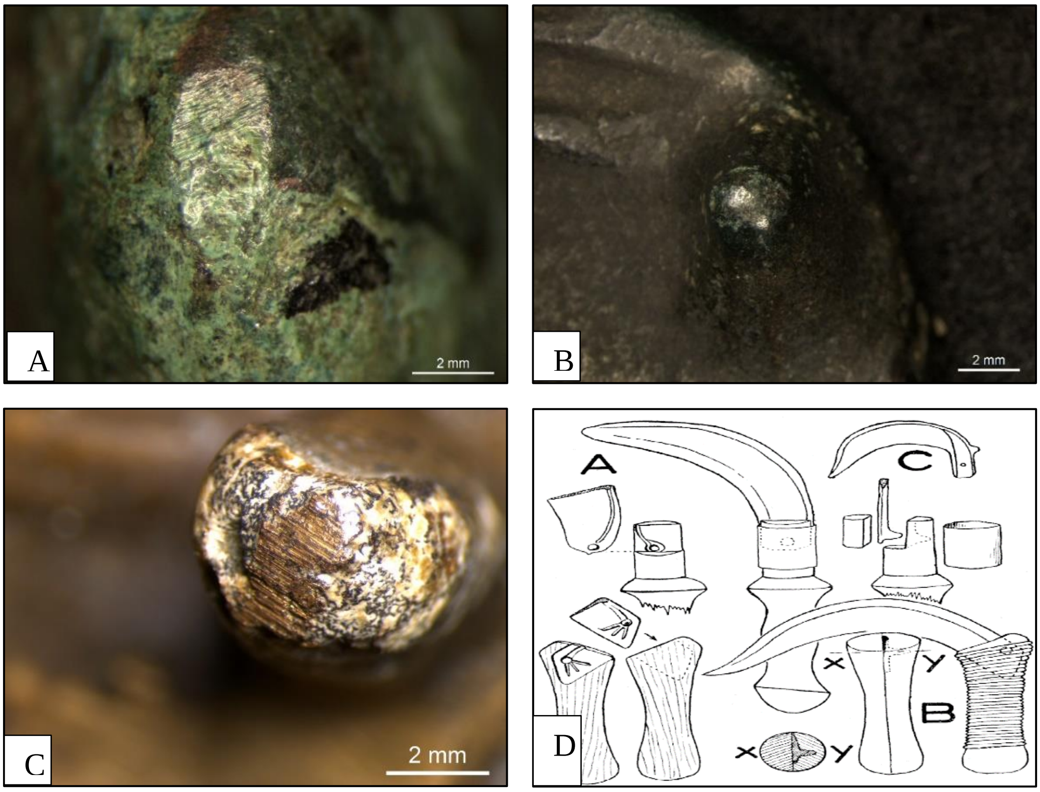

Figure 5.1: detail of the presence of polish and striations on the knob of E2010/Ede (A), WE 7/Epe (B) and on the knob of the experimental sickle Exp1568 (C); on D different propositions for hafting a knobbed sickle (Gaudron 1944, 161)

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<u>G1947</u>

The peg-hole delivered a series of marks which it is more obvious to link to a specific stage of the *chaîne opératoire*[12], as they could especially testify to the process of tool manufacture or give more information regarding the hafting technique. Thus, G1947, which is the only sickle to display a peg-hole to fix the handle, shows a series of interesting traces that can be identified as striations or polish (fig. 5.2A-C). On the one hand, the polish develops on the edges of the hole, where it is rather heavily developed, and as it extends towards the nose of the sickle, it weakens. As the situation appears to be the same on both sides, it could be the result of intensive friction with a nail made of a solid material, most likely metal, which would have made it possible to attach the blade to the handle. The striations are divided into two distinct zones. Inside the peg-hole, their reading is complicated by corrosion,

[12] The biography of objects goes further than the *chaîne opératoire* as it treats the events that happen after the manufacture as well. Here, the concept of *chaîne opératoire* is used since the discussion concerns the hafting technique. See Joy 2009.

which may also have removed any trace of polish linked to the friction of the hypothetical nail. Nevertheless, it is possible to identify deep striations, which certainly originate from the perforation process. Even if the hole was foreseen during the casting of the bronze, it is more likely, given its irregularity, that most of its elaboration was the result of a manual action, using a flint or metal tool (Gutiérrez Saez *et al.* 2017), which could only be identified from experiments that could not be carried out in the framework of this thesis[13].

Figure 5.2: detail of the polish located around the peg-hole on G1947/Heiloo (A; B), the striations displayed on the hafted area (B) and the striations located inside the peg-hole (C); detail of the striations linked with hafting on Exp1568 (experimental sickle), on A-side (D) and B-side (E)

[13] Gutierrez et al. carried out an extensive work about perforation in 2017, but focused on perforating non-metallic materials. It is therefore dangerous to transfer their conclusions on the present situation without further experimentation.

The grooves located on the blade and linked with hafting are different from the grooves of use and sharpening. However, they do not have the same directionality as the traces identified for the experimental sickle, which are irregular and moderately deep, and develop in a half arc towards the tip of the sickle (fig. 5.2D-E). The lack of correspondence between archaeological and experimental traces could either come from the corrosion affecting the archaeological ones, or from a different movement in the action carried out and a hafting following a different angle. Indeed, the movement of the action conditions the resistance that will influence the way the haft moves and provokes friction with the metal of the blade and will determine the type of traces created. If the latter hypothesis proves to be true, the use and probably the type of processed material could be different from harvesting Gramineae, classically considered for sickles.

E2010

Although E2010 is rightly considered as a knobbed sickle, it does have an intriguing feature on the B-side. An incomplete perforation, located more or less in correspondence to the knob, raises questions about the hafting technique. It seems to have been roughly carved, either with a lithic or a metal implement (Gutiérrez Saez *et al.* 2017). The deep striations are patinated, so they may predate deposition (fig. 5.3A-B). Because of its location, it is likely that this perforation was used as part of the fitting. It is indeed possible that it was used as a slot to insert a protrusion of the handle, and thus to add security to the holding of the blade (fig. 5.3C). However, E2010 is the only sickle in the Low Countries (and probably beyond) to present this type of hole in association with a knob. This situation thus considerably weakens the hypothesis developed here, and in the absence of experimentation and parallels, it is difficult to reach any definitive conclusion about the function of this perforation.

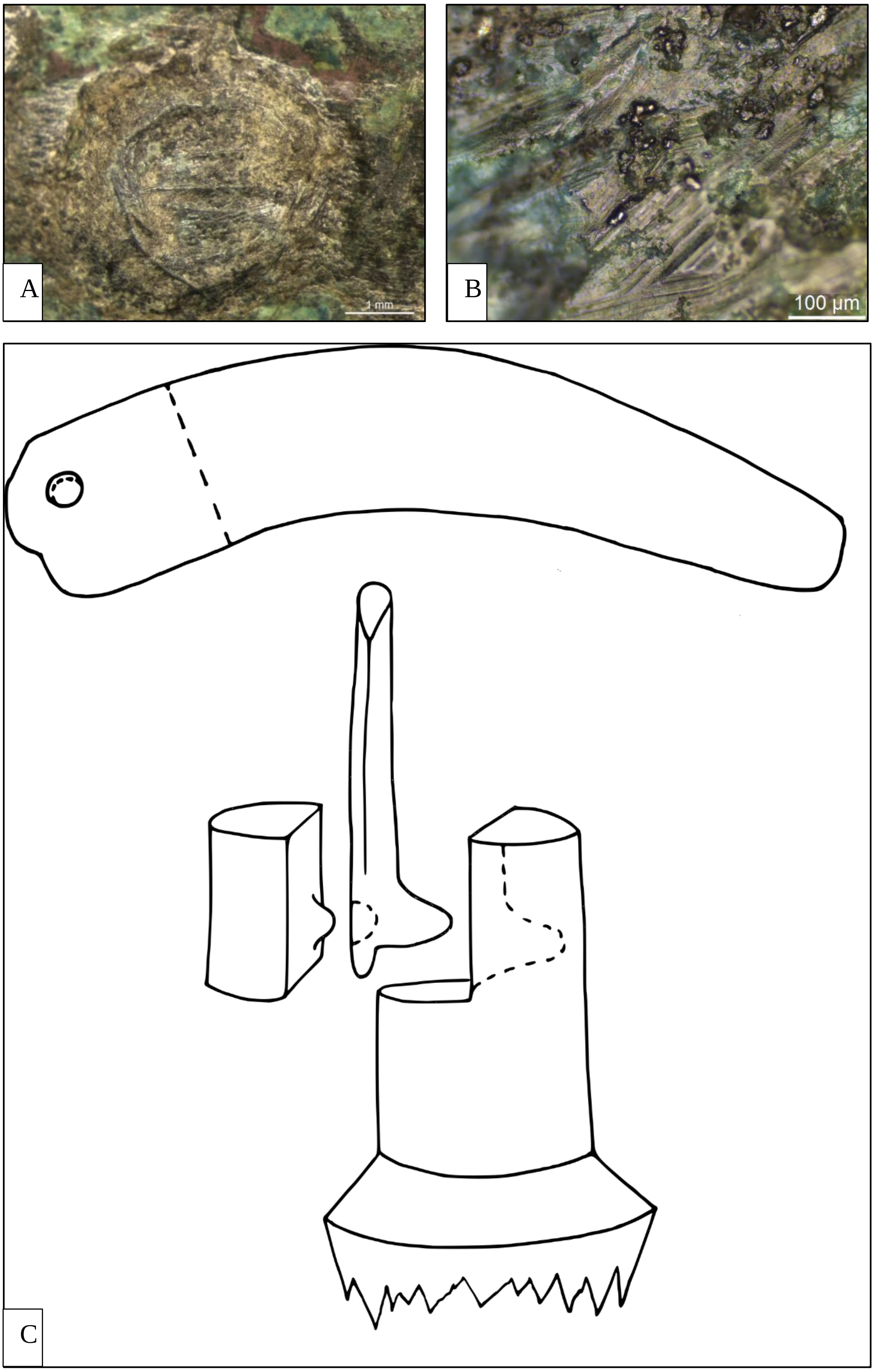

Figure 5.3: detail of the incomplete perforation located on the B-side of E2010/Ede (A) and detail of the patination displayed by the grooves (B); proposition of reconstitution (C) based on the presence of a hole on B-Side of E2010/Ede (after Gaudron 1944, 161, by Marie Vanderlinden)

© Alexandre Wimlot/Universiteit Leiden (metallographic microscope)

5.2.2. Adhesive, residues and patina

Adhesive may have been used in the hafting process and could have left marks on the sickles. It is known that the ancients used materials such as resin to consolidate jewellery and the hafting of bronze implements (Courel *et al.* 2018, 72-79; Gaudron 1944, 163; Morandi *et al.* 2018, 1077-1087). E2010, for instance, presents a material whose antiquity has also been discussed in a previous chapter (fig. 5.4). Nonetheless, it is difficult to settle the matter, since on the one hand the sickle has not undergone any particular chemical treatment that could have caused the development of such a substance[14], and on the other hand, modern brush hairs seem to be trapped in the material identified as glue. The location of this substance could, however, be linked to the hafting since it covers a small section of the blade, which corresponds to the envisaged length of a handle grip as reproduced by Gaudron for knobbed sickles (Gaudron 1944, 1961).

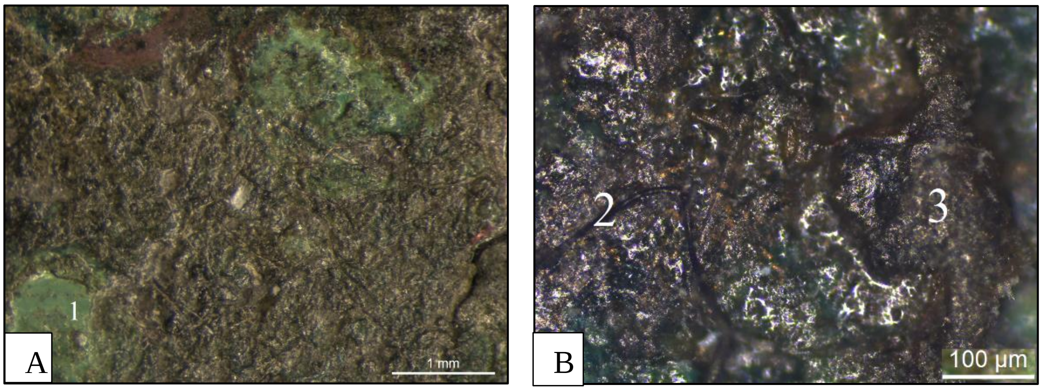

Figure 5.4: detail of glue-like substance displayed on the B-Side of E2010/Ede (1(A): layer of greenish patina; 2(B): layer of brush hairs; 3(B): layer of covering substance)

From a micro-stratigraphic point of view, it seems relevant to distinguish three levels. A first one corresponds to a patina pattern that looks quite dissimilar to the one displayed by the rest of the blade. The second level consists of the brush hairs and the third, finally, is the substance that traps them. Despite the absence of chemical analysis, it is still possible to draw some conclusions. It is conceivable that the sickle may have undergone a treatment either as part of its conservation process or in the framework of its exhibition, which could be reflected in layers 2 and 3, contradicting the indications from the RMO and the RCE. The greenish patina, on the other

[14] As certified by the RMO and the RCE.

hand, could be explained by the presence of a material at the time of use and deposition, be it an adhesive, the wood of the handle, or more likely both. These materials, by their presence and then their decomposition, could have influenced the chemical reaction locally, by not offering the same exposure to air, water or earth (Oudbashi 2018). An elemental analysis of layer 3, which was not possible in the framework of this study, would however allow to definitively determine its nature, and thus to certify or not its nature as an ancient adhesive, already highly doubtful regarding the micro-stratigraphic analysis.

Speaking of patina and residue, WE 7 offers some elements of interest for this study as well. Firstly, traces in the direct vicinity of the upper knob suggest the presence of a ligneous element by their particular vertical fibres, which are not found elsewhere on the sickle (fig. 5.5).

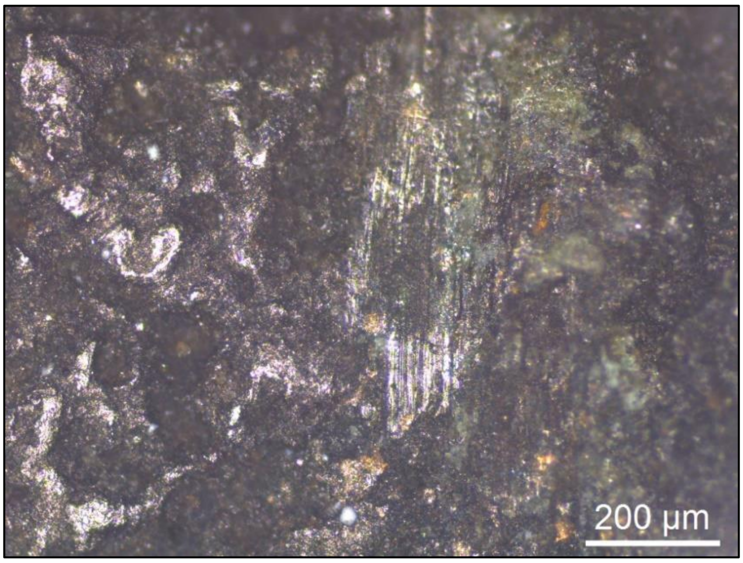

Figure 5.5: detail of the ligneous imprint located on A-Side of WE 7/Epe

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The decomposing wooden handle may indeed have left its imprint in the surface corrosion. Nevertheless, it is legitimate to ask whether the hypothetical wood could have been preserved long enough to leave this imprint in the sickle. In fact, the context of the discovery, recounted in the letter that accompanied the donation of the hoard of Epe to the RMO in 1865[15], states that the elements constituting it may have been wrapped in linen before their deposition. This could thus testify to the good conservation of organic matter around the sickle of Epe and confirm the presence of organic residues on WE 7. But again, the presence of wood could only be certified by carrying out a physico-chemical analysis (Farmer 1962; Umney 1992).

[15] Cited in Butler 1990, 91

The existence of a handle at the time of use and deposition could also be attested by the presence of a distinct patina in the area presumed to have been hafted, compared to the rest of the sickle (fig. 5.6A). Again, this one is greenish, like observed on E2010 (fig. 5.4). The patina, which is however not uniformly distributed, seems to cover the longitudinal striations related to the manufacture polishing. If one accepts to consider this patina as a remnant of a past hafting, it might even give indications about the ergonomics of the handle. This latter would in fact be extended towards the tip and would allow for better blade stability when using the sickle (fig. 5.6B-C).

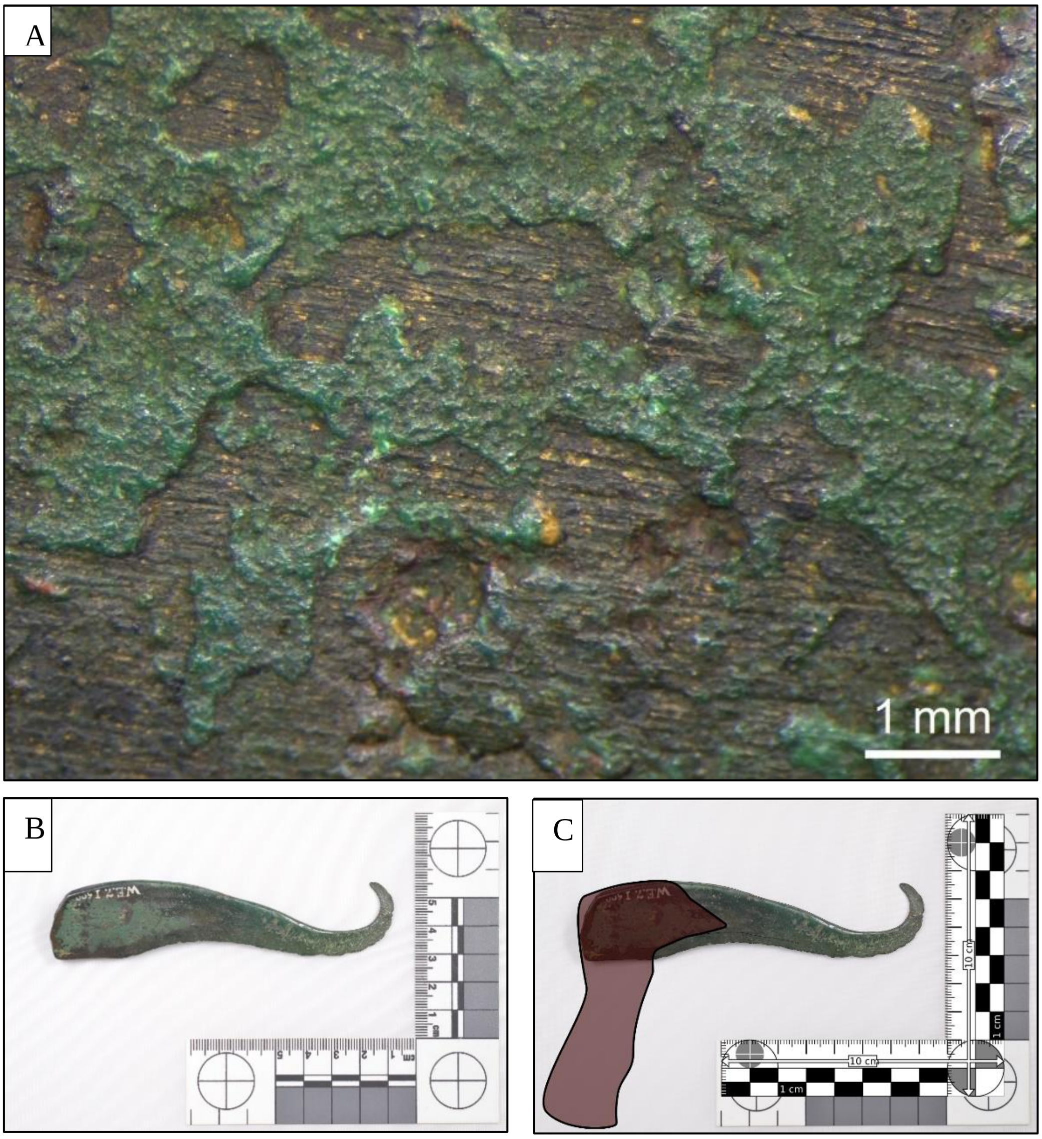

Figure 5.6: detail of the patina covering manufacture striations on B-Side of WE 7, alongside golden spots caused by modern friction (A); reconstruction of the handle (B), considering the bevel, the angle needed for a classic use of the sickle, the greenish patina and the necessary grip (C). The part that is not in contact with the blade is imaginary but inspired by the handles inventoried by Arnoldussen & Steegstra, 2016, 68, fig. 4

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To conclude this section, it is still necessary to note the presence of a drop of resin-like substance, on the A-Side of G1947 (fig. 5.7). Its small quantity makes it impossible to establish its nature, even if its location could argue in favour of its integration among the hafting traces. In addition, it is not clear whether it is necessary to use a resin-type adhesive for this type of hafting, as the peg-hole system is not well known for sickles in the Bronze Age.

