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The Sickle's Edge: an Experimental Use-wear Approach to Investigating Sickle Deposition in Bronze Age Europe

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THE SICKLE'S EDGE:
AN EXPERIMENTAL USE-WEAR APPROACH TO INVESTIGATING
SICKLE DEPOSITION IN BRONZE AGE EUROPE

by

Barbara Ellen McClendon

A Thesis Submitted in
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ABSTRACT

THE SICKLE'S EDGE: AN EXPERIMENTAL APPROACH TO INVESTIGATING SICKLE DEPOSITION IN BRONZE AGE EUROPE

by

Barbara Ellen McClendon

The University of Wisconsin-Milwaukee, 2015
Under the Supervision of Dr. Bettina Arnold

Prehistoric hoards—containing items such as precious metals, tools, ornaments, and weapons—have long fascinated archaeologists and the general public alike. The practice of intentional wealth deposition in hoards was particularly prolific during the European Bronze Age; however, the motivations behind this practice remain unclear. Comparisons of the contents of hoards through space and time can yield valuable data regarding the purpose and process of deposition, but one of the most common items found in Bronze Age hoards—bronze sickles—remains understudied. In order to generate a standardized approach to the comparative analysis of prehistoric sickles in a variety of contexts, I propose a protocol for measuring indications of use-wear, based on the results of experimental trials. Four bronze sickles were cast, hafted, and used in harvesting vegetation. After two harvesting trials, microscopic images were taken of the back and front of each cutting edge; use-wear maps were created identifying bluntness, abrasion, striations, and blade deformation. Similar use-wear maps were created for seven prehistoric bronze sickles in the collections of the Field Museum of Natural History, the Logan Museum of Anthropology, and the Milwaukee Public Museum. The data generated by comparing wear patterns on the experimental sickles with the working edges of the

prehistoric sickles suggest that indications of use can be identified through specific patterns of abrasion and bluntness along a sickle's cutting edge. These sickle-specific use-wear patterns and the process of producing and using the experimental sickles are described in detail to serve as a foundation for further systematic analysis of prehistoric bronze sickles and their depositional contexts.

For my parents.

All that I am, I owe to you.

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CHAPTER 1: INTRODUCTION

Bronze Age hoards and other intentional wealth deposits in Europe represent an important source of archaeological evidence for daily life and social structure. Indeed, the majority of the metal which survives from the Bronze Age has been recovered from such deposits, which represent a near pan-European practice from the Neolithic to the Iron Age with a peak during the Late Bronze Age (Cunliffe 2011:254; Hansen 2013:180). This ubiquity has inspired numerous research questions concerning the circumstances of their deposition as well as their function in society. Were they intended as offerings to deities, mechanisms of economic management, signals of authority, or were they primarily caches intended to be recovered at a later date? These theories largely draw evidence from the contents of the hoards themselves. Surprisingly, very few of these research questions have focused on one of the most common artifacts found in such intentional wealth deposits: bronze sickles.

Bronze sickles and bronze axes are the most common objects in Bronze Age hoards (Bradley 1990:118), but metal sickles are generally understudied in the archaeological literature, particularly in English language publications. Bronze axes, on the other hand, have been the subject of a number of recent studies focusing on use-wear and experimental archaeology (Heeb and Ottaway 2014; Kienlin and Ottaway 1998; Roberts and Ottaway 2003). Similarly, flint sickles have been the subject of numerous research projects in the Old World; a name for a well-known use-wear pattern has even come from these studies: “sickle-sheen” (Cortina and Preysler 1999; Goodale et al. 2010; van Gijn 2010; Vardi et al. 2010). Bronze sickles, however, have so far not been analyzed from the use-wear perspective even though this seems an obvious method of comparing hoards and regions to

one another throughout time. In order to partially alleviate this gap in the literature, this thesis uses a framework of experimental archaeology to approach the subject of use-wear on bronze sickles in an attempt to formulate an understanding of their function in the hoard context and Bronze Age society more generally. The main working hypothesis is that first, there is a conceptual difference between hoards composed of used objects and hoards containing objects in mint condition; and second, this difference has implications for an analysis of the category of Bronze Age hoards as a social, economic, and ideological phenomenon.

Aims and Scope of Research

This thesis aims to expand the body of knowledge concerning intentional wealth deposition in Bronze Age Europe by proposing a methodology that can be used in investigating bronze sickle deposition in particular. Sickles are one of the most ubiquitous inclusions in Bronze Age hoards, so furthering the investigation of this artifact type has the potential to produce significant data concerning the phenomenon of hoard deposition in general.

The central questions addressed by this research project include the following:

- Do bronze sickles in the European collections of the Field Museum, Logan Museum, and the Milwaukee Public Museum show evidence for significant use-wear, and if so, at which locations on the implements? To what extent does preservation impact the working edge of these objects?
- Can the cutting of vegetation be identified through use-wear analysis of the working edges of experimentally produced bronze sickles? If so, what types of wear patterns are observed on which areas of the sickle blade?

- Can the methodology developed by this research project be utilized in analyzing other collections of Bronze Age sickles? Can a protocol for such an analysis be established based on the results of this project?
- What could evidence for wear (or its absence) on sickles deposited in hoards potentially tell us about the nature of such deposits in prehistoric Europe?

This thesis is primarily focused upon developing a methodology; therefore, analyzing a statistically significant sample of bronze sickles in several museums was beyond the project's scope. Rather, the goal of this project was to develop an approach that could be used in future research to analyze and compare collections of bronze sickles (e.g. several sickles from a single intentional wealth deposit; sickles from different types of deposits; or different types of sickles from different periods of prehistory). In order to provide an example of the application of the methodology developed here, an analysis of several Bronze Age sickles from European contexts is presented in Chapters 4 and 5, and a preliminary discussion is provided using the data generated by this project—though the author cautions against viewing these results as representative of overarching Bronze Age practices.

The experimental archaeology undertaken in this study served as more than a method to answer the proposed research questions. The process of creating and using bronze sickles also provided abundant insight into material, social, and technical aspects of metallurgy which could hardly have been gained any other way.

Four bronze sickles were created for the purposes of this research; they were based on known Bronze Age artifacts (Figure 1.1) and technology and created using comparable techniques. Four sickles were cast from a copper-tin alloy in two-piece molds, similar to the



Figure 1.1 Tanged (top) and button (bottom) sickles in the collections of the Manchester Museum (Willett 1954:107).

stone molds commonly used in the Bronze Age, and hafted to wooden handles using leather strips. Microscopic images were taken of the blade edges after cold hammering and whetstone sharpening.

Next, grasses were harvested by hand with each of the experimental sickles and microscopic images were taken of the working edges. The experimentally

produced sickles constituted the control group. Microscopic images were taken of the edges of seven Bronze Age sickles located in Midwestern museums; these constituted the group to be analyzed and compared to the control group. Four sickles from the Field Museum, one sickle from the Milwaukee Public Museum, and two sickles from the Logan Museum of Anthropology served as the comparative specimens. Finally, the microscopic images of the experimental sickles were compared to the images taken of the Bronze Age artifacts in order to determine: a) whether the archaeological specimens had been used; b) whether such use could still be seen on the edges of these implements; and c) whether the type, extent, and location of wear on the archaeological specimens was similar to that on the control group.

This thesis is organized into five chapters with supplementary figures provided in two appendices. The second chapter will present a review of the pertinent literature, provide a background for the project, and situate the artifacts used in their temporal and spatial context. Chapter three represents the most significant contribution of this thesis: its

methodology, including experimental procedures and artifact based data collection. The fourth chapter will present the results derived from using the experimental sickle reproductions as well as the evidence derived from the bronze artifacts. Chapter five will include both analysis and discussion of these results before moving on to a presentation of the conclusions derived from this research and suggesting potential directions for future research on this subject.

CHAPTER 2: BACKGROUND AND REVIEW OF LITERATURE

A study of bronze sickles must consider both functionality and materiality, therefore some discussion of both Bronze Age agricultural and metallurgical practices is useful here, in addition to situating the project spatially and temporally in the Bronze Age of Central Europe. As sickles are overwhelmingly found in intentional wealth deposits in this region (Bradley 1990:118), the focus will be on hoards and their possible function and meaning. A survey of experimental bronze casting and metallurgical use-wear studies will follow, and a description of the contexts of the artifacts analyzed in this thesis will conclude this selective summary of the pertinent literature.

The Bronze Age in Central Europe

The Bronze Age in Europe is a particularly rich area of research due to the widespread change and innovation driven by increasingly extensive cultural contact required by the limited distribution of copper and, especially, tin (Figure 2.1). In particular, isotope analysis has provided evidence of significant mobility and frequent long-distance travel among Bronze Age peoples (Frei et al. 2015:5). Populations during this time period were becoming more agglomerated and social complexity was on the rise. The intensification of cultural contact brought about an increase in trade as well as warfare, as communities struggled to maintain control of resources such as arable land, grazing pastures, trade routes, and metal ore deposits. The Bronze Age is also archaeologically significant due to the increasing visibility, especially during the Middle Bronze Age (Barber 2003:12), of house structures, ditches, palisades, field networks, and stone walls, enabling

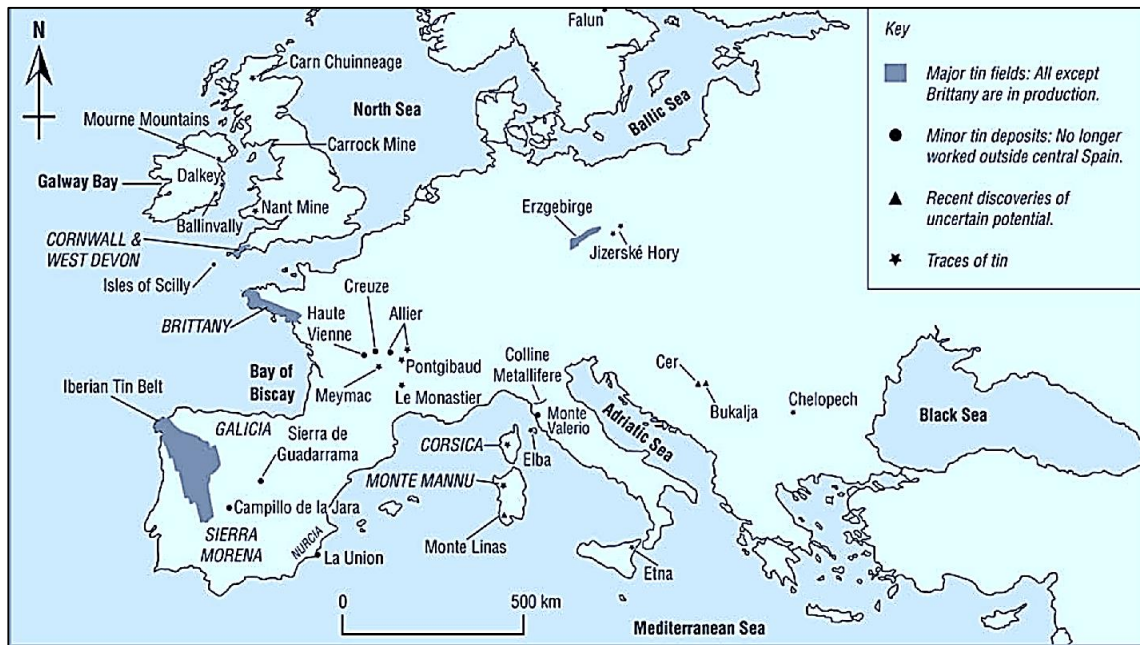


Figure 2.1: Tin deposits throughout Europe (Pearce 2004:7).

archaeologists to paint a more comprehensive and detailed picture of daily life than was possible in preceding periods.

Bronze Age food production necessarily intensified in order to support increasing population levels. In addition to cereal crops and legumes, livestock such as cattle, sheep/goat, and pig provided the basis of subsistence (Cunliffe 2011:180; Harding 2002:295). Once subsistence needs were being met in a stable manner, energy could be expended upon activities not directly related to survival. According to Bartelheim’s research into the Early Bronze Age in Central Europe, this time period’s “agricultural-based prosperity... stimulated the development of metal production” (2009:34). In this climate of economic growth and trade expansion, those engaging in non-essential activities could now rely upon the food surplus of others in exchange for the products of their own part-time or full-time specialist labor.

The Bronze Age is generally temporally defined as the period from 2200 to 750 BCE, (Table 2.1) though regional chronologies are more detailed and often vary significantly

European Bronze and Early Iron Age Chronology			
Outline	Paul Reinecke	Absolute Dating (BCE)	
Early Bronze Age (Únětice and related cultures)	Bronzezeit A	A1:	2200 - 2000/1950
		A2:	2000/1950 - 1600/1500
Middle Bronze Age (Tumulus cultures)	Bronzezeit B	1500 - 1300	
	Bronzezeit C		
Late Bronze Age (Urnfield cultures)	Bronzezeit D	1400 - 1200	
	Hallstatt A	1250 - 1050	
	Hallstatt B1	1100 - 1000	
	Hallstatt B2/3	1050 - 750	
Early Iron Age (Hallstatt culture)	Hallstatt C	800-600	
	Hallstatt D	600-450	

Table 2.1: Chronology of the Bronze and Early Iron Ages; table created from the dating system used by Harding (2002) and Wells (2002) for the Bronze and Iron Ages, respectively, with Paul Reinecke's (1965) widely accepted chronology.

within that temporal range. It is important to note that bronze production is not limited to these years, as in some areas the alloy was first produced during the Late Neolithic or Chalcolithic, and continues to be used in the Iron Age, especially for ornamental purposes.

The first substantial bronze production in Europe is attributed to the Central European Únětice Culture, located near the current border between Germany and the Czech Republic, at approximately 2400 BCE (Pearce 2004:6). The British Isles provide the first solid evidence for a bronze-using economy around 2200 BCE. However, it was not until 1300 BCE that the Bronze Age was finally established across Europe as a whole (Cunliffe 2011:181; Harding 2002:273).

True tin-bronze (hereafter: bronze) was a highly advantageous innovation, being both harder and more aesthetically pleasing than unaltered copper or naturally occurring arsenical bronze. The addition of tin improves the molten quality of copper, making it

easier to cast, in addition to lowering its melting point by approximately 200 degrees, meaning that fewer timber resources were required for smelting—a significant advantage as Europe’s forests and woodlands were already heavily taxed by pyrotechnic industries like pottery production (Pearce 2004:8). These functional and visual advantages lead to bronze’s swift adoption once it was introduced in a particular area (Cunliffe 2011:181). However, the problem of bronze lies in its innovative new component: tin is a very rare commodity throughout Europe. While copper is relatively common, tin has a very limited distribution (Figure 2.1), mainly in areas along the Atlantic Coast, northern Italy, and Bohemia (Barber 2003:97; Coles and Harding 1979:8-9; Harding 2013:374).

Those living in regions rich in tin and/or copper found themselves in particularly advantageous circumstances. Extensive trade networks were developed in the Bronze Age to accommodate demand from those regions that had experienced the benefits of bronze, but lacked the necessary components of tin or copper. Some areas were made wealthy through the trade in tin, including the early second millennium “Wessex” burial complex in south-central England (Pearce 2004:8). Once established, trade networks also enabled the exchange of other goods, such as amber, gold, and salt via land or sea routes, eventually leading to a level of connectedness that had never before been seen in Europe (Bogucki 2004:4; Harding 2013:380). The influence of the bronze trade has led Amzallag, among others, to argue that “metallurgists may be the source of the remarkable cultural homogeneity of the Bronze Age civilizations from Asia, the Near East, and Europe” (2009:113).

Bronze Age Agriculture and the Sickle

Though undoubtedly a dominant part of the lives of Bronze Age Europeans, agriculture and food procurement are underrepresented in archaeological publications. Harding suggests that the mundane nature of these activities has “attracted little attention, and a narrative account of the domestic economy is still barely possible” (2000:124). However, a combination of material evidence and ethnographic analogy allow at least a partial picture to be drawn of agriculture during the Bronze Age in Europe.

Bronze Age peoples relied very heavily on cereals such as wheat and barley—which are of particular interest for this study—as well as legumes, pulses, and oilseeds (Stika and Heiss 2013:349-350). This time period was characterized by heavy dependence on cereal agriculture, though some scholars suggest this may have been overstated (see Entwistle and Grant 1989). Nonetheless, Bronze Age Europeans clearly exploited a range of plant species, both wild and domesticated (Harding 2000:143); evidence for human use of pulses, peas, beans, fruits, oil plants, and tubers is found in archaeological contexts from this period.

Whereas the Early Bronze Age shows little change from the preceding Neolithic agricultural practices, the late Bronze Age Urnfield Phase brought substantial modifications, including a general agricultural intensification as well as a shift towards the cultivation of spelt wheat, millet, legumes, and oil-bearing plants. Explanations vary as to whether this shift was due to environmental changes, population growth, or the need to diversify nutrition and increase yield (Harding 2000:145). Furthermore, as communal drinking and feasting played a greater role in the maintenance of group identity and social

ranking, the need to produce alcohol, and therefore grow the requisite crops, was correspondingly greater (Szeverenyi 2004:25). It is likely that many of these motivations were contributing factors in Bronze Age agricultural intensification.

Field systems, delineated by borders made of hedges, fences, or stone walls, seem to have been in widespread (but not ubiquitous) use during the Bronze Age (Johnston 2013:324). The best evidence for these marked agricultural areas comes from Britain and Ireland, though examples are known from elsewhere, such as the Netherlands and Sweden (Harding 2000:161). Much like the organization of fields, the materiality of agriculture has been similar over the millennia; tools are needed for ground-breaking, weeding, tilling, and harvesting. During the Bronze Age, these tools included spades, ards, hoes, mattocks, digging sticks, yokes for pairs of animals (oxen or horses), and sickles. These implements were often composed of wood, sometimes with the addition of stone or metal blades to increase efficiency.

Metal blades and implements were functionally superior to their stone predecessors in a variety of ways. Bronze tools are more flexible, harder, and less breakable than stone implements; the metal can also be re-sharpened more easily, and unlike flint, bronze objects may be recycled into new products (van Gijn 2010:201). Harding also notes that bronze sickles increased efficiency because they could reap closer to the ground than flint sickles (2000:146). Beyond their functional advantages, metal objects also have an advantage over stone in that they can be inscribed with complex decoration, possibly increasing their suitability as ritual or decorative objects (Bradley 1990:82). Many sickles do exhibit various types of inscribed or cast decoration (Sommerfeld 1994:207). It is these

bronze sickles and the nature of their frequent deposition in hoards that are the focus of this study. A schematic is provided in Figure 2.2 which labels each of the parts of a sickle using the terms that will be used in the following sections. For the purposes of this study, the front or face of the sickle is the side with ridges, and the back of the sickle is the side

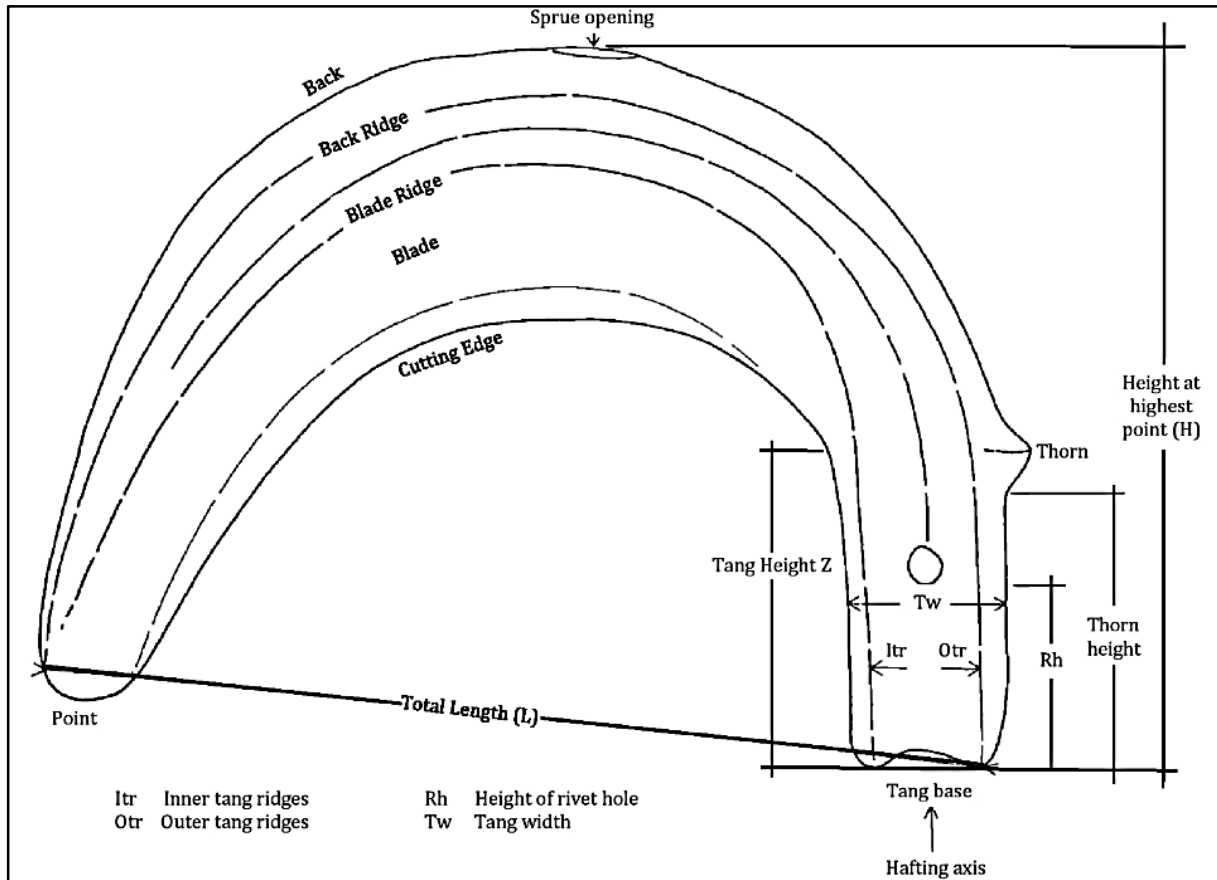


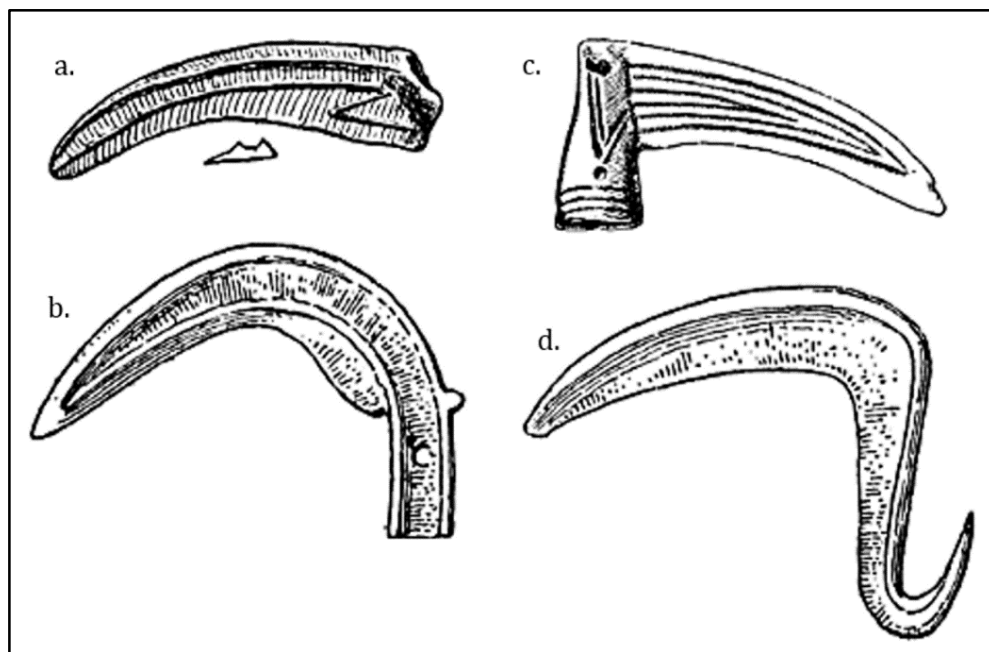
Figure 2.2: Formal characteristics of tanged sickles (Primas 1986:5; B. Arnold, trans.).

that is completely flat.

Sickles are often confused with scythes, best known from their association with the Grim Reaper. However, scythes do not appear in Europe until the late Iron Age, and then initially only in Switzerland (Anderson and Sigaut 2014:91). These tools usually have a much longer and wider blade affixed to a long handle and are used in a swinging motion.

Scythes (without the addition of a cradle) are ill-suited for cereal harvesting and were primarily used for haymaking in prehistory; their difficulty of use, cost of manufacture, and lack of adaptability makes them a less versatile tool than the sickle, though more time efficient if the conditions are right and the user is experienced (Anderson and Sigaut 2014:92; Steensberg 1943).

Four general types of bronze sickles were produced during the Bronze Age in Europe (Figure 2.3). However, the names for these forms are not universally agreed upon, so I will include the two main classification systems as well as a discussion of their uses and similarities below.



*Figure 2.3: Basic sickle forms of the European Bronze Age (Childe 1930:103):
a. button sickle (Type II) c. socketed sickle (Type IV)
b. tanged sickle (Type I) d. hooked sickle (Type III)*

The designations used by Childe (1930) are cited more generally in the literature; however, Steensberg's (1943) types are used when a more specific classification is needed,

as they lend themselves better to a type/variant system of classification. Both of these systems appear to be modifications of the type system first proposed by French archaeologist Ernest Chantre in 1875. Chantre “divided bronze sickles into the five following types: (1) faucilles á bouton, (2) faucilles á talon, (3) faucilles á languettes (4) faucilles á rivets, and (5) faucilles á côtes transversales” (Steensberg 1943:6). The classification used by Childe simplifies this system into button, tanged, hooked, and socketed sickles. Steensberg’s types correspond with Childe’s name designations: tanged sickles are Type I; button sickles are Type II; hooked sickles are Type III; and socketed sickles are Type IV. Steensberg also adds a Type V: the Scandinavian serrated bronze sickle, a type morphologically similar to serrated flint sickles, but not one that will be covered in this analysis. Steensberg, unlike Childe, builds upon the type system by adding variants which reflect more complex regional and morphological differences. Steensberg’s Type II, for example, has seven variants which depend on the curve of the blade and the position and shape of the hafting button. As this thesis is not overly concerned with a detailed typology of bronze sickles, Childe’s classification system is adequate and will be used throughout this thesis—though Steensberg’s types will be referenced when necessary.

The button sickle (Steensberg’s Type II), also called the knobbed sickle, is the most common form in Northern and Western Europe (Childe 1930:102; Steensberg 1943:6). This type dates to the Early Bronze Age and later (Steensberg 1943:157). The button sickle takes the form of a curved blade with one or more ribs running the length of the blade and an oval or round knob protruding from the base end (see Figure 2.3a). This knob was vital in hafting and is also used to differentiate variants of this sickle type.

The tanged sickle (Steensberg's Type I) grew abundant from the Middle to Late Bronze Age and into the Early Iron Age (Pavlin 2014:51; Steensberg 1943:157-8), replacing the button type in Central Europe and France (Childe 1930:102). This type is very common in Lake-Dwelling sites in the Alpine region (Steensberg 1943:6). The tanged sickle typically has two ribs running parallel along the back of the blade as a means of strengthening and reinforcing the blade. A sprue—the stub of excess metal that forms at the opening of the mold when the molten bronze is poured—is found on the back of the blade. One or two holes, often found between the ribs near the base of the sickle, provided a means of attaching the sickle to its handle (Figure 2.2).

The socketed sickle (Steensberg's Type IV) is an invention of the British Isles and is abundant in Late Bronze Age hoards there, though this form does appear occasionally in Western, Southwestern, and Central Europe, likely as an import (Childe 1930:102; Steensberg 1943:161). Socketed sickles are the only type cast in a two-sided mold as the implement needs to be shaped on both sides. The other sickle types are cast using a one-sided or half-mold in which only one side of the mold needs to be shaped.

The hooked sickle (Steensberg's Type III) is found in southeastern Europe and its distribution extends into Asia (Harding 1976:516; Steensberg 1943:152). The hooked form is of less interest here, however, as this thesis focuses on Western and Central Europe. Steensberg also adds a fifth type of bronze sickle, what he calls a crescentic bronze sickle (1943:69). This sickle has a serrated edge and is a near copy of earlier Nordic crescentic flint sickles. As this form clearly derives from earlier flint sickles, its temporal range in the Early Bronze Age is logical (Steensberg 1943:162). The crescentic bronze sickle is

primarily a Nordic phenomenon, and like the hooked sickle, is outside the scope of this thesis project.

It is important to note, especially with a project covering such a wide spatial and temporal area, that the dating and spatial ranges provided above are generalized by necessity. There are instances of hoards containing both Early Bronze Age and Late Bronze Age sickle types together, and sickles occur frequently outside their general region of origin due to the movement of foreign goods through trade and exchange. Sickles represented, together with axes, a form of currency based mainly on standardized weight, and were thus exchanged often. The general distribution of bronze sickles has been considered here, and more specific information concerning the particular museum objects analyzed will be detailed below and in the next chapter.

Though metal implements are of primary interest to this study, flint sickles do merit consideration as they were also used during the Bronze Age, and therefore serve as a basis for comparison in the discussion section of this thesis—especially with respect to the conditions of their deposition. Both van Gijn (2010) and Rosen (1996) point to a lack of archaeological interest in flint tools and objects in the metal ages; van Gijn suggests several causes including: the common assumption that flint became obsolete by the Middle Bronze Age; the use of plowing and poor excavation methods contributing to inadequate recovery of flint objects; and the inclination of researchers towards the more aesthetically valuable metal objects (van Gijn 2010:199). Despite these problems in the research, some archaeologists have undertaken studies of flint sickles in both Neolithic and Bronze Age contexts (e.g., Clemente and Gibaja 1998; Goodale et al. 2010; Vardi et al. 2010).

In the Levant, Rosen (1996) found flint sickle blades to be one of the most resilient tool forms in the face of the introduction of metal. Though most other lithic tool forms, such as arrowheads, drills, and axes, declined severely beginning in the Chalcolithic, flint sickles were recovered consistently through the Iron Age (Rosen 1996:138, 145). To explain this sustained production of flint sickles as compared to other lithic implements, Rosen suggests that though bronze sickles are easier to manufacture, their superiority in efficiency is too minimal to completely overtake the production of flint sickles (Rosen 1996:150). However, van Gijn found that flint axes and sickle blades are notably absent in Bronze Age assemblages; scrapers, strike-a-lights, and arrowheads appear to be the only tools consistently made of stone from the Neolithic on (2010:208-209). Interestingly, the flint sickle blades that are found in southern Scandinavia were used as harvesting implements, but the flint sickle blades from the Netherlands were only used in cutting sod or turf as building materials or for fire fuel (van Gijn 2010:211-212). However, Van Gijn specifically notes that bronze sickle blades in this region have not been tested for use-wear (2010:209).

Sickles would have likely been used for a variety of plant cutting tasks (Table 2.2). The presence of the sickle in archaeological deposits from this period indicates a need for harvesting straw along with grains, implying a value inherent in the straw itself. Bronze Age peoples would have required straw and other material for bedding, thatch, and floor coverings; they would have needed to cut hay, straw, and other agricultural plants to use as fodder for domesticated animals; flax and other similar plants were needed to make textiles and cordage; and they likely would have cleared land of weeds and undesirable

Potential Uses for Sickles during the Bronze Age	
Agriculture	<ul style="list-style-type: none"> • Harvesting food, herbs, and textile plants • Weeding and land clearing
Animal Husbandry	<ul style="list-style-type: none"> • Harvesting hay/straw and other animal fodder • Land clearing
Domestic and Architectural	<ul style="list-style-type: none"> • Harvesting straw for bedding, thatch, floor covering, and basketry • Weeding and land clearing

Table 2.2: Potential uses for sickles during the Bronze Age.

plants in order to prepare it for use. Sickles would have been the tool of choice to accomplish all of these goals. The primary function of bronze sickles, however, would have been to cut cereal grains for human sustenance.

Knowledge of the exact process of harvesting with sickles benefits from

ethnographic accounts of people who used (or still use) sickles in their day to day sustenance activities (Figure 2.4). Anderson et al. describe sickle harvesting in northwest Tunisia thus:

Sickles are used to cut a number of plants in this area. ... Their principal use is for harvesting cereals, an activity carried out by either men or women. ... Cereals are grasped in one hand and the sickle cuts by pulling the blade towards the harvester. The stems are cut at mid-height or slightly nearer the ground, depending upon the preference of the user, but this is done in such a way that stubble is always left for animals to browse. [2014:119]

Anderson and her colleagues also describe the process of tying the grain into sheaves and transporting the sheaves to a threshing floor where the stems are cut into small pieces through the use of a threshing sledge and/or animal trampling. Ethnographic data such as



Figure 2.4: Nepalese women using iron sickles to harvest wheat (Vido 2011).

these greatly informed the methodology of this project; visual evidence, such as in Figure 2.4, was particularly helpful in understanding the body mechanics involved in harvesting with sickles.

In the Bronze Age, sickles were cast most frequently in

ceramic, stone, or sand molds. Soapstone was a common material for molds due to the ease of carving this material and its inherent resistance to high temperatures. One side of the mold would be carved into the negative sickle shape and this piece would be lashed to a flat stone. Molten bronze was then poured into the two-part mold and allowed to cool (Figure 2.5). In sand molding, the bronze is poured into a sickle-shaped cavity formed in very tightly packed sand. Though numerous stone molds survive in the archaeological record (Figure 2.6), their numbers do not begin to account for the large number of bronze artifacts recovered. Therefore, it is likely that sand molds, which are more archaeologically invisible, were very commonly used (Heeb and Ottaway 2014:179). After casting, sickles were cold hammered to increase their hardness. However, the main purpose of this hammering was to sharpen the blade. The hammering was predominantly on the upper side of the blade and it was gradually thinned to a sufficient edge (Steensberg 1943:160). Further sharpening was often completed using a whetstone until the sickle was ready to be used in harvesting. Whetstones are known from Bronze Age burials (usually male) and settlements

(Sørensen and Rebay-Salisbury 2008:62). This process of sharpening was followed in the experimental portion of this thesis.

