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A Matter of Suspension: an Experimental Approach to Hammerstone Hafting in Prehistoric Keweenaw Copper Mining

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A MATTER OF SUSPENSION:

AN EXPERIMENTAL APPROACH TO HAMMERSTONE HAFTING IN

PREHISTORIC KEWEENAW COPPER MINING

by

Katherine Elizabeth Trotter

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ABSTRACT

A MATTER OF SUSPENSION:
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For thousands of years before European contact, the vast deposits of copper in the Lake Superior Basin were exploited by the indigenous population of the Upper Peninsula of Michigan and surrounding areas. The copper used and traded by the Native Americans in and around the Lake Superior Basin came from mines on Isle Royale and in the Keweenaw Peninsula of Michigan. In the process of mining, a number of tools were utilized, including both grooved and ungrooved hammerstones. Grooved hammerstones are most commonly found in the Keweenaw while ungrooved stones are most commonly found on Isle Royale. Caches of these hammerstones were found historically throughout the Keweenaw and on Isle Royale but no direct evidence of hafting or handles has been recorded to date. Despite the lack of evidence, archaeologists believe at least some the Lake Superior Basin hammerstones were hafted to aid in mining. This assumption is based on knowledge of prehistoric mining from other areas of the United States and other areas of the world. Lake Superior Basin hammerstone collections have been studied in the context of how they relate to mining and mining activity but never for the purpose of looking for patterns in wear that may indicate if hafting was used and what material the hafting might have been made from. Seven experimental hammerstones were constructed for this project, four with grooves and three without, and used in a manner to simulate mining.

Three hammers had wooden handles, two had rawhide handles, and two had no handles. Use wear diagrams were created for the experimental stones and compared to wear patterns recorded on a sample of hammerstones taken from three different hammerstone collections: the Chynoweth Collection, the Drier Collection, and the Massee Collection. The Drier and Massee Collections were collected on Isle Royale in the 19th century while the Chynoweth Collection was collected in the Keweenaw in the early 20th century. The wear patterns on the experimental stones were compared to those on the prehistoric stones and the results do not suggest that distinct wear patterns developed as a result of different types of hafting. However, possible evidence for regional or temporal patterns in wear between the Keweenaw and Isle Royale was identified. The regional specific wear patterns and evidence for the creation and use of stone hammers presented here provide the foundation for further analysis of prehistoric Lake Superior Basin hammerstones.

For my family and friends.

Without you, I would not have made it this far.

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Dr. Jean Hudson provided me with a section of deer hide necessary for the construction of hammerstone handles. Natasha Fetzer assisted in the groove creation for the hammerstones by taking pictures of the hammering process and doing some hammering herself. This helped me to complete the grooves faster even though we both came away from the process with sore hands. Connor Will assisted with the simulated mining portion of the experiment and in gathering materials. He cut down several small saplings to be made into wooden handles, helped me find a suitable spot to do the mining, and lent his aid in hammering and in taking videos. His assistance provided me with an alternative perspective from my own on the practicality and use of the hammers and handles. He also let me sleep on his spare mattress on my trips to Houghton often enough over the course of the project that I felt like I should have been paying him rent. Without Connor and Natasha, this project would not have been completed.

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To everyone who helped me complete this thesis and reach this point in my life, I thank you from the bottom of my heart.

Chapter 1: Introduction

Prehistoric mining took place across the world. Resources extracted through mining included stone for knapping, various metals, coal, salt, and other desirable materials (Hack 1942; Shepherd 1980). In some areas, similar technologies and techniques developed independently of one another while in others knowledge of techniques spread from one region to another (Shepherd 1980). In many areas, a technique known as firesetting was used to help miners acquire resources (Shepherd 1980). Firesetting involves heating a target area over a period of time and then rapidly cooling it to promote artificial cracking (Timberlake 1990c). The artificial cracking breaks up the source material of the desired resource, making it easier to mine using simple hammers and picks (Weisgerber and Willies 2000). Firesetting was not a viable technique on all types of source rock, but knowledge of the technique existed in regions beyond those that utilized it (Weisgerber and Willies 2000). Prehistoric miners also tended to have similar basic tools for mining though regional variations in the tools occurred. Hammerstones of varying sizes were often used by miners to break apart the rock that was being mined (Ortiz 2003). Picks made from antler tines or bone were used to pry material away from the rock face being mined (Lewis 1990b). Other tools, such as wedges, were also utilized by miners (Timberlake 1990b).

In the Lake Superior Basin Region of North America, specifically in the Keweenaw Peninsula of Michigan and on Isle Royale National Park, prehistoric mining took place for thousands of years before European contact and settlement (Martin 1999) (Figure 1.1). The Lake Superior Basin has large deposits of native copper, defined as copper uncombined with other minerals to form ores; these are found throughout the region (Stanley 2009: 283).