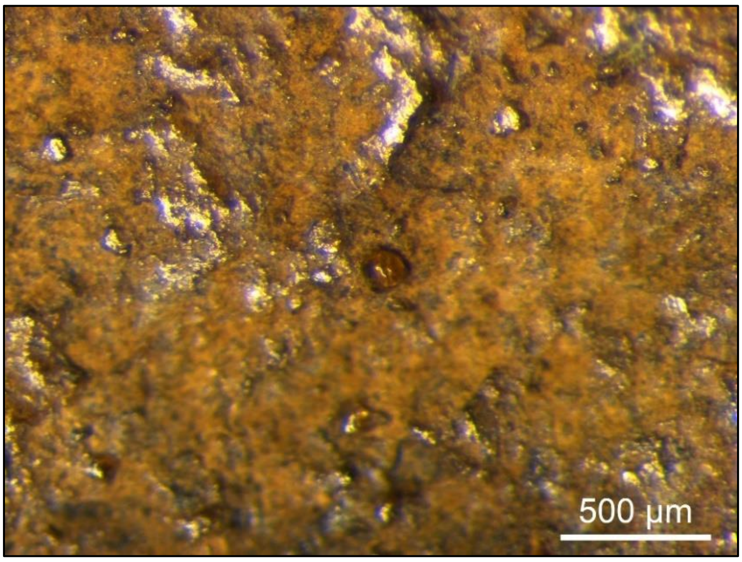

Figure 5.7: detail of the resin-like drop located on the A-Side of G1947

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5.3. Sharpening the blade

5.3.1. Understanding archaeological traces through Japanese sickles

Sharpening has been one of the main focus of this thesis, as the traces associated with it directly interfere with traces of use and manufacture polishing striations. It was therefore vital to identify the differences that make it possible to distinguish them, and it was chosen to consider the modern Japanese sharpening process as a point of comparison. Indeed, since the shape of the sickle blade has changed little or not at all since the Bronze Age, the constraints linked in particular to the arched shape and the type of work to be carried out are similar (Steensberg 1943, pl. 13). As a result, modern sickle sharpening and its trace production has served as a reference for understanding ancient sharpening traces.

The sharpening of Japanese sickles is divided into two movements. The first one, which generally involves the A-Side only, is intended to create the bevel, or at least to re-form it, which will determine the quality of the cutting edge (fig. 5.8A). This movement is transverse and produces, depending on the grain of the whetstone, more or less wide and deep transversal striations.

The second movement is longitudinal, and concerns both the A-Side and the B-Side (fig. 5.8B). The resulting striations formally follow the shape of the blade and usually extend quite well in length. This second step is designed to remove the burrs produced by the first action. This process also seems to be attested for scythes in the Roman period in Gaul by stelae that show blade sharpening activities (Pieters 2013, 105, citing Marbach 2012).

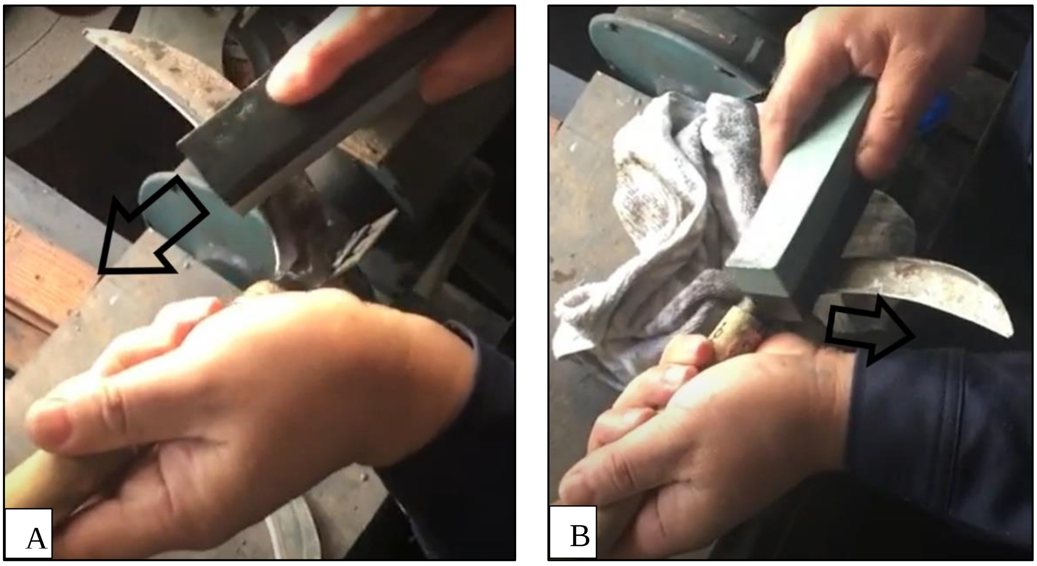

Figure 5.8: transversal motion set to form the bevel on a Japanese sickle (A) and longitudinal motion set to remove the burrs (B) (竹本敏康 2017 on www.youtube.com)

This type of two-step sharpening was used for the experimental sickle, but the blade was also honed. As a result, it displays relatively fresh transversal and longitudinal marks, due to the fact that it was not used intensively[16], as well as skewed striations resulting from honing (fig. 5.9).

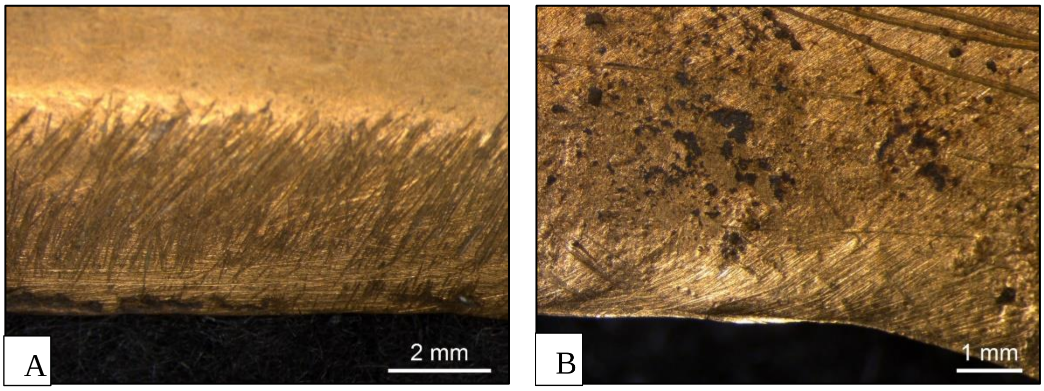

Figure 5.9: detail of the stratigraphy of transversal and longitudinal striations located on the cutting edge of Exp1568's A-Side (A) and skewed striations located on the cutting edge of Exp1568's B-Side (B)

[16] The experimental sickle was used less than one hour because of its inefficiency.

The poor bevel formation that can be seen under the microscope also affected the efficiency of the blade, which made it considerably more difficult to use for reed cutting. Other techniques such as peening could also be used to sharpen the sickles (Arnoldussen & Steegstra 2016, 67; McClendon 2015, 37, tab. 3.1), but since they were not used to make the present experimental sickle, they will not be detailed here.

It is obvious that sharpening marks are much less noticeable on archaeological sickles. This can be caused by several factors. For example, some may simply not have been sharpened, if they were not intended for use, but created for the sole purpose of being deposited. Then, it is also possible that the traces of use have completely or almost completely covered the sharpening striations, which could thus indicate that the tool was deposited without being in a sharp condition. Finally, post-abandon damage, such as corrosion, may have caused the sharpening traces to disappear, since the cutting-edge is also the thinnest portion of the blade.

E2010 (Ede)

On E2010, the longitudinal, transversal and oblique traces seem to have been preserved. In consequence, honing was certainly carried out (fig. 5.10A), and the bevel marking phase is well represented by the regular transversal striations. In contrast, the nature of the longitudinal traces is more difficult to identify here, and it could be that they are rather the result of the manufacture polishing, since they are not dissimilar to those that can be found on the surface of the blade (fig. 5.10B).

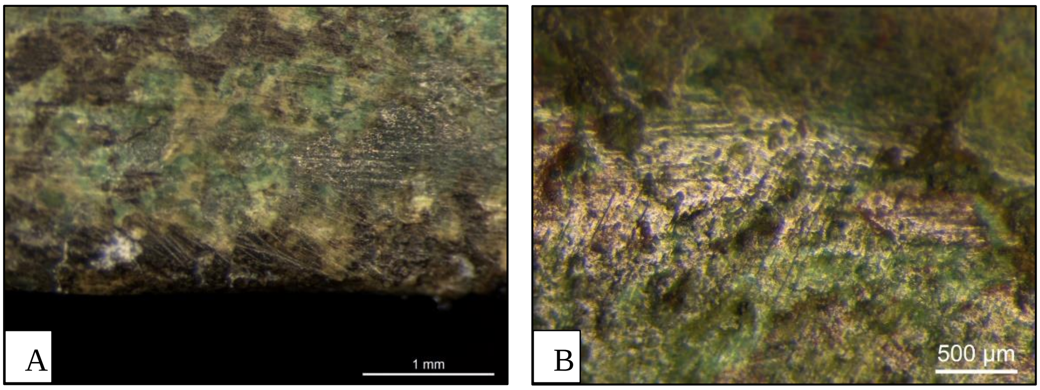

Figure 5.10: detail of the skewed striations located on the cutting edge of B-Side (A), and of the transversal and longitudinal striations, located near the start of the bevel, around ME of A-Side (B) on E2010/Ede

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G1947 (Heiloo)

The higher degree of corrosion of G1947, which probably comes from its iron-rich alloy, greatly complicates the identification of these sharpening traces. Only a few transversal traces linked to the bevel forming phase can be spotted in this way (fig. 5.11). However, these are particularly interesting as they are present on both sides of the sickle. This desire to create a cutting angle on both sides of the tool could indicate two successive and differentiated uses, one with the right hand and one with the left hand. However, caution should be exercised as the bevel is not as pronounced along the entire length of the B-Side, and as the grooves are poorly preserved. As it was already tackled above, the relative absence of longitudinal and skewed striations could be due to several factors. The lack of resharpening prior to the deposition of the sickle, the damage suffered by the cutting-edge, or finally the preservation from the corrosion of the deeper marks linked to use are the most probable hypothesis.

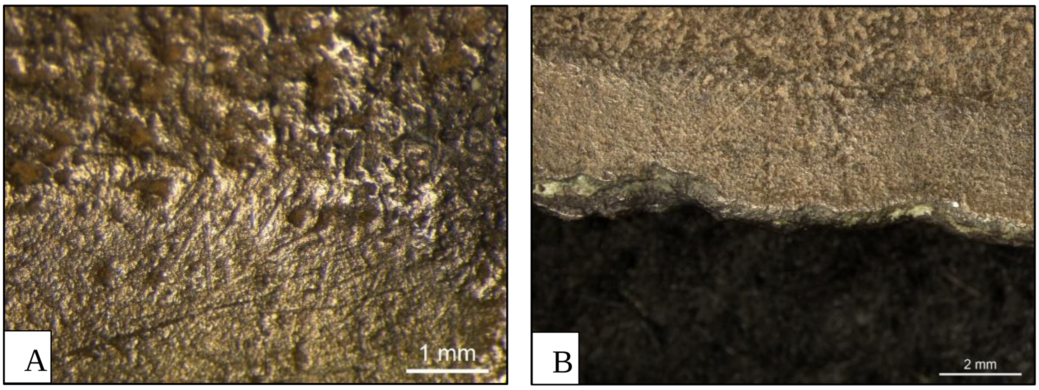

Figure 5.11: detail of the transversal striations, located on the bevel around DE of A-Side (A) and B-Side (B) of G1947/Heiloo

WE 7 (Epe)

For WE 7, the situation is quite different. Here, the transversal striations are almost absent as they were only found at the origin of the bevel, principally on DE, where the cutting-edge is logically less worn out (fig. 5.12A). Longitudinal striations, on the other hand, are abundant and follow the directionality of the edge fairly closely (fig. 5.12B; C). Finally, there is no trace linked with honing on any of the sides. Putting aside the hypothesis of significant post-deposition degradation, which is less likely in this case, the chances are that the bevel was not redesigned anymore after it reached the ribs. Then, the blade was sharpened as it is common to do so with swords, following the edge of the blade, thus creating mainly longitudinal grooves[17]. The weak arc due to the intensive use of the sickle could be the reason for this change in the sharpening process. In addition to the atypical shape of the blade, curved towards the tip, this could finally indicate an unusual use for this sickle, which will be investigated further in the section dedicated to proper use traces.

Hence, it appears that the bevel was recreated as the sickle wore out, as evidenced by the presence of traces that can be linked to this stage of sharpening in close proximity to the cutting edge. In consequence it is possible to conclude that the sickle was used and resharpened repeatedly. This hypothesis is finally further supported by the fact that the final location of the start of the bevel even encroaches on the ribs of the sickle (fig. 5.12D).

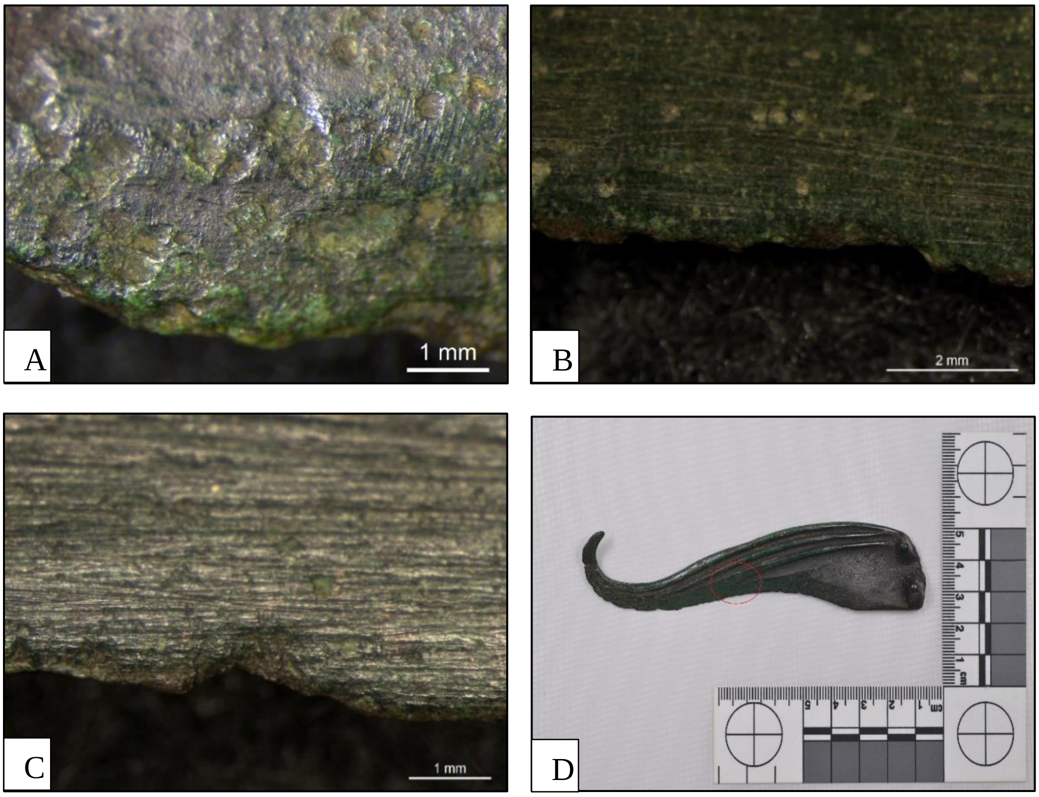

Figure 5.12: detail of the bevel angle displaying some regular transversal striations around DE on the A-Side (A), and detail of longitudinal grooves, deep, stretched and regular on A-Side (B) and B-Side (C) of WE 7/Epe; the bevel encroaching the lower rib (D)

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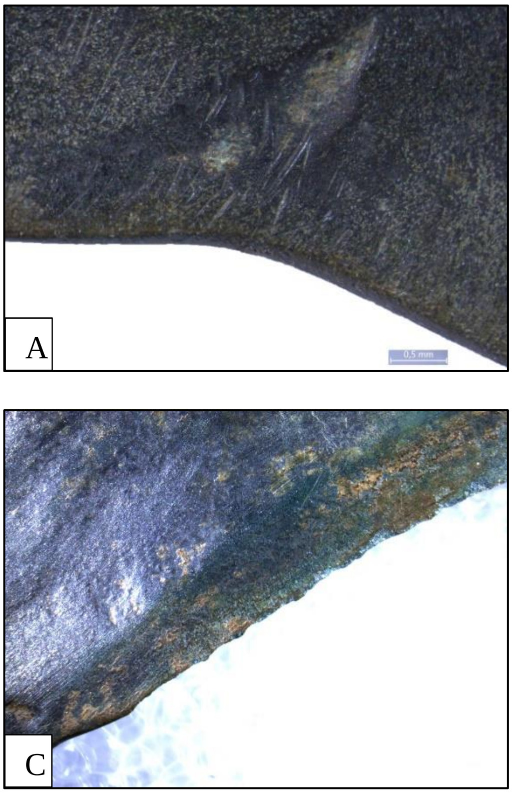
[17] Some of the archaeological swords as well as the replicas investigated by Valerio Gentile display the same kind of stretched longitudinal striations (Gentile 2019, 130-143)

Petigny reconstituted sickle

Then, the only sickle of Petigny that could be well reconstituted from four fragments has similar characteristics to G1947. Indeed, a bevel is displayed on both sides, which could also indicate an ambidextrous use. These bevels are marked in various places by common transversal traces, thus testifying to the execution of the first phase of sharpening (fig. 5.13A; B). On the B-Side, mainly, the regular and rather deep longitudinal striations relevant to the second phase are present (fig. 5.13C). The aspect of the material makes it impossible to identify more of these scratches, but it would seem that they were few in number. This, combined with the sharpness of the transversal striations, may indicate that the sickle may have had little or no re-sharpening.



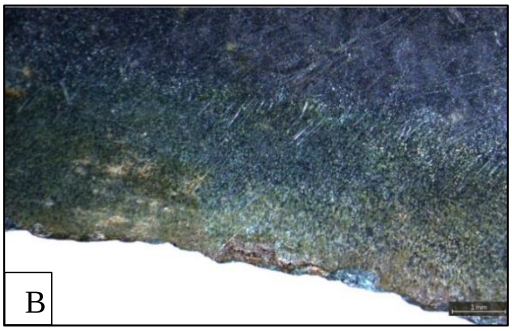


Figure 5.13: detail of the transversal striations, located on the bevel around ME on A-Side (A) and on B-Side (B)of 1/31, and longitudinal, deep, stretched and regular grooves on the B-Side of 1/31 (C) from Petigny

The condition of the other fragments coming from the hoards of Petigny does not make it possible to clearly distinguish traces of sharpening from traces of manufacture polishing. Indeed, the process of destruction seems to have erased most of these traces by exposing the material to torsional stress and sometimes heat, which will be tackled later. However, the impression that emerges from that set is that the sickles have not been resharpened very much, and that the bevel is often poorly formed.

Most of the time, the latter does not display the indicative transversal striations, either because of their poor conservation, or because the bevel was not further marked after the casting of the blade.

5.3.2. Forming the bevel

The observation of regular transverse traces on the ribs led us to believe that they could be engaged in the sharpening process, something that had never been proposed in previous research about sickles. Generally regarded as decorative, and used to define typologies, they could also have a functional role. Indeed, the ribs of the sickle could have been used as a support for the whetstone, to guide it in order to obtain the correct angle for the bevel.