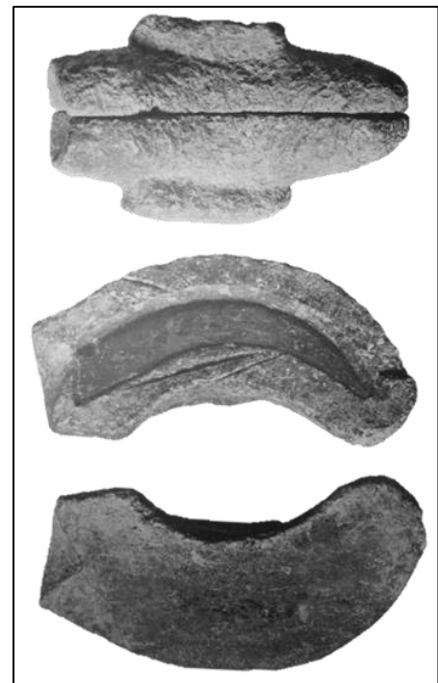
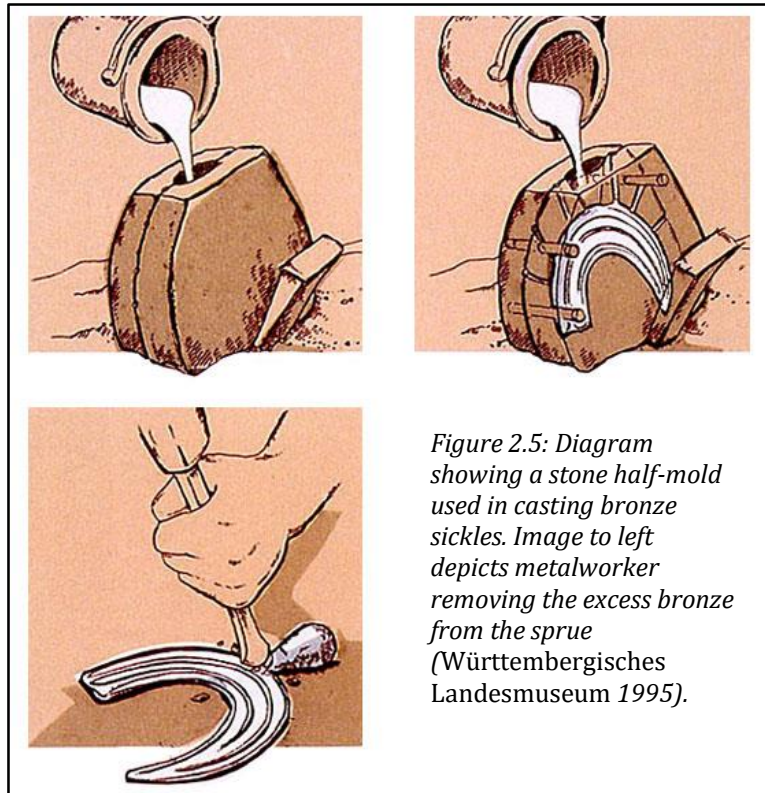


Figure 2.6: A talcose schist mold used to cast bronze button sickles (Steensberg 1943:99).

Bronze Age Intentional Wealth Deposits

Deposition of material wealth in hoards (Figure 2.7) is a fascinating and long discussed phenomenon in Europe, at least partly due to the rich contents and very wide distribution of this archaeological phenomenon (Bradley 1990, 2013; Hansen 2013). Hoards and votive deposits are found throughout the continent, with particularly exceptional examples in Britain, France, Germany, and the Iberian Peninsula. The Nordic bronze hoards are some of the most varied and extensive deposits in Europe, representing incredibly high levels of artisanship (Thrane 2013:764). The ubiquity of these intentional



Figure 2.7: The contents of a Middle Bronze Age hoard found in 1885 at Albstadt-Pfeffingen in Baden-Württemberg, Germany. This hoard contains 41 bronze sickles, as well as knives, axes, spearheads, bracelets, pins, and fragments of a breastplate (Landesmuseum Württemberg, Photo: H. Zwietasch, CC BY-SA 2012).

wealth deposits has led scholars to label them “an identifying structural feature of the Bronze Age” (Hansen 2013:180).

Collins notes that many of the Bronze Age hoards found in Europe “were buried in special, isolated locations in the landscape: in rivers, lakes, or fens; under large rocks; in caves; in mountain passes; on top of hills or mountains” (2004:26). This method of deposition, in which the objects are buried or placed in an inaccessible location, increased the chances of object preservation. In fact,

the vast majority of the European metalwork that survives today was found in hoards and votive deposits (Cunliffe 2011:254). A continuation and expansion of a Neolithic tradition where the focus was on groundstone axes or other lithic caches, deposition in hoards increases throughout the Bronze Age, peaking in the Late Bronze Age and dropping off as the Iron Age takes hold in Europe and wealth deposits are more often relegated to burial contexts (Collins 2004: 214; Hansen 2013:180). This inverse relationship between deposition of wealth in hoards and deposition of wealth in graves has implications for the

function of these deposits as wealth displays in which the goal was to remove items of value from circulation (Bradley 1990).

The function of intentional wealth deposits is debated, and interpretations have ranged from practical caches meant to be recovered to methods of economic management or sacrifices to the gods (Bradley 1990). Many of these interpretations have pointed out the ability of metal objects to “create and recreate alliances, social positions, [and] rank” when used as gifts in a prestige-goods system (Goldhahn 2013:256). Bradley, in particular, has persuasively argued for viewing hoards as a means of prestige accumulation. Unlike competitive gift giving, which raises the stakes dangerously higher with every transaction, deposition in hoards “reduces the pool of valuables available to the other contenders [and] can permit the continuous accumulation of prestige” (Bradley 1990:39).

The contents of hoards vary considerably and are therefore used in classifying these deposits. For example, hoards containing scrap metal, fragments, and unfinished pieces—known as “founder’s hoards” or metalworkers’ hoards—may be distinguished from those hoards with complete products ready for trade. However, these complete products may be accompanied by scraps as well, making the classification more difficult. Ritual killing may produce a votive deposit that looks superficially like a founders’ hoard, for example. Metal items that are common in hoards include weapons, tools, and ornamental pieces as well as scrapmetal. Of particular interest to this study are the tools that are often deposited in these contexts.

Two very utilitarian artifact classes, axes and sickles, “often dominate collections of Later Bronze Age metalwork” (Bradley 1990:118). The former class is most common in

Western Europe, while sickles dominate hoards in Central and Eastern Europe (Bradley 1990:119). Christoph Jahn's map, which shows the geographic distribution of over 8,800 tanged sickles from Middle to Late Bronze Age Europe (Figure 2.8), clearly shows a prevalence for sickle deposits in the central and eastern regions of Europe (Jahn 2012:191). Jahn's distribution includes sickles in hoards, graves, single finds, and

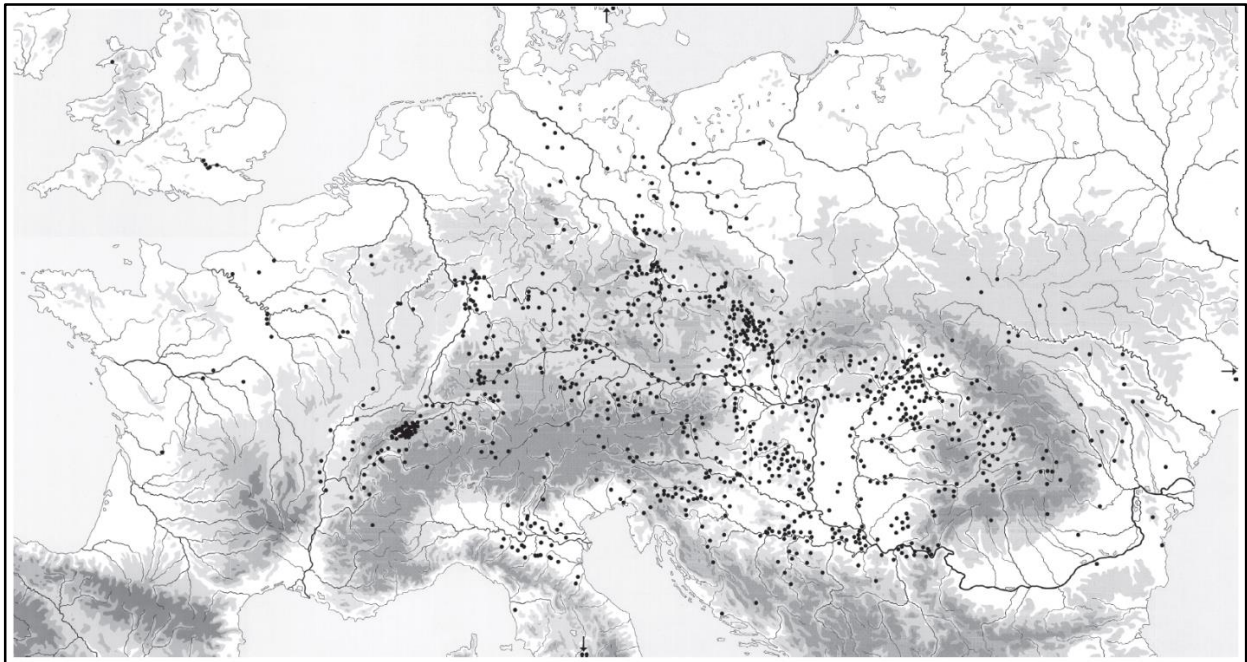


Figure 2.8: Distribution map with the locations of tanged sickles found in hoards, settlements, graves, and single finds from the Middle Bronze Age to the end of the Urnfield Period in Europe (Jahn 2012:191).

settlement contexts, but he emphasizes the fact that the vast majority of sickles (over 83%) were found in hoard contexts.

Throughout Europe, hoards were often made up of only one artifact type (Bradley 1990:119). There are numerous examples, especially in Central and Eastern Europe, of entire hoards comprised of huge numbers of bronze sickles; for example, the Frankleben hoard in Saxony-Anhalt, Germany contained over 300 sickles, while a hoard in Briod, Jura

contained 256 sickles (Steensberg 1943:156). It is clear from the high numbers and wide distribution of such deposits that sickles played a significant role in the economic and ritual activities of the Bronze and Iron Ages.

It is important to be aware that the recyclable nature of bronze changes how researchers should view these deposits of tools. Van Gijn notes that, due to the plastic nature of bronze, “the quite limited range of domestic bronze implements known to us... does not necessarily represent the full range of objects that was once available, but may actually reflect the choice of objects that were considered significant enough to be deposited” in ritual contexts (2010:214). A purely utilitarian object may have been melted down and recycled once it became unusable, but an object viewed as more than a tool may have been preserved more frequently in its original shape.

Sommerfeld (1994) was the first to comprehensively discuss the prevalence of sickles in hoards as being indicative of a particular value, beyond their metal content, being placed upon these objects. He argues that the large quantities of sickles found in Central European hoards cannot simply reflect the needs of the communities that are depositing them, and as they *appear* unused and frequently adhere to specific criteria, including weight, it is likely that they represented a type of coinage rather than a utilitarian object (Sommerfeld 1994). Sommerfeld does cover examples of sickles that appear to be used, but he does little more than mention their supposed use, and he fails to explicitly state what criteria he is using for this assumption—a situation this thesis proposes to rectify by developing a thorough description and standardized system of recording indications of use. The hoard of Heiloo in West Freisland, which contained four bifacially worked flint sickles

and one bronze sickle, all found in an upright position (van Gijn 2010:211), may provide further evidence of a non-utilitarian value placed on the sickle form. Evidence of use on these objects, as provided by the methodology developed in this study, could be used to test Sommerfeld's theory.

Experimental Archaeology and Use-Wear Analysis

Experimental archaeology is becoming a more and more heavily relied upon area of research in archaeology. The field can be dated at least as far back as the 1860s, beginning with the experimental sounding of brass horns, and studies focusing on the process of creating and using stone tools soon followed; metal implements were tested as early as the late nineteenth century (Coles 1973:14, 163).

While studies in experimental archaeology--like all scientific projects--begin with certain questions to be answered, the greatest value of this research framework is the insights it brings to a holistic understanding of historic and prehistoric ideo-technic processes. Reproducing artifacts in various ways and testing them in diverse usages/contexts frequently leads to the development of more complex and relevant questions about archaeological phenomena. John Coles perhaps described it best when he said, "In pursuing these aspects beyond mere recovery and recording, experimental archaeology leads easily and perhaps inevitably into further stages of archaeology work involving more complex and more theoretical models of human patterns of behavior" (1973:13).

The field of experimental archaeology is subject to one major criticism: the fact that the information derived is generally inconclusive. While researchers can prove that a

particular process or type of use was possible, proof that prehistoric or historic peoples actually undertook that process is generally not obtainable (Coles 1973:15). However, experimental archaeology can provide proof that events or processes *did not* occur. Tests for whether a particular goal could have been achieved in a certain amount of time with given materials can provide definitive answers. Researchers simply must ensure that the *possibility* that an event occurred is not interpreted as proof that the event occurred in actuality. Nevertheless, as long as this limitation is explicit in the discussions of the project's results, the benefits and insights provided by this research framework far outweigh its shortcomings.

Until relatively recently, use-wear analysis—which has been productively and widely performed on materials such as bone and lithics—was viewed with trepidation when applied to metal artifacts (Roberts and Ottoway 2003:119-120). Thankfully, due to the breakthrough efforts of several scholars, this approach has achieved wider acceptance more recently, and more archaeologists are pursuing it as a viable field of research (Heeb and Ottaway 2014:183-184).

Use-wear analysis generally goes hand-in-hand with experimental archaeology since “it is generally accepted that the interpretation of prehistoric use-wear on artefacts must be based upon the results of experimental reproduction to find comparable traces of wear” (Roberts and Ottoway 2003:120). Therefore, publications on use-wear are often organized into two parts, with one section describing the process of experimental reproduction and a second section comparing experimental findings with artifact analysis—a structure which this thesis has adopted as well. As the field grows, and

publications become more numerous, the description of the experimental approaches in these reports may be truncated or eliminated in instances where enough data already exist to enable satisfactory comparison of artifacts. This project will contribute to this baseline dataset to enable methodological comparisons and refine techniques in different archaeological contexts.

As has been noted above, use-wear analysis has been performed for Bronze Age axes in several instances. Kienlin and Ottoway's study of North-Alpine flanged bronze axes remains iconic in the field and is a model for other use-wear analyses and experiments related to Bronze Age metalwork. Of particular interest for this study, their results indicated that each of the 29 hoard-deposited axes they analyzed showed indications of damage and wear (1998:285), challenging the idea that votive deposits consist mainly of unused objects. However, Kienlin and Ottoway call for further research, especially in axes deposited in water contexts (1998:285), for which the Swiss Lake Dweller artifacts analyzed in the context of this study will be particularly useful. With some adaptations, the comparative approach that Kienlin and Ottoway created for experimental artifact reproduction followed by use-wear analysis informed the research parameters and experimentation processes of this thesis.

Roberts and Ottoway's 2003 study of Late Bronze Age socketed axes also served as a source of information for the development of the current study's methodology. Roberts and Ottoway found that while "socketed axes were occasionally deposited unused...the majority of the axes fall into the 'variable light use' category" (2003:132). Additionally, these researchers encourage the view of Bronze Age axes as multi-purpose tools and discourage

one-dimensional interpretations of metal objects in such contexts as economic or functional tokens (2003:137). Though sickles may have a somewhat smaller range of potential uses, it is important to keep this criticism in mind and avoid perpetuating a limited view of the role of sickles in the Bronze Age. By way of a conclusion, Roberts and Ottaway encourage further work and accumulation of data in other contexts outside eastern Yorkshire and southeastern Scotland, the foci of their study.

Though flint sickles and bronze axes have enjoyed the benefit of numerous studies in experimental archaeology, the author knows of only one English-language study focused specifically on bronze sickles, and it is over a half a century old. Axel Steensberg (1943) approached the study of harvesting implements through the framework of experimental archaeology, focusing on ranking the efficiency and potential of tools used for this purpose from the Neolithic to the Roman Period. Steensberg recreated and tested a number of flint, bronze, and iron sickles and iron scythes in order to measure the time required to reap straw in an area of fifty square meters and the number of uprooted rather than cut handfuls of straw. Modern iron sickles proved to be the most efficient implements in Steensberg's study; these were followed by the iron scythes of the Viking and Roman periods, bronze sickles, and finally flint sickles—although one flint sickle did out-perform the bronze implements (1943:24). Steensberg's methods were particularly useful in providing variables as well as organizing the experimental approach generated for this project.

These studies in experimental archaeology have a general framework in common. As the number of projects in the field increases, so do the improvements upon the general

process of undertaking this type of analysis. For example, Heeb and Ottaway (2014:163) advocate conducting both “a soft and a hard” experiment. The soft experiment takes place first, and during this stage the experimenter gains experience and knowledge of the materials and processes while refining his or her research questions and goals. The hard experiment benefits from this experience-gaining phase, and the data produced become more meaningful and accurate as a result. This two-pronged approach was used in both the casting and the harvesting phases of this project; the author can say, without reservation, that the experience gained in the soft experiment was absolutely necessary to conduct an informed hard experiment.

John Coles published a very useful set of procedural rules that are outlined below. According to Coles (1973:15-18), the following rules should be applied to experiments in archaeology:

1. The materials used should have been locally available to the ancient society being researched.
2. The methods used to reproduce artifacts should be within the means of the society under study.
3. Modern technology, with the exception of equipment for analysis, should not interfere with the results derived.
4. Researchers should establish the scope of the project and the variables to be tested in advance.
5. The experiment should be repetitive and the results compiled.

6. Researchers will be uncertain whether their methods will succeed and therefore should be ready to improvise with diverse procedures and materials.
7. When the experiment is complete and the results suggest particular conclusions, the researchers should not claim to have absolute proof that a prehistoric or historic process occurred a certain way. Corroborative evidence should be employed to increase the degree of probability, but proof should never be assumed.
8. The experiment should be assessed: errors should be openly stated, the procedure and materials should be considered in terms of their reliability and plausibility, and the questions asked should be evaluated.

Cole's rules seem common sense, yet they can—and should—be honestly and productively applied to any project in experimental archaeology. The following chapters will provide an assessment of this project using these procedural guidelines.

Collections Background

The artifacts that serve as the comparative archaeological collection for this thesis are located in three Midwestern museums. Four sickles are in the collections of the Field Museum in Chicago, IL; two sickles at the Logan Museum of Anthropology in Beloit, WI; and one sickle is located at the Milwaukee Public Museum in Milwaukee, WI. All the sickles are made of bronze and date to the Bronze or Iron Ages. A temporal and spatial description of each artifact will follow to situate them in their proper context and justify their usage in this project.

Field Museum of Natural History



Figure 2.9: Field Museum artifact 25540/675; tanged sickle from French Lake-Dweller context.



Figure 2.10: Field Museum artifact 25541/675; tanaed sickle from French Lake-Dweller context.

Artifact 25540 (Figure 2.9) and artifact 25541 (Figure 2.10) are part of Accession 675, which came to the Field Museum in 1900. These objects are tanged sickles (Type I) with two ridges running parallel with the back of the blade. These artifacts are sourced to a Lake-Dweller context, and based on their form, are likely Middle to Late Bronze Age in origin.

The tip of artifact 25540 was broken off at some point in the artifact's lifespan and the object exhibits high levels of corrosion, which could be expected to affect microscopic measurement of use-wear data. As the majority of the blade is preserved, however, the implement would still have been sufficiently functional to be included in this study and can be used as a source of macroscopic use-wear data. It is possible that the break was due to a need for scrap bronze. There is also a significant warp to the implement, possibly due to

the phenomenon of ritually killing objects prior to their sacrificial deposition (Bradley 1998), a common phenomenon in votive deposits. This warping will be discussed further in the analysis section. It is also of note that this artifact does not have a rivet hole in the base for hafting; these holes were generally procured after the casting of the sickle blank.



Figure 2.11: Field Museum artifact 216329/1922; button sickle (Type II) from north-central France.



Figure 2.12: Field Museum artifact 216348/1922; fragment of a button sickle (Type II) from eastern France.

Steensberg postulates that “those specimens that have no rivet hole in the tang had not yet been used” (1943:151).

The Field Museum’s European collections also contain two bronze button sickles, artifacts 216329 (Figure 2.11) and 216348 (Figure 2.12). The button sickle (Type II) was most common in the Early Bronze Age, though it continued in use until the Iron Age. Both of these sickles came to the museum as part of Accession 1922 in 1931. Artifact 216329 was found in the commune Châtillon-Coligny in north-central France, while 216348 was discovered in the commune of Paray le Monial in eastern France. The former object has two strengthening ridges

running parallel to the back of the blade and a round knob above five vertical lines at the base. Sickle 216348 is highly corroded and appears to have been cut mid-blade, which would have made the sickle unusable.

Logan Museum of Anthropology

The Logan Museum has a large collection of material from Swiss Lake-Dweller contexts, including bone, glass, ceramic, stone, and bronze artifacts. The largest collection contains 173 Neolithic and Bronze Age artifacts that came into the museum prior to the institution of the formal accessioning process, which was implemented in 1927. The material was obtained from the Swiss National Museum in Zurich and was recovered from sites along the shores of Lake Neuchâtel in western Switzerland. Two of these bronze artifacts are tanged sickles (Type 1), a Middle to Late Bronze Age form, as stated above.

They have two parallel ridges running along the back of their blades and a rivet hole near



Figure 2.13: Logan Museum artifact 4.09.49, tanged sickle from Swiss Lake-Dweller context.

the base. Artifact 4.09.49

(Figure 2.13) exhibits

significant evidence of

warping; when the

artifact is resting on the

table the half of the blade

near the point does not lie

flat, as can be seen in

Figure 2.13. Artifact

4.09.48 (Figure 2.14) does

not exhibit this bending, but the rivet hole is quite elongated compared to similar specimens.



Figure 2.14: Logan Museum artifact 4.09.48, tanged sickle from Swiss Lake-Dweller context



Figure 2.15: Logan Museum artifact 53899/19612, tanged sickle from Hungarian Early Iron Age context

Milwaukee Public Museum

The only bronze sickle in the collections of the Milwaukee Public Museum was excavated in Hungary and acquired by the museum as part of Accession 19612 in 1965. This accession was an exchange with the National Museum of Hungary in Budapest. Artifact 53899 (Figure 2.15) is a tanged sickle (Type I) and catalogue records note that it is from the “Early Iron Age” between “900-550 BCE.” This sickle is significantly thinner and longer and appears somewhat more elegant than other sickles analyzed during

this project. It has no rivet holes and the two parallel ridges near the base converge into one larger ridge which runs along the back of the blade.

These seven artifacts represent a diverse sample of bronze sickles from Bronze and Iron Age contexts in Western and Central Europe. The artifacts selected were all the bronze sickles available in the region that were accessible to the author, representing a truly random sample. Each of these sickles will be further described in the analysis and discussion sections of this thesis.

CHAPTER 3: METHODOLOGY

The methodology of this thesis is comprised of two sections: an experimental approach followed by a collections based comparative analysis. The collections component will be based upon the insights gained from the experimental work, and the data gathered from each approach are compared in Chapter 4. The primary goal of this thesis was to create a protocol for casting and using bronze implements in order to generate a methodology for comparing the resulting wear patterns on the reconstructed implements to those present (or absent) on prehistoric artifacts, particularly bronze sickles.

Though one study (the only known source in English) made use of recreated bronze sickles (Steensberg 1943), it does not describe in detail how these sickles were created or the effects of use on the implements. Steensberg asked craftspeople to create replicas for him, thereby forfeiting one of the most useful aspects of experimental archaeology—participant observation. It is the opinion of this author, supported by other proponents of experimental archaeology (Coles 1973), that as much benefit is derived from creating the tools to be used as from using the implements. Furthermore, Steensberg carried out his study in 1943, and though archaeological work on sickles in non-English speaking countries has progressed significantly since then, experimental archaeology work on bronze sickles in English has not been carried out since that time. This project represents a first step toward redressing this situation.

The following sections will describe the materials needed and the process of replicating bronze sickles. A thorough description is also given of the methods used in sharpening and the structure of the harvesting experiments. Finally, the steps taken in performing microscopy and creating use-wear maps are discussed. The amount of time

expended during each step of the experimental archaeology component is listed in Table 3.1 below. It is the author's hope that this process may be replicated by future researchers using the protocol provided here.

Table 3.1 Durations of the Steps in the Experimental Archaeology Component		
<i>Steps</i>	<i>Activity</i>	<i>Approximate Duration</i>
Mold creation	Carving fire brick mold	15 minutes
	Coating the half mold in plaster	5 minutes (allow to dry fully according to plaster instructions)
Casting	Heating the bronze to fluidity	20 minutes
	Pouring the bronze	Should occur as quickly as possible
Hafting	Preparing wooden handles	30 minutes per handle
	Attaching wooden handles to sickles with leather cordage	10 minutes per sickle
Sharpening	Cold-hammer peening	5 minutes per sickle
	Whetstone sharpening	5 minutes per sickle
Harvesting	Trial 1	30 minutes
	Trial 2	90 minutes
Photography	Taking microscopic images of the blade edges	30 minutes per sickle
Use-wear Maps	Aligning each microscopic photo;	2 hours per map
	tracing morphology and use wear indications	45 minutes per map
Total time required per sickle		6 hours and 45 minutes

Environment

The entire sequence of casting and hafting was carried out at the Milwaukee Makerspace (Milwaukeemakerspace.com) in the Bayview neighborhood of Milwaukee, WI (Figure3.1). Thanks are extended in the Acknowledgements section to various members of the Milwaukee Makerspace (MM), but I will reiterate that gratitude and discuss that



Figure 3.1 Milwaukee Makerspace logo (Milwaukeemakerspace.com).

environment here, as the MM was instrumental in the success of this project in several important ways. The MM is a non-profit, member-run organization which provides an outlet, workspace, and resources to create any number of products; potential is limited only by the vast ingenuity of MM members. A myriad of materials and tools are provided in the areas of 3D printing, sewing and embroidery, laser cutting, woodworking, electronics, leatherworking, ceramics, welding, and metalworking.

This environment has several things in common with what is known of craft-working in the Bronze Age. During this time period, “it is not possible to distinguish specific production sites for different ‘crafts’ from one another... instead they seem to be integrated and coincide in time and space” (Goldhahn 2013:258). Unlike earlier and later periods, archaeologists can rarely find areas within a settlement specifically dedicated to working with metal, stone, or ceramics (Bartelheim 2013:172). According to Goldhahn, “where bronze artefacts were created, other ‘specialized’ crafts such as pottery and stone crafts were also practiced” (2013:258). Wells (1986) describes two small Bronze Age settlements in Bavaria which each have evidence of bronze casting, weaving, and bone working, revealing that even in small communities several different crafts took place simultaneously. It is possible, perhaps likely, that craft materials were manipulated in an inclusive environment with many people of various talents working in close proximity to one another.

This inclusive structure also describes the environment of the Milwaukee Makerspace. As the casting and hammering of the sickles took place, many members of the makerspace would come by and offer opinions or comment on the process and ask to learn more. Several innovations and improvements to the experiment were discussed and implemented due to this communal interaction, providing a novel way of thinking about the nature of design and crafting. It is possible to theorize that a similar mechanism for production, and by association a source of innovation, was present during the Bronze Age as well.

Sofaer et al. (2013), in her discussion of ceramic, textile, bone, and metal production posits close relations between different craftspeople in Bronze Age villages. In particular, “the exaggerated ‘horn’ handles and high surface sheen of the black burnished wares of central Europe and north Italy have been considered imitative of metal forms and surface finish;” the Nagyrev and Vatyá cultures in Hungary utilize a peg joint similar to metal rivets; and Polish Bronze Age ceramics occasionally show imprints of bronze objects (Sofaer et al. 2013:477). These instances of multiple craft components incorporated into a particular object suggest a “transfer of know-how from one medium to another [which] requires direct familiarity with other craft practices and the development of social networks among craftspeople” (Sofaer et al. 2013:477). A similar environment of information exchange benefited this thesis, and I believe, contributed to the authenticity of the production process. This concept will be further reflected upon in the discussion section of this thesis.

Casting

The casting process was very much an exercise in trial and error. General guidelines for bronze casting were researched, metalworkers were consulted, and articles by

specialists such as Roberts and Ottaway (2003) and Kienlin and Ottaway (1998) were studied, yet many mistakes were made throughout the experience which likely would have been avoided by a master metalworker. The learning curve experienced by this metalworking novice suggests that a significant apprenticeship period would likely have been required for such work in the Bronze Age. Additionally, there is never sufficient room in academic articles to provide a thorough step-by-step narrative outlining the casting process. Understanding this fact revealed a need for such a description in English, and what follows is an attempt to supply one researcher's methodology for bronze casting replica sickles of Bronze Age type in detail.

The bronze casting carried out for this project took place at the Milwaukee Makerspace, with the significant assistance of MM member and blacksmith Dan Jonke. Despite my initial intention to take this experiment in crafting from start to finish, it was not feasible to acquire the raw materials by hand; instead, the copper, tin, and lead necessary to make the alloy were purchased in ingot form. An alloy ratio of 87% copper, 9% tin, and 4% lead was used. This is in accordance with standard Middle to Late Bronze Age compositions (Kienlin 2013:419; Roberts and Ottaway 2003:124), following the initial more variable compositions of the Early Bronze Age. The melting point of bronze is c. 1800° F (982° C), depending on which alloy composition is used. Both lead and tin greatly improve bronze by decreasing the melting point and increasing the fluidity of the alloy (Pearce 2004:8). The appropriate quantities of each metal were placed together in a clay graphite crucible, and the crucible was heated in a natural gas forge for approximately 20 minutes until the metal was molten. While the natural gas forge, a piece of equipment that reaches temperatures of 2300° F and is primarily used for blacksmithing at the Milwaukee

Makerspace, took a relatively short time to melt the bronze, in prehistory the process would have required large quantities of charcoal in a furnace fitted with a bellows (Armbruster 2013:464). The entire process of mining and metalworking—including smelting with charcoal fuel, fire-setting to remove rock overburden, and constructing wooden braces in mines—required so much timber that deforestation and consequently, woodland management, were commonly the result (O’Brien 2013:450).

Initially getting the bronze to pour smoothly from the crucible with little residue left in the vessel was difficult, and different fluxes were tried to alleviate this problem. Borax (sodium borate), a preferred fluxing agent for iron and steel working, simply exacerbated the problem, causing the pour to fail. Charcoal was then added to the molten bronze, but it too failed to significantly improve the fluidity. Ultimately, a new crucible with a denser mass and thicker walls was used, which allowed the bronze to be heated more uniformly and pour very well; the attempt to add flux was discontinued for the remaining bronze pours.

Bronze Age peoples are known to have used sand, stone, ceramic, and bronze molds for casting bronze objects (Roberts 2013:540). For the purposes of this project a modern substitute for the stone molds used for casting sickles beginning in the Middle Bronze Age was used. Fire brick—an insulating material made of refractory ceramic which can stand extremely high temperatures—was chosen to create the two part molds necessary for casting. Fire brick is typically used to line kilns, and therefore it can stand extremely high temperatures while being soft enough to be carved by hand. Figure 3.2 shows a comparison of the fire brick mold and a Bronze Age stone mold. The fire brick molds used were 10.5 inches in length, 2.5 inches in height, and averaged 4 inches in width. The mold’s thickness

allowed the heat from the molten bronze to be contained sufficiently and, though the firebricks have smaller dimensions than many of the stone molds recovered archaeologically, the excellent heat resistance of these bricks allowed for a smaller mold to be used.

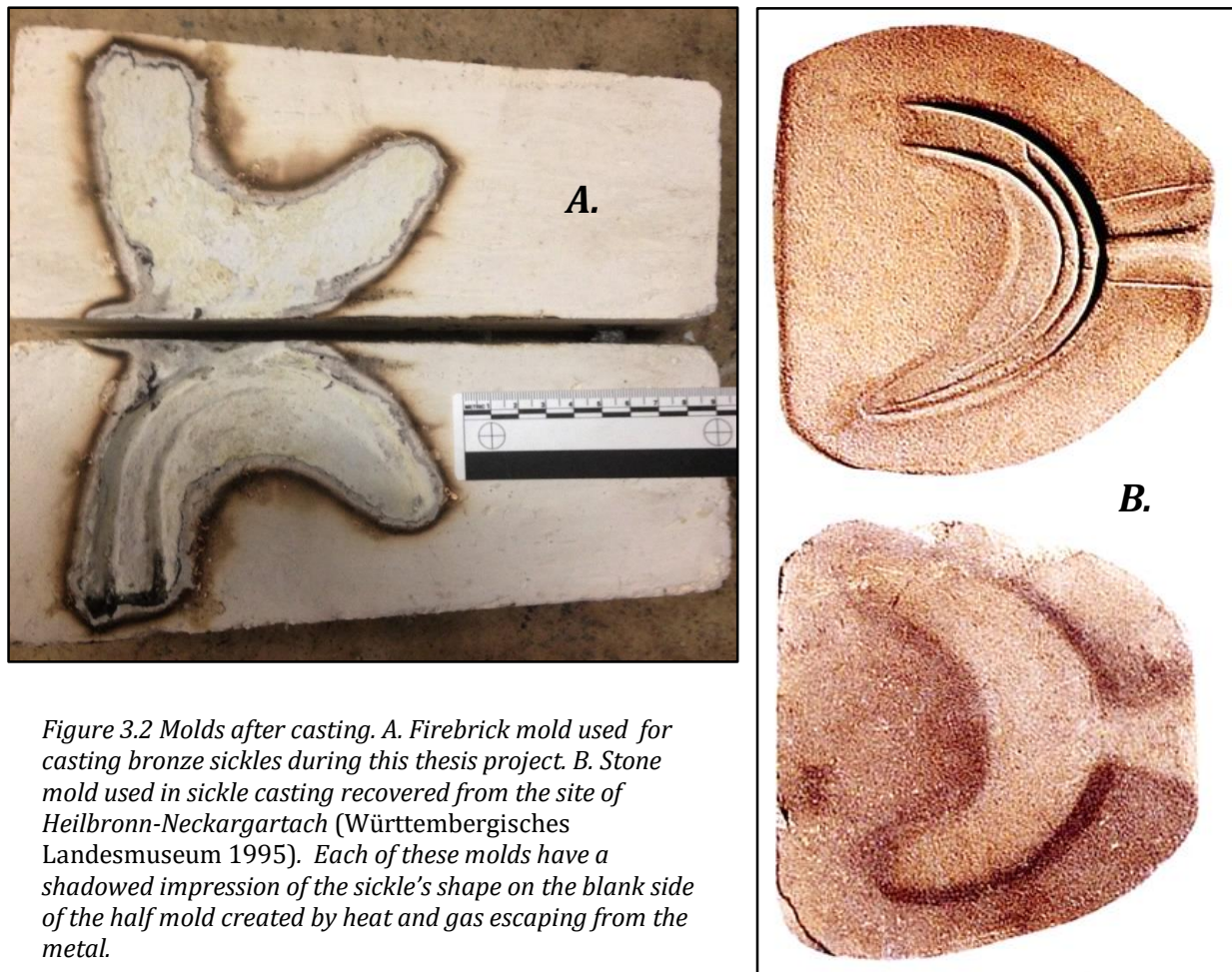


Figure 3.2 Molds after casting. A. Firebrick mold used for casting bronze sickles during this thesis project. B. Stone mold used in sickle casting recovered from the site of Heilbronn-Neckargartach (Württembergisches Landesmuseum 1995). Each of these molds have a shadowed impression of the sickle's shape on the blank side of the half mold created by heat and gas escaping from the metal.