Figure1.1: Map of the Keweenaw Peninsula and Isle Royale (Google Maps)

Indigenous populations in the area exploited the vast copper deposits in two ways: 1) they utilized the pieces of copper found on the surface that were derived from deposits as a result of erosion and 2) they exploited it through mining (Martin 1999) (Table 1.1). Mining in the Lake Superior Basin was a seasonal affair as the harsh winters that are common for the area and lack of food resources would have made mining all year long difficult (Whittlesey 1863). Food resources are scarce year-round in the region and miners probably had to bring food with them or have it brought to them during the mining process. Provisioning is often a problem in prehistoric mining contexts in other areas of the world and has some bearing on how many people, and which people, were involved in the mining activities. Archaeologists who study the region believe firesetting played a part in the mining process in the region (Martin 1999: 92-93). However, few practical experiments with the technique in the area have taken place (Bastian 1967; Trotter 2015).

Table 1.1: Chronology of prehistoric copper mining in the Keweenaw and on Isle Royale (Martin 1999; Pompeani et al. 2015)

Time period	Years before present	Phenomenon
Early Archaic	7800	First evidence of worked copper in Michigan
Late Early Archaic	6500	Copper mining begins on Isle Royale
Middle Archaic to Historic Period	5000-500	Copper mining occurring on Isle Royale and in the Keweenaw Peninsula
Historic Period	500	European contact occurs and European metals begin to be introduced

Throughout the Keweenaw Peninsula and on Isle Royale, concentrations of hammerstones used for mining can be found. Many of these were collected over the years and are now found in various repositories in the Upper Peninsula and beyond. Hammerstones in the Lake Superior basin largely consisted of water-smoothed beach cobbles of different materials and sizes collected from beaches along Lake Superior (Martin 1999). Those from the peninsula and the island differ stylistically. Keweenaw hammerstones were generally partially or fully grooved around the center (Martin 1999:98-99). Full grooves covered the circumference of the stone without any breakage (Martin 1999: 102). Partial grooving took several forms: it could consist of a few small notches on the top or bottom of the stone or grooving covering only part of the circumference of the stones (Martin 1999: 99) (Figure 1.2).

(A) 

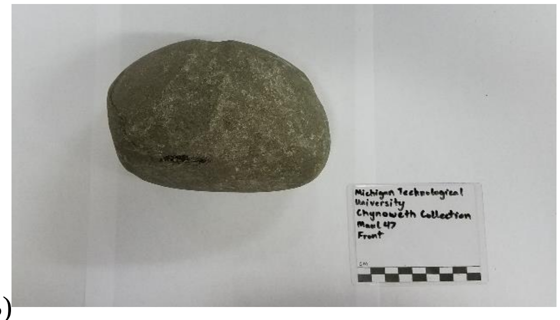
(B) 

Figure1.2: Hammerstone with full groove (A) and hammerstone with partial groove (B)

Unmodified hammerstones are found in the Keweenaw but are rare while hammerstones from Isle Royale are generally unmodified and the few examples of modified stones that are known do not appear to have been a significant part of copper mining practices on the island (Martin 1999). Archaeologists theorize that the grooving on stones may have been used to help secure some form of hafting or handle based on hammerstones from other areas of the world; however, no handles have ever been found attached to hammerstones in the Lake Superior Basin (Martin 1999: 91-92). Ungrooved hammers from Isle Royale and the Keweenaw Peninsula may have had handles even without any apparent modification to help secure hafting. Possible handle materials include rawhide, wood or other materials common to the area. Despite theories about handle construction for hammerstones, no experiments to explore how hammerstones from the area, either grooved or ungrooved, were attached to handles have been carried out. An experiment examining firesetting was performed on Isle Royale that utilized handheld hammerstones (Bastian 1967). The report only briefly described the utility of the handheld hammers and did not explore the possibility of the hammers having handles (Bastian 1967). Nearly fifty years after the Bastian experiment, another firesetting experiment was performed in the Keweenaw that used hammers suspended from rope handles, but the hammers were not the focus of the experiment (Trotter 2015). Multiple firesetting experiments have been performed outside of the Lake Superior Basin that briefly described the hammerstones used for the projects (Crew 1990; Lewis 1990a; Timberlake 1990b). No analysis of wear on the stones was provided in the reports. The presence or absence of handles on hammerstones has the potential to impact rates of copper extraction. For archaeologists to develop a clearer picture of the process of prehistoric copper mining in the Lake Superior Basin, all aspects of mining must be studied, including seemingly simple tools such as hammerstones.

This project set out to answer three primary questions about Lake Superior Basin hammerstones and prehistoric copper mining. Firstly, is it possible to determine whether or not hammerstones from the area did have some form of hafting or handle? Secondly, if the stones did have hafting, is it possible to tell what type of hafting was most likely used? Thirdly, can experimental replication provide new insights into the question of how copper was extracted before European contact in North America? A two-part project was developed in order to investigate the three questions above. The first portion of this project revolved around the examination and documentation of a sample of fifty-six hammerstones from both Isle Royale and the Keweenaw Peninsula. Hammerstones from three collections were examined: the McDonald-Massee Collection housed at the Milwaukee Public Museum (MPM), the Roy Drier Collection housed at Michigan Technological University (MTU), and the Ben R. Chynoweth Collection housed at Michigan Technological University (Table 1.2). The Massee and Drier Collections came from Isle Royale, specifically from a prehistoric mine known as the Minong Mine. The Chynoweth Collection came from an area in the Keweenaw Peninsula near present day Ontonagon, Michigan. Sixteen ungrooved hammerstones from the Massee Collection, fourteen ungrooved and three grooved hammerstones from the Drier Collection, and seventeen grooved and six ungrooved hammerstones from the Chynoweth Collection were examined.