E2010

On E2010, the ribs do show these vertical striations (fig. 5.14), but it is hard to say if they actually come from tracing the bevel. The fact that the lower deformations perhaps obtained by hammering also present these striations make it less likely to be the reason of their presence. In the other hand, the ribs appear pretty much damaged when they are located in correspondence of the areas where the marking of the bevel was the most important (ME). The issue caused by the presence of transversal striations on the deformations could be solved by considering the latter as posterior to the first formation of the bevel. However, the possibility that these traces are actually the result of manufacture polish cannot be discarded.

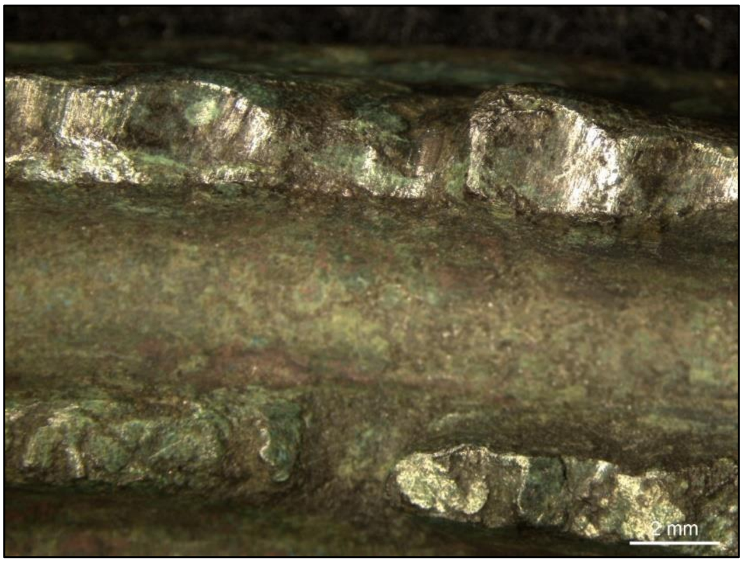


Figure 5.14: detail of the transversal striations located on the ribs and the deformations of E2010/Ede

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G1947

G1947 also bears these traces on the area corresponding to the upper rib, in spite of the particularly poorly developed nature of this decorative element in this case (fig. 5.15A). This could provide an additional element to confirm our hypothesis. In addition, the absence of this slight protrusion as well as the lack of transversal striations in the corresponding area on the B-Side could also explain why the previously identified bevel does not have as regular a shape as that of the G1947 A-Side (fig. 5.15B; C).

Figure 5.15: detail of the transversal striations located on the area of the ribs of G1947/Heiloo (A), and differences in terms of regularity and intensity of the bevel on A-Side (B) and B-Side (C) of G1947/Heiloo, shown by the red line

WE 7

On WE 7, the ribs show regular transversal striations, although the middle one seems slightly less affected. They more or less cover the length of the blade and are also present where the ribs fade into the bevel and the tip of the sickle (fig. 5.16A). Given the number of bevel tracings that probably took place before the bevel and that the two lower ribs actually merge into each other, it would be normal that all three ribs were at some point involved in the sharpening process, if our assumption is considered valid (fig. 5.16B). The angle required to obtain an effective cutting edge would thus have changed as the sickle was worn down. In the specific case of WE7, the absence of deformation makes it easier to rule out the possibility that these marks are the results of manufacture polishing. In addition, the deep transversal striations always cover the longitudinal traces that may be linked to it (fig. 5.16C).

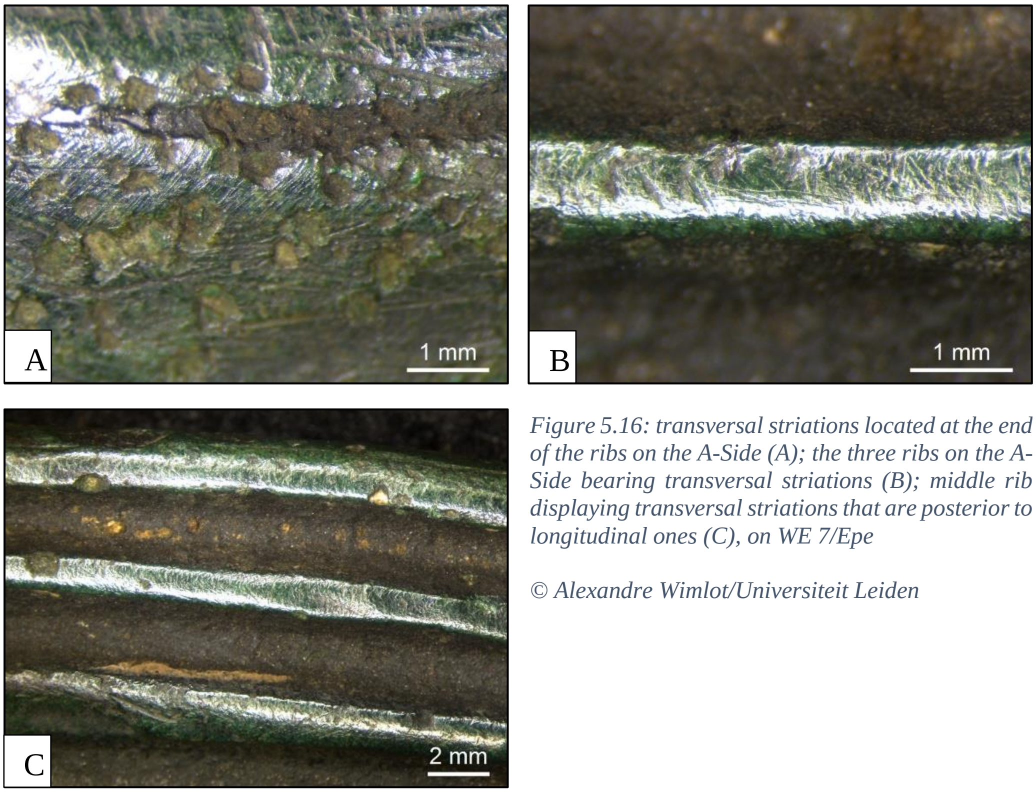


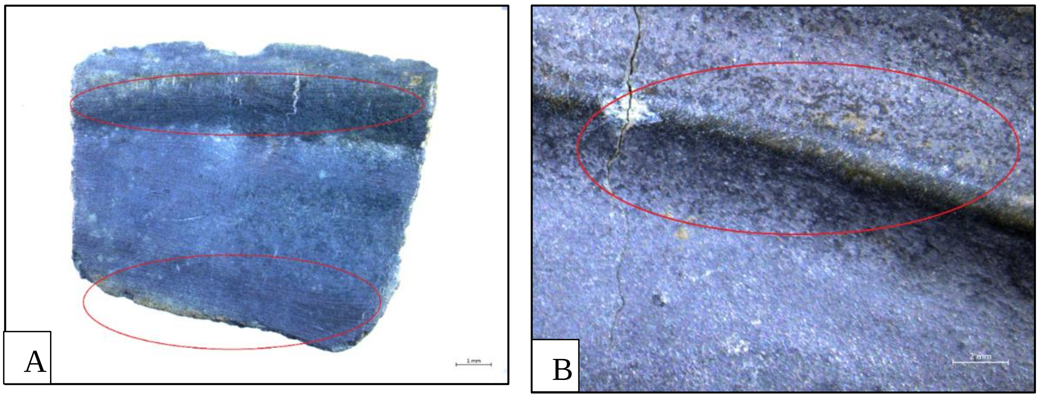
Figure 5.16: transversal striations located at the end of the ribs on the A-Side (A); the three ribs on the A-Side bearing transversal striations (B); middle rib displaying transversal striations that are posterior to longitudinal ones (C), on WE 7/Epe

Petigny

The traces are, again, less visible on Petigny's fragments because of the nature and the aspect of the bronze[18]. It is nevertheless possible to observe slight striations on several of them. On the one hand, the absence of transversal striations on the ribs coincides with their absence on the bevel (fig. 5.17A). In this case, this latter is also less distinctly prominent. On the other hand, sickles bearing these traces also display them on the bevel (fig. 5.17B-C). These two situations seem to further confirm the link of these transversal striations to the sharpening process.

[18] The nature and aspect of the bronze in the case of Petigny's fragments has caused troubles in identifying the traces defined in this thesis as relevant for getting a grasp on the life of the sickles. It may come from the use of heat for fragmentation, or from the fragmentation itself.

Although promising, this hypothesis is still only an intuition that needs to be verified by further experimentation and a more systematic analysis of the ribs. In use-wear analyses, the focus is often set on the cutting-edge, where most of the damages related to proper use are located. Nonetheless, it is important not to limit the observations to that particular zone, as other traces may be indicative of particular stages in the life of the tool. Hence, in addition to looking at the ribs, the angle of the bevel should be more frequently measured and related to rib height to test the plausibility of this proposition.



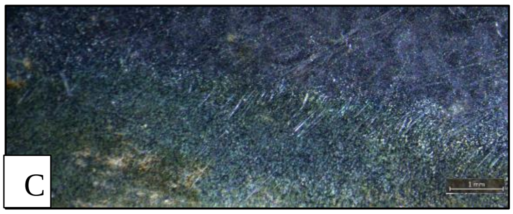


Figure 5.17: longitudinal striations displayed by the rib and the bevel on 1/33 (A); transversal striations both present on the rib (B) and on the bevel (C) of 1/31's A-Side, both sickles from Petigny

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5.4. Dents and notches, an important indication for use

5.4.1. Ancient vs modern, how to distinguish

Dents and notches are an important category of damages. When the cutting edge is preserved, they may provide valuable information on the use of the tool. They may, however, be the result of different processes. Firstly, the presence of dents and notches can be linked to the post-burial degradation of the object. These are located on the cutting edge, which is the first to be affected by corrosion. They may also occur during careless handling, in the course or after the excavation. Those generally do not seem to be associated with any other use trace or displacement of material. This kind of damage has been observed on E2010, where corrosion seems to have affected the cutting-edge quite a bit (fig. 5.18).

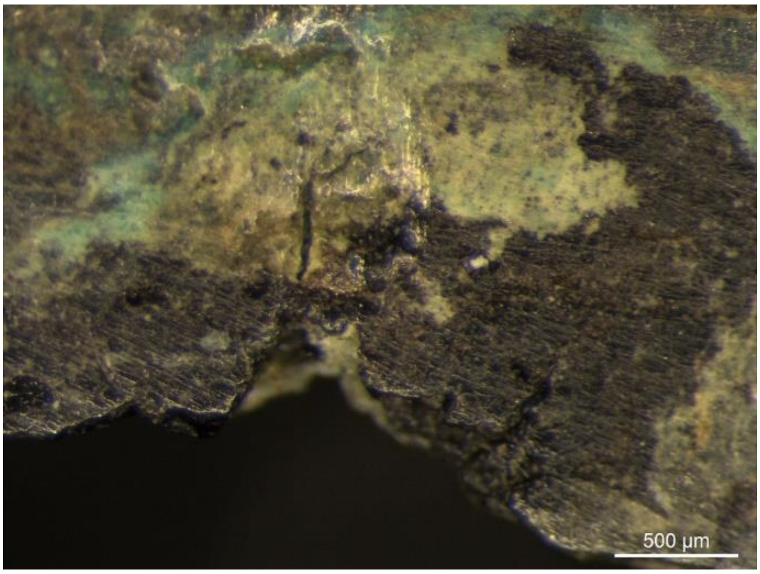

Figure 5.18: detail of a part of the cutting-edge affected by corrosion on E2010/Ede

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Secondly, notches and dents can develop because of use. In this case, they are most often associated with rather deep, irregular transversal striations. Sometimes, when noticeable, they may also be connected to polish or a limited displacement of material. As evidenced by the damages formed on Exp1568, which was used on reeds (fig. 5.19A), as well as on Exp1569 (fig. 5.19B), that was used to cut birch branches, they can testify to the use of the tool on a rather hard material. Archaeological sickles display this kind of traces as well. E2010 has delivered dents associated with transversal striations as well as a very light polish (fig. 5.19C), while G1947 and 2/57 provided examples of polish that developed on the edge of a dent (fig. 5.19E; F).

Finally, these damages may also be produced during the destruction process. When this is the case, they seem to have been caused by a tool or a weapon and are quite similar to what Valerio Gentile observed for some damages resulting from combat (Gentile & Van Gijn 2019, 139). The stress caused in this situation is much greater and can lead to a significant deformation of the blade, as well as a weakening of the blade, which is often materialised by the development of a crack (fig. 5.19G). 1/33 displays a perfect illustration of this phenomenon (fig. 5.19H). Here, the notch is located on the ridge of the sickle and has indeed caused a significant amount of shifted material, as well as a trail.

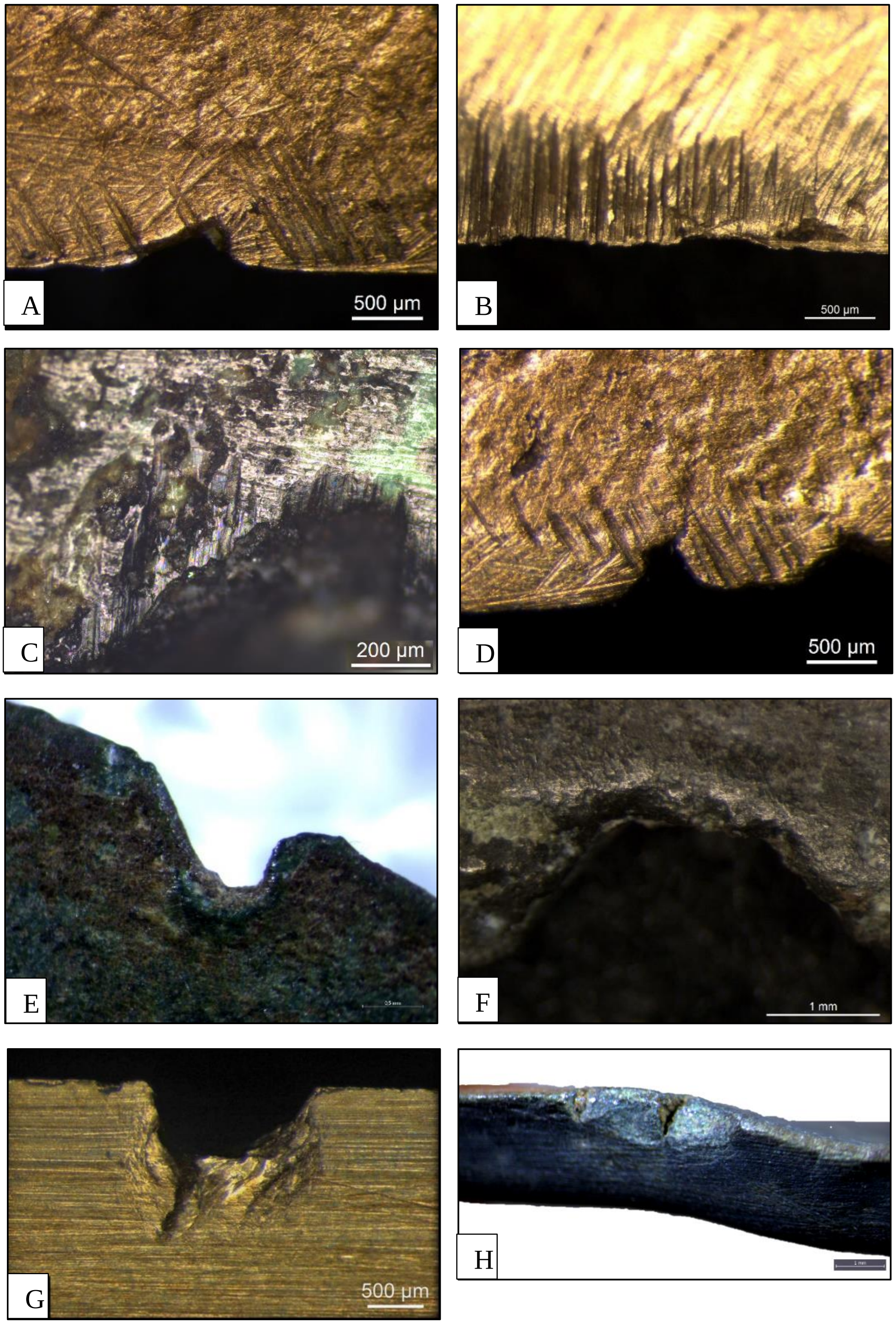

Figure 5.19: transversal striations connected to a notch (A) on the B-Side of Exp1568 (experimental sickle), and transversal striations connected to notches in development (B) on the B-Side of Exp1569 (experimental knife); dent associated to transversal striations and heavy polish on the B-Side of E2010/Ede (C) compared to transversal striations connected to a dent (D) on the B-Side of Exp1568 (experimental sickle); dent associated to a light polish and transversal striations in development on G1947/Heiloo (E) and 2/57 (F); notch displaying a trail (G) observed on an experimental sword (Gentile & Van Gijn 2019, 141, fig. 10b), compared with an archaeological one observed on 1/33 (H), from Petigny

5.4.2. What kind of use?

The dents and notches located on the cutting edge are efficient witnesses to the use of sickles. Their depth and width are able to provide accurate information when a large database of references is available. In the present state of research, and on the basis of the observations made on the replicas available in the context of this thesis, it should be noted that the use of a blade on soft material does not produce this type of damage. The knife used for cutting celery, as well as all the experimental sickles used by McClendon on reed grass (McClendon 2015, 49-75; 101-122), did not show such damage. Furthermore, the notches and dents seem to become more and more consistent as the cut material hardens. For example, they were found on the sickle used to cut reeds and on the knife dedicated to cutting birch branches. There, the damage is well present, but not very impressive, which is probably the result of a limited use in time for experimental replicas. As this damage was found on most of the sickles and fragments studied, it is highly probable that they were not intended for use on gramineous plants. A better definition of the use could only be possible through the analysis of other traces, as well as through the enrichment of the reference collection.

5.5. Micro stratigraphy of polishing events

Different types of polish have been noticed and recorded for the sickles. The first one seems to occur during the manufacture process. After casting the bronze, the tool is rubbed against an abrasive stone to remove impurities, as it will be seen for casting flashes in a later section. This action produces the particular brilliance of the bronze, as well as deep and regular traces, which are usually regular but multidirectional (fig. 5.20A; B). This polishing, which occurs over the entire surface of the blade, is the first phenomenon that leaves traces on the sickle. It is therefore at the base of the stratigraphy and can also be used to identify areas where there is an anomaly that could indicate another stage in the life of the sickle.

The second type of polish is unwanted and located in the hafted area. It is not easy to distinguish, and G1947 is the only sickle to bear it. Furthermore, it could not be noted for the experimental sickle and knives, which were not used sufficiently to allow its development. Thus, experiments will have to be carried out over time to provide a baseline for this phenomenon, which therefore seems to be detectable on archaeological artefacts. On G1947, it is recognisable by the particular brilliance and the special grain observed around the peg-hole that was used to fit the sickle (fig. 5.20C).

Finally, the last type of polish or gloss is related to the use of the tool. It develops on the cutting edge, in association with dents and notches or not. Often obscured by the presence of corrosion on archaeological sickles, it is also difficult to spot on experimental tools. Again, the cause is linked with the time required for its formation and the brightness of the bronze. For the archaeological sickles, this polishing could be clearly identified on E2010 and WE 7 (fig. 5.20D), both being similar, while the nature of that observed on G1947 and 2/57 (see fig. 5.19 above) is to be confirmed. Indeed, despite the patina was not removed as consequently as observed for 1/21, this last polishing could be due to modern manipulations. It can be concluded that the use was rather intensive given the development of a polish. It is also possible to distinguish at least two types of polishing within the latter category. Indeed, E2010 bears a polish that seems to have developed transversally and another one longitudinally which could attest to two different types of use, or at least two different kinds of movement (fig. 5.20E-F). Actually, the directionality of polish development made it possible to distinguish between different types of activities performed in the case of flint sickles (Van Gijn 2010, 63-66).