The fire brick was carved using wooden tools (Figure 3.3) in the negative shape of a right handed tanged sickle (Steensberg's Type I). The powdery nature of the brick required a cycle of carving, shaking the mold to remove the buildup of fine powder, and then resuming the carving. The tanged sickle was selected because more is known about how this type was hafted. The sickle was made right handed due to the author's own



Figure 3.3 Wooden tools used for fire brick carving.

handedness and the fact that the vast majority of sickles recovered archaeologically are right handed—though see Pavlin (2006) for a discussion of three left-handed sickles from Slovenia and a left handed sickle mold from the province of Cremona, Italy. A channel was carved out from the back of the sickle blade to the edge of the mold to serve as the location into which the bronze would be poured—this area is called the sprue. The projection of metal that remains in this area is also called a sprue; this projection was left intact on sickles 2 and 3, but filed off on sickles 1 and 4 as the author was using this area to experiment with manipulating the bronze. Due to the porous nature of the fire brick, the interior surface of the mold was covered in a thin layer of plaster to facilitate removal of the finished piece. Another brick was also covered in a layer of plaster to provide the second, non-carved part of the mold. The process of creating the molds and covering them in plaster took approximately 20 minutes per mold. Once the plaster was dry and firm, the two halves of the mold were bound firmly together with two bar clamps and placed in a box of sand to protect the surface of the floor in case of a bronze spill (Figure 3.4). In prehistory, it is thought that the two-piece stone molds could have been wedged in place in an upright position by being partly dug into the ground (Figure 2.5).

Clearly, Bronze Age peoples would not have had access to such efficient methods of heating and pouring as were utilized during the course of this project. However, these



Figure 3.4 Completed fire brick mold ready for bronze pour.

A. Sprue, or opening into which the molten bronze is poured.
 B. Clamps holding the fire bricks together.
 C. Box filled with sand to prevent or mitigate bronze spill.



modern methods were implemented during production rather than use—which is more central to the research questions generated for this project. As maintaining strictly prehistorically accurate *production methods* was not necessary to answer the research questions posed by this thesis, the substitution of a natural gas forge and fire brick for stone in the mold-making does not violate Coles' (1973) first or third rule for experimental archaeology projects.

When the bronze was heated sufficiently to become molten, iron tongs were used to remove the crucible from the forge and pour the molten bronze into the fire brick mold



Figure 3.5 Pouring molten bronze into the fire brick mold.

(Figure 3.5). The bronze had to be quickly poured into the spout of the mold before it could solidify. Premature solidification did take place once; the bronze subsequently had to be reheated and the pour started over with a fresh mold. The fire brick molds tended to break after two or three pours, and had to be replaced—an advantage stone molds would have had over this modern substitution. Once the bronze pour was a success and the bronze had completely filled the mold, the metal was allowed to cool overnight before the mold was taken apart to retrieve the cast sickle.

Hafting and Sharpening

Once the cast sickle was cool, the hafting took place. Figure 3.6 shows the disassembled tool. For expediency's sake, a drill press was used to create the rivet hole near the base of the sickle; this process would have been done with a punch awl and a hammer in prehistory, but the result would have been the same. A wooden handle of

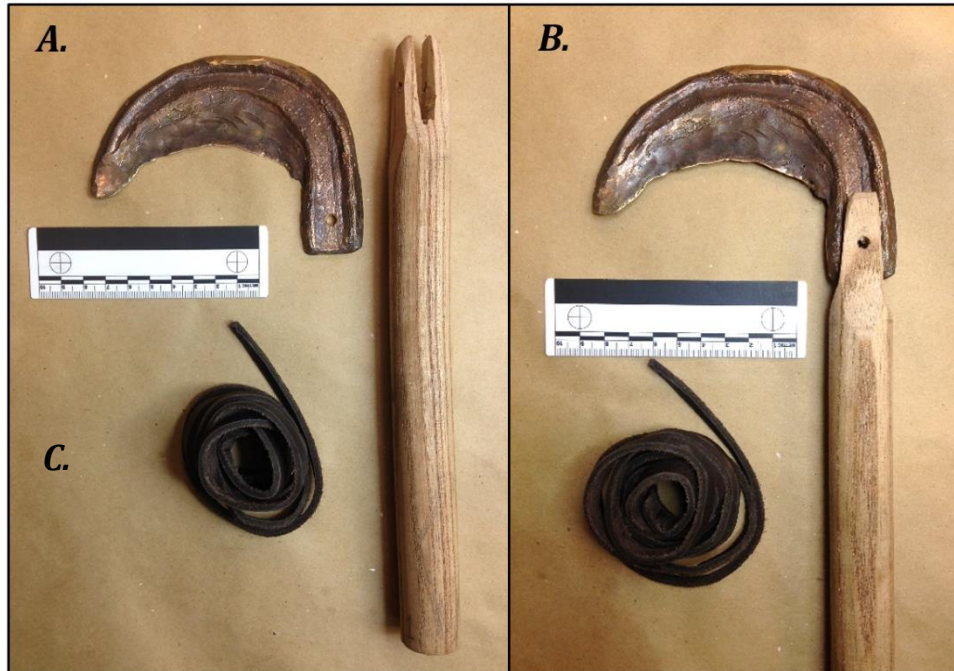


Figure 3.6:
 A. Disassembled
 hafting components for
 Experimental Sickle 1.
 B. Partially hafted
 sickle showing rivet
 hole through split wood
 handle
 C. Leather cord

approximately 25cm was prepared with a split end into which the base of the sickle could be inserted. A leather cord was then threaded through the rivet holes and tightly wound around the hafting point to secure the sickle. This hafting places the sickle at a right angle to the handle, a position consistent with the very few surviving examples and recreations, including one socketed sickle with a preserved wooden handle (Figure 3.7) found in Shinewater Park, England (Brysaert 1998; Gross 1883:43; Keller 1866:138; Primas 1986:

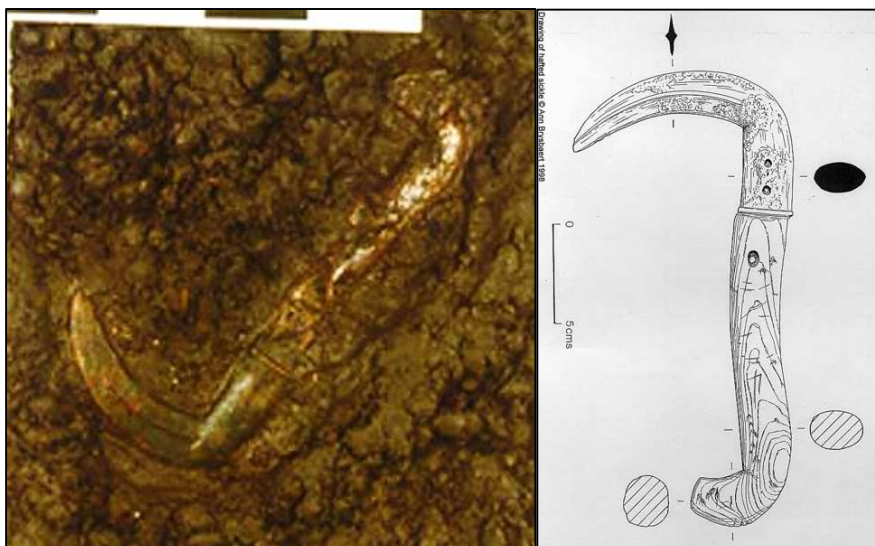


Figure 3.7 Preserved
 socketed sickle from
 Shinewater Park,
 England with in situ
 photo (left) and
 drawing (right)
 completed after
 conservation of the
 artifact (Brysaert
 1998).

plate 123; Steensberg 1943:14, 160). As long as the leather cord was bound tightly, this type of hafting ensured a secure hold between the wooden handle and the bronze sickle. The handles were sanded in order to make them easier to manipulate and remove any danger of splinters for the harvesters.

The sharpening was done after the sickles were hafted so the hammering could be performed more accurately with a firm hold on the implement. Even a small amount of



Figure 3.8 Granitic whetstone and ball-peen hammer used in cold hammering and sharpening each of the experimental sickles at the Milwaukee Makerspace.

cold-hammering serves to significantly harden a bronze blade (Roberts 2003), and ethnographic examples show that sharpening a bronze implement effectively requires hammering as an initial step (Steensberg 1943:160). As Keller (1866:182) found specific evidence of this hammering practice on bronze sickles, this was deemed an effective and prehistorically accurate method to apply to the experimental sickles. The pressure of the hammer against an anvil draws the bronze blade outwards and thins the blade so effectively that sharpening with a whetstone is hardly necessary, and was only used to give the blade edge a more uniform appearance. Each of the experimental sickles was struck by the author for approximately 5 minutes with a ball-peen hammer. Once the cold- hammering was completed a granitic stone was

used to even and further sharpen the sickle blades for approximately 5 minutes each. The tools used for the purposes of sharpening can be seen in Figure 3.8. At the end of this

process the sickles were quite sharp and deemed ready for cutting vegetation. Four complete sickles (Figures 3.9-3.12) were cast, hafted, hammered, and sharpened during the course of this experiment.



*Figure 3.9
Experimental Sickle 1.*



*Figure 3.10
Experimental Sickle 2.*



*Figure 3.11
Experimental Sickle 3.*



*Figure 3.12
Experimental Sickle 4.*

Harvesting

The harvesting for this experiment took place in the fall of 2015. First, in accordance with Heeb and Ottaway's (2014) recommendations for experimental archaeology projects, a soft experiment was conducted to gain further insight into the process of sickle harvesting. The formal experiment consisted of two trials, a thirty minute harvest and a 1.5 hour harvest. The blade edges were examined and microscopically photographed before the trials, after the 30 minute trial, and after the 1.5 hour trial in order to be able to distinguish the patterns derived from both light and heavy use.

Soft Experiment

The soft experiment was conducted by the author in a field of bahiagrass (*Paspalum notatum*), a crop commonly grown for hay and fodder in the Southern United States. This crop is from the same scientific family as cereal crops and made an excellent substitute for the vegetation that would have been harvested or cleared in the Bronze Age. Experimental Sickle 1 (ES1) was used to cut the bahiagrass for approximately 10 minutes. The following procedure was followed in the soft experiment and each participant of the hard experiment was instructed to follow the steps in order to institute a standardized use pattern across the experiment.

Figure 2.4 shows a group of women crouching to harvest; however, as the participants for this project were unused to remaining in that position for a length of time without discomfort, adjustments were made to the posture of harvesting. While kneeling,



Figure 3.13 Method used for sickle harvesting.

handful of grasses were collected in the left hand. The sickle was gripped below the leather hafting and brought behind and under the left hand (Figure 3.13). A cutting stroke was carried out with a trajectory towards the harvester and angled slightly upwards. Two to three

strokes were required to cut through the handful of grasses. With the cut handful of grasses still in the left hand, the harvester then moved forward to grasp and cut a second bunch of grasses. When three to four handfuls had been collected the bunch was laid neatly to the

left of the harvester, a method which would have enabled ease of gathering the harvested plant. Once the soft experiment was complete and these steps articulated, the hard experiment began.

Trial 1

An area of canary reed grass (*Phalaris arundinacea*) in Menomonee Falls, WI, was selected as the vegetation to be cut for Trial 1. The area chosen to harvest (Figure 3.14) was on a slope which had been allowed to go fallow and therefore also contained a small



Figure 3.14 Area of vegetation used during Trial 1.

scattering of weeds of various species (predominantly milkweed and thistle). This multispecies area likely comes closer to the composition of Bronze Age fields than our single-species modern

agricultural fields. The area harvested had a composition of approximately 85% Reed Canary Grass, an invasive species native to Europe that is commonly planted as a method of erosion control. Its erect stems made it suitable for being cut by sickles, and the limited genetic modification of this plant made it an appropriate substitute for Bronze Age vegetation.

Trial 1 of the hard experiment (Figure 3.15) took place with three participants using experimental sickles 2, 3, and 4. The participants cut constantly for 30 minutes and in that time cleared an area of approximately 100 square meters. The sickles were then carefully packaged and returned to the lab for microscopy and comparison. Once imaging had taken

place, the sickles were sharpened with the same granitic whetstone in preparation for the next phase of the experiment.



Figure 3.15 Participants engaged in harvesting during Trial 1.



Figure 3.16 Area of harvesting for Trial 2, showing a participant poised to make a cut. .

Trial 2

Trial 2 of the hard experiment took place with six participants, enabling all four sickles to be used. The location selected for harvesting (Figure 3.16) was an area of prairie reclamation land in Cedar Grove, WI, which contained species of grasses native to North America. Switchgrass (*Panicum virgatum*) was the predominant species in the section where the sickles were used, and the participants were instructed to focus on this species and avoid the few weeds that

were included in the environment. Switchgrass has a hollow tubular stem and was

desiccated at the time of cutting and therefore made an excellent substitute for cereal grains as well as a proxy for the kind of reeds that were cut for thatch.

Harvesting took place for ninety minutes and an area of approximately 35m by 15m was cleared. The bunches of grass were set to the side as they were cut, and participants not involved in cutting stacked the bunches together. Figure 3.17 shows what these large harvesting stacks looked like at the conclusion of the cutting experiment. The sickles were

again packaged carefully to avoid damage to their cutting edges and brought back to the Archaeological Research Lab at UW-Milwaukee for microscopic imaging.

Microscopy and Use-Wear

Mapmaking

Microscopic images were taken of the sickle blades before and after each stage of the experiment to



Figure 3.17 Stacks of harvested grasses at the conclusion of Trial 2.

enable comparisons between the unused, used, and resharpened tools. A Celestron Portable Camera was used to take each of these images at approximately 20x. Once the entire length of the blade, front and back, was photographed, use-wear maps could be created using Adobe Photoshop.

A similar method of microscopic examination and recording was used with the artifacts from the Field Museum, the Milwaukee Public Museum, and the Logan Museum of Anthropology. Data collection was carried out on location at each of these museums, and the images were taken back to UW-Milwaukee for further analysis. Comparable microscopic equipment was used to obtain photographs between 20x and 30x—the exception being at the Logan Museum, which had superior microscopic equipment, enabling images of 60x to be taken as well as the lower magnification settings. These more high-powered images made identifying anomalies on the blades slightly easier, yet 20x was perfectly adequate for creating use-wear maps. One light source was used at a 45° angle to facilitate the observation of abrasions and scratches on the surface of the blades. The microscopic cameras were either placed on a stand or held by hand over the working edge. Once each picture was taken the camera was moved approximately one centimeter further along the blade for the next photo. This produced a slight overlap which would facilitate stitching the photos together in Adobe Photoshop. However, due to this method of staging each photo by hand, photos were taken at different points during each session. This does not enable photos between trials to be compared to each other with identical framing (e.g. see the slight misalignment of photos in Figure 4.2). A mount which allows the camera to move in exact increments with identical coordinates for each framing would alleviate this problem, but this type of equipment was beyond the means of this study. Each of the sickles were photographed front and back. In addition, macroscopic photographs were taken and notes were made of any breaks, corrosion, or deformations observed on the sickles.

Roberts (2003) created schematic diagrams of use-wear traces for his experimental work with socketed axes of the Late Bronze Age (Figure 3.18). He used a key to

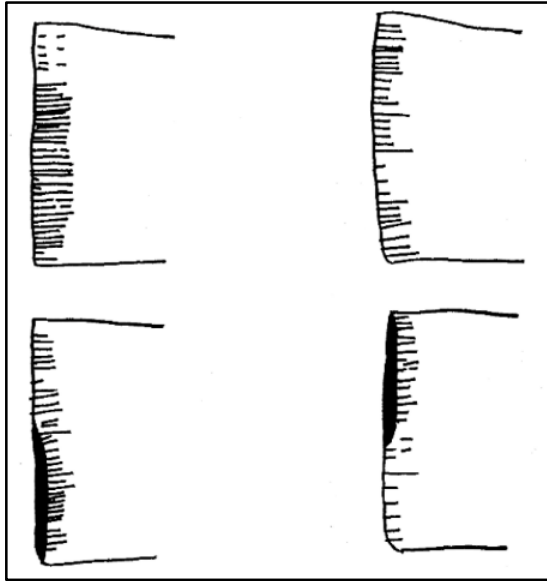


Figure 3.18 Example of Roberts' (2003) use-wear schematics for experimental axes.

differentiate between hammer marks, scratches parallel to the cutting edge, nicks, and other deformations. However, the schematics he included in his article were relatively simple. In order to adapt and improve on Roberts' method, a more detailed schematic, here termed a "use-wear map," was created for each of the sickles analyzed for this project. While the following chapters include selections of these use-wear maps to illustrate the specific arguments

presented, the Appendices of this thesis contain the full array of use-wear maps produced for each of the prehistoric sickles, as well as the before and after maps generated for the experimental sickles.

These maps were created in Adobe Photoshop by stitching the microscopic photos of the sickle edges together (Figure 3.19), carefully tracing over the images to create a sketch of the blade edge and record any traces of use or deformation that could be observed (Figure 3.20), and finally, removing the photograph layers to reveal the schematic (Figure 3.21). The sharpened edges were outlined and filled in with yellow, rounded edges with orange, and bent edges with blue. Any distinct scratches and abrasions were traced with red lines. Black lines represent sickle morphology, including hammer marks from peening. In order to provide quantification of the data produced through this process and enable comparison between the sickles, a nominal scale ranking wear as either "slight," "low," "moderate," or "high" was used to describe the condition of each sickle following the

creation of the use-wear maps. The locations of wear were also noted to identify areas most impacted by use.



Figure 3.19 Adobe Photoshop screenshot showing microscopic photographs stitched together along the working edge of the sickle.



Figure 3.20 Adobe Photoshop screenshot showing tracing of the use-wear indications.

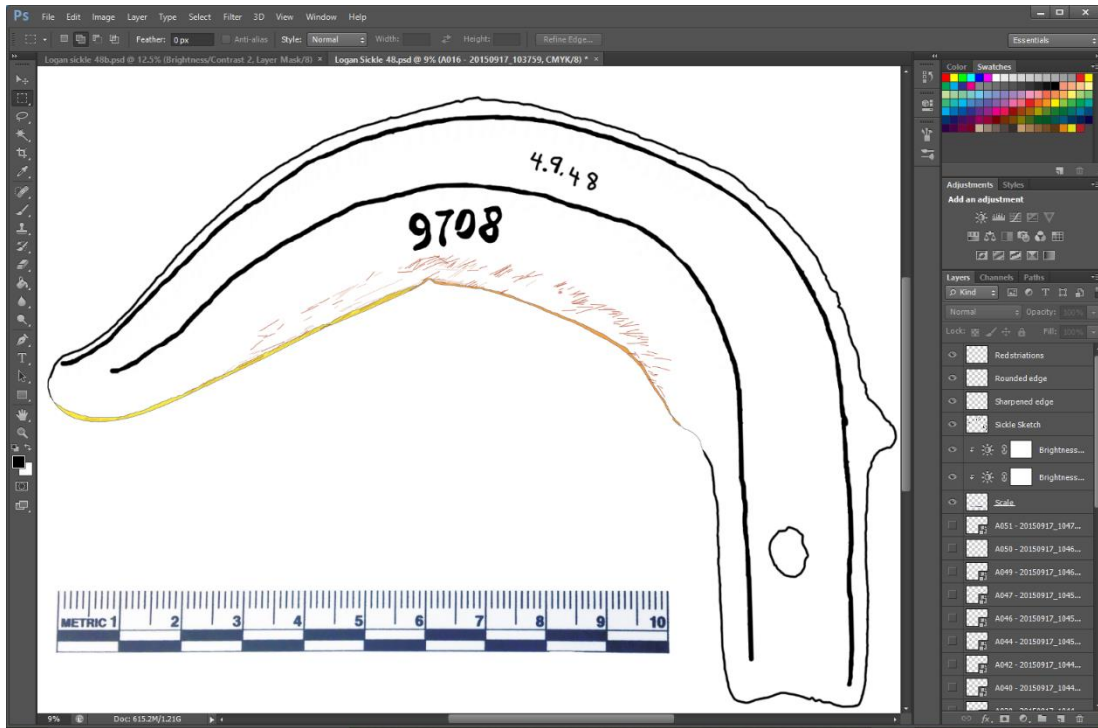


Figure 3.21 Adobe Photoshop screenshot after removal of the photographic layers, leaving completed use-wear map.

This method of use-wear map creation was chosen primarily as a way to bring further transparency to the process of microscopic examination and to enable eventual quantification of differences observed between and within larger assemblages than that analyzed for this project. While it may not be feasible to show thousands of microscopic images, it is certainly practical and helpful to publish comprehensive use-wear maps with select off-set raw images as support. The next chapter will present the results of these experiments, including the microscopic use-wear maps created through the protocol developed for this thesis.

CHAPTER 4: RESULTS

This chapter describes the information gained from performing the experimental trials as well as the data derived from micro- and macroscopic examination of the experimental and prehistoric sickles. Observations from the field trials are noted first. The experimental sickles are discussed next, and each sickle—before and after use—is ranked according to the extent of the use-wear observed and the locations of this wear is recorded. Use-wear indicators included the following: striations, blade deformation, and bluntness of the cutting edge. Each sickle is described in terms of the presence, extent, and location of the use-wear indicators listed above.

Experimental Trials

Conducting the experimental trials using the reconstructed bronze sickles revealed information concerning harvesting practices in the Bronze and Iron Ages that are of value to the reconstruction of past lifeways. Observations made during the hafting and harvesting processes will be described and discussed below. These observations originate with the author as well as the participants of the trials. An open discussion with all participants took place during and after each trial. This period of reflection and discussion facilitated full communication of any problems, changes in harvesting method, and observations that arose in the course of cutting.

Observations from Hafting

Attaching the bronze sickle blades to wooden handles with leather cord required constant pressure and hand strength to ensure a tight hafting. Even with a tightly bound tool, the slightly elastic nature of the leather cord allowed some movement between the sickle and the wooden handle, particularly after the stress produced by sharpening and

harvesting. Sharpening appeared to create more strain on the haft area than the actual cutting of grasses; several sickles came loose after sharpening, which necessitated a re-hafting. Only Experimental Sickle 1 came loose during harvesting trials (45 minutes into Trial 2), but the tool was still quite effective even with the loose handle and adjustments were not made nor were they needed to complete the trial. Nevertheless, future experiments with this type of hafting would benefit from the use of a wooden or bronze peg inserted through the sickle's rivet hole, which would more rigidly secure the sickle to the handle. Binding the hafting area with leather cord, or a similar material, would still be necessary to avoid lateral movement, however. Hafting with a wooden peg was informally experimented with after the harvesting trials and found to be quite successful. As the wooden peg provided such a firm hafting, it would not have been necessary for Bronze Age peoples to waste bronze on creating a rivet—particularly since the wooden peg would have the advantage of swelling when introduced to water through whetstone sharpening or through contact with wet vegetation, further sealing the hafting joint. Leather would also tend to shrink to the handle when wet, tightening the bond between blade and handle.

Observations from Harvesting

The first and second trials using the experimentally produced bronze sickles went very smoothly. The sickles proved more effective than initially anticipated, and participants had no difficulty in cutting through the selected grasses. No noticeable decrease in efficiency over time was noted during Trial 1. The bronze sickles cut easily through the bundles of grasses, particularly during the first half of Trial 1. However, participants did note the blade becoming slightly dull fifteen minutes into the trial. Even with this dullness,

the sickle's edge was still narrow enough to provide a point at which the handful of grasses broke sharply when enough force was applied.

It appears that the short length of Trial 1, 30 minutes, was not sufficient to dull the blade past efficiency. However, the 90 minute length of Trial 2 did produce information concerning the point of lost efficiency. After 45 minutes of continuous harvesting, participants noticed a decrease in the cutting power of the sickle blades. After 75 minutes of harvesting had passed, the bronze sickles were cutting through only half of the handful of grasses and the remainder was uprooted rather than cut. In order to maintain an effective tool past the 75 minute mark, a whetstone carried by the harvester would have been needed to sharpen the sickle blade periodically.

The method of handling the experimental sickles changed slightly throughout the experiment. Each participant noted that their grip on the sickle started very high—just under the leather hafting. As cutting proceeded, participants found that a lower grip allowed for force to be applied more effectively since the energy from the longer swinging motion could be applied to the cut. Near the end of the experimental trials, participants were gripping the sickles 4-6 inches below the leather hafting. For this reason, the significant length of the handle—initially believed to be excessive—was beneficial and should be useful for future studies.

Use-wear Data

Experimental Sickles

The characteristics of use noted during this project were abrasion/polishing on the blade of the sickle, dullness of the edge, and deformation of the sickle. The “before” photographs and use-wear maps—created after the first sharpening, but before Trial 1—

were frequently consulted to ensure that these marks were not present before use. Each sickle was scored for the presence or absence of these indications. If present, the degree of these indications was also noted, according to an ordinal scale of slight (1), low (2), moderate (3), and high (4) extent. This scale was applied to all four sickles through both trials; in the next section, the prehistoric artifacts will be evaluated in reference to this ordinal scale.

The locations at which wear is present as well as its extent both vertically (in from the edge) and horizontally (along the cutting edge) in these areas is noted as well; the blade edge was divided into thirds and these sections were labeled *proximal*, *mid-blade*, and

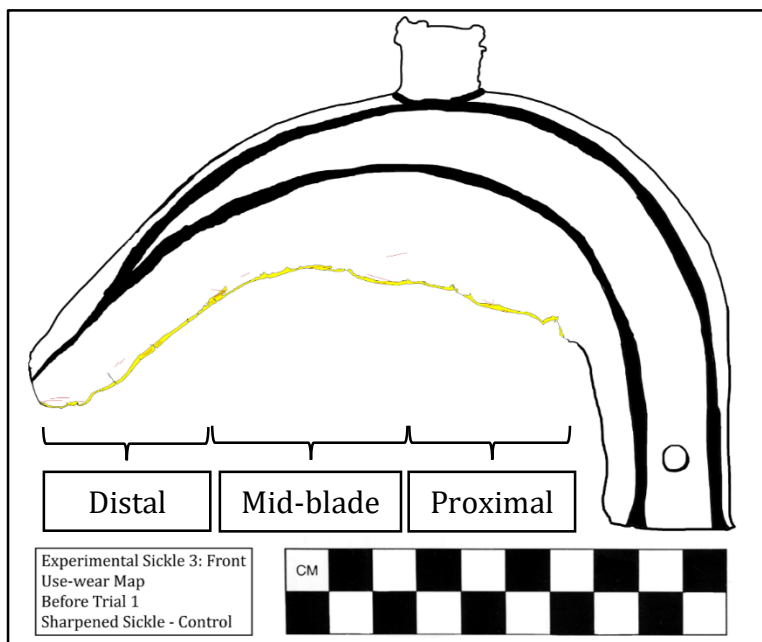


Figure 4.1 Use-wear map of bronze sickle depicting the distal, mid-blade, and proximal sections, terminology which will be used throughout.

distal (Figure 4.1). These labels are used throughout the analysis and discussion that follows to maintain consistency and enable efficient and clear identification of the areas in which use-wear appears. A selection of use-wear maps and excerpts of use-wear maps are included in this chapter, and the entire collection of use-wear maps produced—36

in all—may be found in Appendices A and B of this thesis.

A color-coded system of markings was used consistently for each map to identify certain types of wear or modification to the blade’s edge. Yellow highlighted areas on these

maps represent a sharpened edge; this edge was initially produced by the application of a whetstone and, as we shall see in the discussion of the results, was extended through abrasive contact with the harvested plants. Orange highlighted areas represent locations where the sharp edge has been blunted through use. A small number of the experimental sickles also exhibited a warping or bending backwards of the sickle's edge, indicated by blue highlighted areas on the use-wear maps. This phenomenon occurred most often in areas where the metal was thin and, rather than rounding on contact with the grasses being cut, the metal distorted and folded backwards. Red lines represent areas of striations. The sickle's general morphology, including hammer marks from peening, is outlined in solid black. Figure 4.2 represents a sample of the microscopic images taken showing the progression of a proximal section of Experimental Sickle 2 (ES2). The top image (4.2.A) shows the control stage in which the sickle has a sharp edge and striations from whetstone sharpening. Image 4.2.B shows this same area after completion of Trial 1, and a limited amount of blunting/dulling can be observed along the edge as well as a slight increase in the abraded area. Image 4.2.C shows this area of ES2 after Trial 2; a high degree of blunting/dulling is present along the blade's edge, and the abraded area has greatly increased. The patterns seen in Figure 4.2 are representative of the general changes that occurred on all the experimental sickles during the harvesting trials. However, some variability was observed, and the changes to each sickle edge will be considered and described in detail below.

Control Stage

Each sickle was photographed microscopically before the experimental trials and a use-wear map was created. Abrasion with a granitic whetstone produced an edge along the

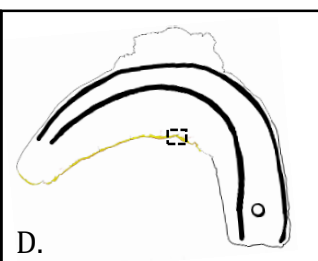


Figure 4.2 Microscopic images of a proximal area of Experimental Sickle 2 before and after trials. A. shows the control image with a sharp edge. B. shows the sickle after Trial 1 with a slightly rounded edge and slightly extended abraded area. C. shows ES2 after Trial 2 with a highly rounded edge and greatly extended area of abrasion. Image location is indicated in the dotted box on the sickle schematic above (D).

cutting surface
 which was very
 sharp, and the
 bright bronze-
 colored metal
 shone from this
 abrasion in an area
 approximately 1-3
 millimeters from
 the edge. Many
 striations were
 also visible,
 typically running
 parallel to the
 cutting edge,
 though some
 striations were at
 angles of less than
 45° to the cutting

edge.

Experimental Sickle 1 (ES1) exhibited a sharpened cutting edge running the entire length of the blade, both back and front. Many striations from whetstone sharpening were present within 1.5 centimeters of the blade edge. These striations were concentrated on

the middle section of the blade on the front of the sickle. The back of the sickle had a small number of sharpening striations running parallel to the edge.

Experimental Sickle 2 (ES2) was sharpened the length of the blade edge front and back. This tool also had obvious striations from whetstone sharpening evenly dispersed in each of the three blade areas, though the striations were lighter in the distal section on the front of the blade. These striations were predominantly parallel or at angles of less than 45° to the cutting edge; however, the distal section exhibited light striations nearly perpendicular to the cutting edge. This angle was due to the awkwardness of sharpening the distal area of the sickle in a continuously smooth stroke—the treatment used on the rest of the cutting edge.

Experimental Sickle 3 (ES3) again had a sharpened edge running the length of the sickle's blade, back and front. The back of the blade exhibited a larger area of sharpened edge in the mid-blade and distal sections; this area extended approximately 3-5 millimeters from the tool's edge. Sharpening striations were evident running parallel to the blade in the proximal and mid-blade areas, while the distal area exhibited striations angling 45° or greater to the cutting edge.

Experimental Sickle 4 (ES4) exhibited a sharpened edge on the entirety of both the front and back surfaces of the blade. Comparatively few striations from sharpening were visible on the sickle's front surface, and these were at angles of approximately 45° to this cutting edge on the proximal and mid-blade sections. Striations were visible on the back surface of the sickle but were located .5-1.5cm away from the sickle's edge, in the proximal and mid-blade sections. Some light striations were located in the distal area; these were parallel on the front surface but at approximately 30° on the back surface.

In general, these sickles exhibited an abraded edge sharpened between 2 and 5mm from the blade edge which tapered to an effective cutting point. Light striations from the whetstone sharpening ran parallel or at angles of less than 45° to this cutting edge. These data served as the control for the experimental portion of this thesis project. Any changes observed in the sickles following the harvesting trials were noted through comparison with the initial appearance of the sickles after the sharpening stage. All use wear maps for this section can be found in Appendix A.

Trial 1

Trial 1 of the experimental portion of this project was a thirty minute harvesting session in which approximately 100 square meters of canary reed grass (*Phalaris arundinacea*) was cut using ES2, ES3, and ES4. The blades were still quite effective at cutting through the handfuls of grasses even at the end of the initial thirty minute trial. It was concluded that sharpening would not have been needed to increase effectiveness of the blade after use for that length of time. However, sharpening was recommended for longer harvesting sessions, as discussed below in the section describing Trial 2.

The sickle blades did not exhibit any macroscopically observable changes after Trial 1. Yet, several changes were noted on the microscopic level, indicating that both methods of observation are necessary to achieve a comprehensive analysis. In general, these blades exhibited slightly rounded edges with striations apparent at perpendicular angles to the blade edges. The indications of use for each sickle are described below as well as summarized and ranked in Table 4.1.

ES1 was not used during Trial 1; the use-wear data derived from this sickle will be described in the Trial 2 section. ES2 exhibited a lightly rounded edge on the proximal and

mid-blade areas. Some rounding was seen on the distal portion, but this was not continuous. Small areas of bending could be seen on the mid-blade and distal surface, likely due to the thinness of metal in this location. On the proximal portion of the blade, the abraded edge was also extended further towards the back of the sickle than the abraded area produced by the original sharpening. Friction between the silica-rich vegetation and the bronze edge produced this increase in the abraded surface, an effect similar to what is known as “sickle sheen” on flint tools. The extent of the abraded area appeared relatively unchanged in the distal and mid-blade portions of the sickle’s edge.