Table 1.2: Collections, place of origin, collection size, and sample size

Collection	Place of Origin	Institution	N =	n =
Chynoweth	Keweenaw	MTU	101	23
Drier	Isle Royale	MTU	134	17
Massee	Isle Royale	MPM	83	16
Total			**318**	**56**

The focus of the examinations was on wear patterns on the hammerstones that developed during mining activity in order to determine if there were any differences in the wear seen on Isle Royale and Keweenaw hammerstones and whether any distinct patterns were seen on some

stones but not others. Images of each hammerstone were taken from six different angles, diagrams of the stones were created, and written descriptions of the stones were generated to document any patterns identified within and between collections. The second part of this project focused on creating and testing hammerstones using different forms of hafting and without hafting in order to determine if handles were more efficient and whether the material were made of impacted that efficiency. Finally, the results of the experimental project were compared to the existing wear patterns on the archaeological artifacts and new research questions were generated based on the conclusions drawn from that comparison.

This thesis is organized into five chapters. Chapter Two provides the background for the project as well as a review of the relevant literature. Chapter Three covers the methodology utilized in the development and execution of this project. Chapter Four presents the results of the examination of the prehistoric hammerstone collections and the experiment. Chapter Five includes a discussion of the results of both parts of the project, how the results potentially impact prehistoric copper mining in the Lake Superior Basin, suggestions for future research and experimentation, and concluding remarks.

Chapter 2: Literature Review and Background

The Lake Superior Basin

Between 1.2 and 1 billion years ago, the Lake Superior Basin, an area that consists of Lake Superior and the land masses immediately surrounding it, formed when a rift opened at the top of the North American Craton and subsequently failed (Stanley 2009: 282). Before the rift failed, large flows of basaltic lava came to the surface and hardened, but air pockets remained throughout the hardened basalt (Stanley 2009: 282-283). Hot, mineral rich water filled these pockets and left behind a number of different types of deposits, including copper, silver, iron and other minerals (Moyer 1966: 22). The copper found throughout the Lake Superior Basin is known as native copper, which is defined as copper uncombined with other minerals (Stanley 2009: 282-283). The formation of native copper deposits is a very rare occurrence especially in the volume found in the North American Craton (Stanley 2009: 282-283). Subsequent erosion resulted in the exposure of sections of these native copper deposits millions of years before the first humans set foot in the area (Martin 1999:26-27). Much of the copper mining in the Lake Superior Basin occurred in the Keweenaw Peninsula of Michigan's Upper Peninsula (UP) and on Isle Royale, an island in Lake Superior between the Keweenaw Peninsula and Canada (Moyer 1966). When Native American populations from the lower portion of Michigan, Wisconsin and Canada first began to appear in the Keweenaw and Isle Royale approximately 9,000 or more years ago, they would have encountered a wooded landscape hiding massive resources of vein copper and loose boulders of copper known as float copper (Drier and Du Temple 2005: 16-17; Martin 1999: 29-30) (Figure 2.1).