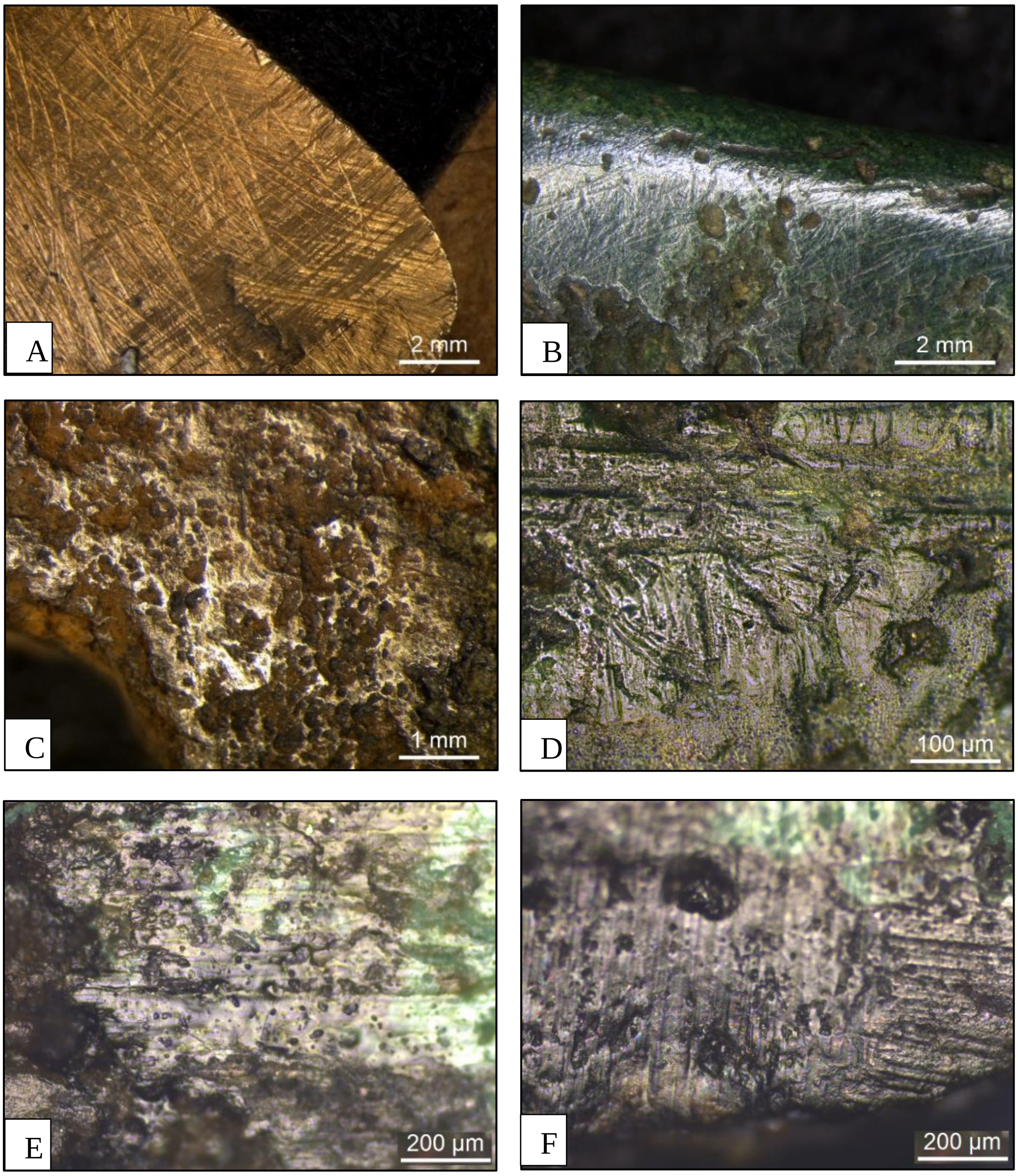

Figure 5.20: multidirectional striations covering both surfaces of the experimental sickle Exp1568 (A) and WE 7/Epe (B), due to manufacture polishing; polish resulting from hafting, located around the peg-hole on G1947/Heiloo (C); metallographic detail of polish located around the middle of the cutting-edge on WE 7/Epe (D); metallographic detail of longitudinal (E) and transversal (F) polish located around the middle of the cutting-edge on E2010/Ede

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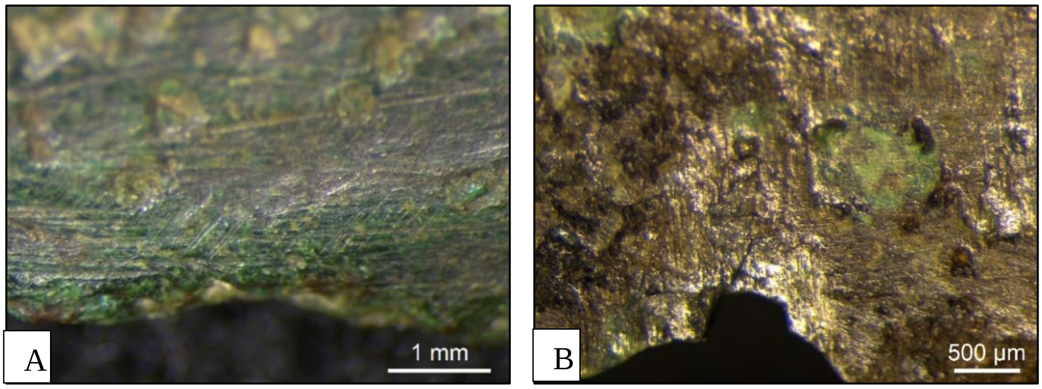
5.6. Use scratches and striations

As we have already seen, there are several types of striations. Some are related to manufacture polishing, some to hafting, most to sharpening and a few of them to use. All that remains now is to address the last category. Since the cutting-edge bears both sharpening and wear traces, the identification of the former makes it possible, by elimination, to distinguish the latter. Establishing the stratigraphy of these grooves then allows to determine sequences of actions. It is therefore feasible, theoretically, to determine on the basis of these traces the succession of the different sharpening operations with the phases of use, and possibly to distinguish between the different types of use. However, there are some weaknesses in this analysis. Assuming the perpendicularity of the sickle's movement while cutting any material leads to consider mainly the irregular and fairly deep transverse traces as being the witnesses of utilisation. However, if the sickle were used differently, with a longitudinal movement for example, the grooves produced would not be the same. They would thus be difficult to distinguish among the more regular longitudinal traces related to sharpening (Gutiérrez Saez & Martin Lerma 2015, 177-178).

Thus, when it is possible to distinguish them from traces of manufacture, sharpening and hafting, these traces can inform the movement of the use, more than the nature of it. Indeed, its intensity, the corrosion, the patina, or the number of successive sharpening or honing greatly influence the characteristics of these traces. In addition, the composition of the alloy, the hardness of the blade and the quality of the cutting edge may also contribute to these characteristics. Their association with notches and dents binds them with more certainty to use. All these constraints make the striations from use very difficult to identify in the case of archaeological tools, and therefore even more difficult to interpret. Nonetheless, if these traces could be identified for E2010, G1947 and WE 7 (fig. 5.21), and linked to a perpendicular motion, they are on the other hand much more complicated to distinguish on the sickles from Petigny.



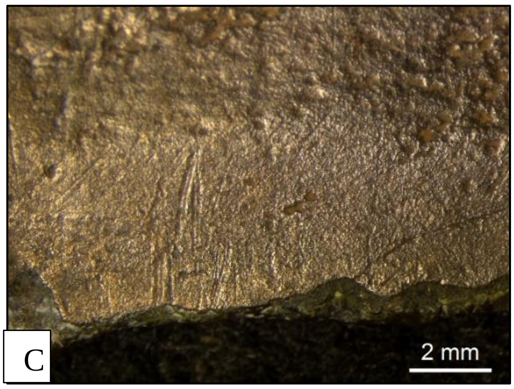


Figure 5.21: transversal striations from use, associated with dents, on WE 7/Epe (A), E2010/Ede (B) and G1947/Heiloo (C)

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5.7. Casting flash and care for production

When the bronze is poured into the mould, and as the metal cools, some casting flash form. They come either from an excess of metal filling the channels that allow the molten bronze to flow into the mould, or from a bad tightening of the latter, allowing some of the metal to escape out of the desired shape (Eogan 2000, 5). Depending on the situation, the casting flash that occurs will have a different appearance. Furthermore, these flaws are more or less inevitable, and the way the craftsman deals with them is the only element that may change from a tool to another. They can be found on both archaeological and experimental sickles and may take different forms. They are also likely to appear anywhere on the tool, but they concentrate mainly on the extremities and the ridges.

Several techniques for getting rid of them, which require more or less care with respect to the tool, have been identified on the studied archaeological sickles. One of the most commonly used one, often concomitant with manufacture polish, consists in rubbing the tool against an abrasive surface until the flashing reaches the state desired by the craftsman (fig. 5.22A). By doing so, he or she can improve the cutting edge and the general appearance of the tool.

Alternatively, the casting flash can be folded back by hammering or pressing it out when it is thin enough (fig. 5.22B; C). This technique gives poorer aesthetic results but does not affect functionality when the casting flaw is not located on the cutting edge. Sometimes both techniques can coexist with folding occurring first to facilitate polishing.

As already mentioned, these two techniques produce different results, which were observed on archaeological sickles. From this point of view, two groups seem to stand out clearly. On the one hand, there are the sickles found in the Netherlands. They bear casting flashes which, although still observable, have been reworked to the point where they appear as insignificant protrusions. Firstly, E2010 and G1947 display casting flashes that are difficult to identify. In both cases, the only one that can really be distinguished is located at the hafted extremity (fig. 5.22D; E). Secondly, WE 7 bears a casting flash which is located on the cutting edge (fig. 5.22F). It has also been extensively reworked, particularly on the lower extension of the casting flash. Furthermore, it seems to have undergone both correction processes, since its contours have been preserved on the surface of the blade.

The second group is constituted by the fragments of Petigny. The nature of the casting flashes is a little different here. Indeed, it seems that less care has been taken to make them disappear. Thus, on the upper end of 1/31, near the hafted area, it is possible to observe a casting flash that has simply been folded (fig. 5.23A). The other ones, less significant, extend along the length of the same side of the sickle. Then, still in the same area, 2/55 presents a series of casting flashes that have been slightly polished but form a ridge-like protrusion (fig. 5.23B). Next, 1/18 presents two particular casting flashes. These, although heavily polished, form two small spikes on the upper side of the sickle (fig. 5.23C). They are clearly the remains of the metal that partially filled the casting channels during the flow of the bronze. Finally, 2/57 display an upper side that is completely distorted by the casting flashes, which appear to have been neglected (fig. 5.23D; E). This seems all the more surprising since the ribs are nevertheless decorated with digits-like traces.

Hence, it seems that the care given to the realisation distinguishes these two groups. The first one, composed of the Dutch sickles, presents tools whose finish seems to be important to the craftsman. The casting flashes are conscientiously reworked, and the sickles have a finished appearance. The second, which comprises the fragments of Petigny, presents a radically different situation. The casting flashes are neglected and worked on simply in order to complete the tool quickly, without impairing its functionality. This analysis is crucial for retracing the life of the sickles and should be combined with traces of intensity of use in order to draw conclusions on the destination and function of these tools. However, through this brief section alone, it has already been possible to identify a very conclusive element of distinction.

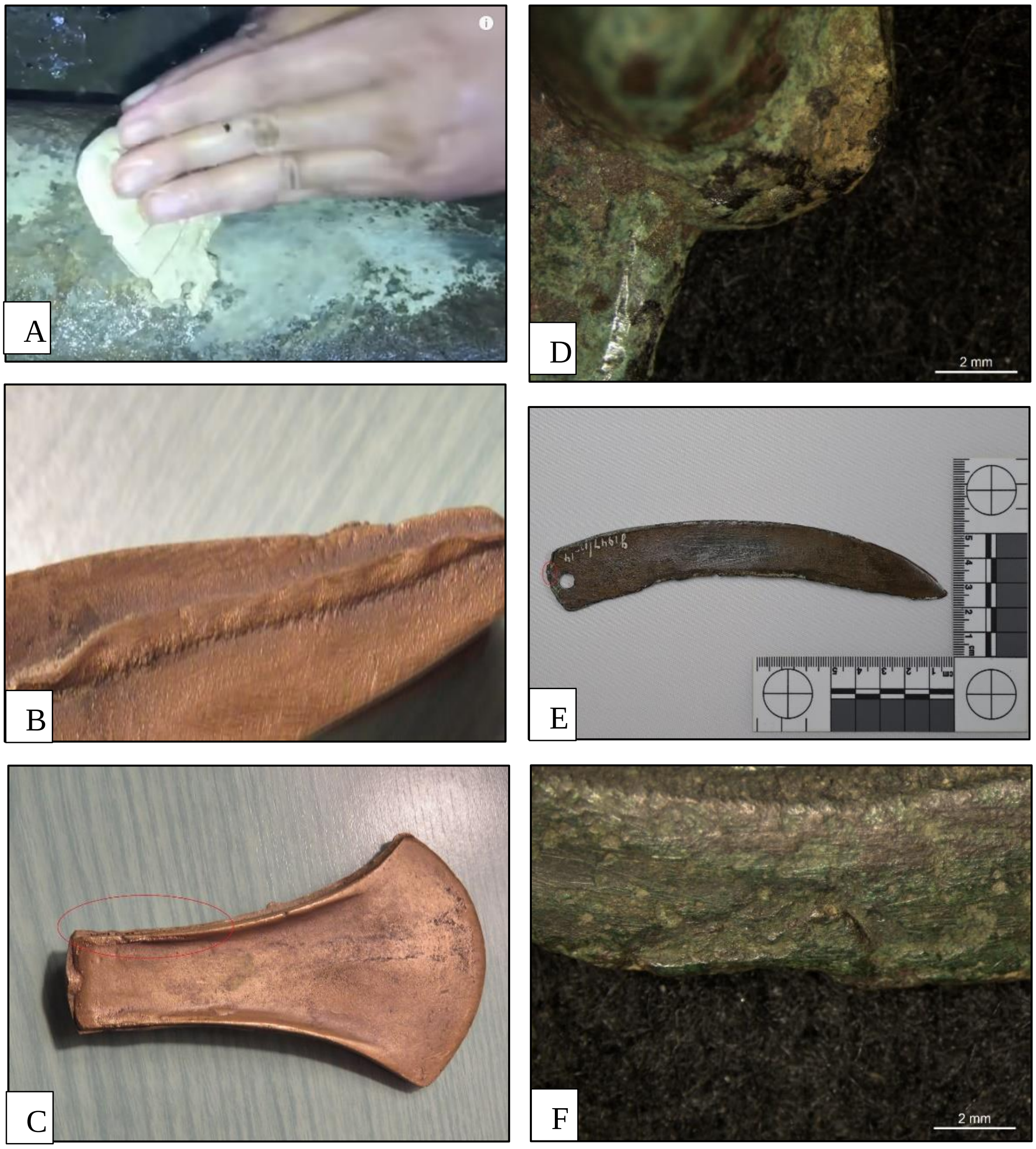
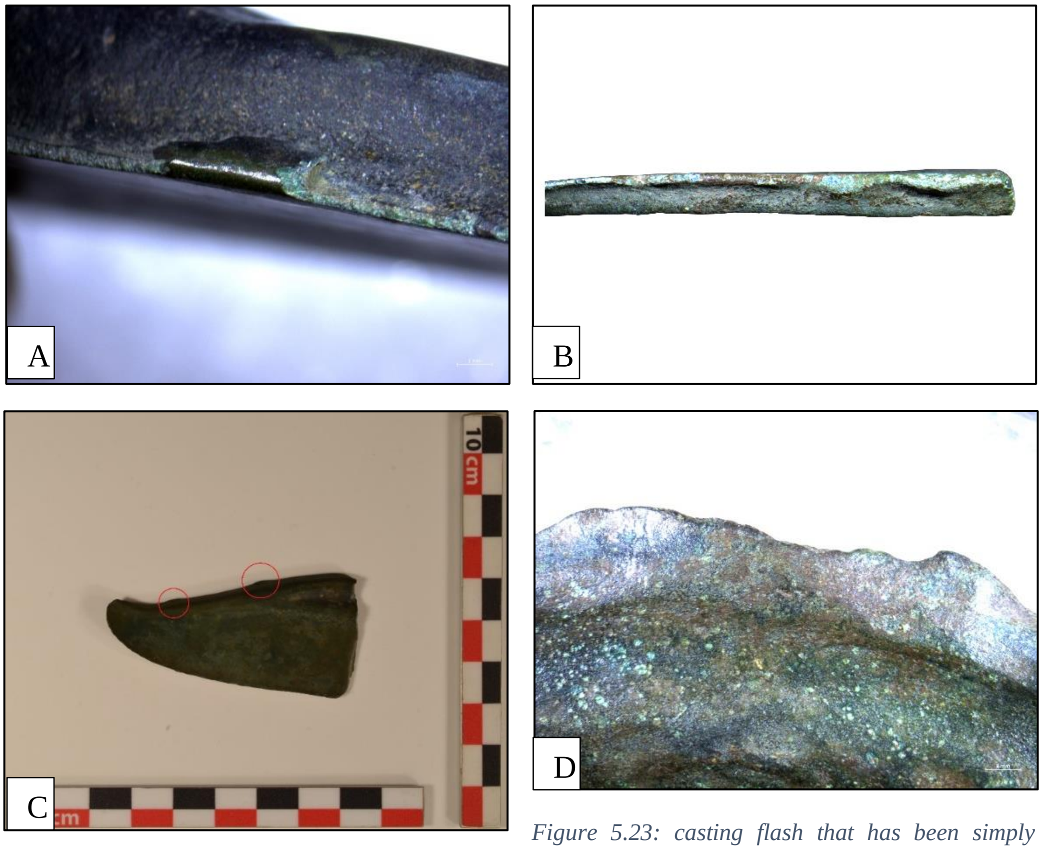


Figure 5.22: rubbing of a bronze axe against an abrasive stone (A) to remove the casting flashes formed on the edge (Survival Skills Primitive 2019 on www.youtube.com); folded casting flash on a bronze axe (B; C) realised by the present author at the Archéosite of Aubechies (Belgium); heavily polished casting flash located on HA of E2010/Ede (D) and G1947/Heiloo (E); casting flash that has been folded and heavily polished, located on the cutting edge of WE7/Epe (F)



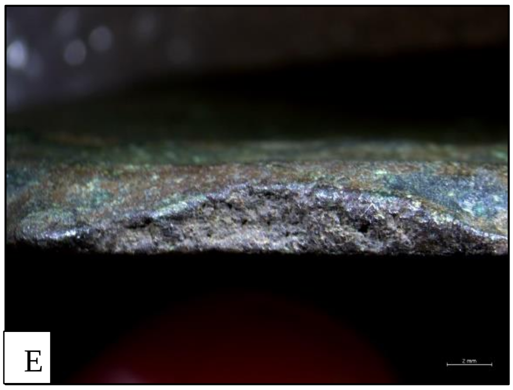


Figure 5.23: casting flash that has been simply folded on the upper side of 1/31 (A); casting flashes that have been folded and slightly polished on the upper side of 2/55 (B); casting flashes forming spikes on the upper side of 1/18 (C); series of casting flashes on the upper side of 1/18 seen from the side (D) and from above (E), from Petigny

5.8. The destruction processes

Fragmentation is a common process for artefacts found in multiple depositions, particularly from the Late Bronze Age. It has been at the centre of the debate between those who favour the rational vision of fragmentation for the purpose of recasting and those who envisage a social construction in the act of intentionally destroying an object and abandoning it (Brandherm 2018; Brück 2006; Dietrich 2014; Rezi 2011; Toune 2009).

Knight proposed a system for assessing damages displayed by Bronze Age artefacts, which it seems appropriate to use in the present case, since most of the sickles concerned by the present study show damage and breakage (Knight 2019). It will make it possible to achieve greater uniformity, which is still sorely lacking in use-wear studies applied to metal. This system, which is presented in the form of a table, is mainly used to determine which damages are deliberate and which are not (tab. 4). In addition, in order to complete this study of the traces of fragmentation, I sought the help of Georges Verly. Indeed, he has conducted numerous experiments in archaeometallurgy, notably on fragmentation of bronze tools and weapons (Verly *et al.* 2019). He gave me the pleasure of looking at the sickles studied and was able to identify the processes of fracturing. The determination of the use of heat or not is thus here conditioned by his analysis.