Striations were lightly dispersed across the blade, generally parallel to the cutting edge—similar to the pattern observed at the control stage. However, the proximal and mid-blade areas exhibited striations *perpendicular* to the cutting edge. Figure 4.3 shows the

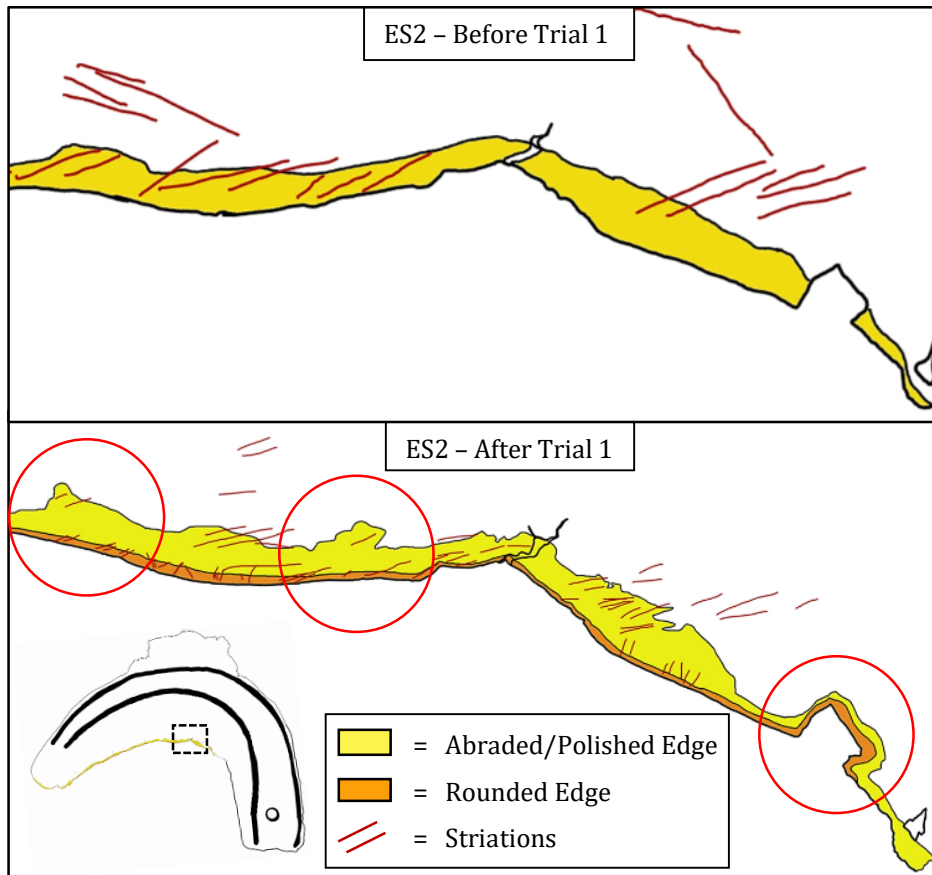


Figure 4.3 Close up view of the proximal edge of Experimental Sickle 1 before (top) and after (bottom) Trial 1. Indications of use, including a slightly blunted edge, extension of the abraded area, and striations perpendicular to the edge are apparent in the bottom image. Locations circled in red exhibit the greatest change. The area shown is within the dotted box on the inset sickle schematic.

increased size of the abraded area, the rounded edge, and the perpendicular striations produced during Trial 1, with the same section of the control stage use-wear map shown for reference and easier identification of these changes.

ES3 displayed low levels of blunting/dulling nearly continuously along the length of the cutting edge, though this rounding of the cutting edge was slightly more severe in the distal and mid-blade areas. There was no significant increase noted in the areas of abrasion on the front or back surfaces. The striations apparent on the sickle slightly increased on the sickle face, and greatly increased on the back, introducing a number of scratches greater than 45°, particularly in the mid-blade and proximal areas. ES3 did exhibit some blade deformation in the form of widening of cracks and loss of surface area on the blade. Figure 4.4 shows two areas of blade surface loss before and after Trial 1. It can be clearly seen that areas of the blade which were intact before the trial are missing after the experimental harvest, torn away by friction produced in cutting the vegetation. These fractures likely occurred in areas where there were casting flaws in the metal due to air pockets.

ES4 exhibited greatly increased areas of abrasion on the proximal and mid-blade regions of the sickle face. On the back surface the delineation of the abraded edge was too difficult to distinguish with accuracy after Trial 1, and therefore, these data were omitted to avoid erroneous conclusions. A rounded edge could be distinguished on both surfaces. The edge of ES4 exhibited low, discontinuous levels of blunting/dulling in each section. A moderate increase in striations greater than 45° degrees was observed on the edge of the sickle blade, fairly continuously in each section along the front surface. The back surface also exhibited a moderate increase in these striations along the proximal and mid-blade

sections, and a low increase in the distal section. Cracks seen on the cutting surface of the blade were slightly expanded following Trial 1.

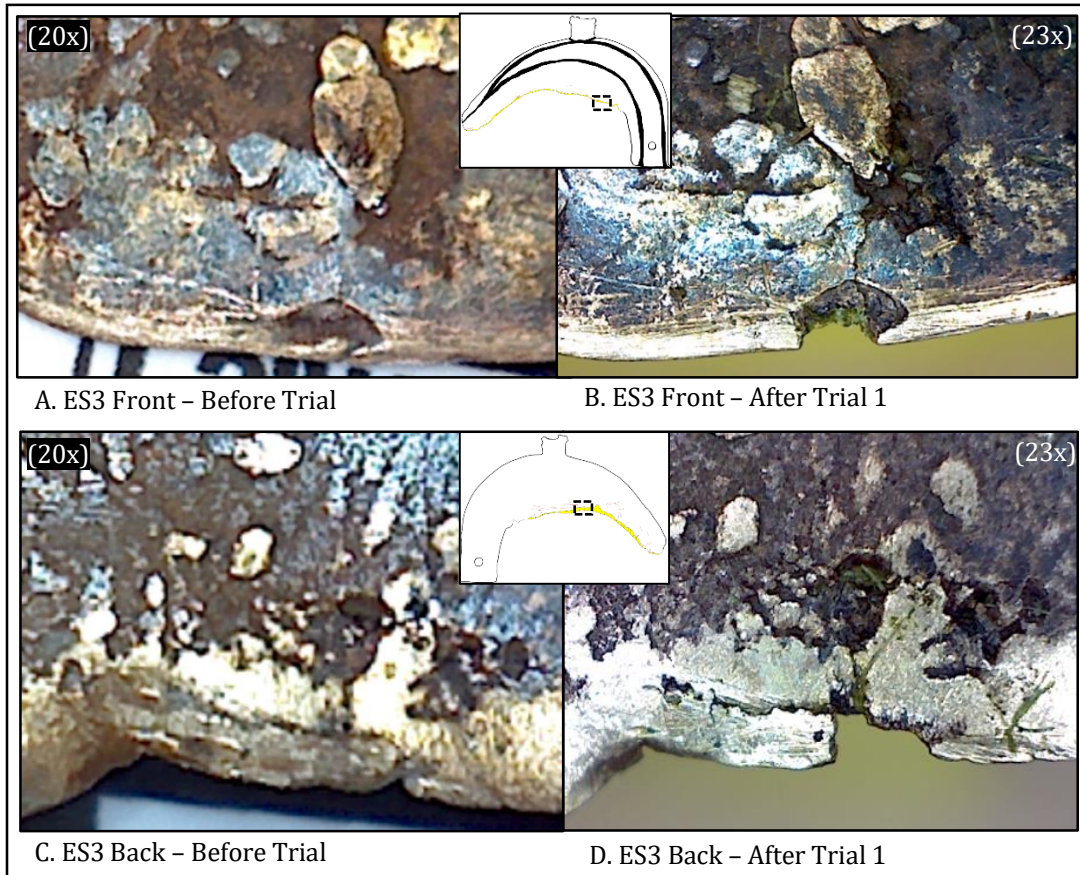


Figure 4.4 Microscopic images showing loss of the cutting edge after Trial 1 on the front (top) and back (bottom) of ES3. Inset schematics show locations of these areas of loss.

To summarize (see also Table 4.1), the cutting edges of ES2, ES3, and ES4 exhibited low levels of microscopic change as a result of the 30 minute harvesting process. The area of abrasion noticeably increased for ES2 and ES4, especially on the proximal sections. Each blade edge exhibited low levels of bluntness fairly evenly along each section of the edge surface. Striations generally increased from low levels at an angle less than 45° to the cutting edge in the control phase to moderate levels of striations greater than 45° . The greatest concentration of these striations occurred on the proximal and mid-blade surfaces, though ES3 exhibited high levels of striations on the distal section of the back surface. Blade deformation in the form of crack expansion occurred at low levels on ES3 and ES4.

From these results, I posit that sickles used for short periods of time can be identified based on a slightly blunted cutting edge and a moderate number of striations at angles greater than 45° to the blade edge.

Trial 2

Trial 2 of the experimental portion of this project was a 90 minute harvesting episode in which approximately 500 square meters of switchgrass (*Panicum virgatum*) were cut using all four experimental sickles. Six participants were involved in cutting during this trial. Near the 45 minute mark of the experimental use, participants noted a decrease in efficiency of the sickles. A small portion of the grasses comprising the handfuls were uprooted rather than cut through. At 75 minutes, approximately half of the handful of grasses were being uprooted rather than cut. Cutting with a bronze sickle with this level of bluntness/dullness would not have been an efficient method for harvesting plants such as cereal grains, as a Bronze Age agriculturalists would have wanted to limit the amount of soil taken away with the harvested vegetation. It was determined that an hour of constant harvesting would have required resharpening of the sickle blade before continuing to cut vegetation. The level of bluntness/dullness exhibited by the sickles at the conclusion of 90 minutes of harvesting was so severe it could be observed macroscopically. All the experimental sickles exhibited a rounded edge as well as secondary indications of use as described below.

ES1 was not used during Trial 1, and so the results of Trial 2 will be compared only to the control phase. ES1 shows a moderate increase in the area of abrasion on the mid-blade section of the front surface and the distal portion of the back surface. Little change in area of abrasion was noted outside these two areas. Blunting/dulling of the cutting edge

was observed on the entire length of the blade's edge, but was particularly severe on the distal section of the blade edge. Moderate levels of additional striation were visible on the mid-blade sections of both the front and back, and high levels of striation were present on the distal section of the back surface, corresponding to the high area of abrasion here (Figure 4.5.A). This pattern of high abrasion and high striation density on the distal portion of the sickle's back surface can be seen on all of the experimental sickles after Trial 2. This pattern will be discussed below.

ES2 shows a high level of additional abrasion along the entire length of both surfaces of the sickle's edge. Dulling is also continuous along the blade's length and is

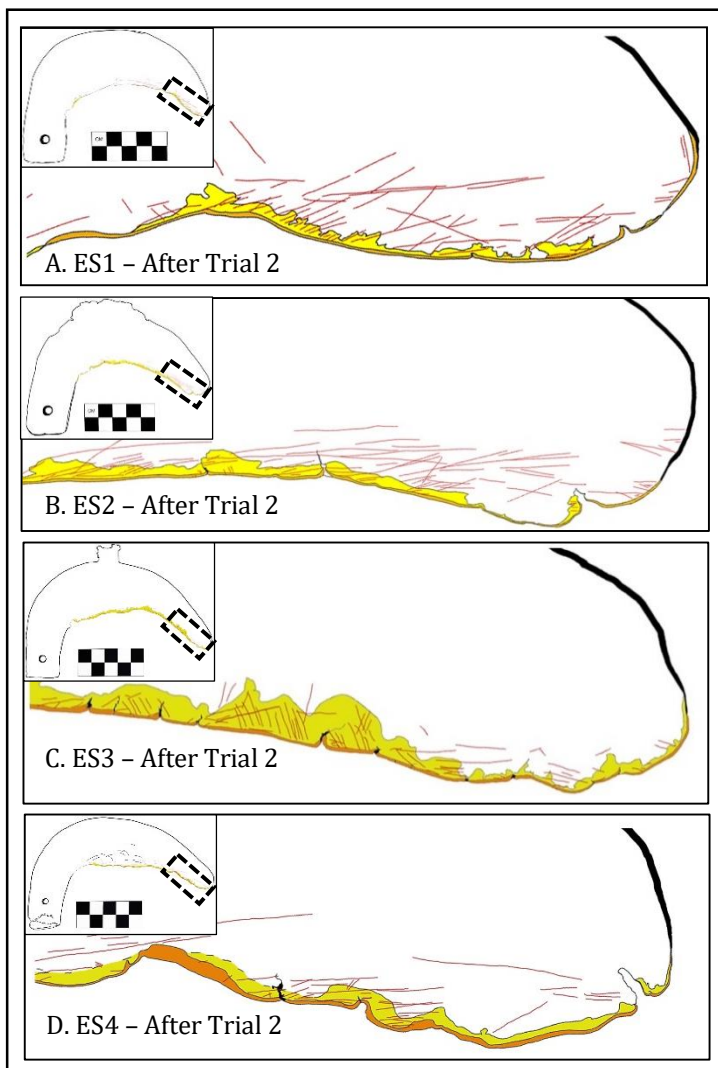
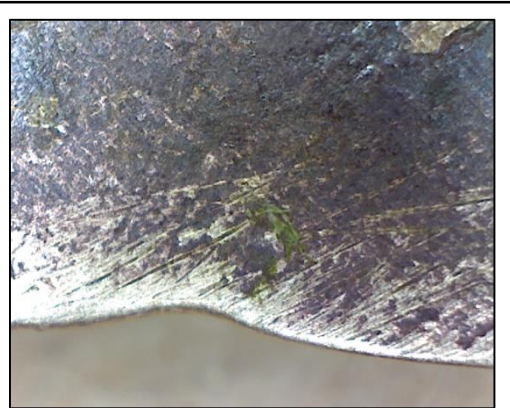
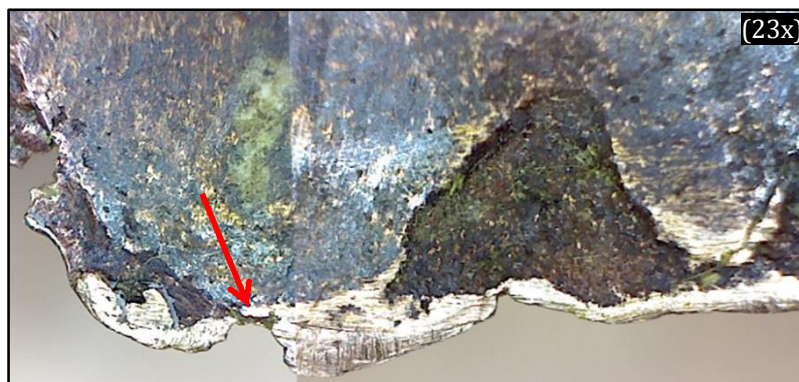


Figure 4.5 Distal sections of the back surfaces of ES1, ES2, ES3, and ES4 showing a significant increase in the area of abrasion and extent of striation present after Trial 2. Image E, from the distal area of ES4, shows how these areas of heavy striation appear microscopically. Dotted boxes in sickle schematics show the locations of these areas of abrasion.



particularly pronounced on the distal section of the cutting surface. Like ES1, ES2 also exhibits high levels of striation on the distal section of the back surface (Figure 4.2.B). In addition, this sickle shows moderate levels of striation $<45^\circ$ to the blade's edge in all other areas excluding the proximal section of the back surface. Moderate blade edge loss can be seen on ES2, particularly on the distal section of the blade (Figure 4.6). The abrasion against the vegetation cut during Trial 2 was enough to smooth the surface of many significant divots and irregularities which were obvious before heavy use.

ES3 exhibited a very high level of additional abrasion along the entire length of both surfaces (Figure 4.7). The distal section on the back surface exhibited high levels of abrasion after Trial 1, but this area remained relatively unchanged after Trial 2. These results suggest that the area of potential abrasion through use does not extend further than



ES2 Front – After Trial 1



ES2 Front – After Trial 2

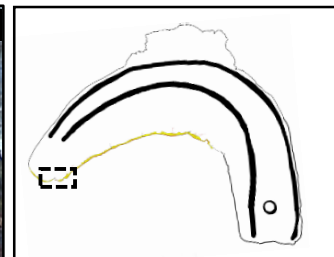


Figure 4.6
Blade loss exhibited on the edge of ES2 after Trial 2. The red arrow indicates a significant divot present after Trial 1 which is almost entirely reclaimed after Trial 2. Note also the larger abraded area produced along the blade edge in the lower image.
Above schematic shows locations of this area of blade loss.

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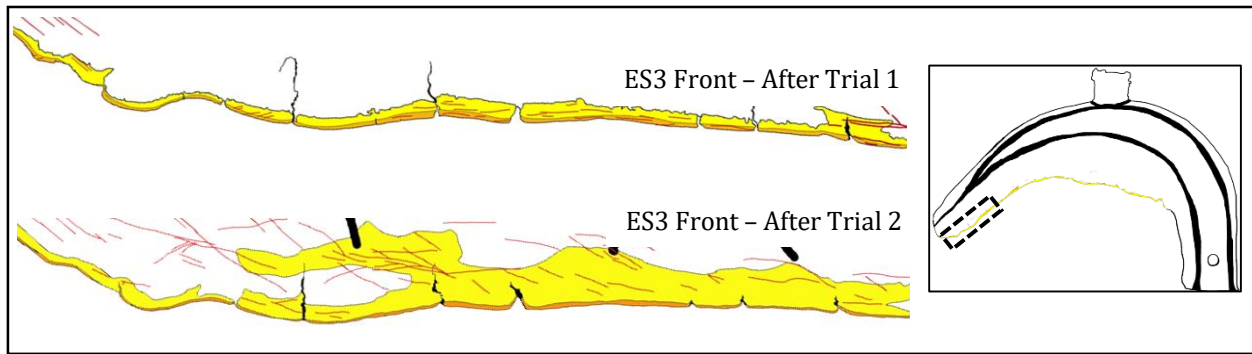


Figure 4.7 Distal section of ES3 showing an increase in the area of abrasion and extent of striations present between Trials 1 and 2. Dotted box in sickle schematic shows the locations of these areas of abrasion.

approximately 5mm past the blade's edge. A blunted edge can be observed even macroscopically, especially on the distal edge where it is most severe; the entire blade edge shows continuous bluntness/dulling. ES3 exhibited the same pattern of heavy striations on the distal section of the back surface seen above (Figure 4.5.C) as well as moderate levels of striations on the entirety of the front surface. Some blade loss was observed on the sickle's edge, particularly on the mid-blade surface.

ES4 exhibited a high area of abrasion over the entire blade surface, front and back. Rounding of the blade edge was also apparent throughout, and was particularly severe on the distal section of the sickle. Striations marked the blade over the entire surface with particular density on the mid-blade and distal sections of the back surface and the mid-blade section of the sickle face surface. Many of the striations on the mid-blade of the back surface were perpendicular or at angles greater than 45°. Moderate blade loss was observed, manifesting as a general smoothing away of the irregularities along the blade surface. Had the sickle been used further in harvesting over a longer period of time, it is possible to posit that the surface would have become very even and regular. The generally uniform appearance of the working edges of Bronze Age sickles therefore may be evidence of use over long periods.

To summarize (see also Table 4.1), the cutting edges of each of the four sickles experienced moderate to high levels of microscopic change as a result of the 90 minute harvesting process. The blunting and dulling of the sickle edges was so pronounced as to be apparent macroscopically as well. The area of abrasion, comparable to “sickle sheen,” greatly increased in comparison to the control and Trial 1 phases. Most distinctively compared to the Trial 1 phase, each sickle exhibited continuous bluntness/dulling along the entire working edge and the distal sections appear to have particularly severe levels of this rounded surface area. The most distinctive and unexpected pattern that emerged from the Trial 2 data is the extremely abraded and striated appearance of the distal section of the back surface (Figure 4.5). This phenomenon appeared distinctively in each of the four sickles following the Trial 2 phase. ES3 did exhibit this pattern at the conclusion of Trial 1, but overall it appears that heavier use is required to fully develop this specific indication of wear. Low to moderate blade edge loss was observed on the sickles, generally manifested as a smoothing of the surface area and elimination of jagged areas, leaving a blunted, smoother edge behind. I posit from these results that a sickle which has experienced heavy use can be identified through a continuously blunted edge over the entire working area and a large area of abrasion over the working edge with severe striations and abrasion occurring on the distal section of the back surface.

Prehistoric Sickles

Seven Bronze and Iron Age sickles were examined in three museums. Four of these sickles were from the Field Museum of Natural History, two from the Logan Museum of Anthropology, and one from the Milwaukee Public Museum. They were photographed microscopically and examined macroscopically as well, and each is described using the

Table 4.1 Ranking and Locations of Use-wear Patterns Before and After Completion of Trial 1 (T1) and After Completion of Trial 2 (T2)				
<i>Sickle Number</i>	<i>Area of Abrasion</i>	<i>Blunted Edge</i>	<i>Striations</i>	<i>Blade Deformation</i>
ES1	Control: low (2) area of abrasion continuous along the length of both blade surfaces	Control: none (0)	Control: low (2) level of striations at angle <45° to cutting edge on the front surface; slight (1) level of striations on the back of blade parallel to edge	Control: none (0)
	After T2: moderate (3) increase in abraded area continuous along the length of both blade surfaces	After T2: low (2) level of continuous bluntness. Moderate (3) level on distal section	After T2: moderate (3) level of parallel striations on mid-blade and distal sections of front surface; high (4) level of striations of angles <45° on distal section of back surface	After T2: none (0)
ES2	Control: low (2) area of abrasion along length of blade	Control: none (0)	Control: low (2) level of striations <45° throughout	Control: none (0)
	After T1: moderate (3) level of additional abrasion on the proximal section	After T1: low (2) level of bluntness on the proximal and mid-blade sections. Slight (1) level of discontinuous bluntness on the distal section.	After T1: moderate (3) level of additional parallel and perpendicular striations on the proximal and mid-blade sections	After T1: low (2) instance of a bending of the blade towards the back surface on the mid-blade and distal sections
	After T2: high (4) level of additional abrasion along entire length	After T2: low (2) level of continuous bluntness. Moderate (3) level on proximal section.	After T2: high (4) levels of striations at <45° on the distal section of the back surface; moderate (3) levels along entire front surface and mid-blade section of back surface	After T2: moderate (4) blade loss, particularly in distal section

ES3	Control: low (2) area of abrasion along length of blade	Control: none (0)	Control: slight (1) level of striations <45° throughout	Control: none (0)
	After T1: No significant increase in abraded area.	After T1: low (2) level of bluntness on the mid-blade, proximal, and distal sections	After T1: low (2) level of additional parallel and perpendicular striations on front. High (4) level of additional striations >45° on mid-blade and distal sections of the back.	After T1: low (2) occurrence of crack widening and surface loss on sickle edge
	After T2: high (4) area of abrasion extending 3-5mm nearly continuously along the blade, and particularly pronounced in the mid-blade and distal sections	After T2: moderate (3) level of bluntness on the proximal and mid-blade sections; high (4) level of bluntness on the distal surface	After T2: high (4) levels of striations at <45° on the distal and mid-blade sections of the back surface; moderate (3) levels of striations on the front surface	After T2: low (2) amount of additional blade loss, particularly on the mid-blade section.
ES4	Control: low (2) area of abrasion along length of blade	Control: none (0)	Control: slight (1) levels of striations at approximately 45° angle to the cutting edge on front and back surfaces	Control: none (0)
	After T1: high (4) increase in area of abrasion on the proximal and mid-blade regions on the front surface. No data from back of blade	After T1: low (2) levels of bluntness throughout all sections, though discontinuous	After T1: moderate (3) levels of additional striations >45° on entirety of front surface and on proximal and mid-blade sections on the back	After T1: slight (1) expansion of cracks along the cutting surface
	After T2: high (4) levels of abrasion over entire length of sickle blade.	After T2: high (4) levels of bluntness continuously over edge, particularly severe on the distal section	After T2: moderate (3) levels of parallel striations across entirety of blade surface. High (4) levels of striations on the mid-blade section of the front surface and the mid-blade and distal sections of the back surface	After T2: moderate (3) blade loss, particularly on the mid-blade and distal sections

same schematic system as the experimental sickles above. Again, the caution must be issued against viewing this section, and the conclusions drawn from it, as statistically representative of prehistoric sickles due to the very small sample size. This section represents an example, in the form of a pilot project, of how the methodology developed here could be applied to prehistoric collections to answer larger questions about sickles in the context of hoards in Bronze Age Europe.

Field Museum of Natural History

Each of the four sickles from the Field Museum (FM) exhibits very high levels of corrosion—a condition which detrimentally impacted the information that could be obtained concerning their use. Two of the sickles (25541 and 216348) are incomplete, which also limits the data to be derived from their working edges. Each sickle is described below in order of catalogue number.

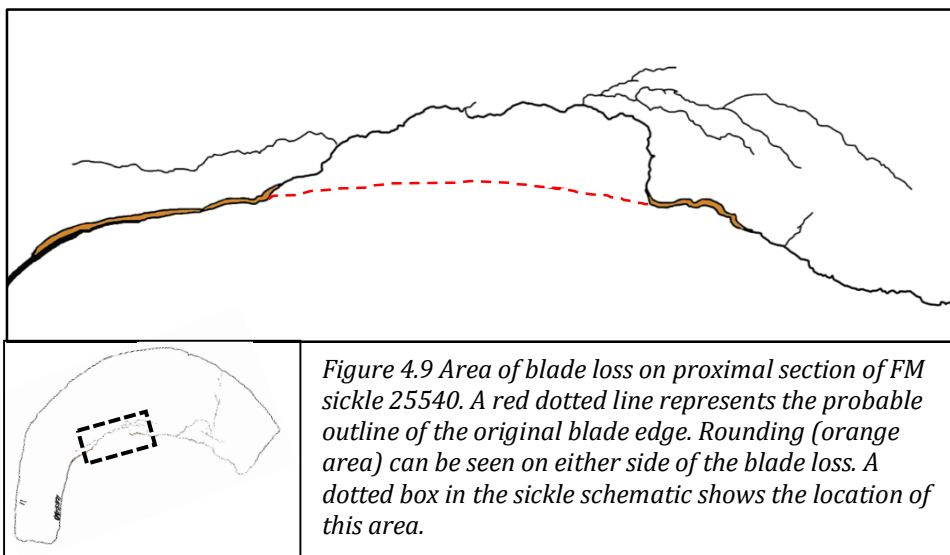


Figure 4.8 Bottom view of the warping evident on FM 25540.

Sickle 25540 of Accession 675 is a tanged sickle exhibiting very high levels of corrosion and missing its distal portion. There is a major amount of blade loss and cracking along the working edge.

The sickle is also significantly warped and bent (Figure 4.8). Torsion of the blade in this manner could be indicative of extensive use over a long period of time; this concept will be further explored in the analysis section below. Alternatively, the extreme warping may be attributed to an attempt to break the object into smaller pieces. Seeming to support this latter hypothesis, the tang

has not been perforated in preparation for a rivet, the customary means of hafting this type of sickle. However, areas of rounding can be observed along the blade's edge. On the proximal section an area of the cutting edge has been lost, yet rounding can be seen on either side (Figure 4.9). It is possible that the entire proximal surface would have exhibited this blunted edge. No striations or areas of abrasion were observed on this sickle. So much of the working edge of this sickle has been lost that definitive conclusions cannot be drawn with any certainty.



FM 25541 is part of Accession 675. This sickle belongs to the tanged type (Type I); the blade is

complete and the tang contains a rivet hole for hafting. FM 25541 exhibited a small area of edge bluntness on the proximal section of the blade. Though this sickle was significantly corroded, an area along the working edge appears free from the most severe bronze disease. This area corresponds to the location in which abrasion would have resulted from use. It is possible that the lack of corrosion here delineates a former area of abrasion, i.e. a working edge. Silica from vegetation binds to the edges of flint sickles, producing "sickle sheen;" if this process occurs in the same manner when using bronze sickles, the silica coating could protect the working edge, resulting in differential corrosion. Further studies

at higher magnification may produce more definitive evidence concerning this phenomenon. Sickles 216329 and 216348 also exhibit this pattern of potential differential corrosion along the working edge (*n.b.* the use-wear maps for these three sickles show the delineation outside the highly corroded area, but this area is not filled with yellow on any of the sickles, as it is not clear that these areas of differential corrosion were once areas of abrasion). The proximal edge of 25541 also shows small areas in which the very edge of the working blade has been bent backwards; this area appears similar to what occurred on ES2 during Trial 1 (Figure 4.10). It is possible that this bending is an indication of light use (the bent portion on ES2 was completely abraded away during Trial 2); however, the bending

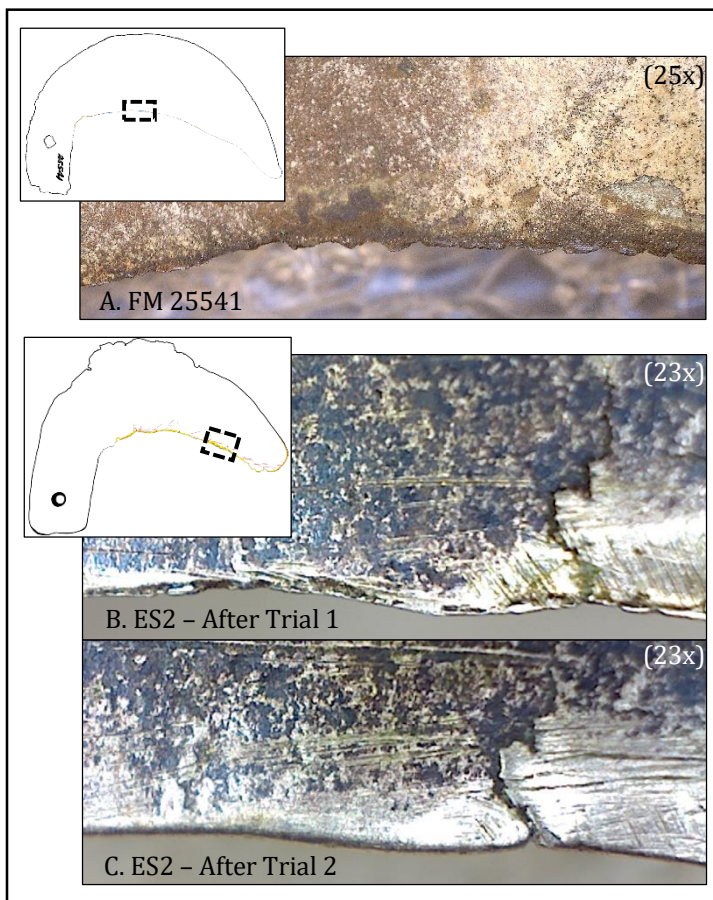


Figure 4.10 Bent area of working edge on (a) FM 25541, (b) ES2 after Trial 1. This area was abraded away after Trial 2 (c). Dotted boxes on sickle schematics show the location of the bent blade.

on 25541 could also be the result of post-depositional damage.

FM 216329 (Accession 1922) is a complete button sickle. As with FM 25541 and FM 216348, this sickle exhibits an area of differential corrosion that could correspond with what was once an area of abrasion from use. This area extends to outline the raised surfaces of the undulations on the base of the sickles. As these areas would have been in contact with the handle and abraded against the

wood as the sickle was used, it is likely that the differential corrosion here represents an old abraded surface. The proximal section of this sickle, particularly around the base, also exhibits a high level of bluntness/dullness. Whether this tool was used or not the weight of evidence suggests that it was, at the least, attached to a handle at some point before deposition.

FM 216348 of Accession 1922 is the proximal section of a button sickle. This is the smallest artifact examined for this thesis project. This sickle exhibits differential corrosion in a similar pattern to FM 216348 and FM 25541. It also has a significantly rounded edge, continuous for almost the entire blade edge. Light striations are visible on the back surface and a few very striations on the front surface as well. These marks are near the middle of the fragmented sickle.

Logan Museum of Anthropology

The two tanged sickles examined from the Logan Museum (LM) were in remarkably good condition, a hallmark of their Lake Dweller deposition context (Keller 1866). These sickles exhibit little corrosion, have very even edges, and are both complete artifacts.

LM 4.9.48 has a distinctly even edge exhibiting both abrasion and bluntness. The distal and mid-blade sections of the front surface exhibit a moderate degree of abrasion with a high density of parallel striations. The rounded edge is most pronounced in the proximal and mid-blade sections but is also discontinuously present on the distal edge. With the exception of the front distal surface, the rest of the sickle shows a heavy density of striations at 45° angles to the cutting edge. LM 4.9.48 also exhibits slight warping; this can be seen in Figure 4.11 in the form of a shadow under the distal end, indicating the sickle is not lying completely flat on an even plane.



Figure 4.11 LM 4.9.48 showing warping of the sickle blade. The red dotted line outlines the shadowed area, revealing the warped nature of the blade.

LM 4.9.49 exhibits a low level of discontinuous abrasion on each section of the back surface and on the distal section of the front surface. There is also a moderate level of bluntness along the blade edge which is nearly continuous and

particularly noticeable on the distal and proximal sections. The only deformation observable on this sickle is an unusually large rivet hole that has a stretched or deformed appearance.