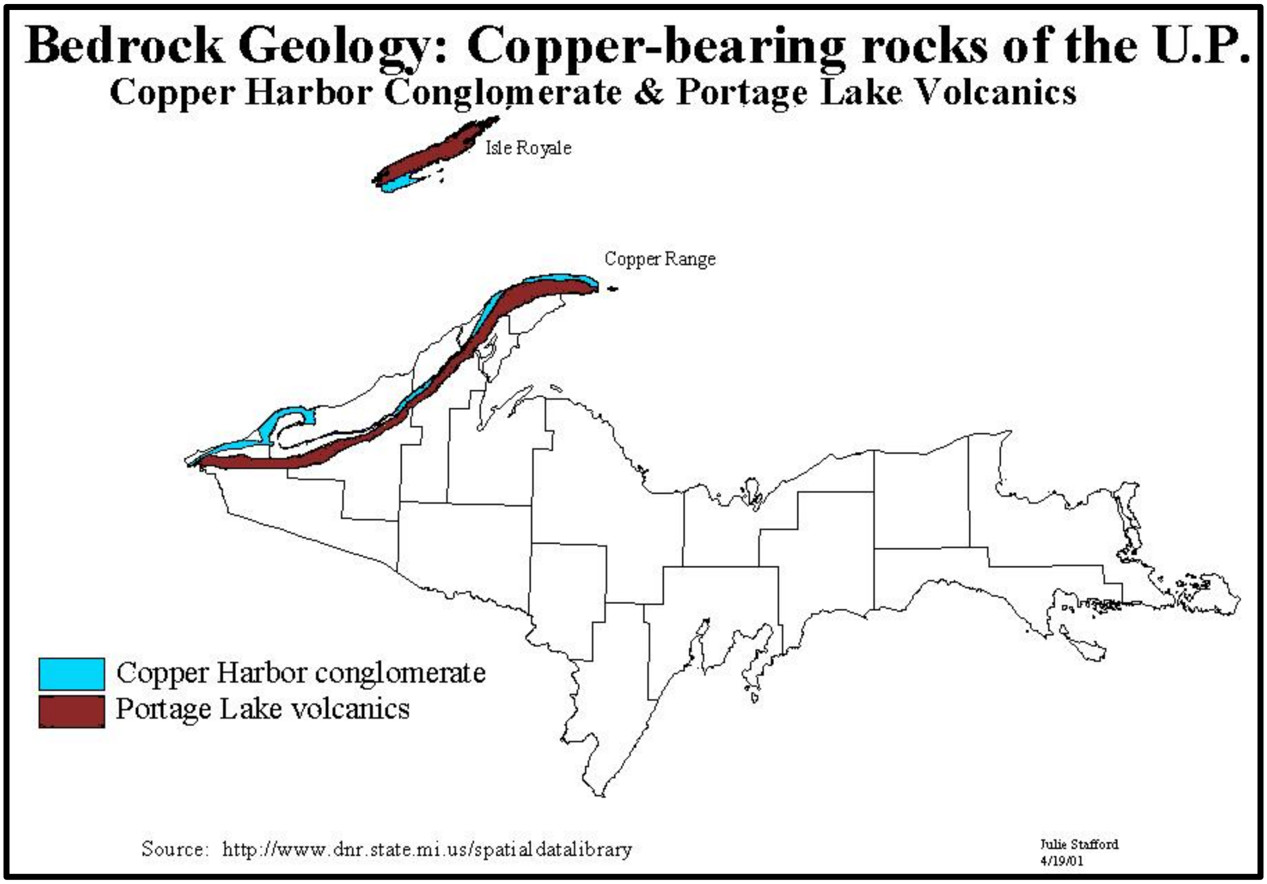


Figure 2.1: Map of native copper deposits in the Keweenaw Peninsula and on Isle Royale (Schaetzl 2017: Figure 9).

Prehistoric Mining Around the World

By the time the first copper was collected in the UP mining for resources had been a part of human activity for thousands of years across the globe. The earliest mining activities consisted largely of exploitation of shallow deposits of a desired resource (Shepherd 1980: 12). The first resources acquired through early mining activities consisted of stone for knapping—such as flint and obsidian—as well as salt, cobalt, and other desirable minerals and rocks (Shepherd 1980: 12; Stöllner 2011: 623; Weisgerber and Pernicka 1995: 159). Rocks used for pigments were also acquired through mining (Weisgerber and Pernicka 1995: 159). Resources were also traded to populations that were at some distance from the original mining area (Shepherd 1980: 108). Eventually, a transition to mining metals such as copper, tin, gold, silver, and iron occurred in the so-called Old World although quarrying for stone never stopped

(Shepherd 1980; Wagner et al. 1980). Mining for other resources, such as coal, occurred as well (Hack 1942). Copper and iron were generally mined for use in the production of tools, weapons, and other practical items as well as jewelry and personal ornamentation (Cunliffe 2008: 211). Gold was not a metal generally used for weapons, though it was used as decoration for such items; it was generally a status symbol and was frequently used to make ornaments, jewelry, and was added to other items to increase their value (Eluere 1995; Ruiz-Galvez 1995). Copper was one of the first metals that was mined (Stöllner et al. 2011: 535). Initially, copper was mined only as a native metal (Shephard 1980: 153-155). However, the development of bronze technology increased the demand for copper ore and for other materials used in the production of bronze (Shephard 1980: 153-155). Unlike in the Lake Superior Basin, copper ore rather than native copper was mined because deposits of pure copper are extremely rare (Stanley 2009: 282-283; Stöllner et al. 2011: 535). Moreover, industrial mining in the areas where preindustrial mining operations occurred often destroyed the earlier mines (James 1990; Lewis 1990b).

As new resources were exploited and demand for mined resources increased, two basic types of mining took place: mining that utilized firesetting and mining that did not. Firesetting involves using fire to superheat an area of rock containing a desired material over an extended period of time in order to encourage artificial cracking in the rock, promoting easier material removal (Weisgerber and Willies 2000). Firesetting can either utilize water quenching to promote further rapid cooling or the target rock can be left to cool naturally over time before working (Timberlake 1990c). Water quenching cools the rock more quickly but application of fire alone results in artificial cracking (Timberlake 1990c). Firesetting can only be used in certain areas for mining because it is variably effective depending on the stone being heated and the material being mined (Weisgerber and Willies 2000). Material type can also impact the

length of time a surface needs to be heated in order for firesetting to be an effective method for artificially cracking the rock (Trotter 2015). In areas where firesetting could not be used, unassisted mechanical mining would have been performed (Weisgerber and Willies 2000). Firesetting was a very long-lived mining method. It persisted in many places from the Neolithic into the 17th century (Timberlake 1990c). In certain areas where fuel resources were abundant, firesetting persisted into the industrial period even with the development of industrial mining technologies because it was cheaper than implementing those technologies (Stöllner 2011; Timberlake 1990c). In many places, modern mining operations destroyed earlier preindustrial mines (James 1990; Timberlake 1990a). However, many of those operations are described in written records that document the evidence of the preindustrial mines before their destruction (James 1990; Timberlake 1990a).