Table 4: evaluation of damages observed on Bronze Age artefacts (after Knight 2019, tab. 3)

Damage ranking	Destruction indicator	Criteria/considerations	Object type(s)
0 Definitely not deliberate	All	Post-depositional/post-recovery processes causing damage (corrosion, ploughing, dredging, cleaning), informed by knowledge of the context/post-recovery history	All
1 Probably not deliberate	Bending	Associated with other use-wear	All
		Objects thinner than 7.5mm	
		Up to 30° with no associated marks or breakage	Thin-bladed implements
		Present on tools put under pressure causing material stress	Chisels, gouges, pins, possibly knives
	Twisting	Up to 45° with no associated damage	All
	Notching	Supported by experimental research indicating use	
		Irregular edge damage	
		Various depths (<7mm) and/or singe notches	
	Breakage	Patterns of breakage linked to use or structural weakness (e.g. side-loops, blade tips, rivet holes)	

		Casting flaws and evidence of manufacture flaws	
2 Probably deliberate	Bending	Up to 30° with associated marks	All
	Twisting	Up to 45° with associated damage	Thin-bladed implements
	Notching	Deep notches (>7mm)	All
		Regular, repeated notching	
		Notches in unusual positions	
	Breakage	No associated plastic deformation	
		Associated transverse bending less than 45°	
		Patterns of breakage unlikely to be linked to use or structural weakness	
		Fragments and pieces associated with deliberately damaged material	
		Multiple broken pieces of different objects conforming to a similar size and/or weight within a single accumulation	
3 Definitely deliberate	Bending	Transverse bending over 30°	All
		Objects thicker than 7.5mm	
	Folding		
	Twisting	Over 45°	Thin-bladed implements
	Breakage	Associated with plastic deformation and/or bending greater than 30°	All
		Associated tool marks	
		Multi-piece breaks (3+ pieces) except where post depositional processes can be identified	
		Mid-section fragment indicating an object was once in 3+ pieces	
	Burning	Associated with other burnt material and/or associated Dis	
Uncertain		Applied when objects cannot be classed within the ranking system and it would be misleading to do so. This includes:	All

		- Burning evidence with no associated context or damage - Damage to objects for which there are no indicators of how it may break - Damage to objects for which there is limited understand-ing of how such ob-jects were used - Objects for which breakage and damage is not clear, such as those obscured by corrosion	

The two groups already defined after the analysis of the sickle finish can be distinguished once again, even from macroscopic observation. E2010, despite the already studied notches and dents due to corrosion and use, as well as the incomplete perforation located on the hafted area, did not deliver any damage that could be interpreted as deliberate. In addition to damage similar to E2010, G1947 displays a deformation of less than 30°, which ranks it as probably not deliberately damaged. The case of WE 7 is a little more complex since the torsion is associated to a break. However, the angle, of less than 30°, as well as its location on the tip places it among the probably unintentional damage.

The fractures presented by Petigny's group is of a different nature. Based on Knight's table, they can all be categorised as tools that suffered from deliberate harm. 1/18 appears to have been intentionally broken when cold, by folding the blade, as evidenced by the curved protrusion present at the proximal end of the fragment (fig. 5.24A). The tip is also slightly twisted, which is on the other hand more indicative of damage from use. The only sickle that could be partially reassembled, by using 1/14, 1/15, 1/23 and 1/31 was in fact fragmented into at least five parts. This fracturing appears to have occurred while heated. The section that was hafted also suffered a significant twist that may also be indicative of wilful damage. Either this action, or a blow to the top of the sickle may have caused a large crack on the sickle (fig. 5.24B).

Then, 1/21 is the first sickle to show undeniable traces of blows. These appear to have been carried on both sides, and although modern damage has affected the patina located at the level of these blows, they may still have been inflicted prior to the deposition (fig. 5.24C). The vast folded section appears to indicate a hot break (fig. 5.24D). 1/33 shows the most impressive traces of destruction. Despite its small size, the fragment bears a notch on the upper side that has already been analysed, but which is also related to the cracking of the blade and maybe the slight twist of it. In addition, multiple blows cover the proximal area of the B-Side (fig. 5.24E). Both types of damage must be attributed to a thin blade. According to Georges Verly, the crack was produced when cold, whereas the fragmentation occurred while being heated. Given the size of the fragment, it is highly unlikely that the notch was caused after fragmentation. Thus, it allows to reconstruct a sequence of events.

Afterwards, 2/55 displays a bending of more or less 30° that occurred in cold condition (fig. 5.24F). This makes it difficult to assess its intentionality. However, the fracturing appears to have been caused with the help of heat. Finally, 2/57 seems to have suffered a break by folding while being heated, evidenced by the curved protuberance located at both the proximal and the distal ends (fig. 5.24G). The fragment itself is bent, probably as a result of the pressure applied to split the object in several parts.

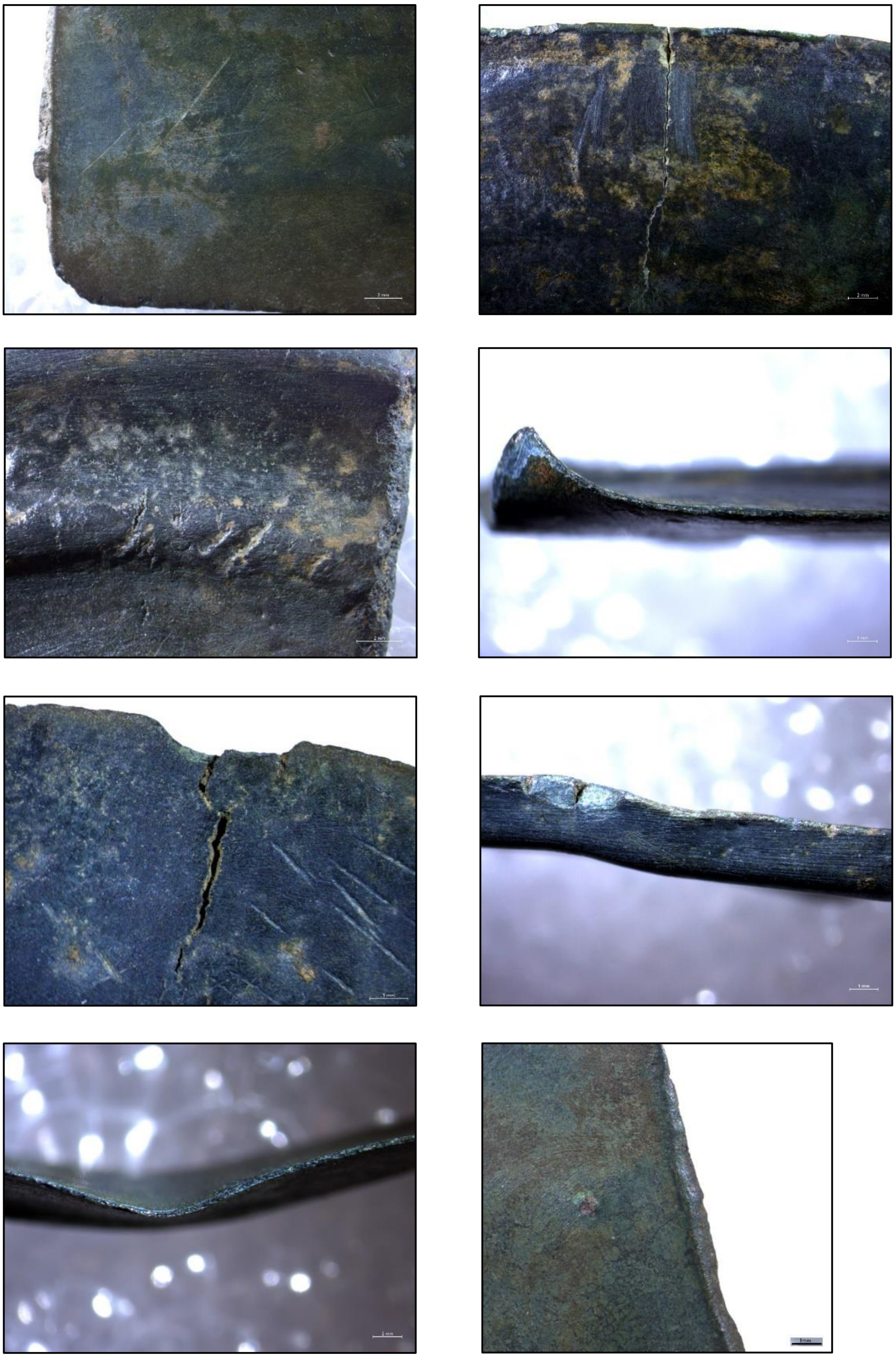


Figure 5.24: curved protrusion consistent with a folding of the blade, 1/18 (A); cracking either caused by the torsion or by a blow on the top of 1/31 (B); blow marks located on the ribs of 1/21 (C); bending of the lower distal extremity the blade, 1/21 (D); on the top, notch and bending of the blade; on the bottom, crack and bow marks, 1/33 (E); bending of the blade around 30°, on 2/55 (F); curved protuberance testifying to the folding of the blade, 2/57 (G)

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5.9. Comparing the biography of the archaeological sickles

In conclusion, it is necessary to return to the distinction between two ensembles which has been emphasised several times in this chapter. Indeed, these two sets may be distinguished in terms of context, use, manufacture and destruction. We will therefore try to reconstruct the biography of these sickles from the numerous and detailed observations, bearing in mind the limitations associated to bronze use-wear analyses.

E2010 has been crafted with care as evidenced by the manufacture polish it has undergone. The casting flashes are only visible at the hafted base. It was then fitted, with the help of an additional perforation on the B-Side, to which was maybe added some glue. After being sharpened, it was used with a transverse motion on a rather hard material, causing dents, gloss and transversal striations. After a rather intensive use and probably some successive sharpening, it was finally deposited as it stood, alone, near an earlier Bronze Age site.

G1947 has received similar attention during its manufacture. Well polished, it was fitted through a peg-hole that was finished thanks to a mechanical action, as testified by its irregularity. It probably served for a long time, as evidenced by the consequent development of a polish around it, as well as by the slight bending presented by the blade. The dents, which are less present, maybe because of the corrosion of the cutting-edge, could however indicate a transversal use on a softer material. After numerous sharpening operations and the formation of a bevel on the B-Side, which could attest to its use by a left-handed person and thus to its transmission within the community, it was finally deposited away from any settlement. Its standing position among a batch of flint sickles lined up in a row emphasises the ritual nature of the deposition.

Next, WE 7 is the sickle that seems to have been used the most. Again, it was particularly carefully finished as only a casting flash remained on the cutting edge which was polished so that it did not affect its functionality. Perhaps fitted ergonomically, as shown by the hypothetical residues and the peculiar corrosion pattern on the B-Side, it has been subject to repeated use and sharpening. This was illustrated by the receding bevel on the two lower ribs. The breakage of the tip also seems to be the result of this intensive use, probably on a soft material as well, since the dents are particularly small despite a good preservation of the cutting edge. The lack of transversal striations, the way it was presumably hafted, and the nature of the sharpening could indicate a function closer to the one of a knife, characterised by a longitudinal motion. Finally, after this long life, it was buried, either as a deposition or as funeral equipment, among allogenous elements that were perhaps wrapped in a linen.

In short, these 3 Dutch sickles were well crafted, have been used intensively on a rather hard material, except for WE 7, and did not undergo any fragmentation before their deposition. That hard material could have been small wood and may have been cut in the action of hedge laying, as it is possible with English billhooks, an activity that may prove relevant for creating fences and borders[19], and to breed animals.

On the Belgian side, it is not the same situation. All in all, they display a rather neglected aspect, with casting flashes that have not been corrected, or have not been polished enough. Hafting and use are difficult to determine, since most of the traces seem either never to have existed, or to have been erased by the nature of metal's corrosion and the process of destruction. Sharpening does not appear to have been carried out many times, and the bevel is generally poorly formed. However, the case of the reconstructed sickle should be highlighted, as its bevel seems to have been marked also on the B-Side which could, like G1947, signify a use by a left-handed person. A few dents displayed by 2/57 show a use on a rather hard material while the other sickles do not bear any of them, which could indicate a very limited use on a soft material.

Their destruction, on the other hand, requires a great deal of attention. Indeed, it is systematically characterised by fragmentation. This was carried out either when cold or through heating, or even through both processes. When the sickle was broken while cold, it would seem that it was the result of blows from a blade, mainly on the upper edge, as evidenced by 1/31, 1/33 or 2/55. When heating was used, the blade was folded until it broke, as most sickles testify. Anyway, it seems that these tools were destroyed with a great effort. Furthermore, apart from the sickle which

[19] This activity was mentioned in Julius Caesar's Commentaries on the Gallic War (2, 27) as used by Celts in Belgium during the Battle of the Sabis as a blocking element.

could be almost reconstructed, each fragment represents a different sickle. This element prevents the hoards of Petigny from being interpreted as a stock intended to be recast. Indeed, given the relentlessness intended for destruction, it is unthinkable that this fragmentation is due to use. The individuals who broke these sickles therefore possessed the entire tool each time. It is therefore difficult to imagine that only a few fragments were subsequently destined for recycling.

In short, these poorly finished sickles have been subject to severe fragmentation after little use. They may have been occasionally used for specific tasks, before being destroyed. Some fragments could also have been distributed among the community, while the remnants were deposited together with fragments of objects representative of a complete arsenal of tools, weaponry and ornaments. The violence and the use of other blades to fragment these sickles is another indication of the ritual nature of the destruction. Finally, in the deposits of Petigny where they are associated in particular with panoply elements, it could appear that the sickles embody a particular social value, linked to a context of aristocratic exhibition or votive transaction, as recently proposed by Pare following Verger and Boroffka (Pare 2019, 76-78).

6. Conclusion

6.1. Review of the results

The lack of research about metal and bronze sickles especially has considerably influenced the course of this study. Indeed, it has been necessary to discuss extensively the type of traces and their attribution to particular stages in the biography of the tools before embarking fully on their interpretation. Two studies have served as basis. Sych had proposed an effective study, which however lacked some graphic documentation, while McClendon instead had attempted to present a new methodology applicable to bronze sickles (McClendon 2015; Sych 2015). The latter work is in line with the prescriptions commonly encountered in the discipline in the past few years but does not yet go far enough (Dolfini & Crellin 2016; Gentile & Van Gijn 2019; Gutiérrez Saez & Martin Lerma 2015). This thesis therefore fits into the stream of study in progress, which is still desperately trying to establish its methodology and terminology. This accomplishment would finally allow scholars to multiply use-wear analyses of archaeological bronze material. This progress would also permit the traceological studies of non-ferrous metallurgy to reach a scientific level equivalent to that of the studies concerning the lithic industry, which have acquired their letters of nobility since the last decades of the 20th century.

It has therefore been necessary to first distinguish between the different types of traces bore by the experimental tools, the Dutch sickles and those of Petigny. Striations, dents and notches, polishing, casting flash, bending, or fragmentation are the main ones, and most certainly the most identifiable. After being distinguished, it has been necessary to characterise these traces, to understand what changes from one area of the tool to another, from one sickle to another. Directionality, location, regularity, and dimensions determine the striations. Dents and notches are characterized by their dimensions, but also and above all by their location. The latter is also of interest for polish, which is also distinguished by the direction of its development and its extent. Casting flashes are differentiated by the quality of their removal, while bending and fragmentation are characterised by their absence or presence.

Once these traces were identified, they have been attributed to a step in the succession of operations. This has been made possible by the use of experimental tools and by using the characteristics already detailed for the archaeological traces. The *chaîne opératoire* of the sickle is divided into several key moments. The first is the gathering of the materials needed to make the tool. These could either come from ores or from recycling, a generally preferred option given the estimated number of bronze objects in circulation during the Bronze Age (Kuijpers 2018, 240-241 citing Bray and Pollard 2012). Once these materials were collected, the sickle was then cast and the manufacturing operations such as deburring and polishing that give it its brilliance took place. After this step, the bevel of the sickle had to be formed, then further sharpened, before being hafted and then used. Afterwards, the events of the use phase, interspersed with sharpening or honing phases, constitute the essential of the tools' biography. Finally, the sickles were either recycled or deposited, intact or fragmented beforehand. Some steps in this succession of steps were not always carried out, which can provide interesting information about the destination of the sickle. Once distinguished and integrated into a stratigraphy, the traces have therefore been attributed to manufacture, friction with the handle, use, sharpening or destruction. By integrating the archaeological context in the research, the different steps presented finally allowed to reconstruct the cultural biography of the sickles (Appadurai 1986; Kopytoff 1986).

Once the framework has been defined, this method has therefore been applied to the archaeological sickles studied in the present thesis. It has made it possible to clearly distinguish between two sets in terms of their life and death, while these sickles already fell within two different chronological and geographical groups. Indeed, the Dutch sickles, which are the oldest, have shown a particular care dedicated to their manufacture, an intensive use on a probably hard material, a succession of sharpening and finally a discard among other tools or as a single deposit. On the younger sickles of Petigny, traces of another nature could be observed. The manufacture seems to have been rather neglected, the use was brief and probably linked to a less resistant material, and above all the tools suffered a particularly brutal fragmentation. These two sets thus had different trajectories, which probably correspond to different communal and cultural practices. But apart from these conclusions, it is also important to note that these sickles were probably not intended for cutting grass plants, as is often envisaged for this type of tool (McClendon 2015, 10-20; Sych 2015, 124).

6.2. Limitations

To come to the limitations that have been determined during this research, it is necessary to distinguish several categories of events that can prevent a correct reading of the traces. The first one, inherent to the nature of the alloy, consists of corrosion and patina. These, by covering the blade, can obfuscate polish, notches and dents by concealing their true depth, and especially the striations linked to use, which seem to quickly disappear under a layer of tenorite (Gutiérrez Saez & Martin Lerma 2015, 177-178). These various elements can thus hinder the reconstruction of certain key stages in the biography of the sickles and thus be detrimental to a systematisation of the use-wear of the kind observed in the lithic industry.

The second category consists of modern damage, or at least of damage occurring after the deposition. Here, we can group together damage due to agricultural activity, damage caused during the excavation of the object, or damage inherent to the handling of objects in the context of artefacts studies or transfers from the reserves to be exhibited in museums. The conservation and restoration processes can also either obscure the traces of use or make them clearer, as it was recently investigated (Sych *et al.* 2020). These events produce traces ranging from the simple removal of patina to the fragmentation of the object. It is therefore always wise to look at the stratigraphy of the traces, which can reveal their modernity, as well as the differences in the corrosion pattern, or patina.

The attenuation of the archaeological traces can, however, be overcome by carrying out more experiments. This would allow a refinement of the observations. In order to allow the diffusion of these experiments, and thus the access of the greatest number of scholars to the references, these results should be compiled in publicly accessible databases (Dolfini & Crellin 2016, 85). Unfortunately, the constitution of these latter is only at the initial stage. However, it is worth noting that in Leiden, the Material Culture Laboratory wants to provide such a tool, with a project that will be developed during the summer of 2020. Finally, the last problem in the setting up of these experimental devices is the cost represented by the non-ferrous metallurgical work. Indeed, it requires the use of specialised craftsmen, and above all expensive materials, which archaeological institutions do not always have at their disposal. The poverty of the archaeological sector thus explains why there are so few references for bronze artefacts.

6.3. Further work needed

The number of references must necessarily be increased, in order to clarify the possible interpretations from the traces present on bronze. In spite of the limitations presented, such work remains possible. Indeed, with a standardised and exhaustive documentation of each of the phases performed with the sickle, several sequences may be carried out. In fact, by starting from the softest to the hardest material, and by intersecting each use with a complete sharpening, it is possible to obtain interesting results, and above all to limit the costs linked to the experimentation of bronze. To get these results, it is also necessary to use these tools more intensively to allow the development of traces that take, for lithic tools, much less time. By the way, this more intensive and therefore more demanding use is in accordance with the succession of experiments advocated above.