Milwaukee Public Museum

MPM artifact 53899 is a particularly elegant tanged sickle without a rivet hole. This sickle is quite thin and has a very regular blade. Of all the prehistoric sickles examined, this tool shows the most potential indications of use wear. Most significantly, the distal section of the back surface exhibits high levels of abrasion and a high density of striations, similar to the results produced after heavy use of the experimental sickles (see Figures 4.5 and 4.12). Abrasion was highly varied over the rest of the surface of MPM 53899, with low levels of discontinuous abrasion along the front surface (particularly dense on the proximal area) and moderate levels of discontinuous abrasion on the back surface. The sickle exhibited a moderately to lightly blunted edge over the entire blade edge. Striations were

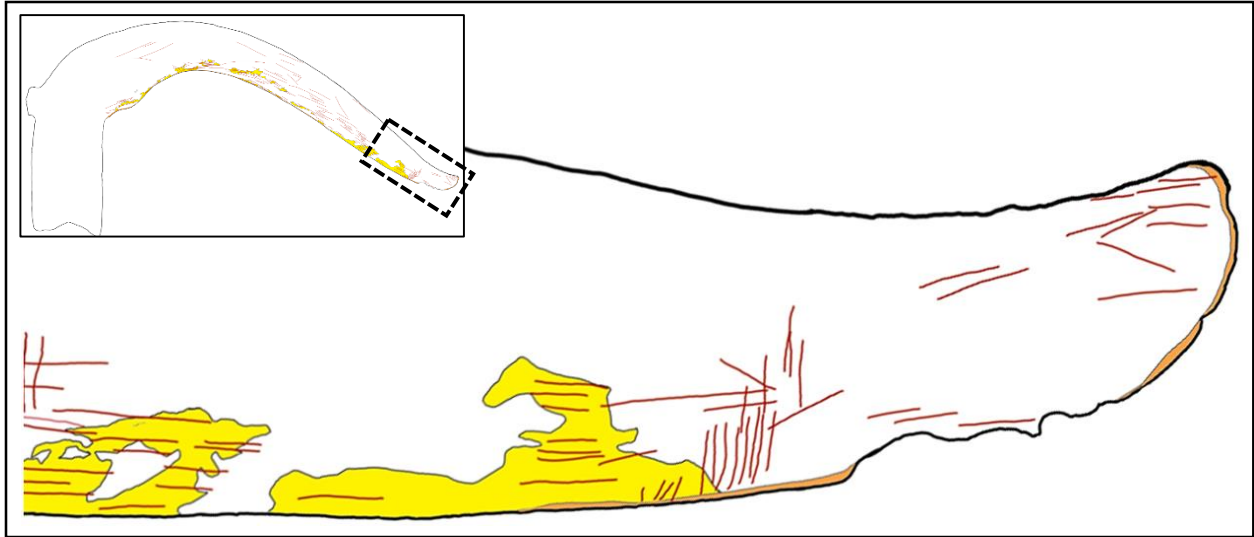


Figure 4.12 Distal section of MPM sickle 53899 exhibiting high density of striations and moderate level of abrasion. Compare image to Figure 4.5. Dotted square in sickle schematic shows the location of this use-wear.

visible over the entirety of the back surface at heavy density while the sickle face surface exhibited slight striations on the distal section. This sickle is extremely thin relative to other Bronze Age sickles. There is a protuberance at the proximal end which may indicate the location of the original blade extent. Due to the regularity of the blunted blade and this protruding proximal area, I posit that the original blade was much wider than it now appears and heavy use has caused significant blade loss. Figure 4.13 shows the posited original blade surface.

In the same manner as the above section on the experimental sickle blades, Table 4.2 ranks the indications of use seen on each of the prehistoric sickles. Table 4.3 compares the experimental sickles to the prehistoric sickles in a more simplified manner using only the ordinal system for each indication of use. In Table 4.3, numbers were averaged in each category and blade deformation from corrosion was not tabulated.

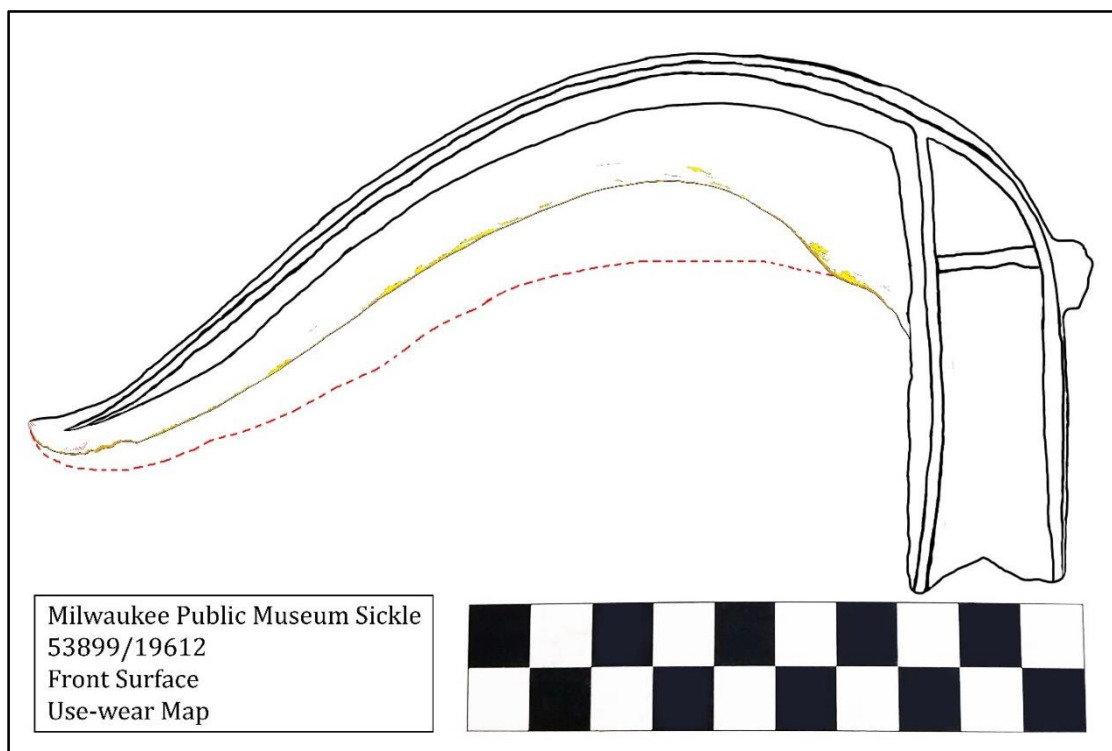


Figure 4.13 Schematic of MPM Sickle 53899 showing posited original blade extent with red dotted line.

In the next sections the information in these three tables and the descriptions above will be utilized in comparing the use-wear indications identified during the experimental trials to the data produced from examining the prehistoric sickles.

Table 4.2 Ranking and Locations of Use-wear Patterns on Prehistoric Sickles				
Sickle Number	Area of Abrasion	Blunted Edge	Striations	Blade Deformation
FM 25540	None (0)	Slight (1) rounded edge on the proximal section	None (0)	High (4) level of warping and blade loss due to breakage; high (4) level of corrosion
FM 25541	Undetermined	Slight (1) rounded edge on the proximal section	None (0)	Slight (1) Bending back of the working edge on the proximal surface; moderate (3) level of corrosion

FM 216329	Undetermined, but probable	High (4) level of bluntness on proximal section of blade	None (0)	Low (2) level of corrosion
FM 216348	Undetermined	Moderate (3) level bluntness along entire proximal fragment	Low (2) density of striations on the mid-blade section of both front and back surfaces	Mid-blade and distal sections are missing; High (4) level of corrosion
LM 4.9.48	Moderate (3) area of abrasion in the mid-blade and distal sections of the front surface	Moderate (3) level of bluntness—continuous along the proximal section and discontinuous along the mid-blade section.	High (4) density of striations throughout. Striations are approximately 45° on all sections except the distal front surface on which majority is parallel.	Slight (1) level of blade warping; Notch present in the middle of the blade edge.
LM 4.9.49	Low (2) , discontinuous areas of abrasion on each section of the back surface and on the distal section of the front surface	Moderate (3) , nearly continuous level of bluntness throughout,	Slight (1) density of striations on the distal portion of the back surface, near the middle of the back surface	Widening of the rivet hole
MPM 53899	Low (2) levels of discontinuous abrasion on the front surface; Moderate (3) levels of discontinuous abrasion on the proximal and mid-blade sections of the back surface; high (4) levels of abrasion on the distal section of the back surface	Low (2) to moderate (3) continuous blunted surface over entire working edge.	Heavy (4) striations over each section of the back surface. The majority of these are parallel to the cutting edge. Slight (1) striations over the distal section on the front surface.	Extreme thinness likely indicative of heavy (4) blade loss

**Table 4.3 Ordinal Ranking of Use-wear Patterns on
Experimental and Prehistoric Sickles**

Sickle Number		Abrasion	Blunted Edge	Striations	Blade Deformation
ES1	Control:	2	0	1.5	0
	T2:	3	2.5	3.5	0
ES2	Control:	2	0	2	0
	T1:	3	1.5	3	2
	T2:	4	2.5	3.5	3
ES3	Control:	2	0	1	0
	T1:	0	2	3	2
	T2:	4	3.5	3.5	2
ES4	Control:	2	0	1	0
	T1:	4	2	3	1
	T2:	4	4	3.5	3
FM 25540		0	2	0	4
FM25541		Undetermined	1	0	1
FM216329		Undetermined	4	0	0
FM216348		Undetermined	3	2	4
LM 4.9.48		3	3	4	1
LM4.9.48		2	3	1	0
MPM 53899		3	2.5	3	4

CHAPTER 5: DISCUSSION AND CONCLUSIONS

This final chapter presents a discussion of use wear evidence from the experimental and prehistoric sickles as well as an evaluation of the indications used in determining use-wear. Conclusions from the experimental and comparative studies are presented—including a return to the initial research questions—and finally, future research directions are considered.

Discussion of the Results

Evaluation of Use-wear Indications

Abrasion

Many of the sickles exhibited large areas of abrasion in which the surface was highly polished due to friction. The experimental sickles often showed areas of abrasion over the entire length of the working edge. The polishing of the distal section of the back surface was a pattern seen on all four experimental sickles following heavy use during Trial 2. However, as the majority of prehistoric sickles demonstrate, abrasion/polishing on a bronze surface is very difficult to confidently identify on a tool affected by corrosion and bronze disease. Therefore, abrasion is here suggested to be a secondary indication of use-wear, of very limited use on corroded surfaces. However, as discussed below, the combination of abrasion and striation on the distal section of the back surface is posited as a primary indicator of use-wear.

Striation

The production of striations along the cutting edge was inconsistent in the experimental sickles—the exception being along the distal section of the back surface. This area was an unexpected location of abrasion and striation due to its tangential location to

the site at which the most cutting took place. However, this result may be explained through closer examination of the harvesting process. As the handful of grasses was cut, the desiccated stems were left behind and the cutting motion brought those rigid stems into contact with the area of the sickle where heavy striations are observed. This phenomenon occurred over the entire blade of the sickle, yet this distal section bore the brunt of the damage. Furthermore, striations leave an enduring mark on a bronze sickle blade which survives corrosive forces more readily than simple polishing. This was one of the more important observations resulting from the experimental/archaeological specimen comparison: some degree of protection seems to be conferred on the working edges due to changes resulting from wear, leading to visible and recordable differential preservation. Therefore, striations (particularly in the distal section) are here suggested to be a primary indication of use-wear.

Bluntness/Dullness

A uniformly blunted or dull edge was consistently seen as an indication of moderate to heavy use in the experimental sickles. Abrasion against vegetation had a smoothing effect on a sharpened edge, and sickles required resharpening after approximately one hour of harvesting to maintain efficiency. While light use produced discontinuous blunting along the working edge, moderate to heavy use generated bluntness along the entire blade edge of the experimental sickles. Though corrosion will have an effect on the appearance of a sickle's edge over time, this rounded surface was also observed on a number of the prehistoric sickles. A blunted edge, particularly one which extends far along the cutting surface, can be viewed as a primary indication of use-wear.

Blade Deformation

Minimal blade loss due to blunting, breakage, and tearing of the thin blade edge was observed on nearly all of the experimental sickles. However, this use-wear indication would be difficult to confidently identify without the benefit of knowing the original appearance of the sickle blade's surface.

Warping of the blade was evident on FM 25540 and LM 4.9.48. This torsion of the blade could have been caused by repeated use—especially as it seems to be focused on the proximal area of the working edge. The experimental sickles did not show this degree of warping, but it is entirely possible that further use would have created a similar pattern. Future research would certainly benefit from expanding this experiment to include assessment over longer periods of use and resharpening. However, as blade deformation may have any number of post-depositional causes in addition to being difficult to identify without knowledge of the original blade surface, the phenomenon is here suggested to be a tertiary means of identifying use wear.

Evaluation of the Prehistoric Sickles

In order to provide an example of the application of the protocol developed in this thesis, the seven prehistoric sickles are evaluated below based on whether use could be inferred from the micro- and macroscopic data generated in comparison with the working edges of the experimental sickles.

- **FM 25540** does exhibit very slight bluntness and extreme warping; but, due to the high level of corrosion over the entirety of the blade, no conclusions can be safely drawn concerning the use of this artifact.

- **FM 25541** produced very similar data to 25540. Some blade deformation was observed, but the level of corrosion proved prohibitive and evidence of use-wear could not be determined.
- **FM 216329** is less afflicted by corrosion than the other FM sickles. The high level of bluntness on the proximal section of the blade, in areas that would have been abraded by a handle, allows the conclusion that this sickle was hafted. However, data from the blade itself was ultimately inconclusive, though it appears likely that use took place.
- **FM 216348** provides similar data to 216329, with the addition of striations observed on the mid-blade section. This sickle can also be posited to have been hafted, though use could not be determined due to corrosion and the small fragment of the blade which remains.
- **LM 4.9.48** exhibits warping, very high levels of striations, as well as a blunted and abraded edge. Due to the abraded/blunted edge and striations which have not been worn smooth from use, I suggest that this sickle experienced several use episodes and was at least partially resharpened prior to deposition.
- **LM 4.9.49** provides indications of use in the same locations as all of the experimental blades—the abraded and scratched distal section of the back surface. This indication, as well as the sickle’s continuous blunted edge and warped rivet hole, provides evidence for a well-used sickle, deposited after use and before resharpening. It is possible that the widened rivet hole became too prohibitive for the sickle to have been effective as a tool.

- **MPM 53899**, like LM 4.9.49, exhibits striations and abrasion on the distal section of the back surface together with other indications such as a continuous blunted edge, abrasion, and striations. This sickle can be confidently put forward as an example of a used tool.

In sum, I suggest that each of the Logan Museum sickles and the Milwaukee Public Museum sickle were used as harvesting tools. The data derived from the Field Museum sickles, though suggestive, was not enough to confirm use. It is important to note here that no evidence for use does not constitute proof of an unused artifact—especially in cases where the corrosion on the artifact made the data inconclusive. Concerning FM 216329 and 216348, this author suggests that a sickle which was hafted was likely used in harvesting as well.

Experimental Insights

The experimental archaeology portion of this project was integral to acquiring an understanding of how bronze sickles were made and functioned. As is the norm for such studies, more insights into the process were gained than initially expected. Though a more detailed explanation of the observations from experimentation is included in Chapter 4, there were several overall points that merit mention here.

When approaching a prehistoric sickle with the intention of determining use, the researcher must first determine the extent of preservation. If the sickle is very poorly preserved, as the four sickles from the Field Museum were in this study, macroscopic morphology, indications of hafting wear, and the presence of striations on the working edge should be focused on. Should the sickle be well-preserved with low or moderate levels of corrosion, the researcher should look for blunting of the use-wear edge and areas of

abrasion and striation on the distal section of the back surface. These indications represent the most significant and applicable findings of the experimental portion of this project.

Addressing the Research Questions

The research questions undertaken in this thesis are explicitly addressed here.

1. *Do bronze sickles in the European collections of the Field Museum, Logan Museum, and the Milwaukee Public Museum show evidence for significant use-wear? To what extent does preservation impact the working edge of these objects?*

Three of the prehistoric sickles—LM 4.9.48, LM 4.9.49, and MPM 53899—show evidence of use. Corrosion of the surfaces of these sickles was very light, and the remaining four sickles analysed exhibited heavy corrosion which significantly lessened my ability to make conclusive statements, though corrosion was not, in itself, entirely prohibitive. I suggest that corrosion should not be blindly used as a limiting factor in selecting artifacts for analysis. In cases where corrosion limits the observations that can be made, the researcher should pay close attention to striations and macroscopic evidence such as blade warping. Overall, this project has indicated that use-wear can be identified on select bronze sickles in museum collections.

2. *Can the cutting of vegetation be identified through use-wear analysis of the working edges of experimentally produced bronze sickles? If so, what types of wear patterns are observed on which areas of the sickle blade?*

Yes, cutting of vegetation provides significant abrasion on bronze blades and produces observable patterns. The primary wear patterns which indicate use are

(1) abrasion and striations on the distal section of a sickle's back surface and (2) continuous bluntness over the working edge of the sickle.

3. *Can the methodology developed by this research project be utilized in analyzing other collections of Bronze Age sickles? Can a protocol for such an analysis be established based on the results of this project?*

Yes, the methodology which was implemented for the sickles in these three Midwestern museums can be applied to collections of Bronze Age sickles from other sites, and the author offers the methodology section of this thesis as a protocol for future analyses.

4. *What could evidence for wear on sickles deposited in hoards potentially tell us about the nature of such deposits in prehistoric Europe?*

Should this or a similar methodology be used to positively determine use-wear on collections of prehistoric bronze sickles, the scholarly discussion which now views these implements primarily as an early form of currency due to their prolific presence in the Late Bronze Age, would be obliged to expand the interpretation of bronze sickles to include a higher level of consideration of context for their functional nature. This thesis, however, does not propose to significantly add to the data set of use-wear on bronze sickles, given the limited sample size, and no claims to wider patterns are made herein. Nonetheless, the protocol developed herein can be used to explicitly test the assumption that sickles in hoards and votive deposits were generally unused. Should the protocol be applied to reveal that all of the sickles in a particular hoard were deposited unused, conclusions can be drawn about the practice of deposition. For example, if these sickles came from a votive

deposit, we may suppose that those who deposited the sickles placed ideological value in the tool form or the concept of the sickle and what it could be used to procure. If, however, the sickles were placed in a votive deposit after heavy use, it may be more likely that they represent a quantity of metal which, after it has served its purpose, may be returned to the earth. Many hypotheses can be generated and tested through use of the protocol developed here.

Conclusions

The stated general goals of this thesis were to redress the deficit in use-wear analyses of prehistoric bronze sickles and provide a protocol for future projects to correct that deficit. This protocol included experimental research into making and using bronze sickles as well as macroscopic and microscopic evaluation of use-wear on both the experimentally made sickles and prehistoric sickles from three museums. It has been demonstrated above that the cutting of vegetation with bronze blades does leave behind evidence which centuries later can be rediscovered on these tools, opening new avenues of interpretation and allowing more insightful questions to be asked in the archaeological endeavor to recreate past lifeways. To that end, a section of potential for future research is less of an obligatory inclusion and rather becomes the central purpose of this project. The author hopes that the protocol developed in Chapter 3 and illustrated in Chapter 4 will be used in studies such as those suggested below.

Future Research

Directions for future research on this subject fall into two main categories. First, the central purpose of applying the methodology to museum collections, and second, the expansion of the original protocol. As was illustrated in the review of the existing literature,

few if any scholars writing in the English language are exploiting the huge resource bronze sickles represent for understanding aspects of the Bronze and Iron Ages. The ubiquity of this artifact type allows for entire museum exhibits to be constructed around artistic placement of hundreds of these sickles. The fact that examples of these artifacts are located in three different museums within a 100 mile radius in the Midwestern United States, several thousands of miles from their archaeological sites of origin, speaks to the ubiquity of bronze sickles in museum collections worldwide. In addition, this high frequency and distribution also means that scholars of many different traditions can add to the data set without necessarily facing the geographic limitations of their location. Documentation from European museums reveals that in the face of limited storage, suggestions have been made in the past (and thankfully rejected) to melt down these artifacts due to their overwhelming ubiquity (Bettina Arnold pers. comm). Artifacts once viewed as an unnecessary storage burden should now be understood to be an untapped resource for comparing Bronze and Iron Age sites both regionally and throughout time.

Archaeological research in this temporal and spatial area would benefit from future projects that attempt to identify patterns in the sickles recovered both intra- and interregionally. Selecting and analyzing sickles from a single hoard can answer questions concerning the variability of the ritual program practiced in Bronze and Iron Age communities. Should there be uniformity in the presence or absence of use-wear indications on sickles from a single deposit, a proscribed condition for the artifacts deposited—whether they should come from a “pure,” freshly cast context or whether they were utilized as tools before being given back to the earth—can be inferred. Variability in the indications of use-wear among sickles in the same deposit may be used as evidence for

either a less strict program of object selection for deposition or as suggestive that considerations other than whether an object had been used as a tool were among the criteria for deposition.

The second category of future research I would suggest is an expansion of the experiment undertaken here. As the first foray into constructing a detailed protocol for use-wear identification, the project was inherently limited. It is virtually impossible to anticipate or identify all areas that would benefit from examination through experimentation before the initial experiment takes place. For example, as the title suggests, the focus of this thesis was on the blades of these bronze tools rather than other areas of the morphology—though these areas were touched upon. Further experimentation addressing whether indications that a sickle was hafted can be consistently identified on prehistoric artifacts would be useful to this research avenue.

It was noted in reference to FM 25540 and LM 4.9.48 that warping of the blade is a potential indication of tool use over a long period of time. Therefore, a lengthier experimentation phase, in which sickles are repeatedly used and resharpened, would provide additional understanding concerning how a bronze blade endures abrasive forces over time. Should this type of blade warping be seen more frequently in longer experiments, this phenomenon could be added to the list of primary indications of use.

Similarly to hafting indications, an expansion of the type of sickle experimentally recreated and used would be beneficial. Though they share a similar approach to harvesting and cutting angle, different types of hafting and handle lengths create subtle differences in how use-wear presents itself on different sickle types. As tanged sickles were reproduced during this project, button sickles—the other type which appears in significant

numbers throughout Europe—might productively be the subject of a similar type of experimental archaeology project.

Directions for future research on this topic are limited only by the imagination of the researcher. Suffice it to say that both the expansion of the experimental data set and the application of the use-wear indications identified above to collections of bronze sickles could result in a substantial contribution to our understanding of ritual programs in the Bronze Age, and the author looks forward to reading such contributions.

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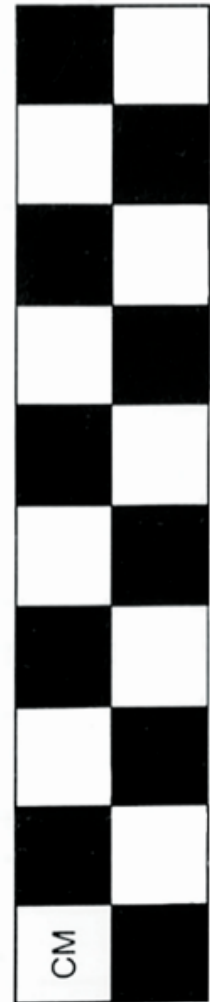
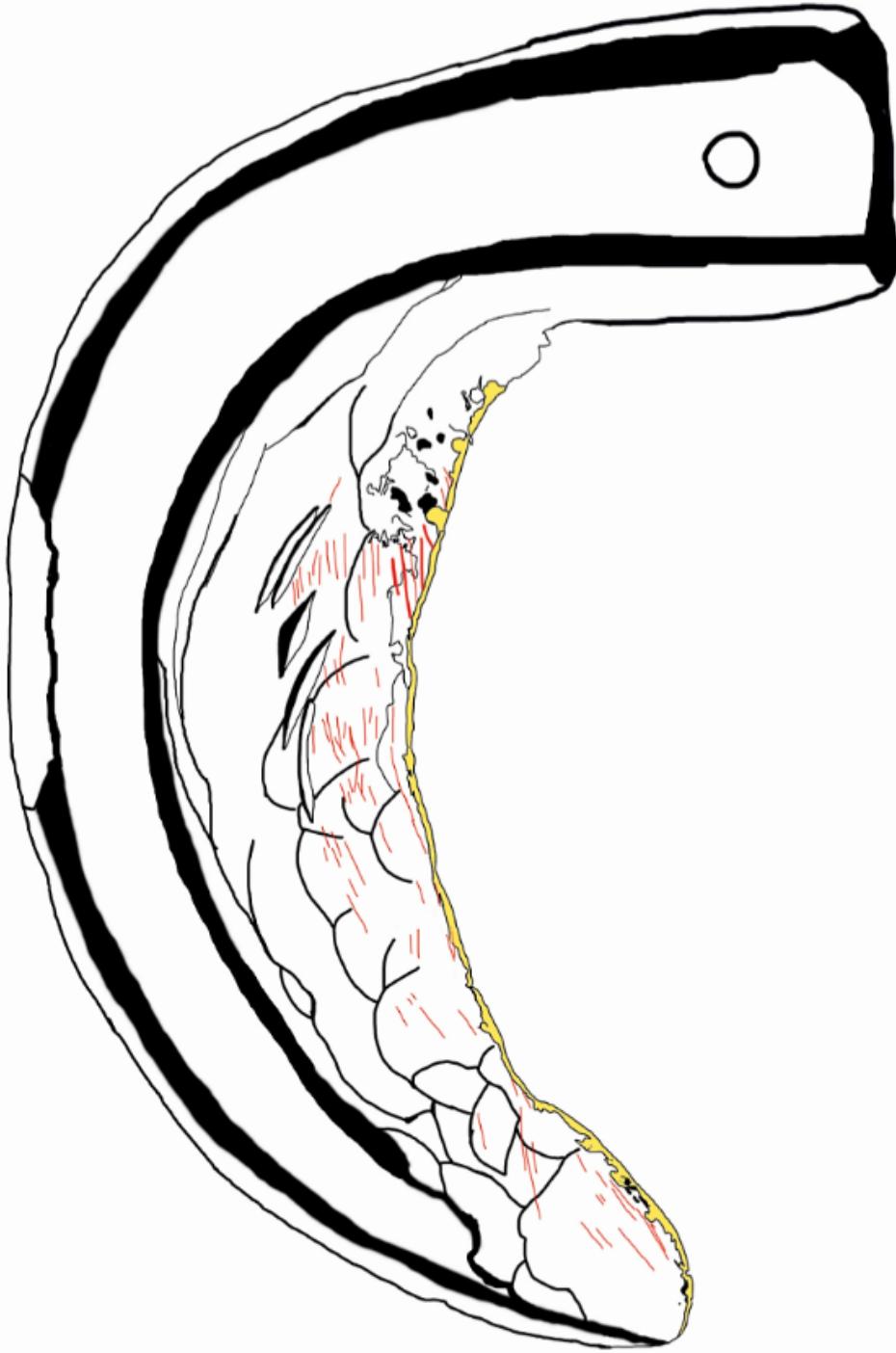
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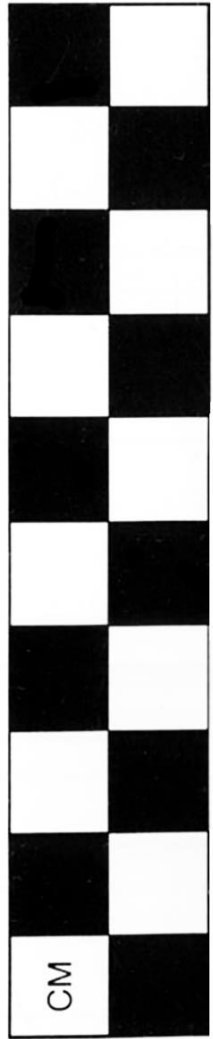
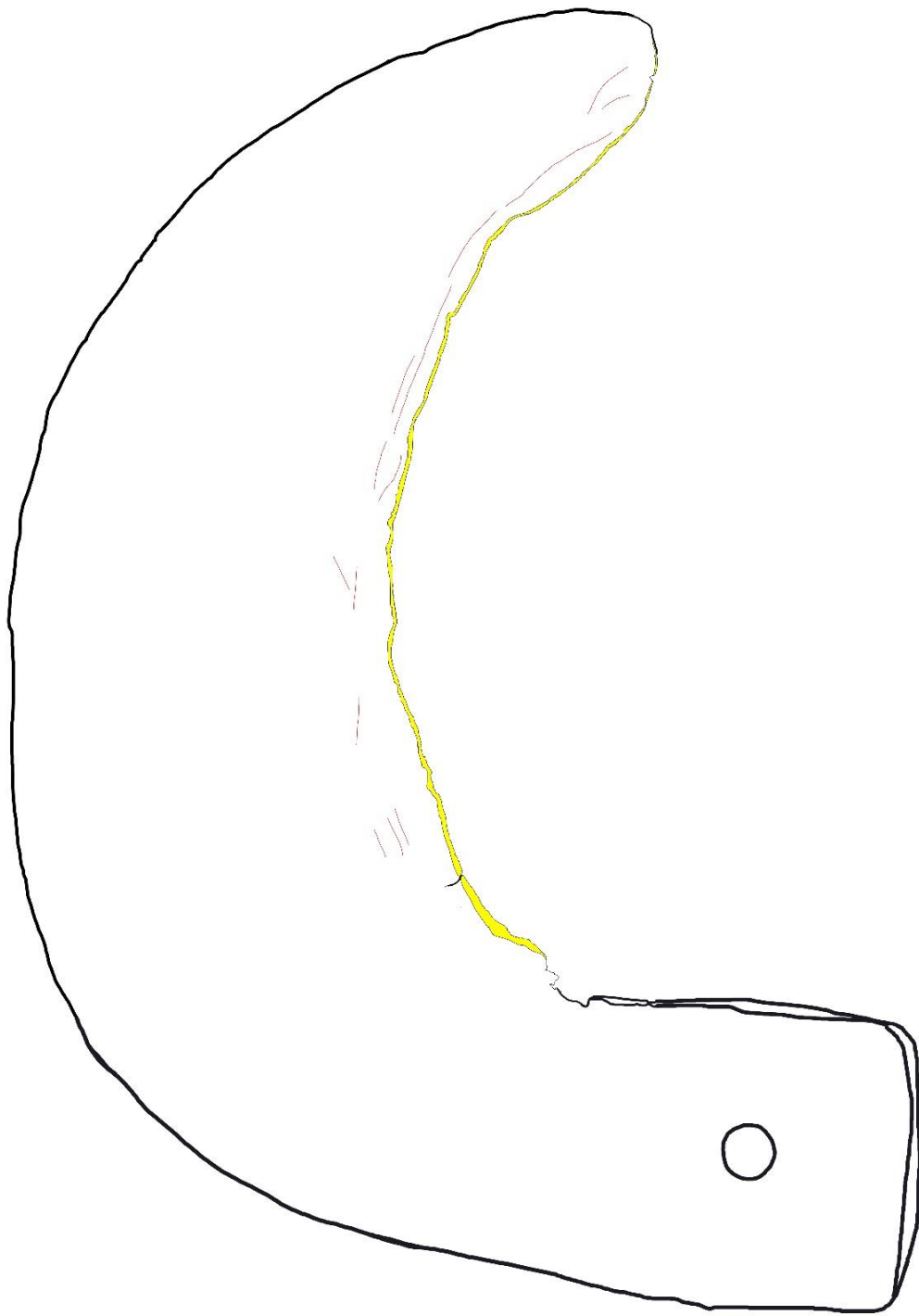
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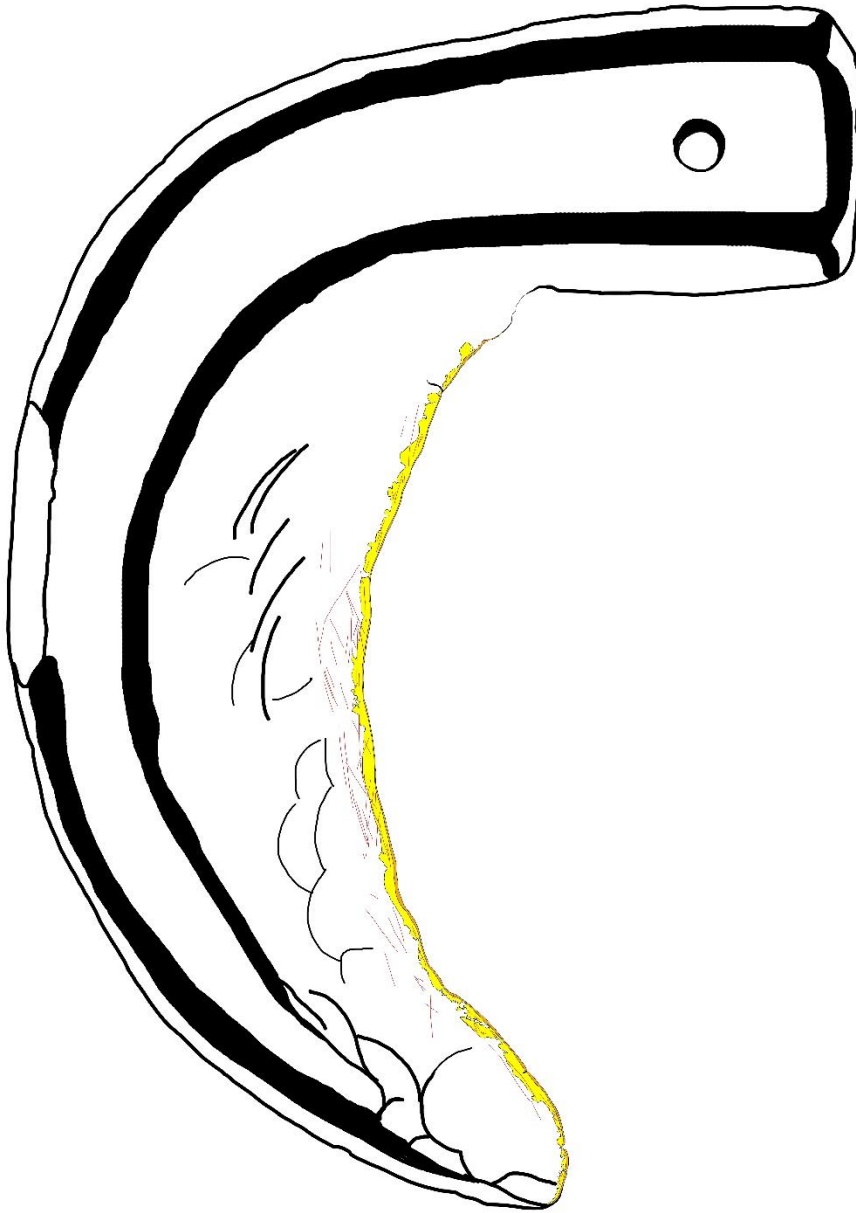
APPENDIX A:
EXPERIMENTAL SICKLE USE-WEAR MAPS