Despite the destruction of many of the preindustrial mines, archaeologists can still study the remains of the mining activities through the tools left behind, evidence of environmental impacts from mining, and the activity sites around the mines that were not destroyed by modern mining. In many cases, mining tool caches and mine tailings were not destroyed when industrial mining took place, though they were often removed from their original context (James 1990; Lewis 1990b). In some cases, the industrial mining operations preserved parts of the preindustrial mines under rubble (Lewis 1990b). In places where firesetting was used heavily for mining, pollen from soil cores can corroborate periods of intensive mining (Breitenlechner et al. 2013; Mighall et al. 2017). In areas where large scale firesetting occurred, a large amount of wood harvesting was necessary, resulting in deforestation (Breitenlechner et al. 2013; Mighall et al. 2017). Moreover, processing the mined resources in the form of smelting required fuel (Breitenlechner et al. 2013; Mighall et al. 2017). The decrease in vegetation is reflected in the

types of pollen seen in soil cores and in increasing deposition of sediments (Breitenlechner et al. 2013; Mighall et al. 2017). Mining is not the only activity that can result in these effects but in areas where mining was known to take place, studying soil cores can offer archaeologists insights into cycles of deforestation as a result of mining and activities to support miners, such as an increase in farming activities (Breitenlechner et al. 2013; Mighall et al. 2017). In many cases, the ore or resource being mined was processed near the mine. Areas of smelting can be found around mines so that the metals could be transported to other areas in their metal form or in the form of complete or near complete artifacts (Helwing 2011: 15; Ortiz 2003: 46-47). Smelting and firesetting required fuel for execution, taxing fuel resources around the mines further (Ortiz 2003: 46-47).

Prehistoric mining took place across the world in some fashion. In Southern Australia, deposits of silcrete were exploited by aboriginal miners 2,400 years before present (Sullivan et al. 2013). Silcrete is composed of quartz crystals cemented together by microcrystalline silica (Sullivan et al. 2013). The miners created quarry pits to collect the silcrete and knapped it at the mines; no evidence of firesetting was found (Sullivan et al. 2013). In the Iranian plateau, mining for metal and stone took place from the early prehistoric into the industrial period (Stöllner 2011: 621; Stöllner et al. 2011: 543). Some of the earliest copper mines can be found on the Iranian Plateau dating to the sixth millennium BC (Stöllner et al. 2011: 535). Firesetting and stone hammers were used on the Iranian Plateau for multiple periods of mining (Stöllner et al. 2011: 543). Across Europe, stone, copper, iron, silver, and gold were mined with and without the aid of firesetting and again stone hammers were used in the extraction process (Ruiz-Galvez 1995; Mighall et al. 2017; Wagner et al. 1980; Weisgerber and Pernicka 1995). In the British Isles, Bronze Age copper mining was a major industry and mining of resources continued into the Iron

Age and beyond with the exploitation of iron and other metals (Eluere1995; Pickin 1990). In South America, metals such as gold and copper were mined and traded (Bird 1979; González 1979). Prehistoric copper mines are scattered across Southeastern Asia and Bronze Age China consumed huge quantities of copper and tin (Higham 1996). In present day North America, aboriginal mines for copper, lithics, and turquoise are documented (Hedquist et al. 2017; Martin 1999). Native copper occurs in areas in Connecticut, Massachusetts, Appalachia, and eastern Canada in addition to the deposits in the Lake Superior Basin (Levine 2007). These sources of copper were mined by local Native American groups in order to make tools, arrow and spear points, as well as ornaments (Levine 2006). Accounts from early European contact in southeastern Canada indicate that the indigenous populations mined and processed the local native copper there as well (Levine 2007). The copper was also traded across the northern and eastern areas of the United States and in parts of southeastern Canada (Levine 2006). Copper from multiple sources was traded across the same regions, although not always during the same time periods (Levine 2006). For example, during the Late Woodland period in Georgia, the copper sources were Appalachian prehistoric mines, whereas before the Late Woodland period, the Lake Superior Basin had supplied copper to Georgia (Levine 2007).

Prehistoric Mining Tools

Across the world, the prehistoric miner's tool box looked similar with respect to its basic components (Gale and Ottaway 1990; Martin 1999; Ortiz 2003; Pickin 1990). Hammerstones are a very common mining tool seen at prehistoric mining sites. They range from cobbles of varying sizes that could be easily wielded by hand to larger stones that may have been hung from some sort of sling slung over someone's shoulder or suspended from some sort of built structure and swung into the rock being mined (Lewis 1990a). Hammerstone technology across the world

in areas where early mining occurred was superficially similar but variations do exist. Hammerstones were either modified or not modified before use (Pickin 1990). Modified stones could be altered in several different ways. Some hammerstones had modifications in the form of light pecking around the body of the stone that was too shallow to be considered true grooving (Pickin 1990) while other hammerstones display notching along the edges or partial grooving (Pickin 1990). Many hammerstones display full grooving around the body of the stone (Ortiz 2003; Pickin 1990; Stöllner et al. 2011) but modified hammers can display partial grooving, one or two full parallel grooves pecked around the stone, or a groove around the body with another stretching from the center of the groove around the butt of the stone (Ortiz 2003; Pickin 1990; Stöllner et al. 2011) (Figure 2.2).