But the main teaching of this thesis is that one must think outside the box, especially in the experimental phase. Indeed, preconception applied to a tool because of its morphology can influence the interpretation made of the archaeological traces (Reeves Flores & Paardekooper 2014, 74). For example, in the case of sickles, they have often been attributed a role related to agriculture. However, their absence from settlements and their reduced number implies that another type of tool was probably used for more common crops (Van Gijn et al. 2014, 85-132). Their deposition, sometimes accompanying other types of object, also raises the question of their significance for ancient populations. Based on these observations, it is therefore difficult to attribute a conventional role to them, and experiments should therefore make it possible to broaden the scope of possibilities. Then, the materials and movements reproduced should be as numerous as possible, in order to provide the use-wear researcher with a basis for comparison that allows all options to be considered, without any typological bias.

Furthermore, standardisation of methodology and terminology is still necessary, as Gentile and Van Gijn, as well as Dolfini and Crellin have stated it (Dolfini & Crellin 2016, 84-85; Gentile & Van Gijn 2019, 136). This work is a further step in this direction, since it is partly based on the methodology defined by McClendon (2015, 36-56). However, it is necessary to go even further, in order to develop the discipline as widely as possible. More than an improvement in descriptions, such a step forward would make it possible to clarify interpretations.

To conclude, the bronze sickle is not a simple tool, it is an object that carries a message that evolves over the course of the Bronze Age. Its use and its abandonment are part of actions that can be functional and symbolic. Its life and death are punctuated by many events, many ideas, that a man or a woman concretised during a stage of the biography of the tool. This study of striations, polish, dents and cracks has proved able to get a better grasp on the latter. Behind the traces, humans and their practices.

7. Abstract

Microwear analyses, although well developed for stone or bone for example, still have many shortcomings when it comes to non-ferrous alloys. Indeed, apart from weaponry and axes, there are few studies concerning bronze artefacts. Thus, it is proposed here to focus on an object - the bronze sickle - that is purely functional at first glance, which could allow to investigate many themes from the traces of wear and tear. The reconstitution of the biography of these tools would make it possible to provide information on the use of a tool that seems to have struggled to replace its flint equivalent, and which was found in single or multiple deposits from the Middle Bronze Age B to the Final Bronze Age in the Low Countries. Were these sickles used on gramineous plants, how often, did they have a long life; these are the main questions that were addressed in this thesis. In order to make this restitution possible, it was necessary to determine, thanks in particular to elements of comparison from experimental archaeology, the characteristics that could indicate each of the stages in the *chaîne opératoire*, and then the events that occurred up to the end of the sickle's life for the Bronze Age populations. Thus, polish, striations, damage on the cutting-edge, or traces of residues were isolated, identified, and characterized, in order to determine the differences between the objects studied. The traceological analysis has therefore made it possible to strictly distinguish the three Dutch sickles found at Epe, Ede and Heiloo from the nine fragments found at Petigny in Belgium. The first set seems to have been used massively on rather solid materials before being deposited in an unharmed condition, while the second set presents only slightly worn artifacts, which seem to have been subjected to great ritual violence, leading to the complete fragmentation. This study therefore made it possible to learn a little more about the evolution over time of deposition practices during the Bronze Age within a common cultural group in the broadest sense, since both the Belgian and Dutch sides were located at the intersection of several important exchange zones. Additional studies could provide further insight into the biography of these tools, and to gain more confidence in the identification of the processed materials. The present thesis also highlighted the limitations that are linked to the study of metal, which can sometimes be complicated due to the presence of corrosion, damage to the objects or the age of discoveries. It was possible as well to draw conclusions regarding the progress needed to enable better results

for the use-wear studies on bronze artefacts. Indeed, already prescribed by Dolfini and Crellin, the creation of large reference databases seems necessary, and the research carried out at the laboratory of material culture at Leiden University seems to be moving in the right direction in this respect.

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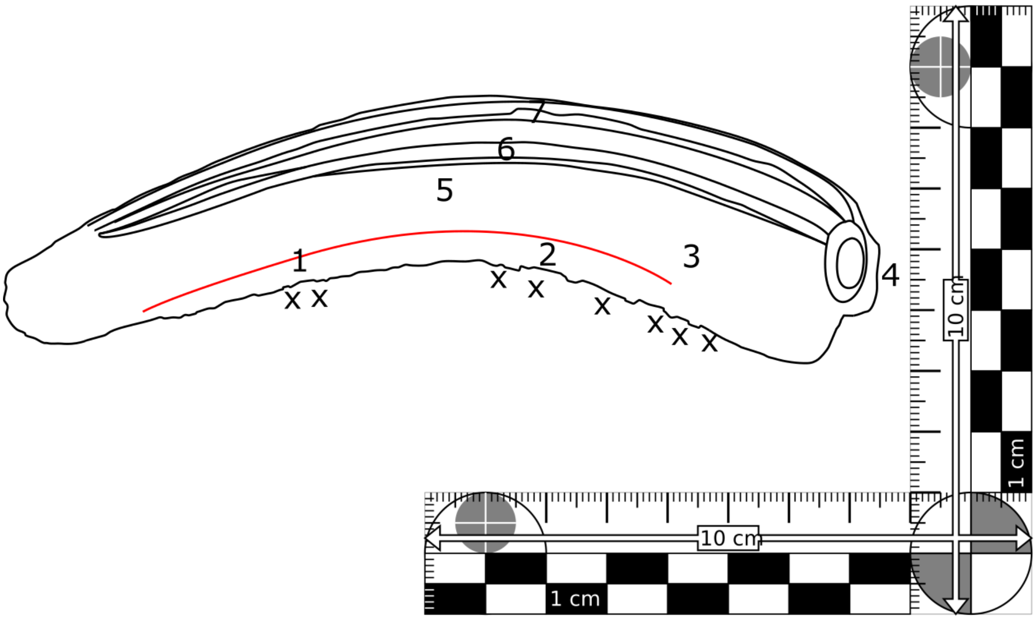
9. Figures

10. Tables

11. Appendix

App. 1: results and drawings

Drawing of E2010 and observations, A-Side



1 Irregular transversal striations associated to cutting edge damages such as notches on DE

2 Fairly regular transversal striations associated with a light polish and deeper on ME

3 Sequence of regular transversal striations, shallower than the ones from the cutting edge

4 Possible polish on the knob, but due to the location and the difficulty to spot polish on metal, highly dubious

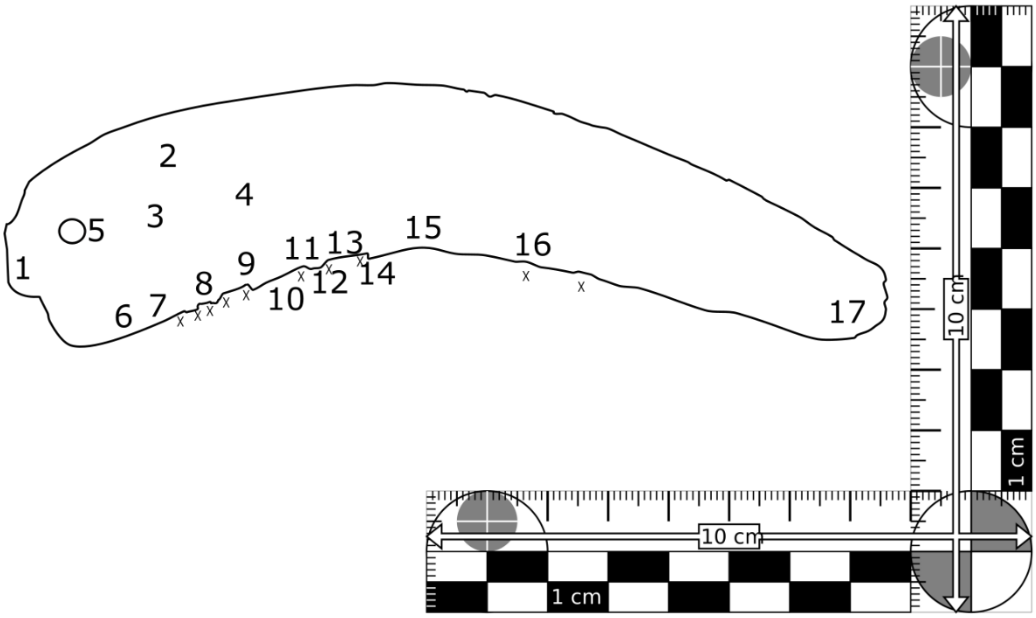
5 Longitudinal striations covering the blade, being more or less regular

6-7 Regular transversal striations located both BR and BlR

X Edge damages

The patina was damaged in a few areas

Drawing of E2010 and observations, B-Side



1 Casting flash

2 Differentiated patterns of corrosion

3-4 Sticky material covering a greenish patina

5 Semi-pierced hole with deep multi-directional striations

6-7 Transversal striations prolongating far inside both located on HE and HA

8 Shallow and short diagonal striations

9 Shallow and short transversal striations

10-12 Deeper transversal striations associated with some polish, finishing around the start of ME, covered partially by long longitudinal striations

13-14 Edge damages more clearly associated to polish and vertical striations

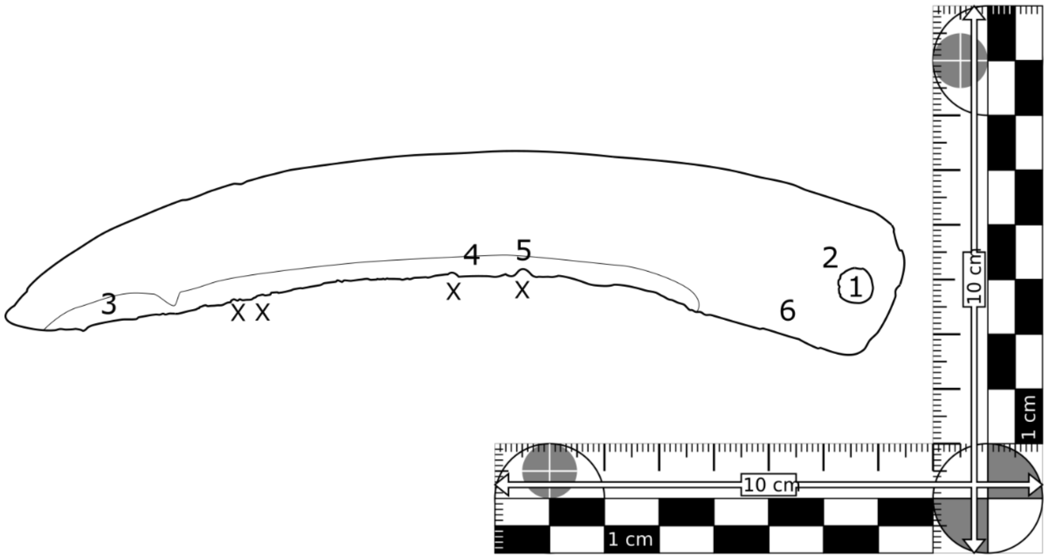
15 Small strip of polish associated with slightly shallower striations cut by longitudinal striations

16 Polish associated with longitudinal striations

17 Small sequence of transversal striations without polish on N, irregular in depth

X Edge damages

Drawing of G1947 and observations, A-Side



1 Hafted part, with multi-directional striations inside the peg-hole

2 Polish on the edges of the peg-hole and on HA associated with long and deep longitudinal striations

3 Transversal striations on a side deeply affected by corrosion associated to a dent, which gives information about the original size of the cutting edge

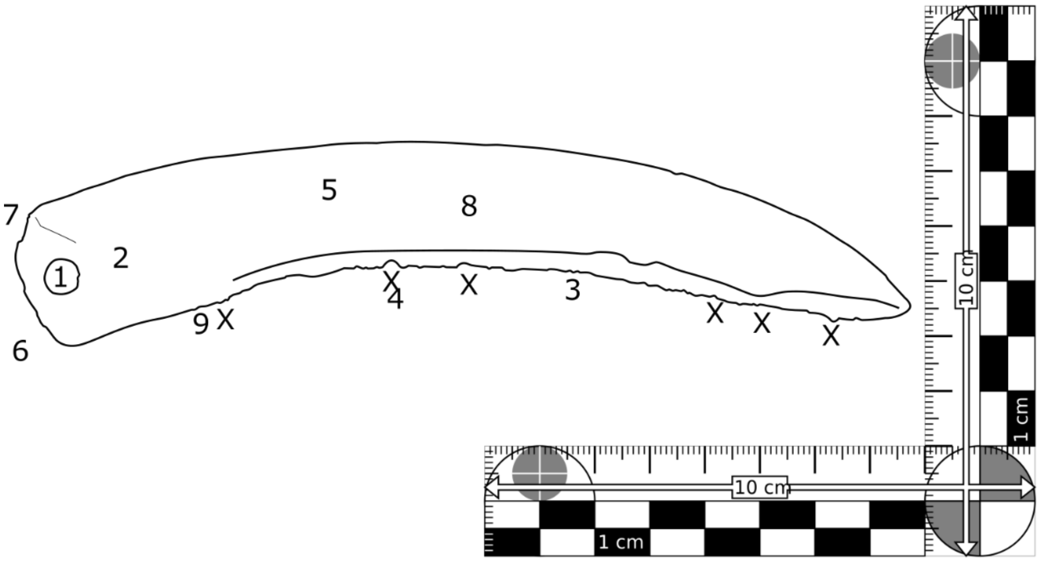
4 Small strip of polish running principally on ME

5 Notches associated with shallow transversal striations and polish

6 Goldish/amber-like residue, not more than a drop, located on HE

X Edge damages

Drawing of G1947 and observations, B-Side



1-2 Polish on the edges of the peg-hole and on HA

3 Shallow diagonal striations

4 Notches associated with shallow transversal striations and polish

5 Concentration of longitudinal striations on MS

6 Hafted part, delimited at the top by an abrupt change in thickness of the blade

7 Strip of blackish material

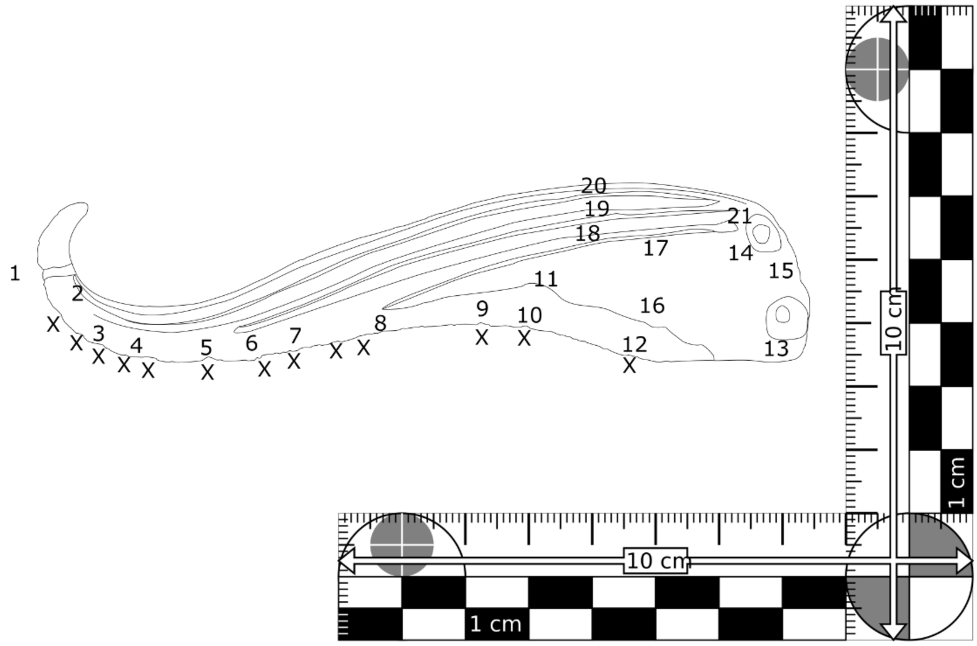
8 Material deformation showing deep longitudinal striations

9 Casting flashes seem to have been folded and extensively polished at the transition between HE and PE

X Edge damages

Slightly bent towards A-Side

Drawing of WE 7 and observations, A-Side



1 Breakage point, caused by bending of the N

2 Transversal striations

3 3 notches without material displacement with the third one (counting from N) bearing some transversal striations

4 Folded and polished casting flashes

5-7 Notches associated to transversal striations

8 Notches without transversal striations

9 Triangular dent associated with some transverse scratches partly erased by longitudinal striations

10 Rounded notch

11 Deep transversal scratches possibly posterior to longitudinal striations

12 Deep transversal striations

13-14 Knob with possible polish from hafting

15 Blackish agglomerates on HA (corrosion)

16 Slightly different blackish agglomerates than 15 (corrosion)

17 Transversal blow mark

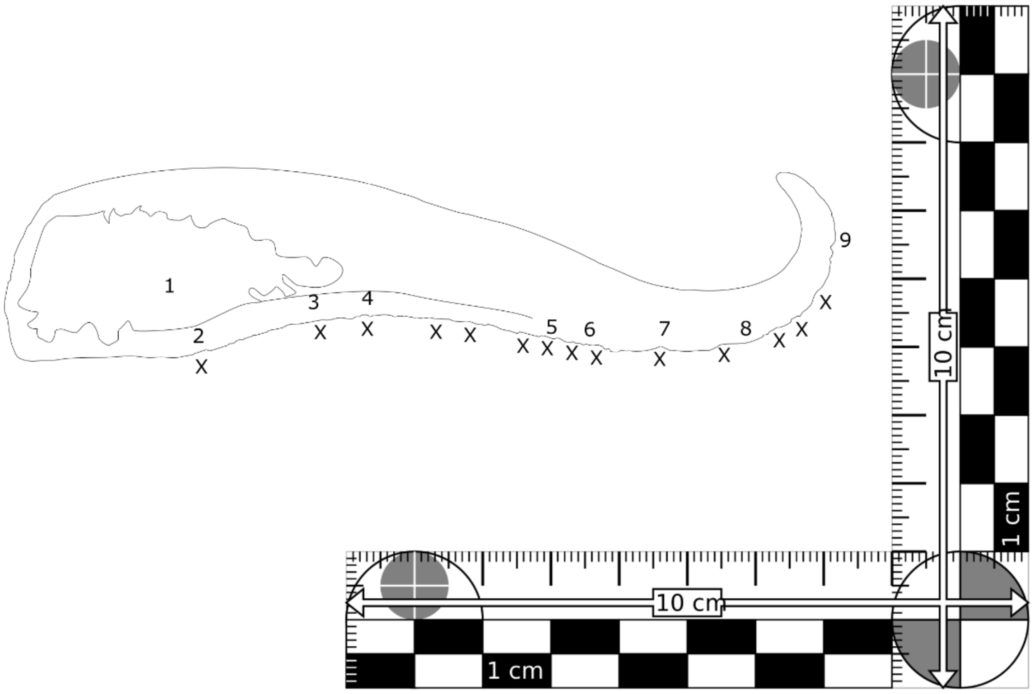
18-20 Ribs with striations, mainly irregular and transversal

21 Striated imprint looking like the structure of a wooden element, in corrosion surrounding HA, near the top knob

X Edge damages

Possible presence on a slight polish on the cutting edge, on ME principally

Drawing of WE 7 and observations, B-Side



1 Greenish patina with a different corrosion pattern. Associated with the same kind of blackish material than on A-Side next to the knobs. This patina is scratch-free and covers the bronze surface that displays longitudinal striations

2 Notch associated with transversal striations, cut by deeper longitudinal scratches

3-4 Notches associated with shallower and narrower transversal striations, cut, again, by longitudinal scratches

5 Series of small edge damages, associated with transversal striations cutting longitudinal scratches but cut by deep and large longitudinal grooves, with diverse sizes that allow to establish a clear stratigraphy, principally on DE