Experimental Sickle 1
Use-wear Map
Before Trial 1
Sharpened Sickle - Control



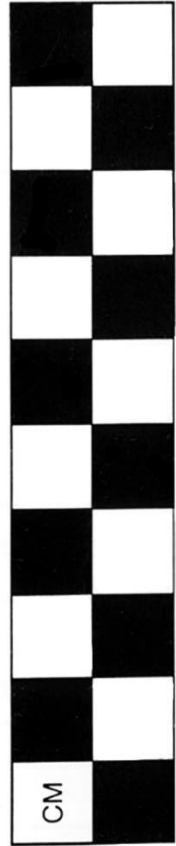
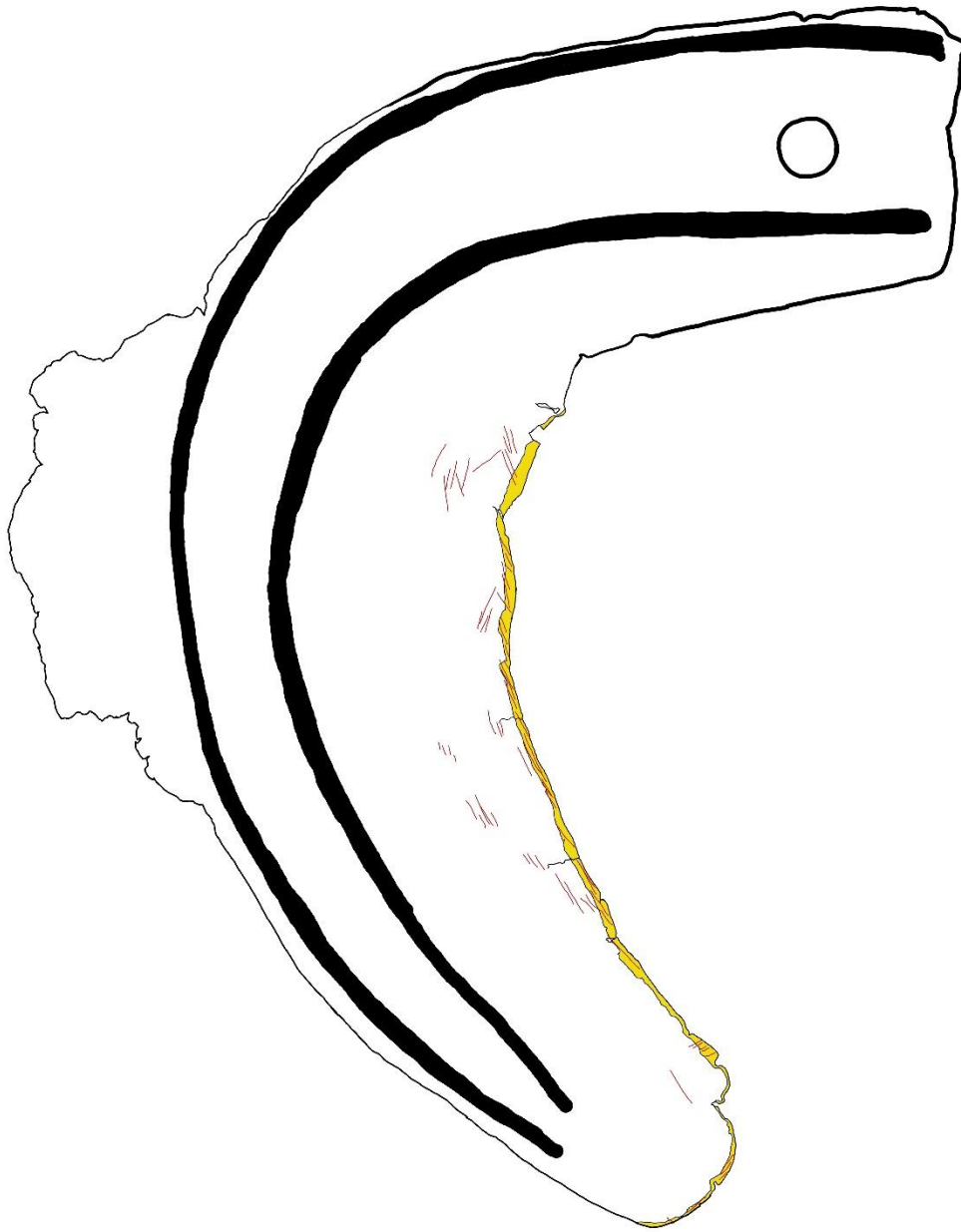
Experimental Sickle 1: Back
Use-wear Map
Before Trial 1
Sharpened Sickle - Control



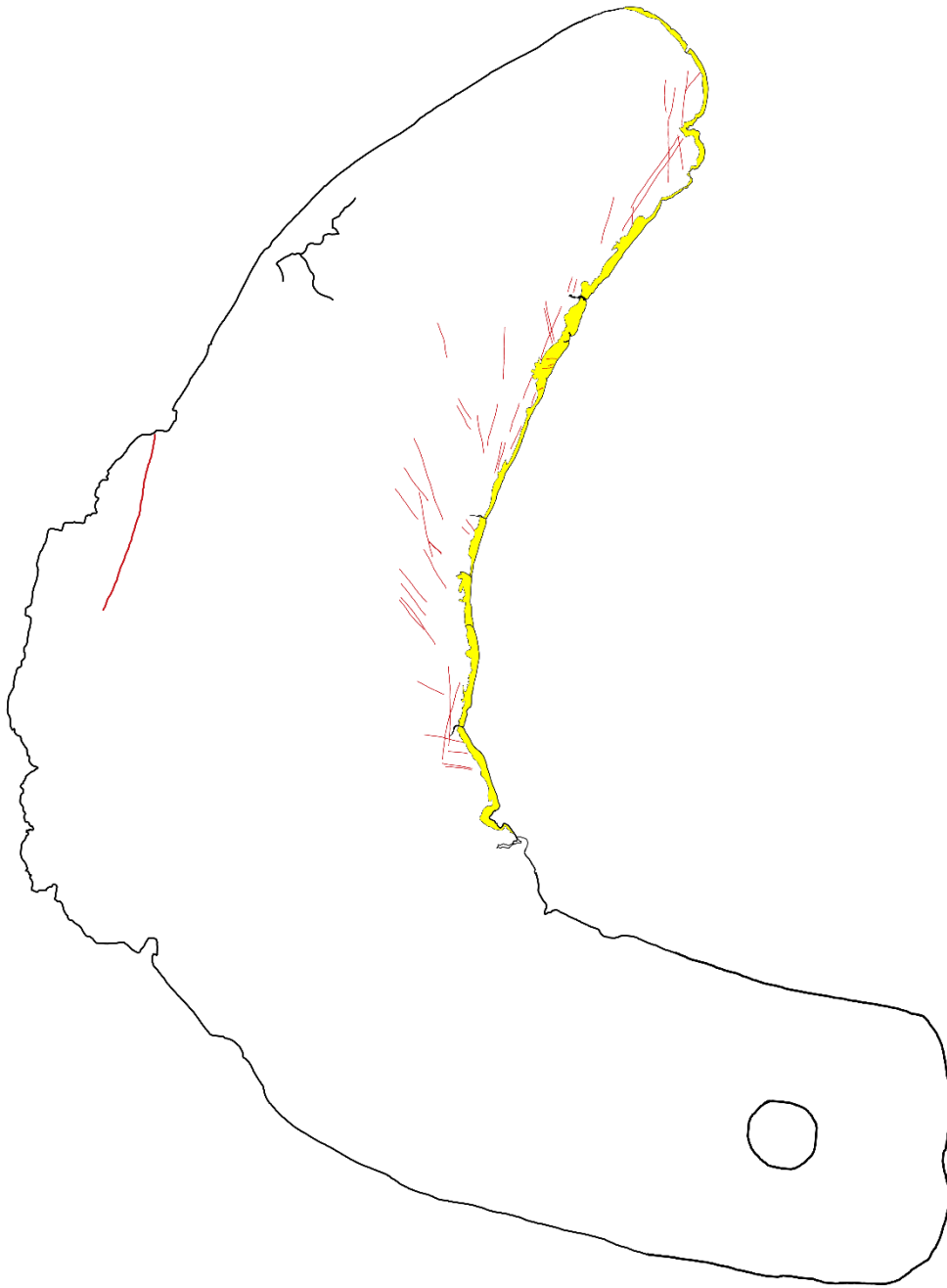
Experimental Sickle 1: Front
Use-wear Map
After Trial 2
90 minutes of use



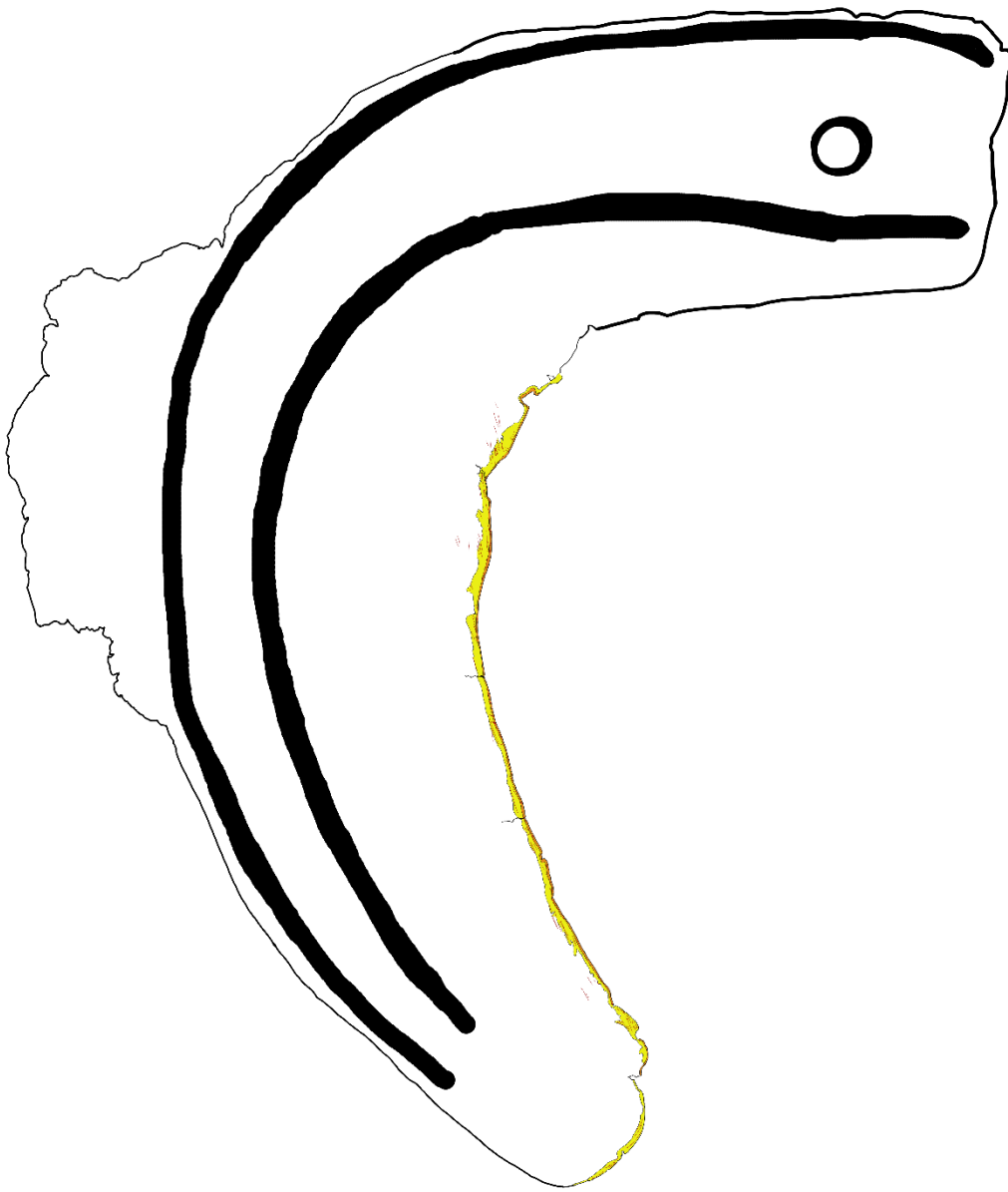
Experimental Sickle 1: Back
Use-wear Map
After Trial 2
90 minutes of use



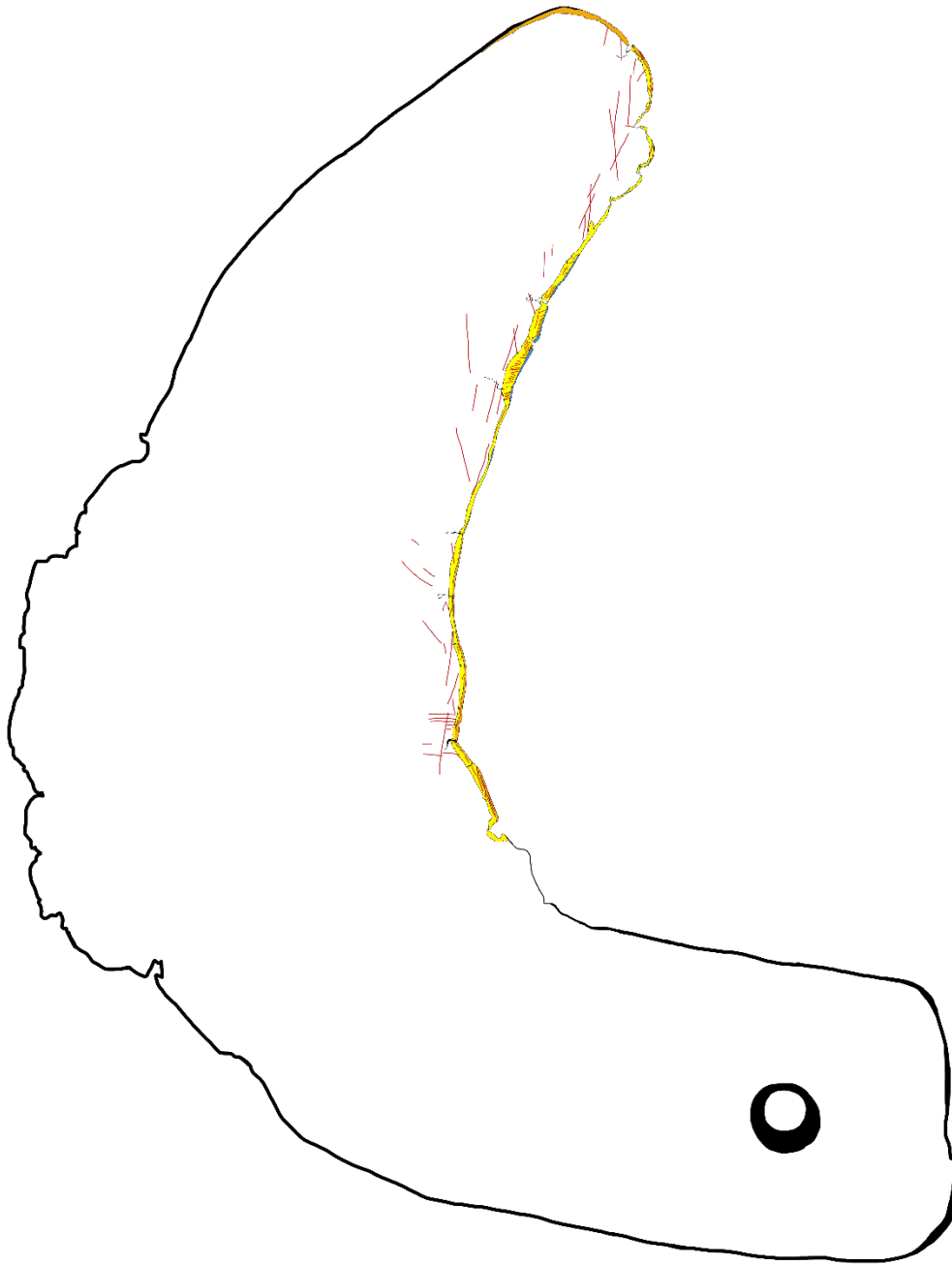
Experimental Sickle 2: Front
Use-wear Map
Before Trial 1
Sharpened Sickle - Control



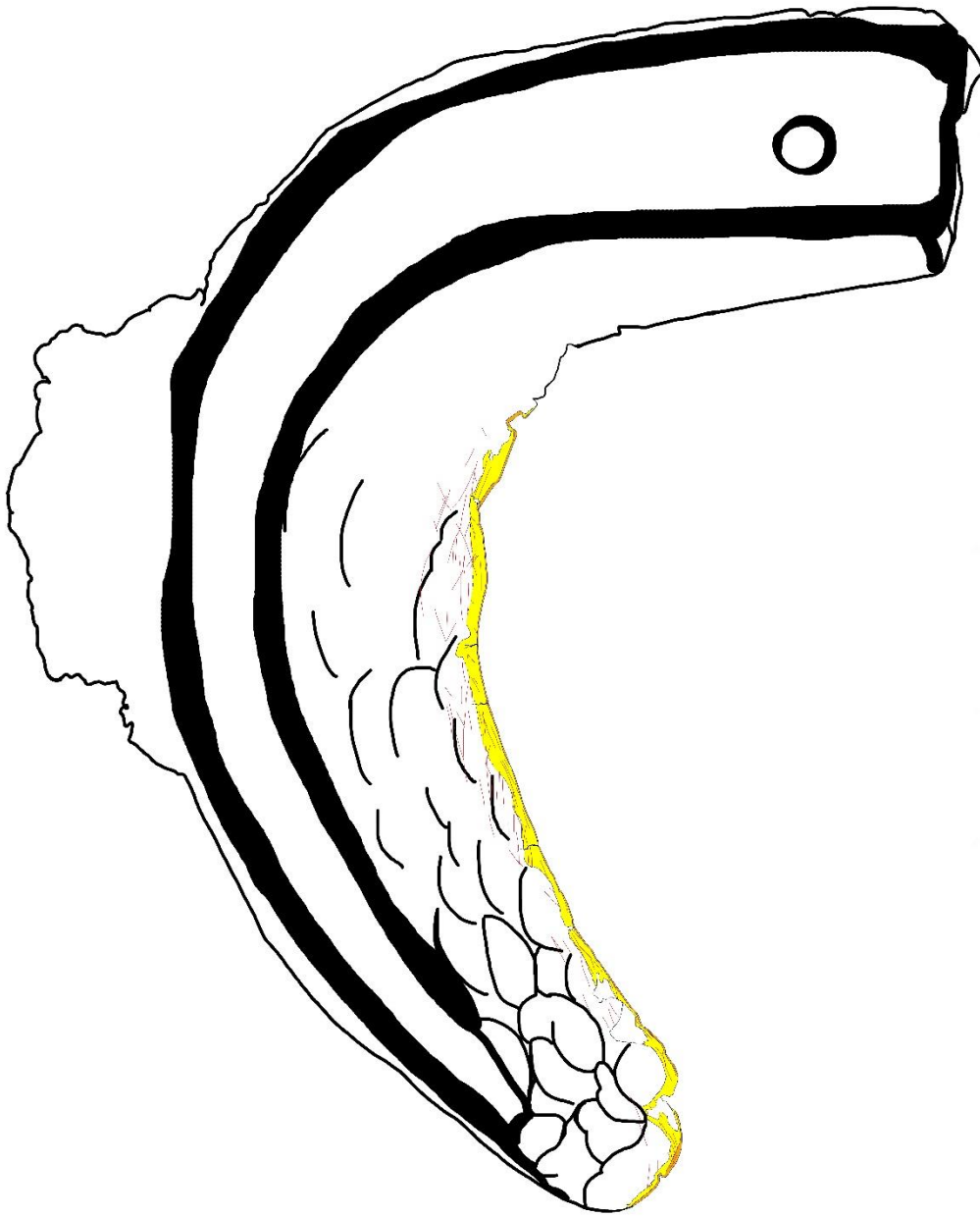
Experimental Sickle 2: Back
Use-wear Map
Before Trial 1
Sharpened Sickle - Control



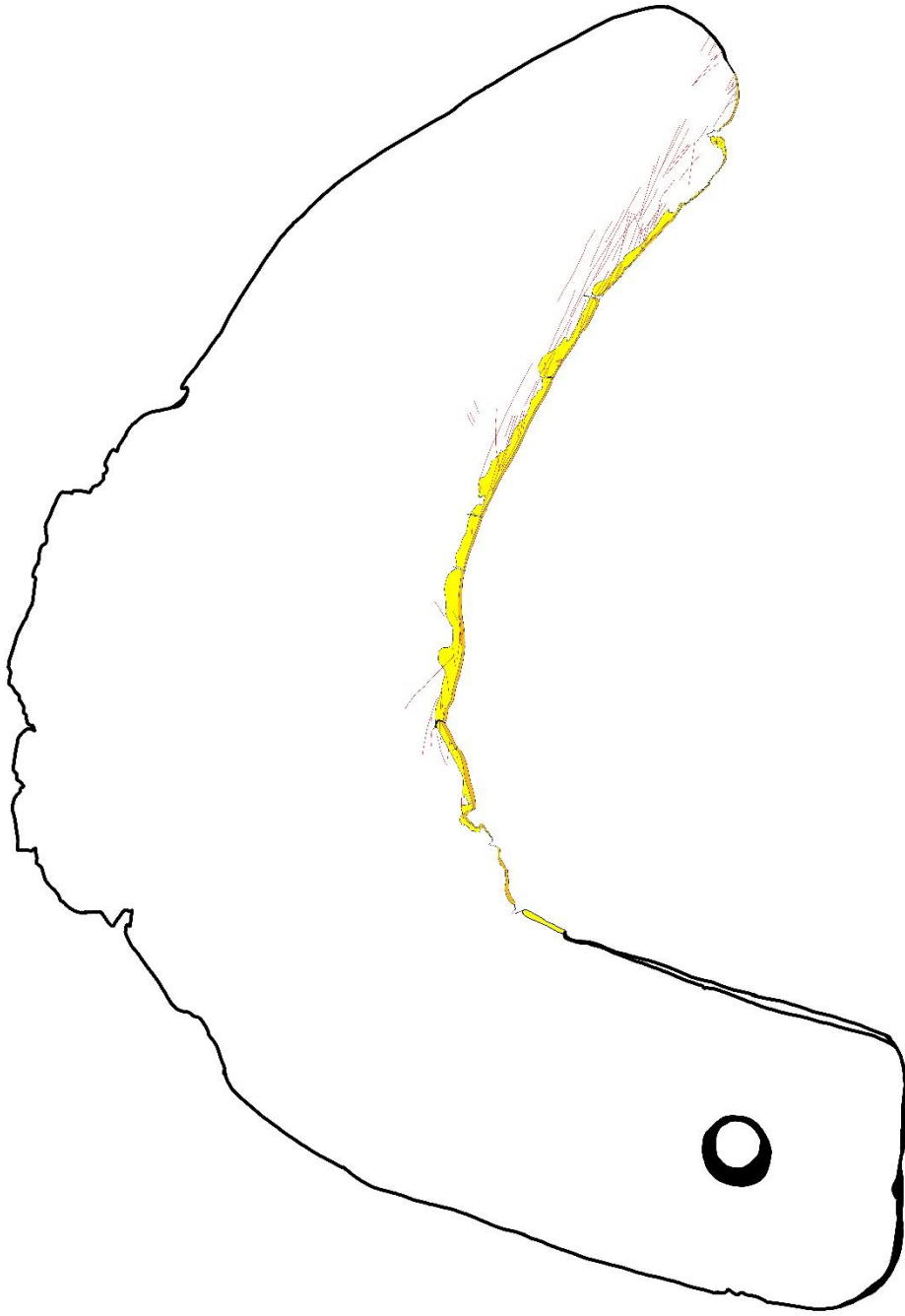
Experimental Sickle 2: Front
Use-wear Map
After Trial 1
30 Minutes of use



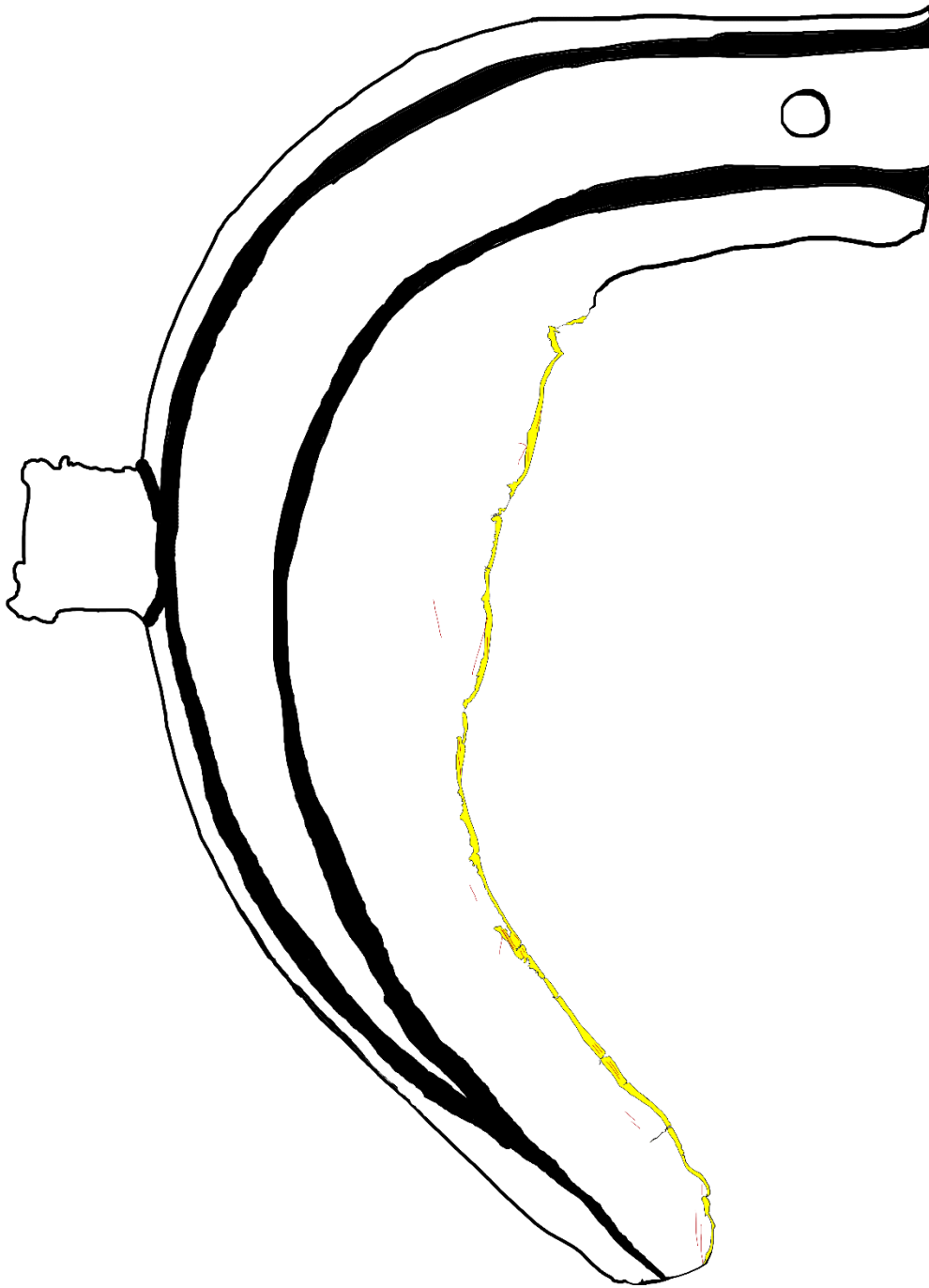
Experimental Sickle 2: Back
Use-wear Map
After Trial 1
30 Minutes of use



Experimental Sickle 2: Front
Use-wear Map
After Trial 2
90 Minutes of use



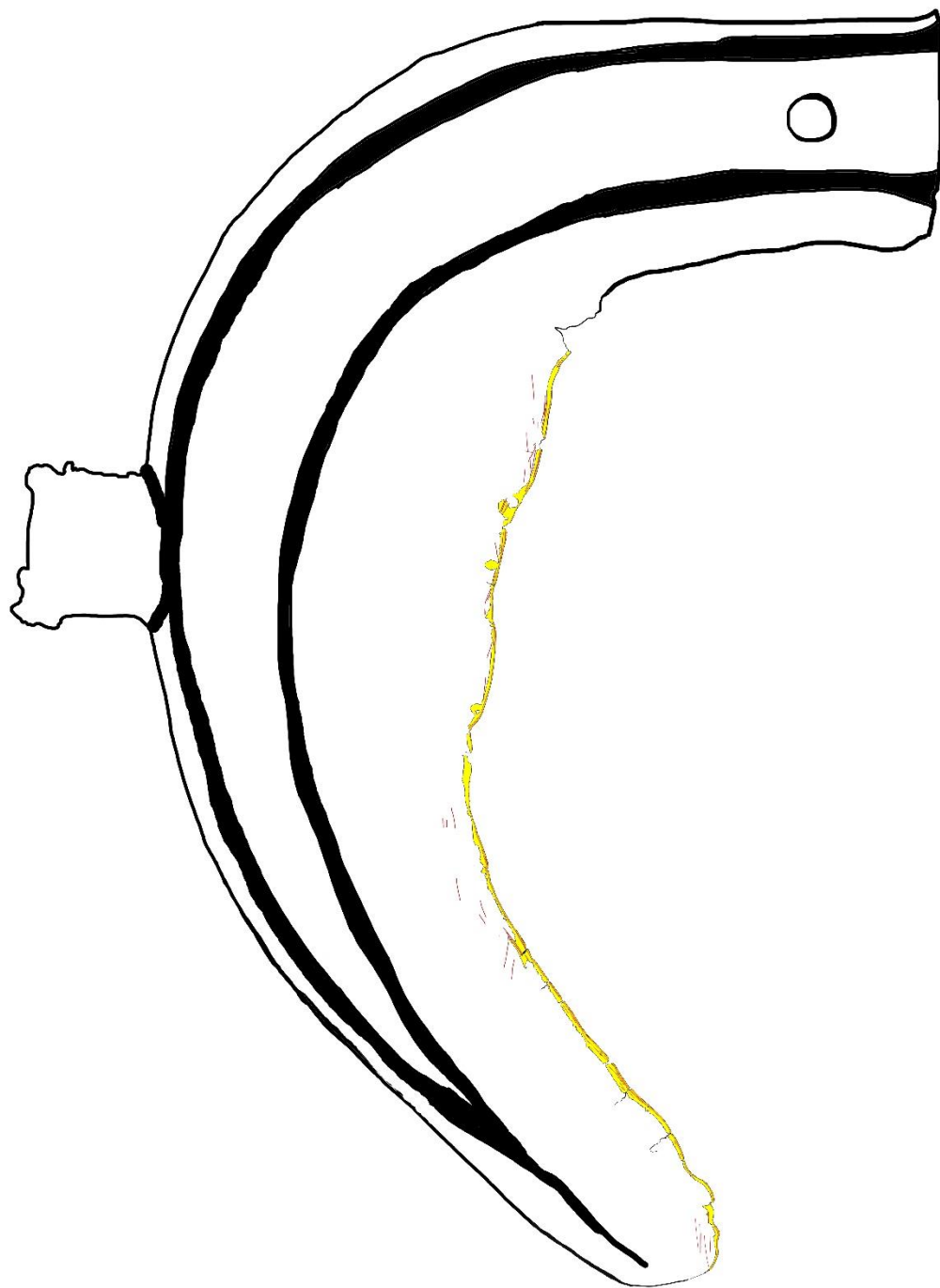
Experimental Sickle 2: Back
Use-wear Map
After Trial 2
90 Minutes of use



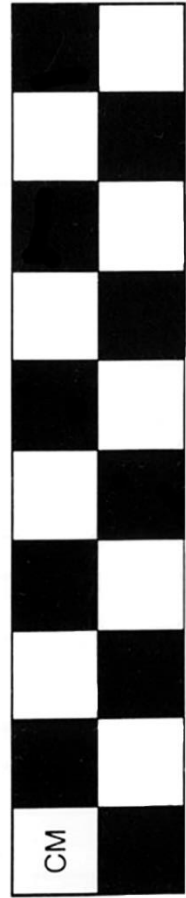
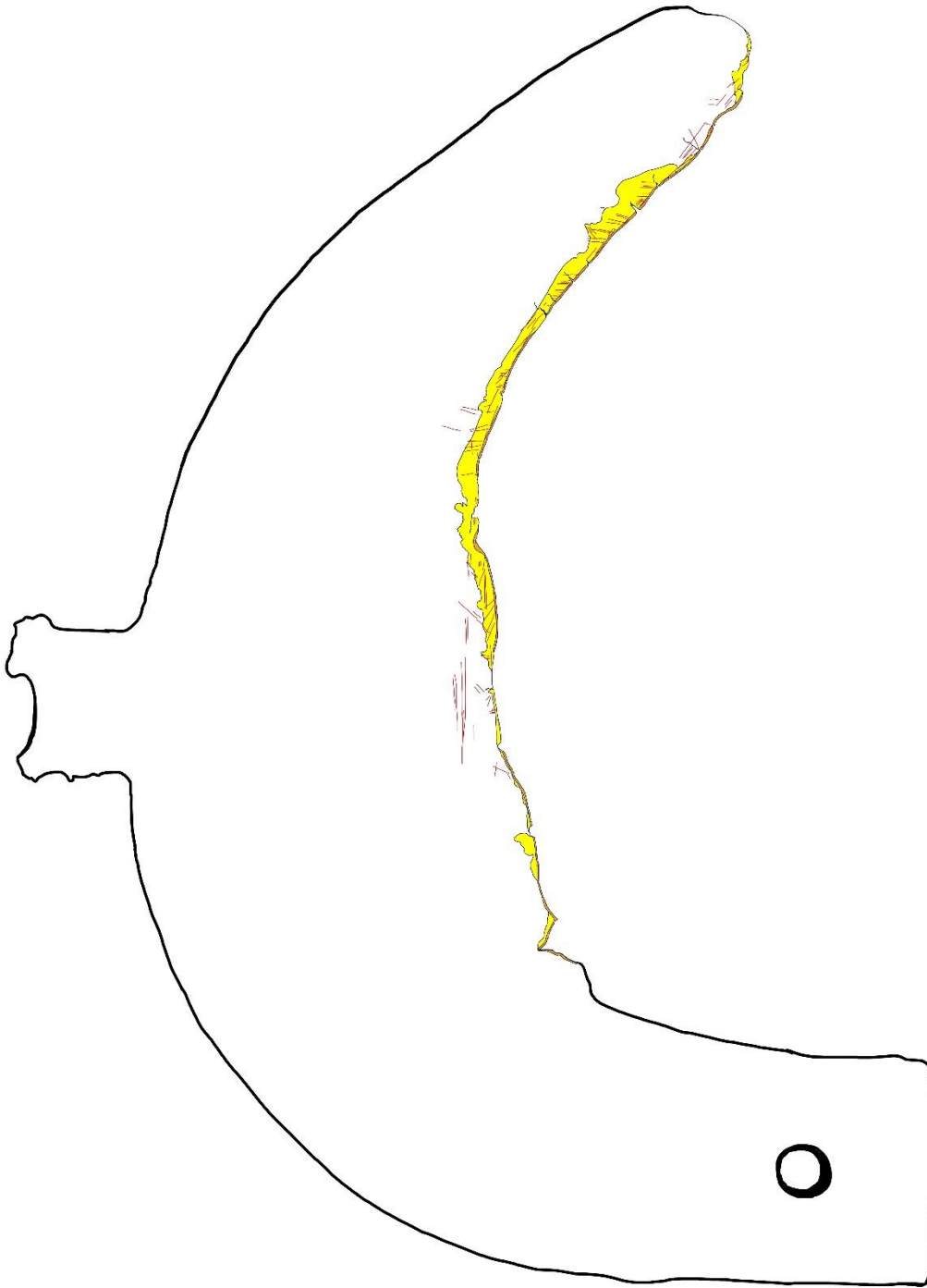
Experimental Sickle 3: Front
Use-wear Map
Before Trial 1
Sharpened Sickle - Control