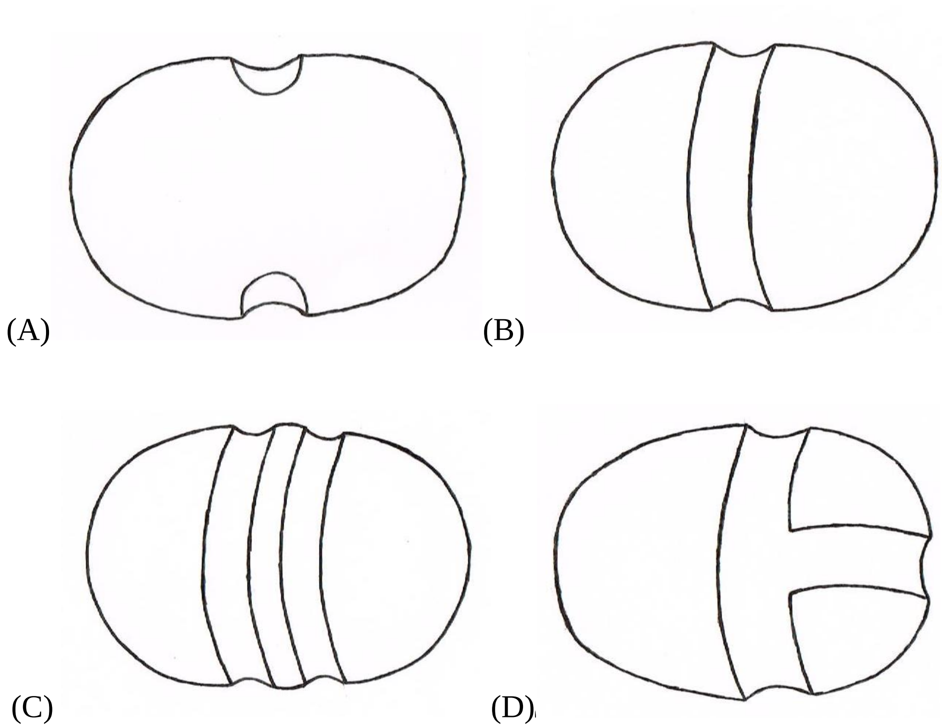


Figure 2.2: Notching (A), single groove (B), parallel grooves (C), and perpendicular grooves (D)

Other tools used for mining include picks made from antler tines or bone, wedges made of wood or other material, stone mortars, and millstones (Dutton 1990; Gale and Ottawa 1990; James 1990). Bone and antler picks were used to assist in prying rock away from the rock face

(Timberlake 1990b). Wedges were used to extend already formed cracks (Timberlake 1990b). Millstones and mortars may have been used to grind up ore in order to make it easier to smelt (Dutton 1990; Gale and Ottawa 1990).

Prehistoric Mining in the Lake Superior Basin

Exploitation of float copper by indigenous populations of the Lake Superior Basin predates more systematic mining operations. Some of the earliest known workings of surface copper appear around 7,800 years ago and predate mining by less than 1,000 years (Martin 1999: 143-144). Prehistoric copper mining on Isle Royale began at least 6,500 years ago and mining on the peninsula likely began around the same time but due to the destruction of many of the prehistoric mines by later industrial mining operations, determining exact dates of the start of mining on the peninsula is more difficult (Martin 1999: 144-145; Pompeani et al. 2015). Two types of copper deposits, lode and fissure deposits, were primarily exploited by aboriginal miners in addition to float copper (Martin 1999: 91). Fissure deposits are small, narrow veins of copper that tend to go deeper than lode mines and more tunneling resulted from mining fissures (Martin 1999: 89). Lode mines are mines that consist of masses of copper closer to the surface and can be much shallower and wider than fissure mines (Martin 1999: 90). Lode mining was more common on Isle Royale compared to the Keweenaw Peninsula and fissure mining was much more common in the Keweenaw than Isle Royale; however, both types of mining occurred in each region (Martin 1999: 89-90).

The first step in mining both lode and fissure deposits involves finding a source rock where a potential copper deposit may reside (Martin 1999: 91). Unfortunately, while the original miners in the Lake Superior basin cannot be interviewed to get specifics about the techniques

they utilized to discover copper deposits, inferences can be made based on knowledge from other cultures that mined metal resources in similar ways (Martin 1999: 82). Experienced miners would be able to pick up on surface indications in the rock where copper might be located just underneath the surface or rock face and would have been able to detect parts of exposed fissures and lodes (Martin 1999: 83). Discolored vegetation and stunted trees as well as other forms of vegetation patterns could have also acted as indicators for the presence of large quantities of metals (Martin 1999: 83). Prehistoric mining pits are a common type of mine found on Isle Royale (Martin 1999: 85-86).   Pits resulted from chasing lodes of copper down into the ground and are similar to mine shafts although they do not go as deep into the ground as industrial mine shafts do (Martin 1999: 86). Mining pits can vary in size from less than a foot wide and deep to five or more feet in depth and diameter (Martin 1999: 86) (Figure 2.3).