6 Irregular transversal striations forming a confusing stratigraphy with longitudinal scratches

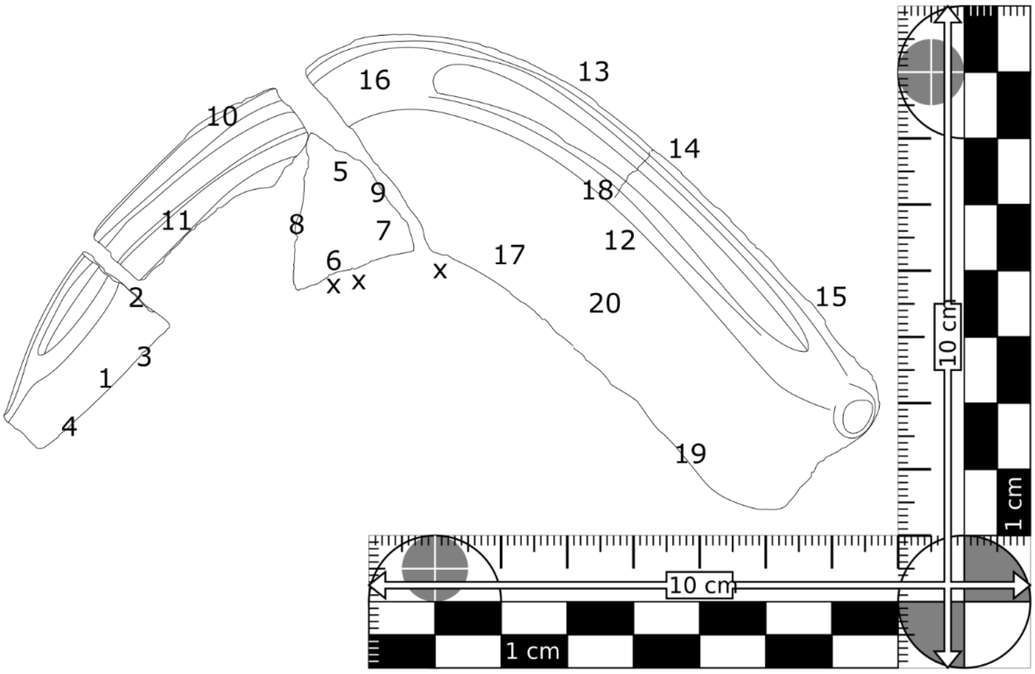
7 Notch associated with transversal striations

8 Material displacement from folding the casting flash

9 Damage by bending, rupture in sharpening striation's directionality, suggesting that the blade was not sharpened again to this point after the folding of the blade

X Edge damages

Drawing of Petigny 1/14 + 1/15 + 1/23 + 1/31 and observations, A-Side



1 Longitudinal striations running on DE, while the bevel is extended rather far along on the blade

2 Sharp fragmentation

3-4 Slight indentation coming either from corrosion, use, or both

5 Long regular transversal striations prolongating towards ME

6 Notches more likely to be linked with use because of their shape

7 Lightly marked bevel

8-9 Rather coarse fragmentation

10 Casting flash that was not bent over

11 Shallow transversal striations

12 The blade is twisted right after HA, around PS

13-15 Folded casting flashes

16 Casting failure, filling the gap between BR and BlR

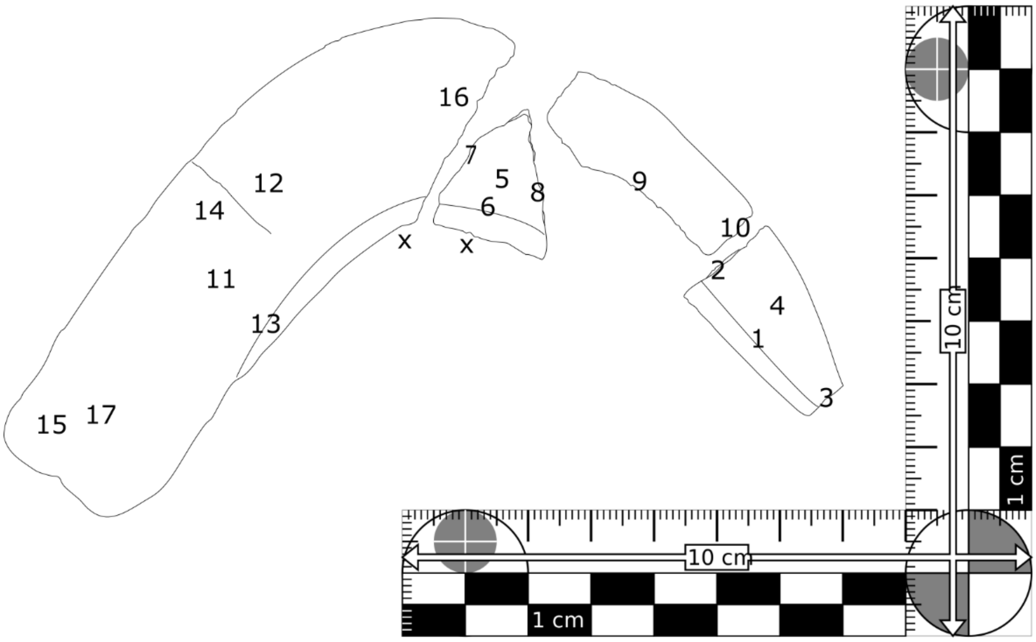
17 Longitudinal striations running on PE-ME

18 Crack caused by torsion, blow or torsion

19-20 Transversal striations on HE as well as on the bevel

X Edge damages

Drawing of Petigny 1/14 + 1/15 + 1/23 + 1/31 and observations, B-Side



1 Bevel particularly marked for a B-Side, and especially for DE, while there are no transversal striations

2-3 Sharp fragmentation

4 Longitudinal scratches on DS and DE which are dissimilar (on DE, shallower and more concentrated)

5 Regular multi-directional striations

6 Bevel much less formed on ME than on DE

7-9 Rather coarse fragmentation

10 Displacement of material that could indicate fragmentation by twisting

11 Twisting of the blade

12 Crack linked with the torsion, a blow, or both

13 Unique but clear presence of transversal striation located on PE

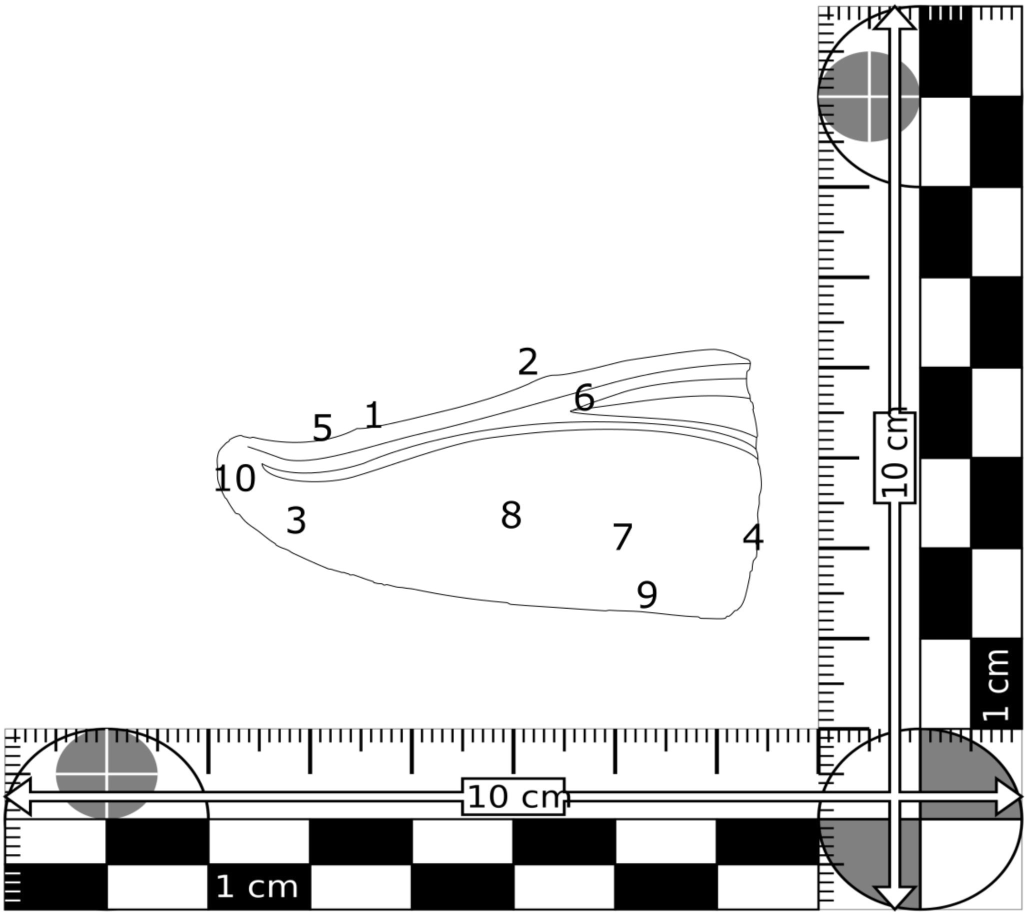
14-15 Light multi-directional scratches maybe linked with the torsion, as they can be found on both the material deformation of HA, around the crack and following the line of fragmentation on MS

16 Crack that may come from the fragmentation, rather from a blow than a torsion

17 Material deformation that may come from the torsion

X Edge damages

Drawing of Petigny 1/18 and observations, A-Side



1-2 Casting flashes unfolded but seemingly polished to reduce them

3-4 Slight bending, corresponding either to use (3) or to destruction (4)

5 Transversal striations towards the distal end of the rib, very local

6 Longitudinal striations

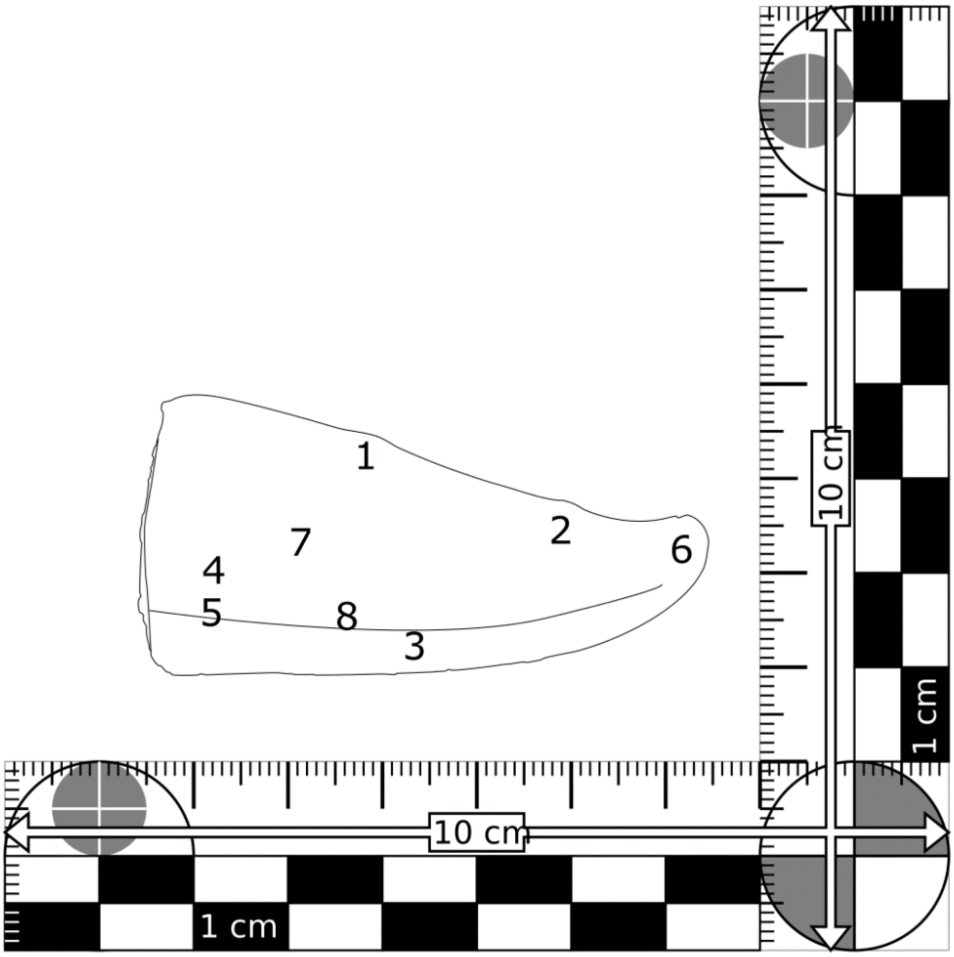
7 Absence of clearly marked bevel, maybe because only DE has been preserved

8 3 kinds of grooves, with large but few transversal ones which are cut by a curvy pattern of regular, shallow and narrow striations, maybe a result of the deformation of the material, and that cut longitudinal and regular ones

9 Longitudinal striations probably coming from sharpening

10 No real dents or notches, but N seems to have suffered the most and is totally rounded and presents what could be a light polish

Drawing of Petigny 1/18 and observations, B-Side



1-2 Casting flashes

3 Irregular longitudinal deep grooves preceded towards ME by smaller and more numerous scratches

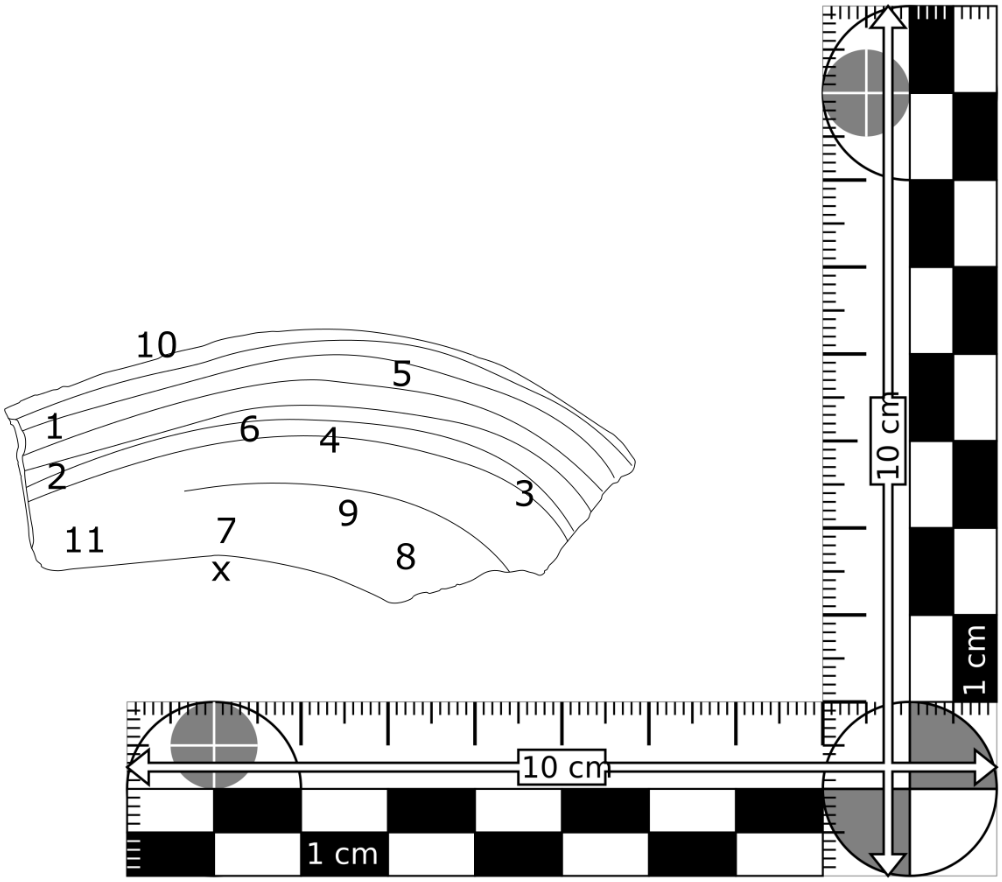
4-5 Multi-directional striations of various length and depth, associated with regular and shallow ones, the latter coming possibly from the material deformation occurred during the bending

6 Light band of polish on N, associated with rare and deep transversal striations towards DE

7 Short blows, that may have been caused in the process of destruction

8 Bevel rather lightly marked

Drawing of Petigny 1/21 and observations, A-Side



1-3 Deep blow marks, located on both ribs, on both edges of the fragmentations

4 Multi-directional hits between the ribs

5-6 Damaged patina on BR and BlR, maybe by modern action

7 Deep and large transversal striations cutting long shallow and narrow longitudinal striations, maybe associated with a forming notch on ME

8 Narrow and shallow diagonal striations

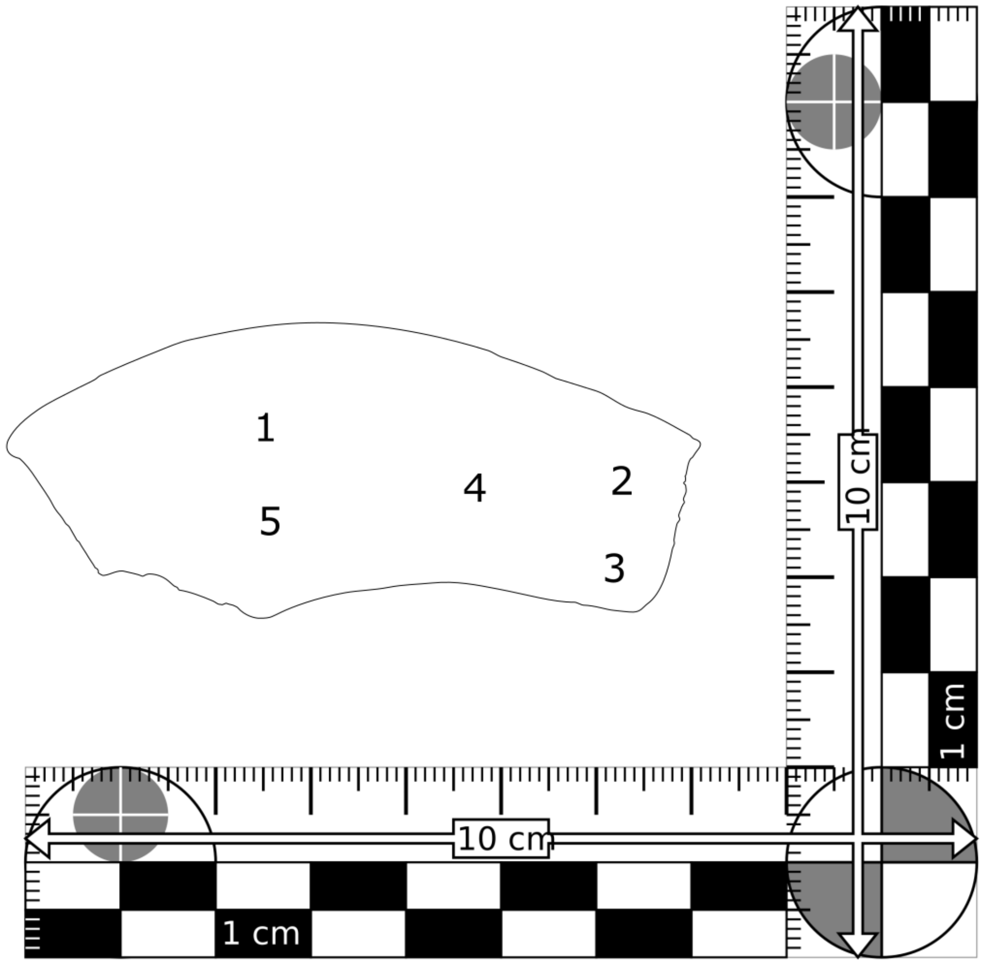
9 Lightly marked bevel

10 Partially removed casting flashes from casting

11 Torsion of the blade towards DE

X Edge damage

Drawing of Petigny 1/21 and observations, B-Side



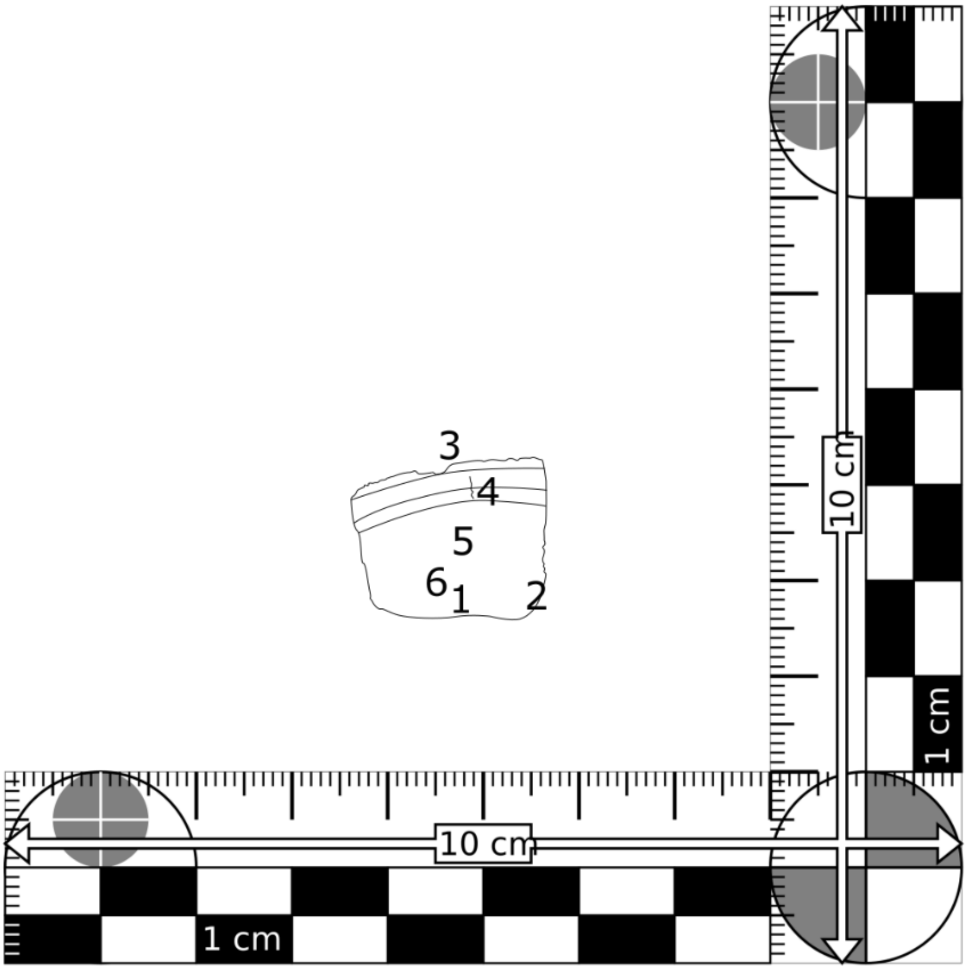
1-2 Deep blow marks

3 Torsion of the blade, towards DE, where the blade is fragmented, associated with blow marks (2) and very shallow and narrow scratches, maybe coming from the deformation of the material