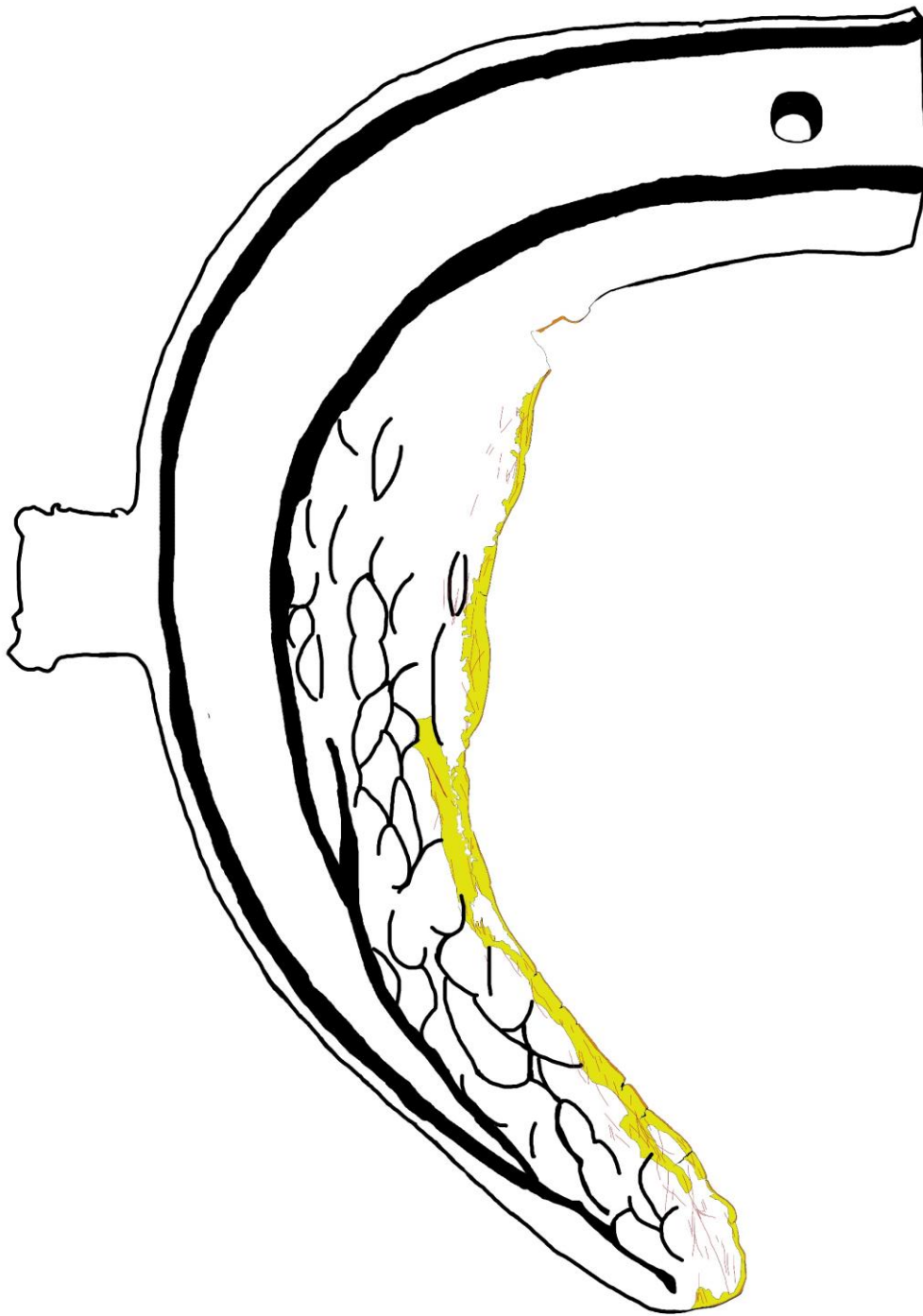
Experimental Sickle 3: Back
Use-wear Map
Before Trial 1
Sharpened Sickle - Control



Experimental Sickle 3: Front
Use-wear Map
After Trial 1
30 Minutes of use



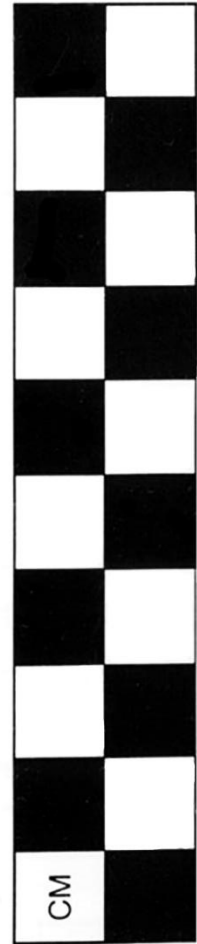
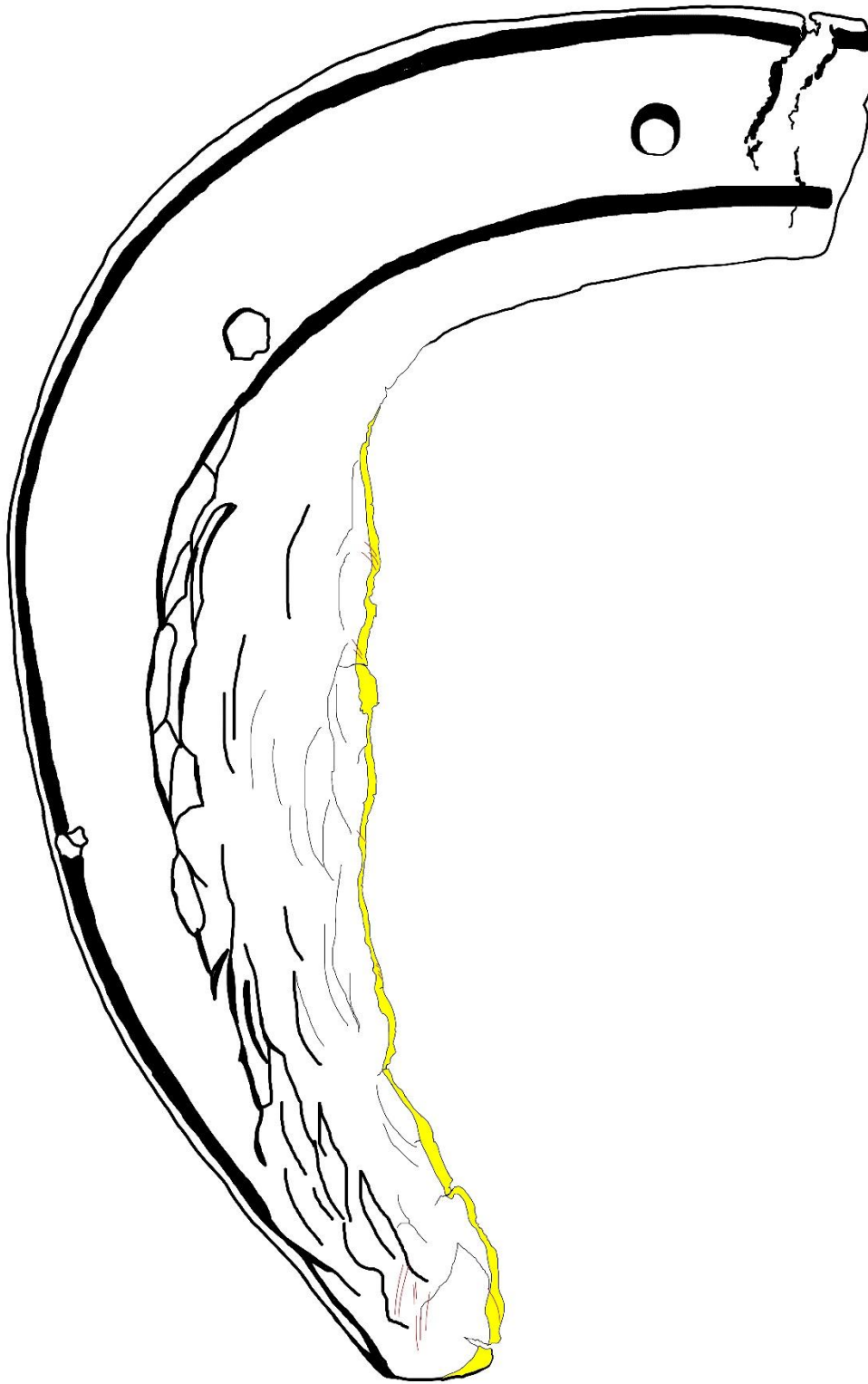
Experimental Sickle 3: Back
Use-wear Map
After Trial 1
30 Minutes of use



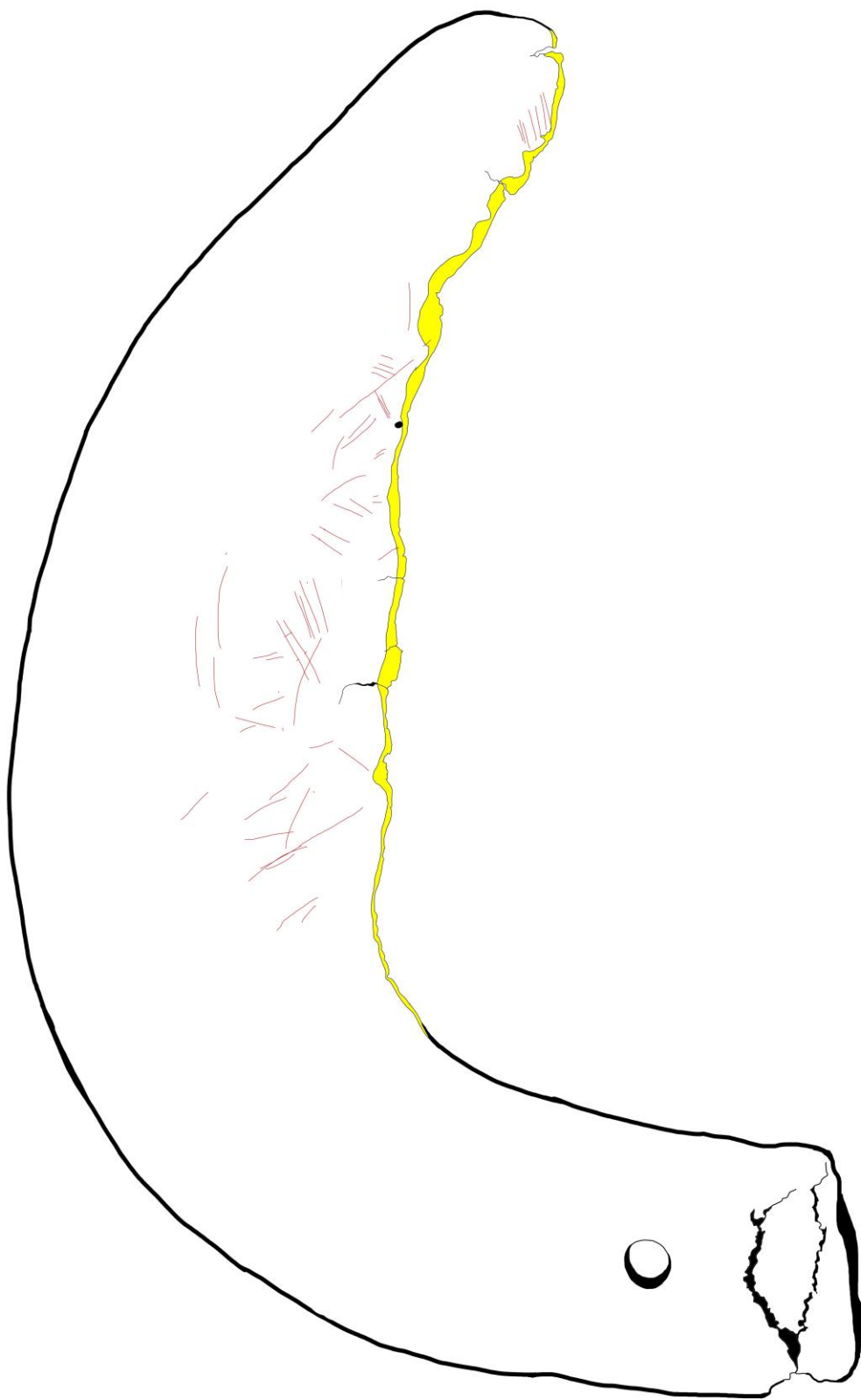
Experimental Sickle 3 - Front
Use-wear Map
After Trial 2
90 minutes of use



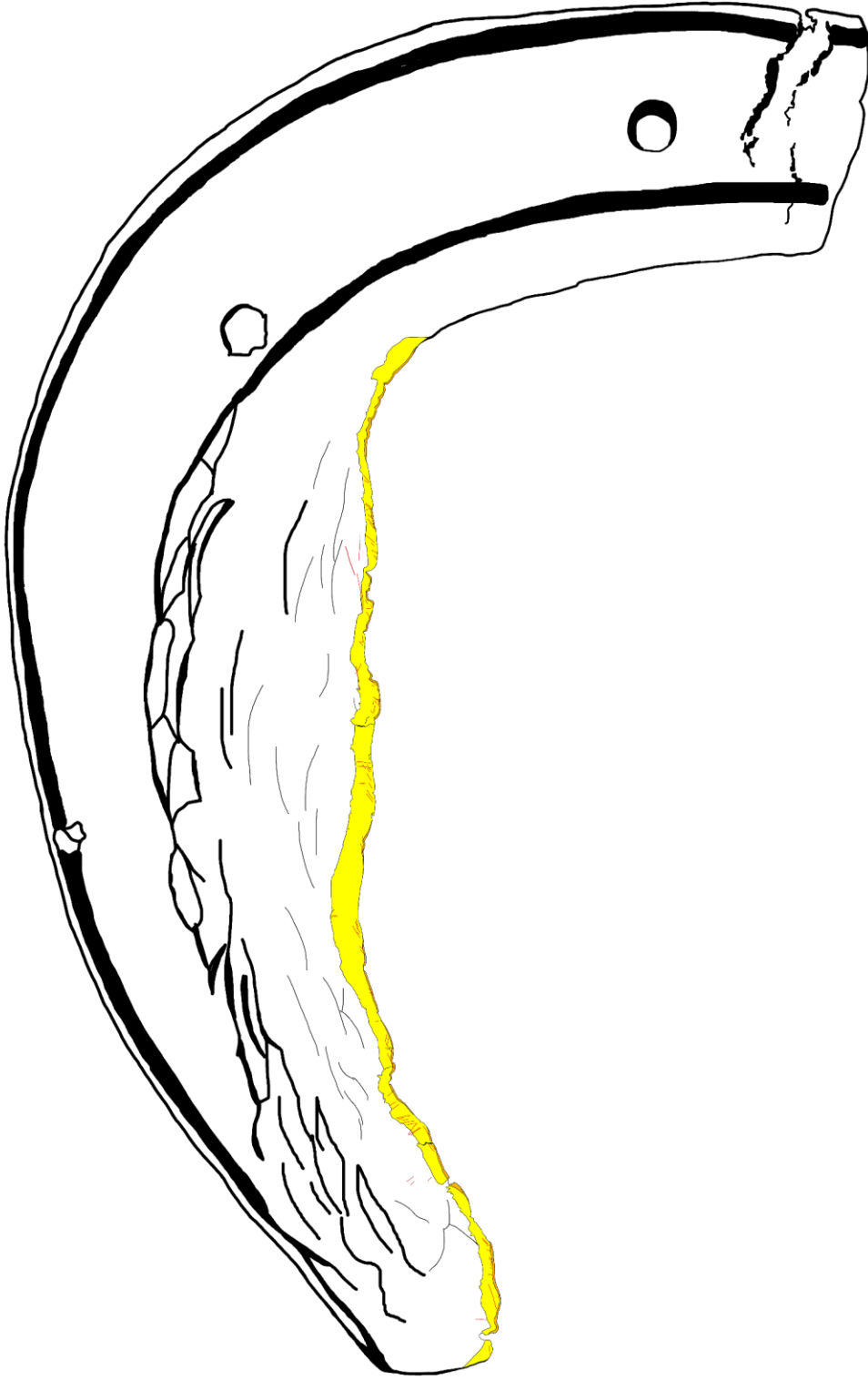
Experimental Sickle 3 - Back
Use-wear Map
After Trial 2
90 minutes of use



Experimental Sickle 4: Front
Use-wear Map
Before Trial 1
Sharpened Sickle - Control



Experimental Sickle 4: Back
Use-wear Map
Before Trial 1
Sharpened Sickle - Control

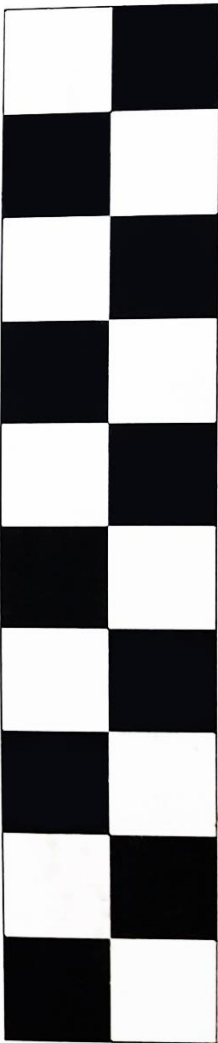
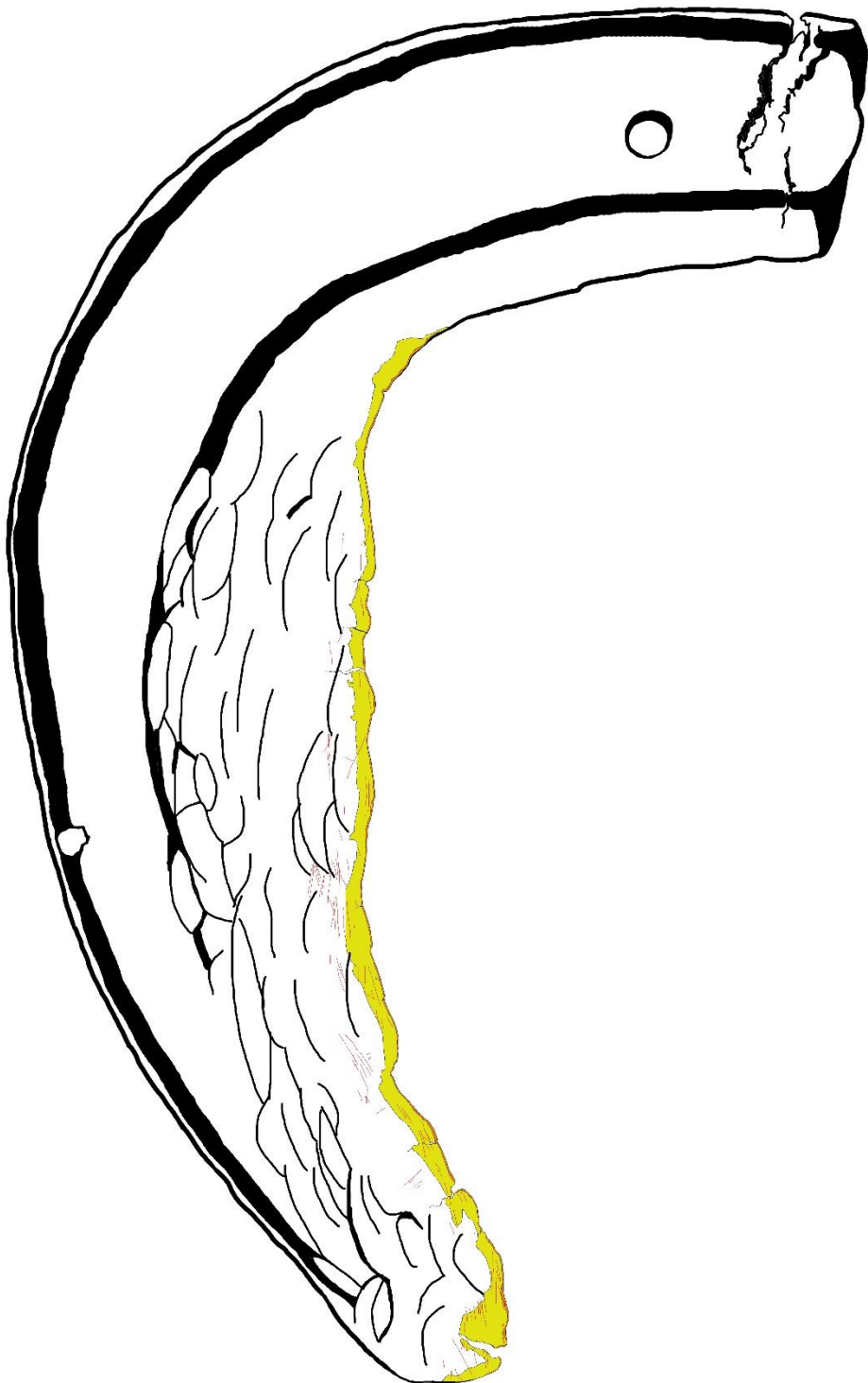


Experimental Sickle 4: Front
Use-wear Map
After Trial 1
30 Minutes of use

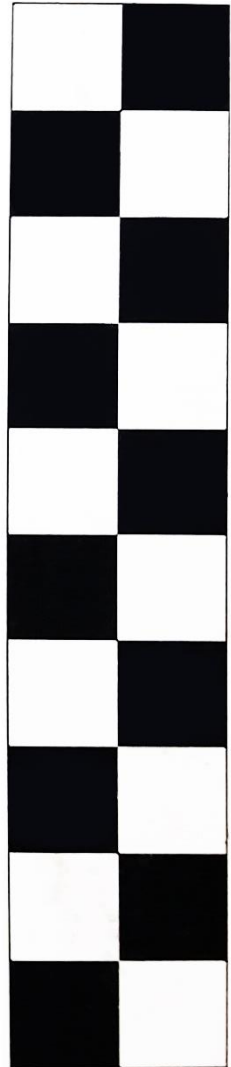


Experimental Sickle 4: Back
Use-wear Map
After Trial 1
30 Minutes of use



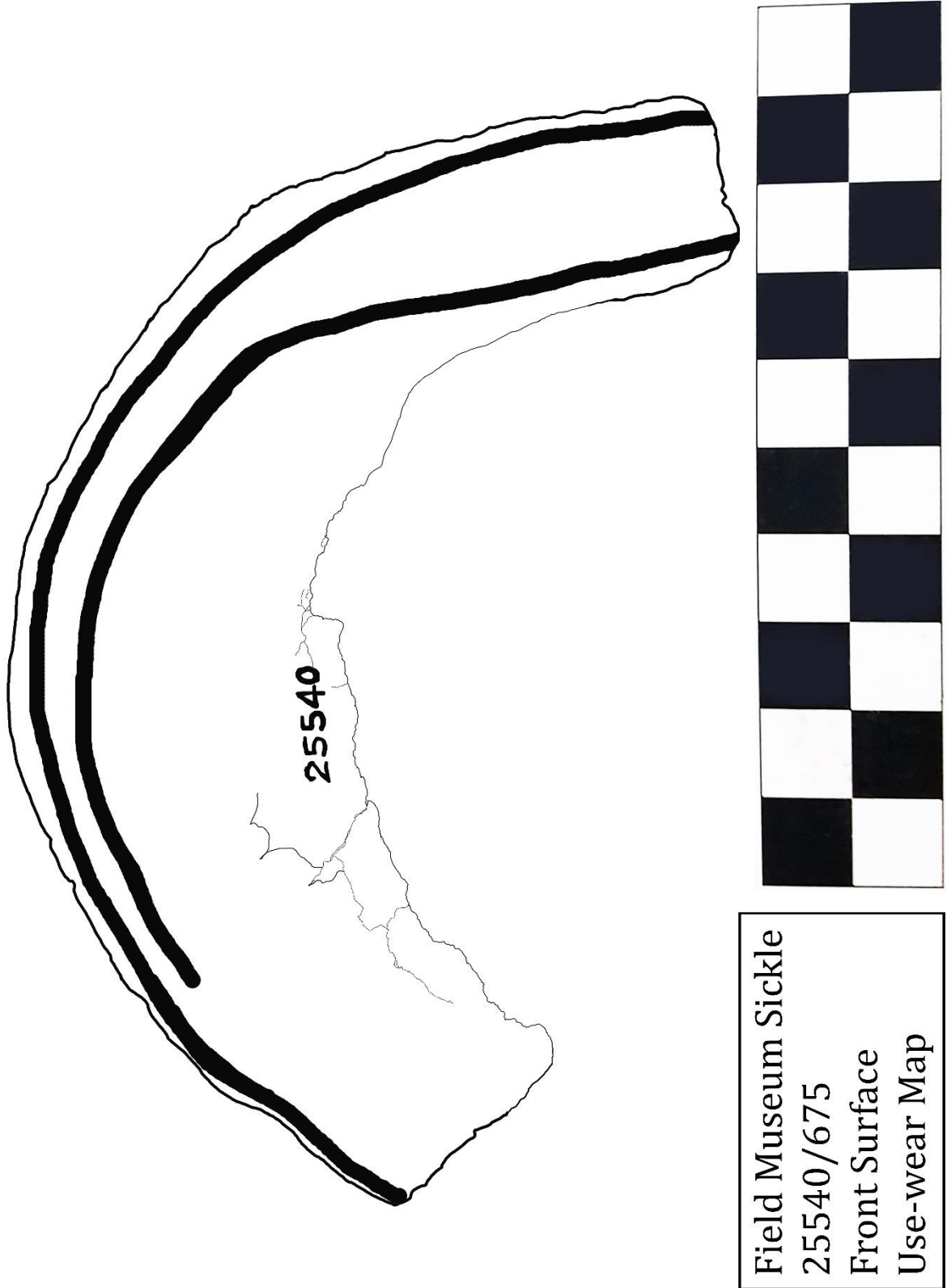


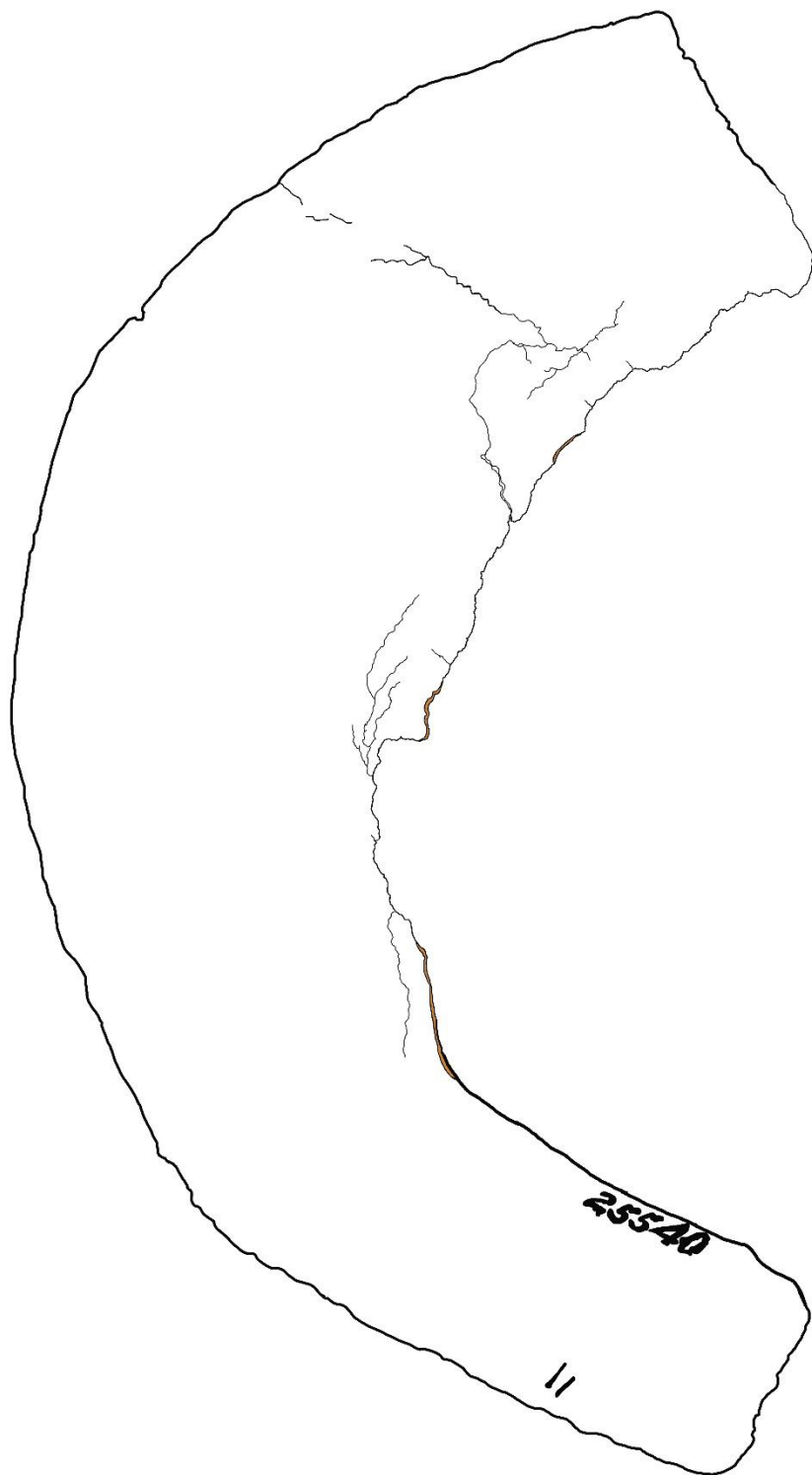
Experimental Sickle 4 - Front
Use-wear Map
After Trial 2
90 minutes of use



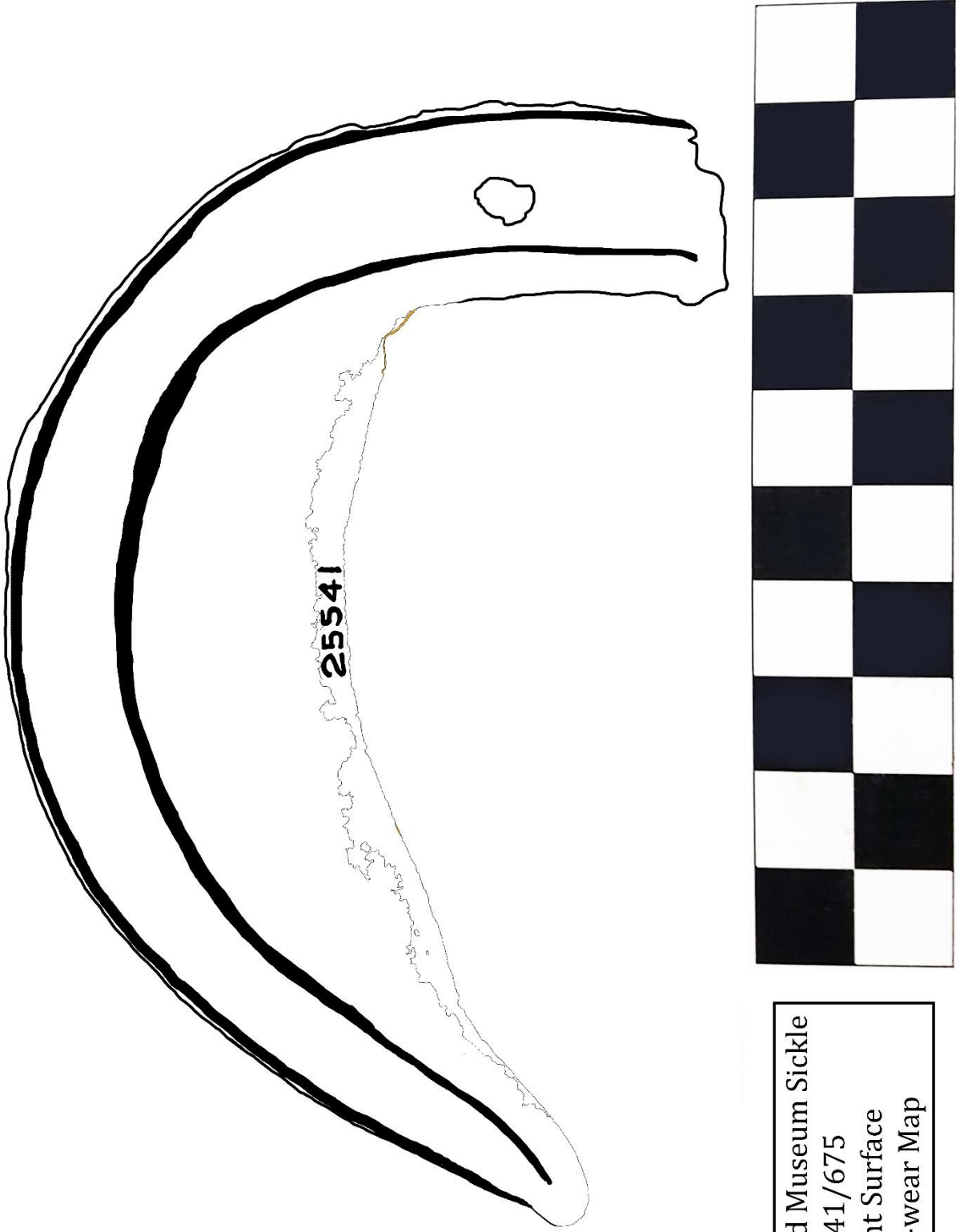
Experimental Sickle 4 - Back
Use-wear Map
After Trial 2
90 minutes of use