(A)  (B) 

Figure 2.3: Large prehistoric mining pit on Isle Royale (A) and smaller mining pit on Isle Royale (B)

Prehistoric mines varied widely in size and not all of the mines were successful (Martin 1999: 91). Potential mines could quickly fizzle out as a result of the lode or fissure ending abruptly after only a short time of mining (Martin 1999: 91). On the other hand, they could also contain too much mineral. Copper masses unearthed by mining activity could be too large to process and remove and they were abandoned as a result (Martin 1999: 91). There are accounts of later European miners coming across large masses of copper unearthed by earlier Native American miners that were too large to process, as reported in a newspaper article about industrial miners on Ontonagon County, Michigan who came across an exposed mass of copper buried under brush and trees (Johnson 1882). Once extracted, the copper was made into tools or ornaments (Martin 1999: 113-114). Evidence of camps near mining sites (West 1929: 27) includes the remains of fires, pottery sherds, faunal remains, and byproducts of copper working, indicating that the miners stayed in the area during the period of time they were mining (Drier 1961; West 1929). Food supplies would have had to be transported to mine sites due to the scarcity of resources in the Keweenaw and on Isle Royale (Whittlesey 1863). No evidence for copper smelting has been found in the Lake Superior Basin before European contact (Martin 1999). Native Americans continued to exploit Keweenaw copper up until the introduction of European metals in the seventeenth century (Martin 1999: 180). Early studies of the preindustrial mines attributed the mines to the mythic mound builder civilization or even the activity of Norseman but based on archaeological evidence, these activities were eventually correctly attributed to the indigenous populations of the Lake Superior Basin (Kellogg 1924; Martin 1999; West 1929: 20).

Copper from Isle Royale and the Keweenaw was part of a very extensive trade network that spanned a significant portion of the modern day United States (Drier and Du Temple 2005). Copper artifacts are found in areas of Canada, Minnesota, Wisconsin, and beyond (Levine 2007).

The prehistoric miners of Isle Royale came down from Canada because the island is much closer to Canada than it is to Michigan (Levine 2007). Miners on the peninsula came overland from Michigan and Wisconsin (Levine 2007). Copper would have been taken from the mines already worked or as a raw material to be worked and traded for other resources, such as material for stone tools which came from areas as much as two hundred miles from Michigan (Hill 2006). The mining operations that supplied this copper utilized a number of different tools and techniques for material extraction. Due to the strength and density of the copper-bearing rock, firesetting was probably utilized to make mining less labor intensive (Martin 1999). Indigenous copper miners would have also used tools such as hammerstones and picks made out of antlers to make harvesting copper easier (Martin 1999). Antler picks would have been wedged into cracks that already existed or were artificially created in the target rock and used to pry away sections of the rock while hammerstones would have been primarily smashing tools designed to loosen cracked material and make removal easier (Shepard 1980). Firesetting and the use of stone and antler tools for mineral mining were not exclusive to the Lake Superior Basin; in fact, these tools and techniques were used for preindustrial mining across the globe (Shepard 1980).

In the Keweenaw archaeologists consistently find two types of indigenous hammerstones: hammerstones with grooves pecked into them and hammerstones without grooves. For the most part, the grooves are either pecked all the way around the stones or pecked into either end and extend a few inches around the stone (Martin 1999: 98-99). Some hammerstones have small or shallow notches pecked into them as well (Martin 1999: 99) (Figure 2.4). A hammerstone with two parallel grooves weighing 16kg was found at Minnesota Mine in Ontonagon County, Michigan but no double grooved hammers of any size were present in the collections examined for this project (Drier 1961: 63; Whittlesey 1863)

(A)

(B)

Figure 2.4: Hammerstone with groove (A) and hammerstone without groove (B)

On Isle Royale, hammerstones without grooves are most common although several examples of stones with notching or minor grooving have been found. Stones with grooves are thought to have had some form of handle or hafting attached to them while the stones without grooves appear to be handheld. This hypothesis is based on ethnographic evidence for similar tools as well as archaeological contexts from other areas of the world (Martin 1999). Archaeologists theorize that hafting material may have been made from wood, fibrous material, or rawhide but no stone has yet been found in the study area with the remains of any sort of hafting still attached (Martin 1999: 106-107). One stone was found in association with pieces of knotted rawhide believed to be the remains of hafting (Martin 1999: 106-107). However, degradation of the material was too severe for positive identification (Martin 1999: 107). Moreover, it is possible that the stones did not have hafting at all and the grooves were for some other purpose such as providing a better grip when holding the stone in hand. Very little investigation into forms of hammerstone hafting has been undertaken either in the Keweenaw or in other areas of the world where preindustrial mining occurred (Craddock 1990; Martin 1999: 91-92) so one of the goals of this thesis is to test the utility of grooving in the use of hafting these hammerstones.

A Brief Background on Experimental Archaeology

While a number of hammerstone collections have been examined in some capacity in the Keweenaw, no practical investigations have been carried out to determine whether

hammerstones did have hafting or if one type of hafting was more effective than another (Martin 1999). A few projects in Michigan and other areas of the world have investigated prehistoric mining practices, although most of these studies focused on firesetting and not the tools produced and used for mining (Bastian 1963; Crew 1990; Lewis 1990; Timberlake 1990b; Trotter 2015). These projects utilized a method of archaeological research known as experimental archaeology to investigate the usefulness of firesetting as a mining method. Experimental archaeology generates data through the construction and execution of experiments designed to test past processes, behaviors, and techniques archaeologists believe cultures utilized to interact with their environments (Mathieu 2002). Experimental archaeology can be used for everything from testing flint knapping techniques to pottery replication to Neolithic farming techniques and even methods of textile manufacturing and dying (Flores and Paardekooper 2014). It can also be used in conjunction with ethnoarchaeology to establish possible ways similar technologies were used across cultures (Marsh and Ferguson 2010: 1). Ethnoarchaeology involves using observations recorded in ethnographies about tools and techniques and applying those observations to the development of ideas regarding similar artifacts or activity waste seen in the archaeological record (Marsh and Ferguson 2010: 1). However, it is important to keep in mind that ethnographic observations and experimental archaeological processes do not definitively explain how past cultures performed activities or made artifacts, only how they may have done so (Marsh and Ferguson 2010: 1).