4 Shallow and narrow scratches that do not have the same directionality than the longitudinal ones

5 Confusing set of striations of different depth, shape and directionality

Drawing of Petigny 1/33 and observations, A-Side



1 Longitudinal striations

2 Displacement of material probably coming from a folding action

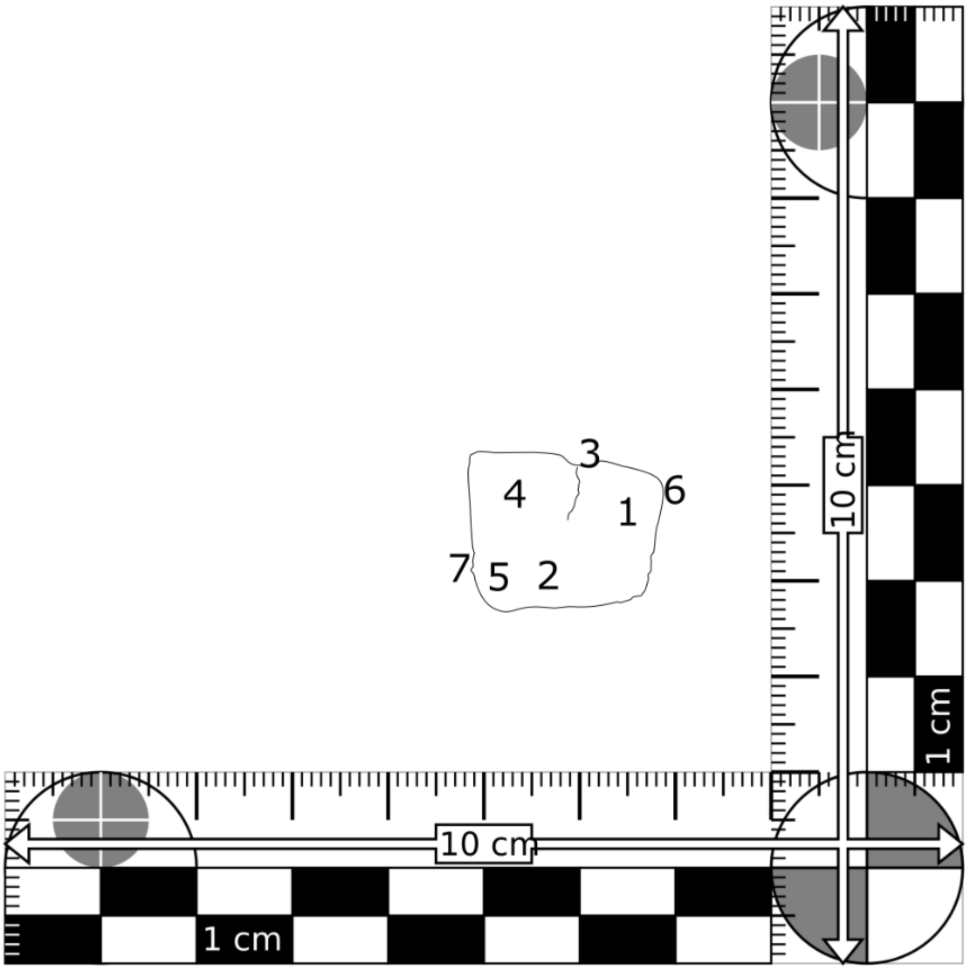
3 Notch that seems linked to a blow with a sharp object, causing a torsion effect to the top of the blade

4 Crack resulting from the blow and the torsion

5 Shallower longitudinal striations

6 The bevel is slightly marked, which, together with the size of the portion, may be the sign that the fragment conserved the DE of the blade

Drawing of Petigny 1/33 and observations, B-Side



1-2 Blow marks, probably ancient, seeming to be related to the destructive process

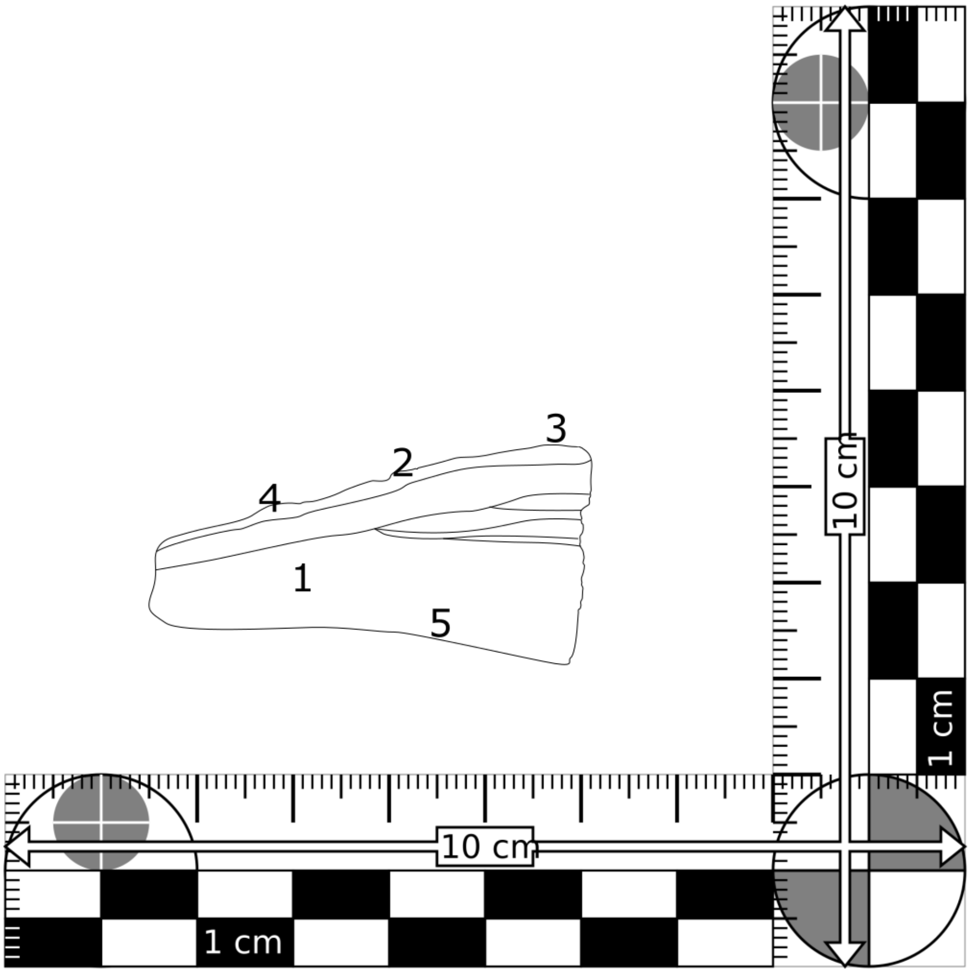
3 Break at the middle of the fragment, associated with the notch, maybe a hit on dorsal edge with a sharp object

4 Several places where the patina was removed, probably modern

5 Confusing set of striations, of different depth, shape and directionality, located on DS

6-7 Displacement of material probably caused by the torsion of the blade during the destructive process

Drawing of Petigny 2/55 and observations, A-Side



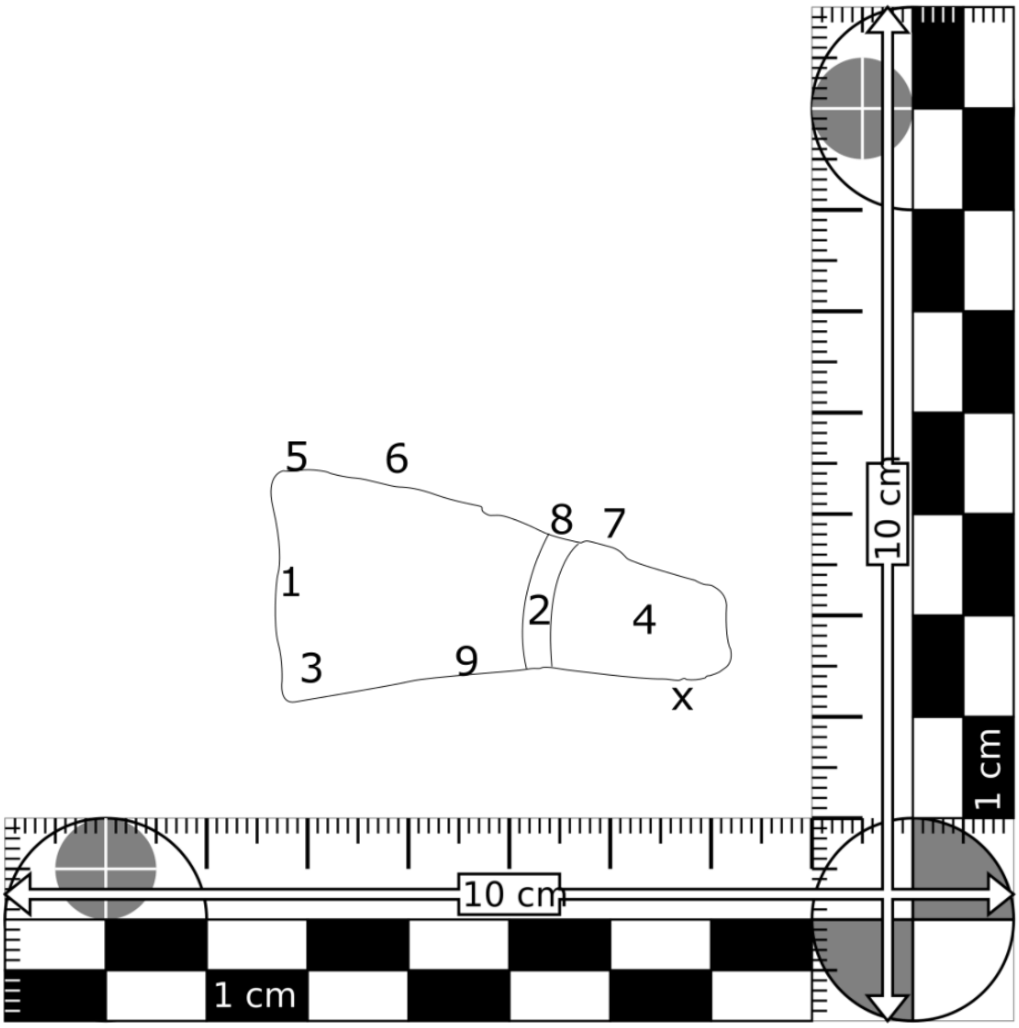
1 Torsion on DE

2-3 Casting flashes, incompletely polished

4 Displacement of material caused by the torsion

5 The nature of the material makes it impossible to clearly spot striations on the cutting edge

Drawing of Petigny 2/55 and observations, B-Side



1 Displacement of material probably due to fragmentation by bending

2 Folding of the blade, associated to transversal narrow striations

3 Long longitudinal striations

4 Confusing set of striations, principally narrow and shallow, of different directionalities, located on DS

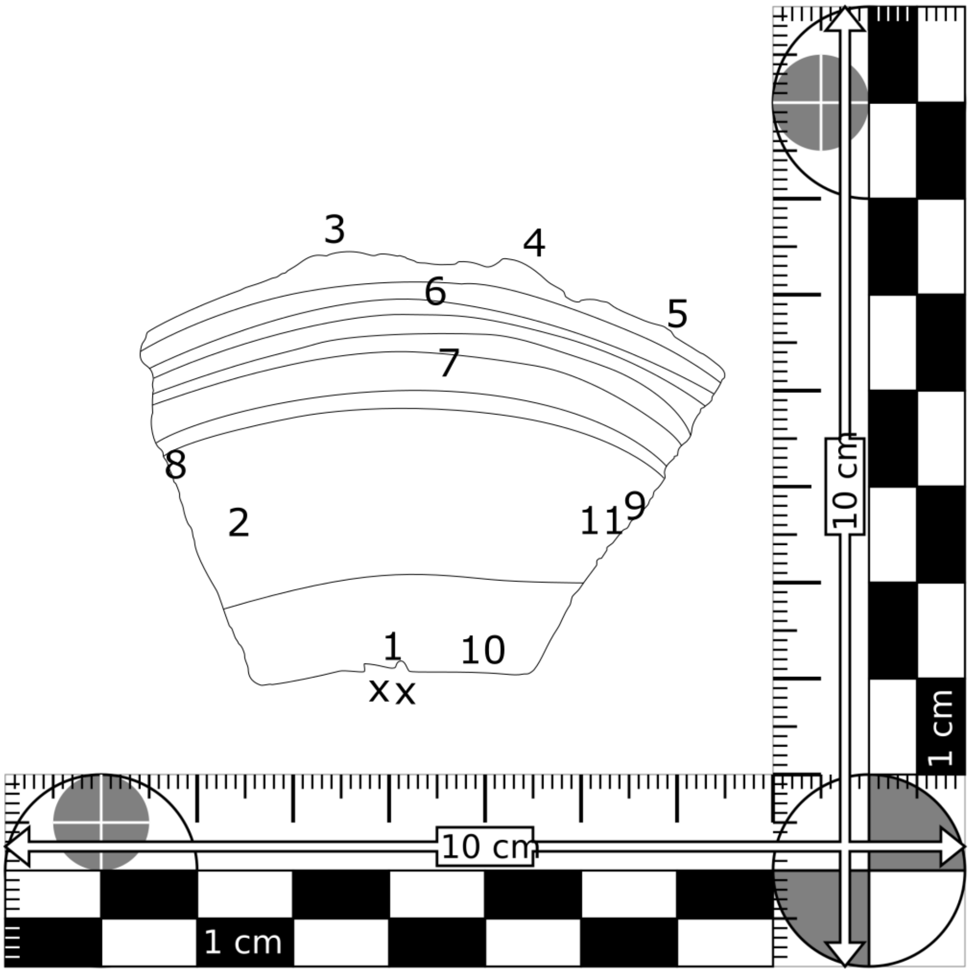
5-7 Slightly polished casting flashes

8 Displacement of material due to the bending of the blade

9 No trace of any bevel, and as for A-Side, impossible to spot any striations

X Edge damages

Drawing of Petigny 2/57 and observations, A-Side



1 Notches probably posterior to sharpening, associated with what may be a light polish, with a massive displacement of material, located right on ME

2 Blade bent towards DS

3-5 Casting flashes coarsely polished and hammered

6-7 Mechanical pression on BR and BlR to form some kind of decoration (Primas 1986)

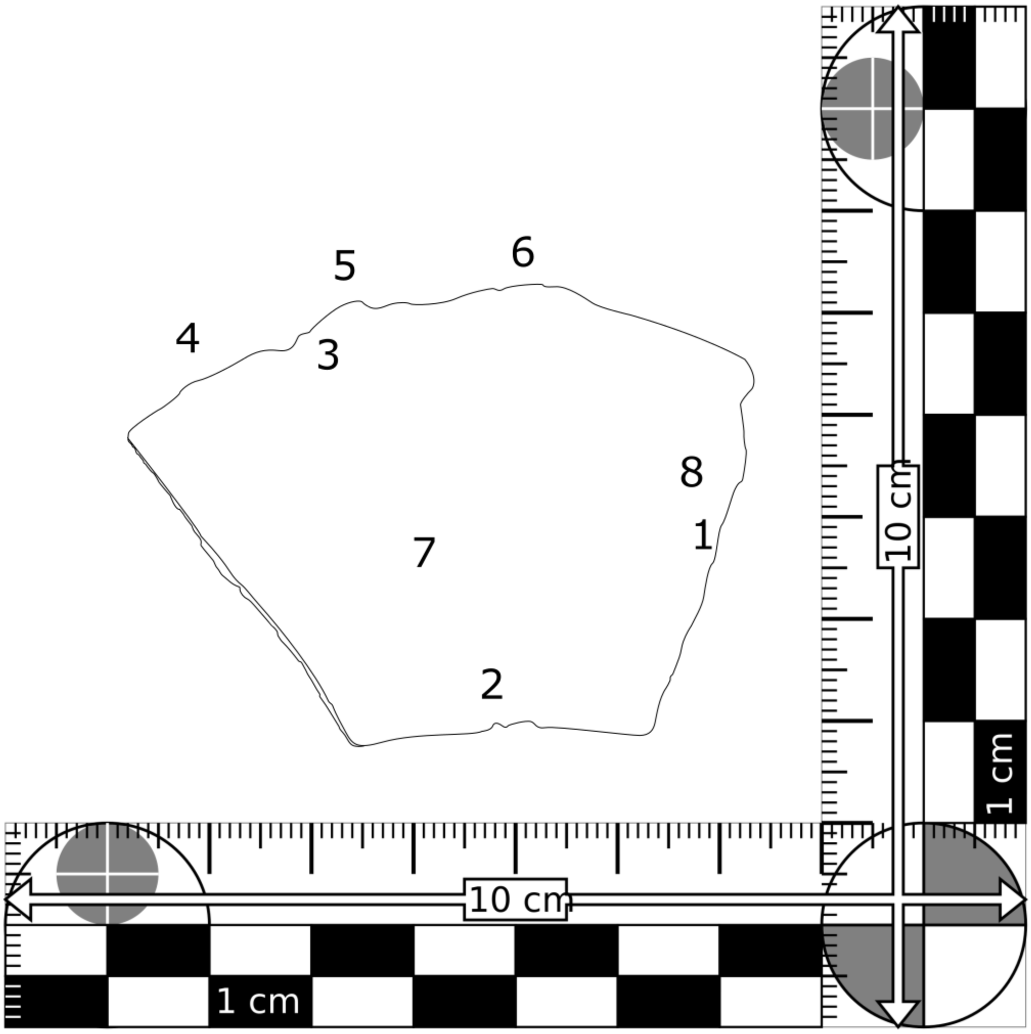
8-9 Patina on the broken sides as well, testifying that the fragmentation is ancient

10 The material makes it difficult to spot any striations on the edge, but it is still possible to observe longitudinal striations

11 Transversal striations probably caused by the deformation during the bending leading to the fragmentation of the blade

X Edge damages

Drawing of Petigny 2/57 and observations, B-Side



1 Massive displacement of material caused by the fragmentation of the blade, by bending it
2 Shallow transversal scratches cut by longitudinal striations cut by notches

3 Notch with a possibility to be caused by a hit, or more probably appearing because of the casting flashes

4-6 Casting flashes coarsely polished and hammered

7 Confusing set of numerous, short, shallow and multi-directional striations

8 Transversal and multi-directional shallow striations