APPENDIX B:
PREHISTORIC SICKLE USE-WEAR MAPS

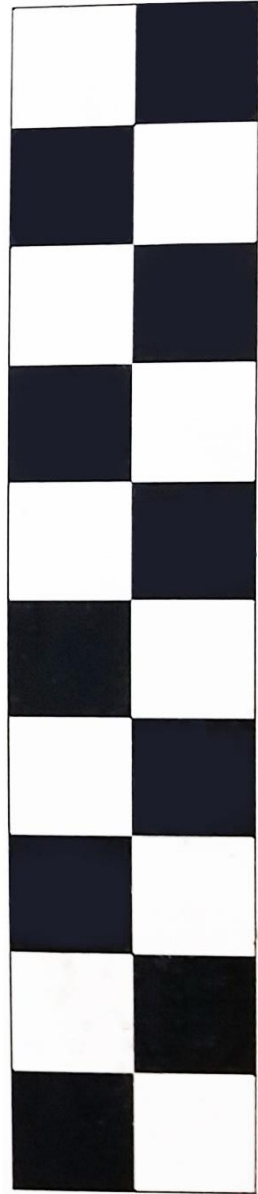
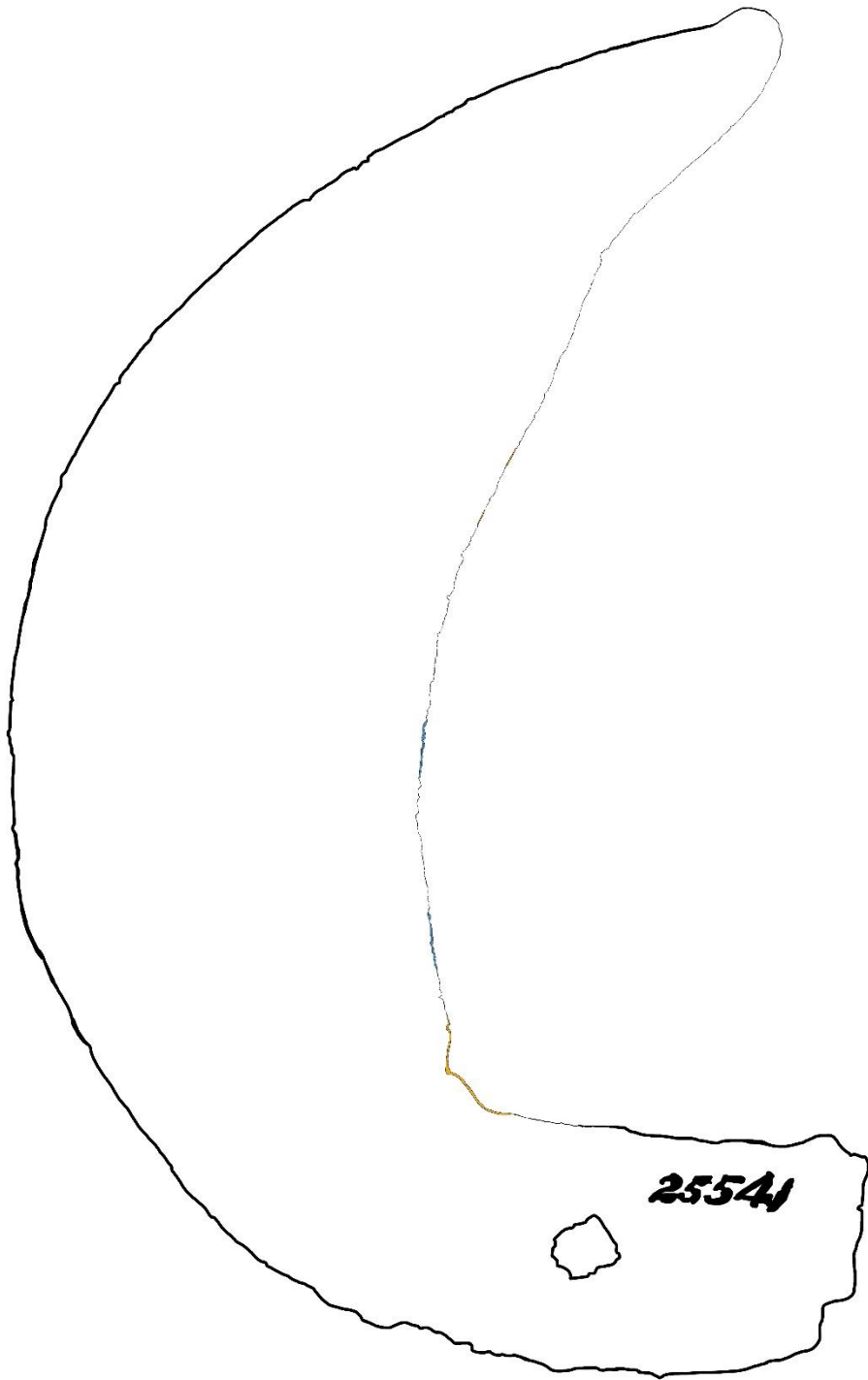




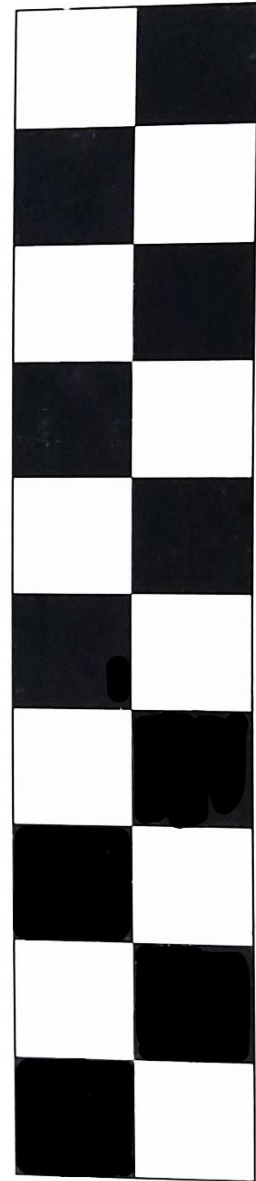
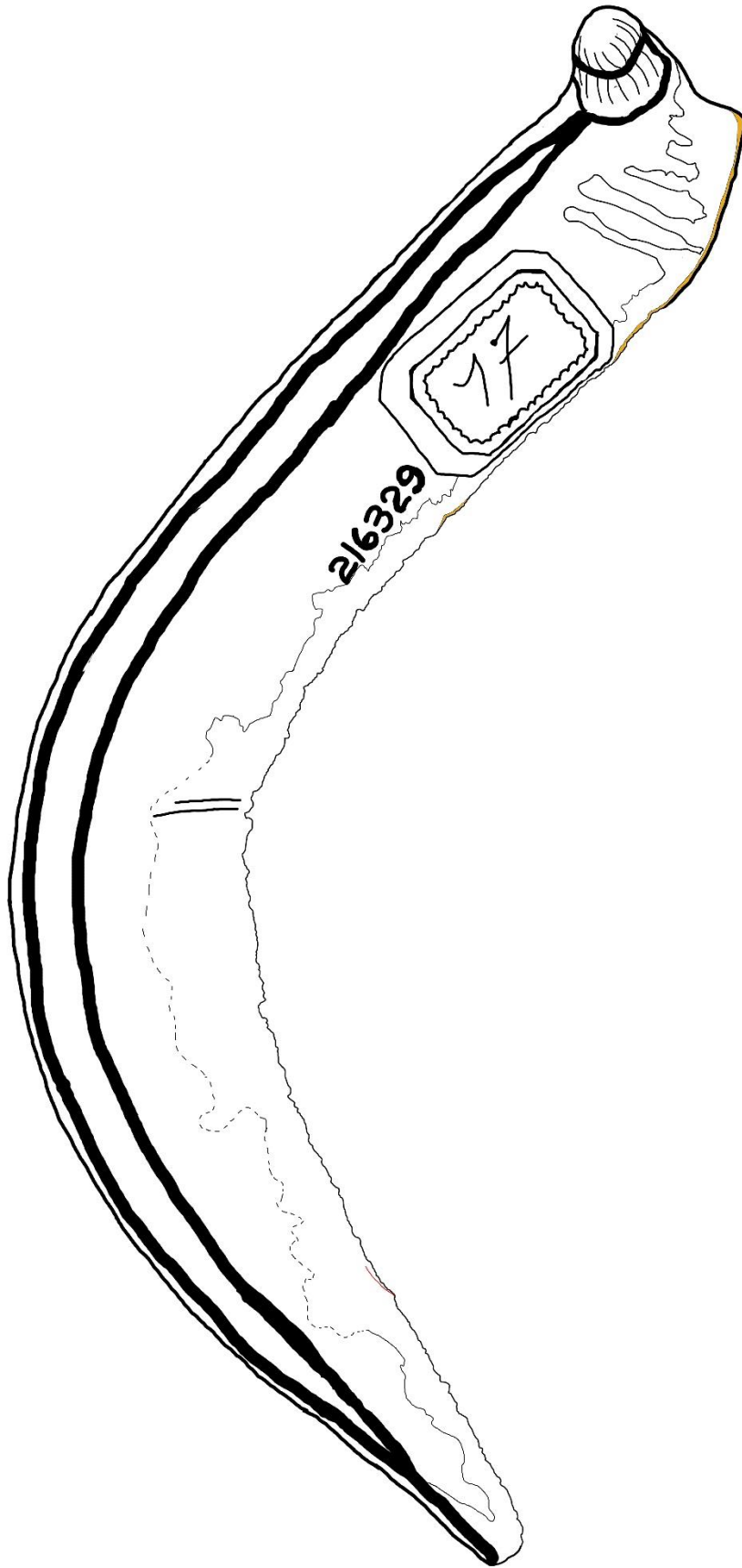
Field Museum Sickle
25540/675
Back Surface
Use-wear Map



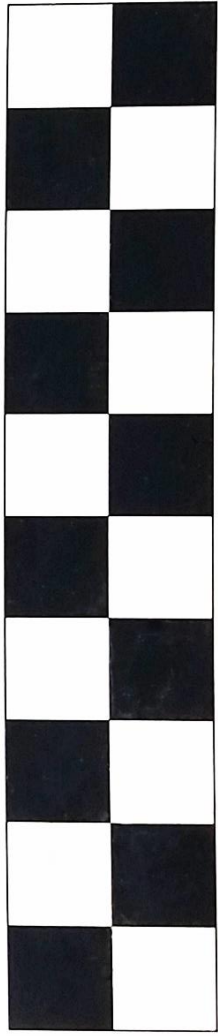
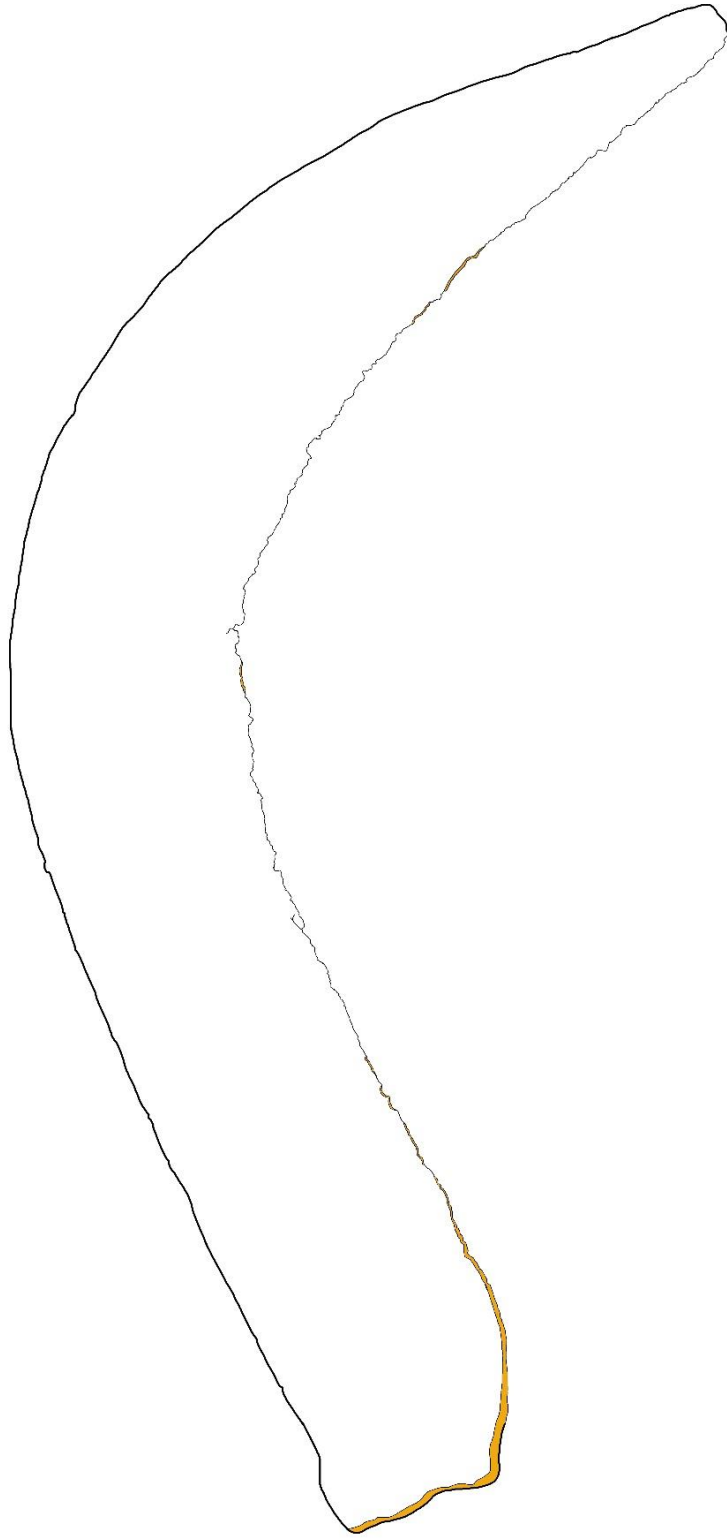
Field Museum Sickle
25541/675
Front Surface
Use-wear Map



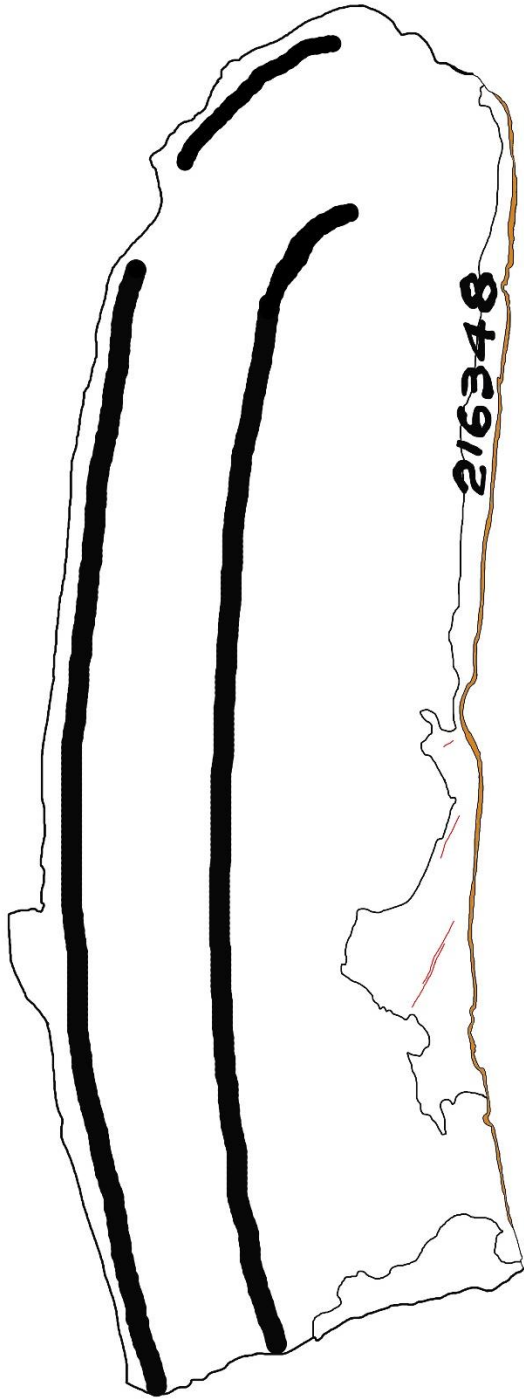
Field Museum Sickle
25541/675
Back Surface
Use-wear Map



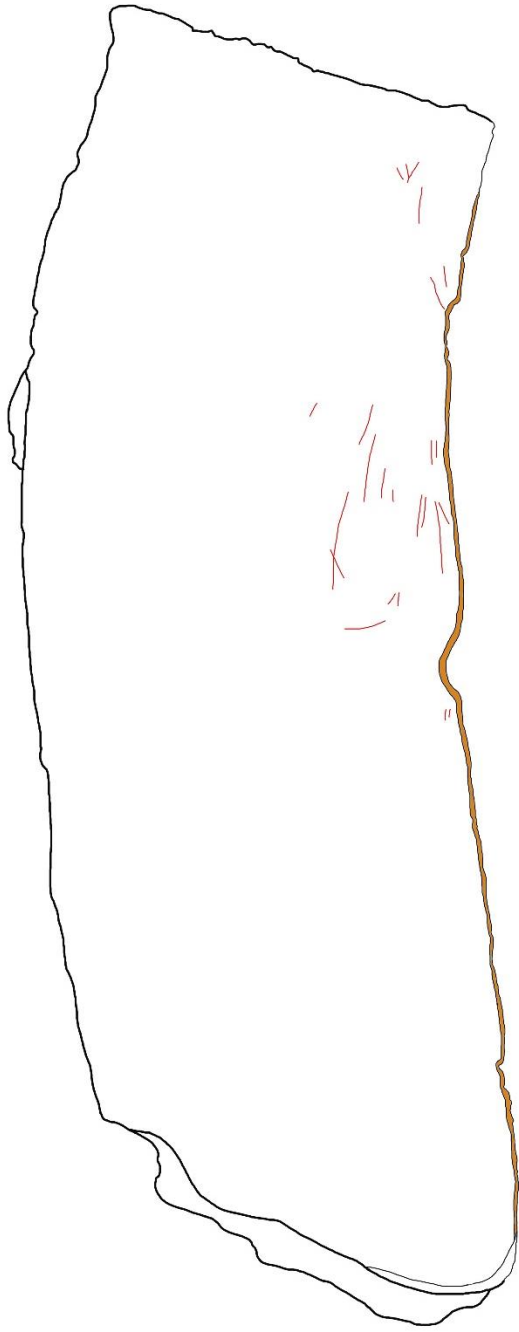
Field Museum Sickle
216329/1922
Front Surface
Use-wear Map



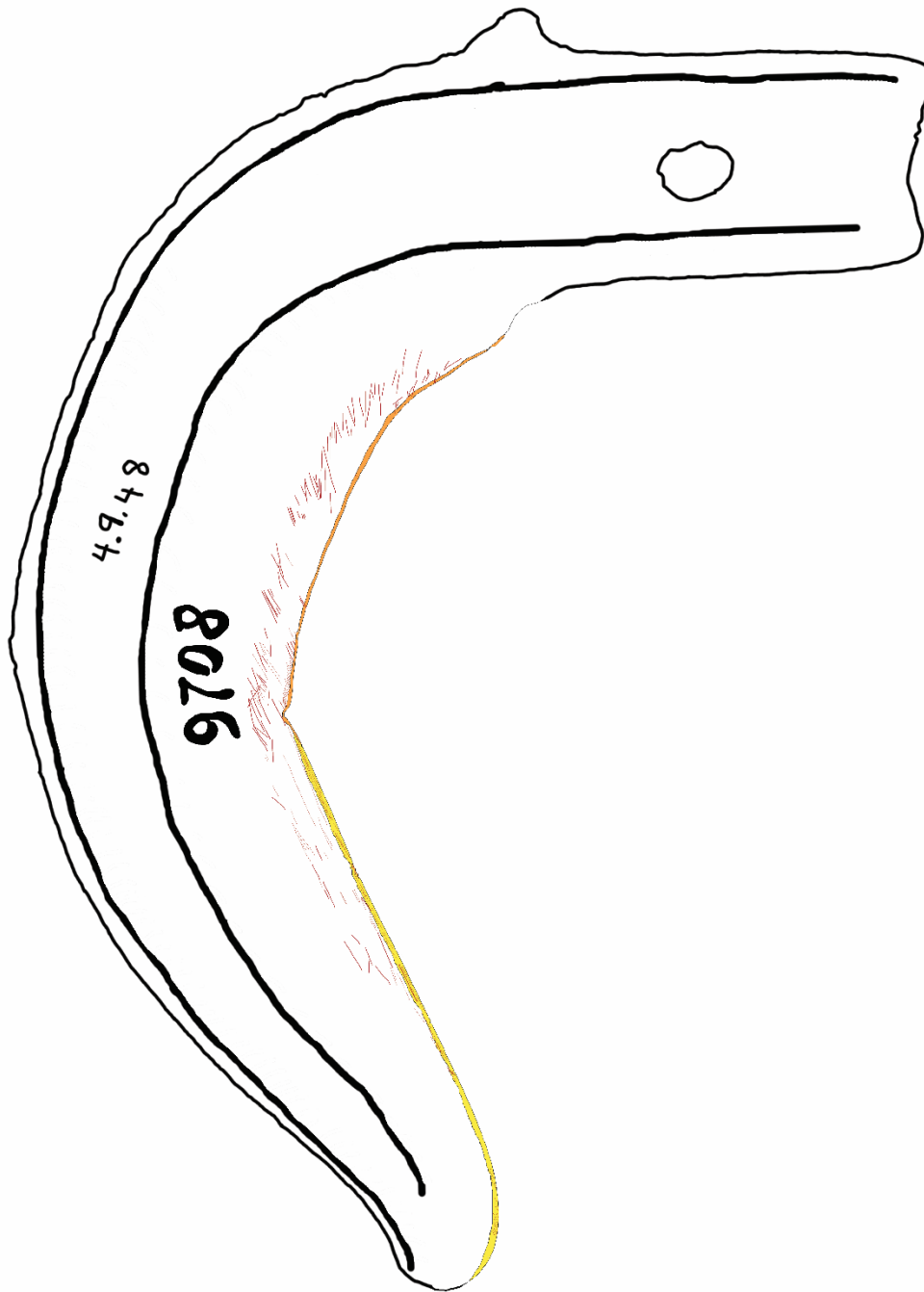
Field Museum Sickle
216329/1922
Back Surface
Use-wear Map



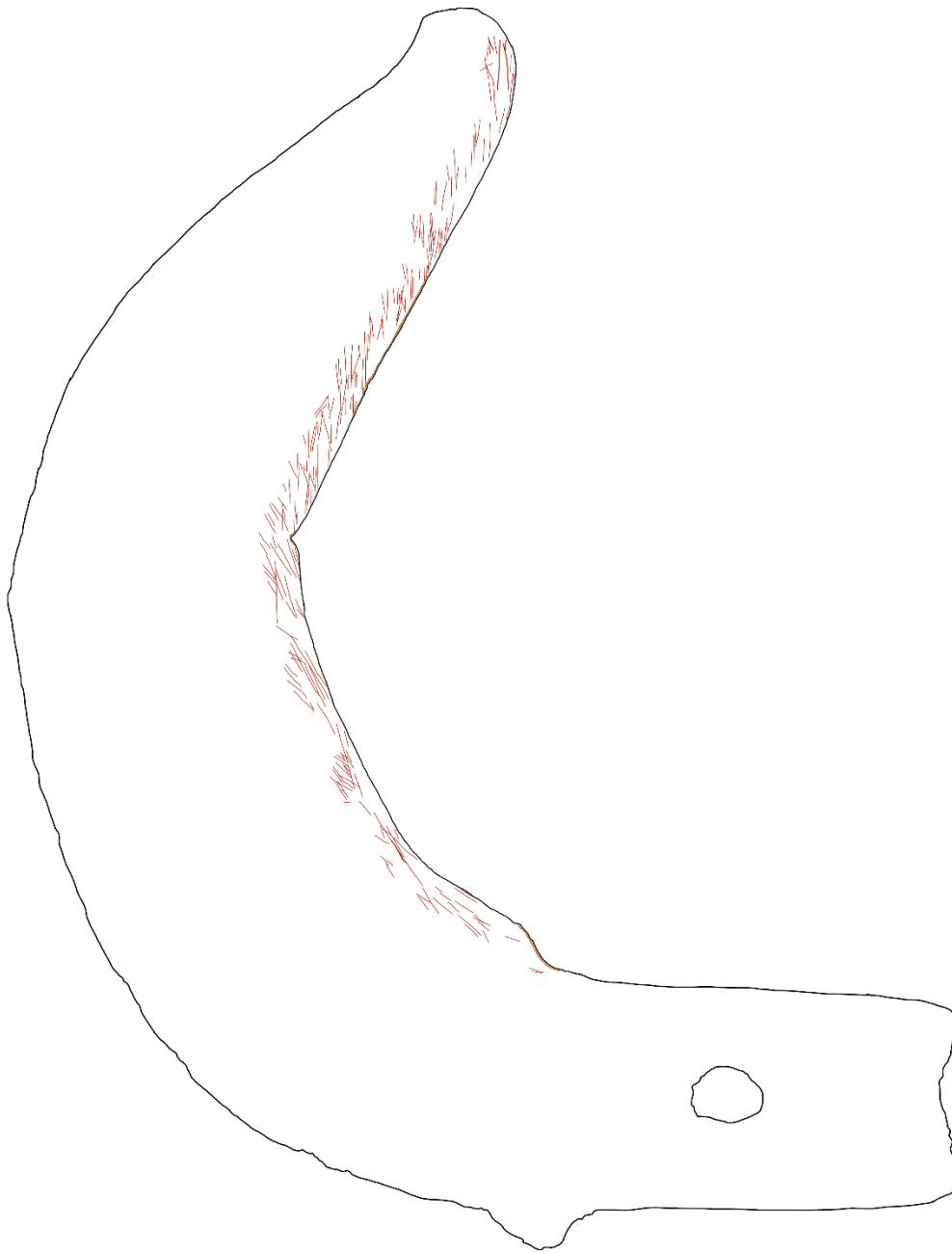
Field Museum Sickle
216348/1922
Front Surface
Use-wear Map



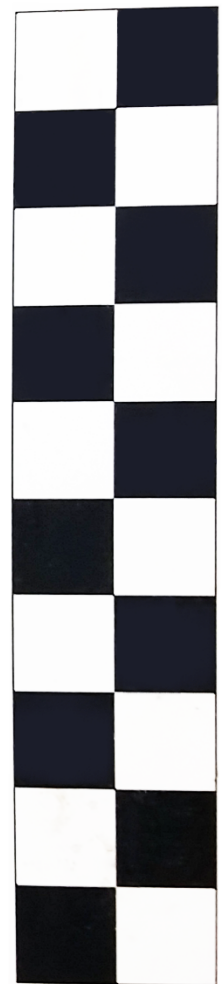
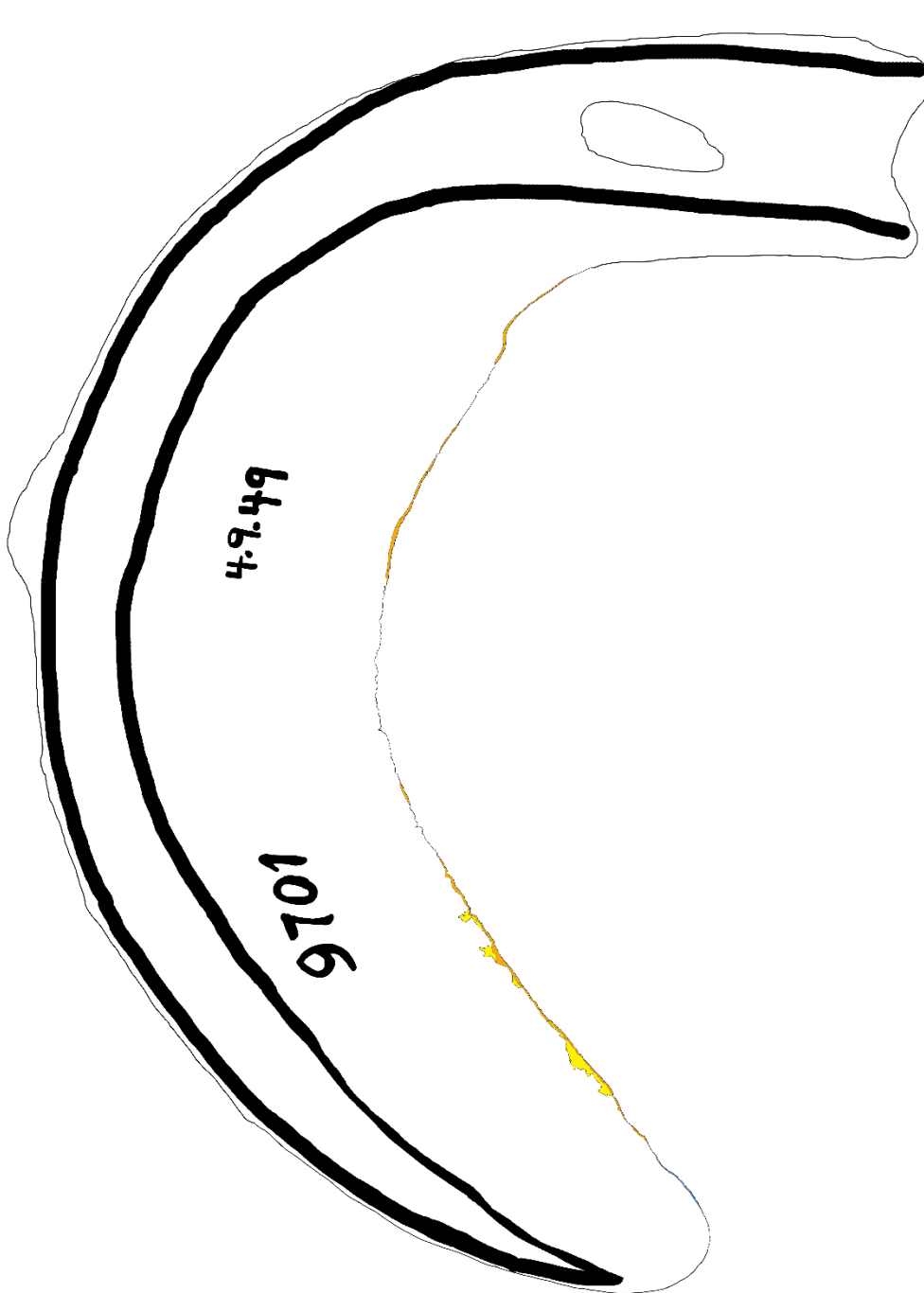
Field Museum Sickle
216348/1922
Back Surface
Use-wear Map



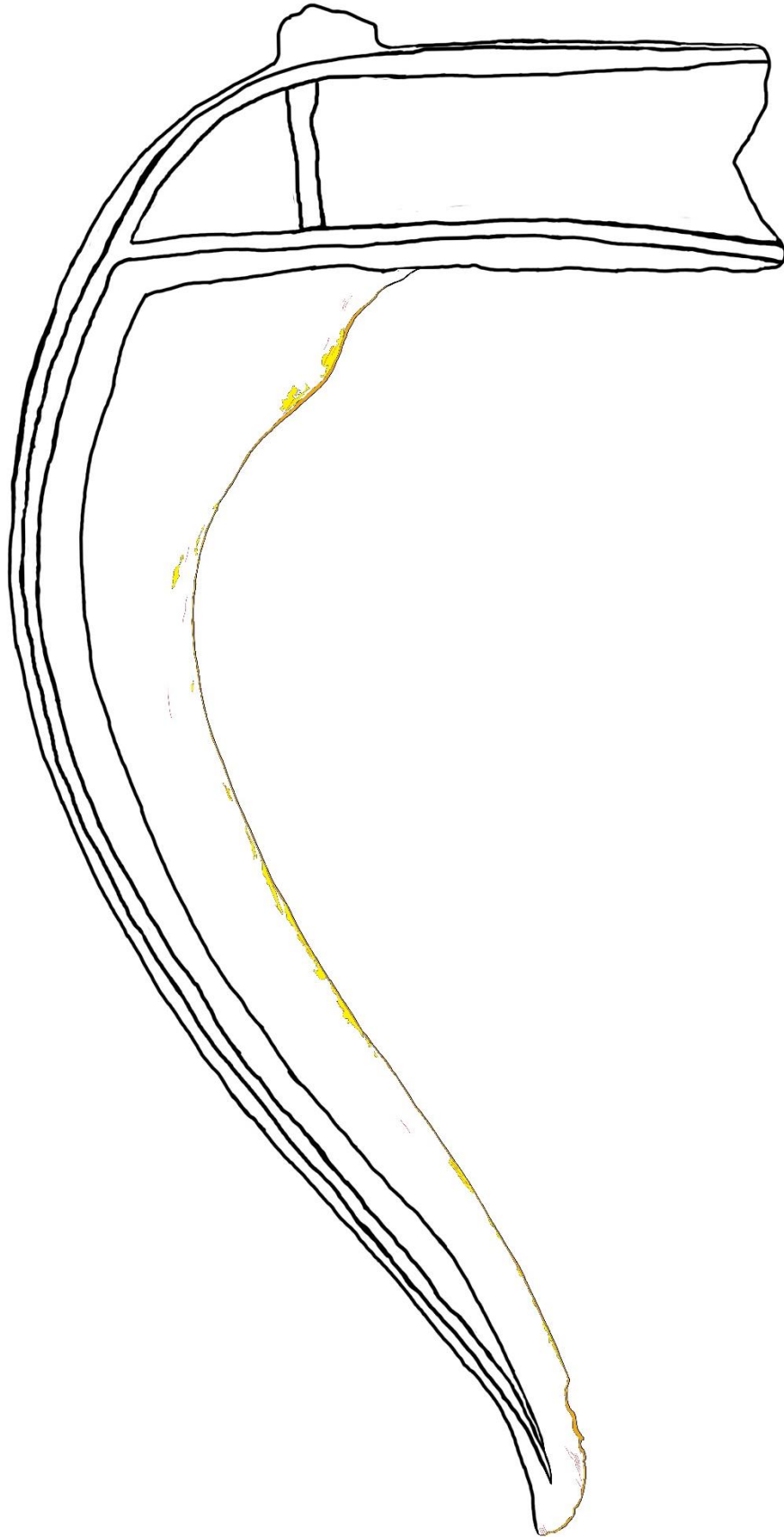
Logan Museum Sickle
4.9.48
Front Surface
Use-wear Map



Logan Museum Sickle
4.9.49
Back Surface
Use-wear Map



Logan Museum Sickle
4.9.49
Front Surface
Use-wear Map



Milwaukee Public Museum Sickle
53899/19612
Front Surface
Use-wear Map



Milwaukee Public Museum Sickle
53899/19612
Back Surface
Use-wear Map