Experimental archaeology has its roots in the late 18th century when those interested in history examined artifacts and performed experiments with them to determine how the artifacts were made (Coles 1979: 13). Arguably one of the first true experimental archaeology projects was executed by General Pitt-Rivers during an excavation in Cissbury, Sussex in 1876 (Coles

1979: 18). During the excavation, Pitt-Rivers and his team found examples of antler tools used for digging ditches that the team replicated and used to dig at the site (Coles 1979: 18). As time went on, archeological experiments occurred in much the same fashion, even as other archaeological processes evolved (Coles 1979). It was not until theoretical revolutions began in archaeology in the mid-20th century that experimental archaeology evolved into a scientific methodology (Coles 1979: 32-33). The emergence of processual archaeology helped to standardize experimental archaeological practices and define what it can contribute to archaeological study (Millson 2010).

When performing experimental archaeology, a number of rules should be followed so that meaningful and scientific data are generated. Experiments should always be based on archaeological knowledge and tools and techniques used should not exceed what was believed to be available to the culture and time being studied (Coles 1973: 15). If multiple techniques can achieve similar result, the one most appropriate for the society being studied should be utilized (Jeske et al. 2010: 117). Modern technologies and shortcuts can be used for portions of the experiment only if they do not affect data collection (Coles 1973: 16). All portions of the experiment should be carefully documented and, when possible, the experiment should be replicable (Coles 1973: 17). Whenever possible, control samples for the experiment should be present because they become baseline comparisons for the experimental results (Jeske et al. 2010: 117). Experiments can be performed either in lab or field settings; in lab settings, it is easier to control variables but conditions in field settings are more similar to the environment where the activities were actually taking place and may better reflect how real people may have used the tools (Marsh and Ferguson 2010: 5).

Prehistoric Mining Experiments

Few experiments focused on testing different types of hammerstone hafting have been conducted. An experiment was performed in 1989 in Britain testing the durability of two different types of wood when used as handles for hammerstones (Craddock 1990). Three hammerstones were made from cobbles found on Aberystwyth Beach, Wales, two with hazel wood handles and one with a willow wood handle (Craddock 1990). A piece of quartz was used to peck shallow grooves into each stone before handles were attached (Craddock 1990). Twine and rawhide were used to secure the handles to the stones and the hammers were then subjected to a use-wear test that investigated the comfort and durability of the two handle types (Craddock 1990). The experimenters found that the hazel wood handles held up better than the willow wood because it was a harder wood; however, because the willow wood was springier, it absorbed shock from hitting the rock better and was easier on the user's wrist (Craddock 1990). Repairs to the hammers had to be made regularly as stones would frequently come loose and small wedges of wood were used to secure the stones back in place (Craddock 1990). The experiment concluded that there would have likely been a tradeoff between durability and comfort of use when choosing material to construct handles for hammerstones (Craddock 1990).

No such hammerstone studies have taken place in the Keweenaw or Isle Royale but a prehistoric mining experiment that took place in the area did briefly describe the hammerstones the research team used to conduct the experiment. In 1962, an archaeology research team on Isle Royale conducted an experiment utilizing firesetting in order to determine whether the technique made copper mining easier (Bastian 1963). The team had one fire that lasted two hours and determined that heating the local basalt for that amount of time did not significantly loosen material (Bastian 1963). They then spent thirty hours hammering at a patch of unfired basalt so

the rate of material removal utilizing only manual labor could be assessed (Bastian 1963). After the conclusion of the experiment, 25 cubic feet of material was removed. The team used three handheld hammerstones for their experiment, two for one-handed use and one for two-handed use (Bastian 1963). The two one-handed hammerstones were utilized most due to the difficulty associated with using the two-handed stone (Bastian 1963). The research team determined that the hammerstones were fairly effective without handles in removing material; however, they were also uncomfortable to use and resulted in the loss of fingernails for several of the researchers (Martin 1999: 92). The study drew few conclusions in regards to the hammerstones themselves, as the focus of the experiment was on firesetting, but they did determine that hammerstones without handles could be used to mine fairly effectively (Bastian 1963). Another experiment was performed in the fall of 2014 evaluating the effects that varying the length of fires have on mining using firesetting in the Keweenaw. The experiment compared the effectiveness of fires of different duration, two hours like the Bastian experiment and four hours (Trotter 2015). Researchers found that longer fires resulted in artificial cracking of the basalt while two hours had no visible effect (Trotter 2015). As a result, the fire-cracked basalt became brittle and material removal using hammers and antler picks was expedited (Trotter 2015). After the completion of the experiment, .57 cubic meters of material had been removed (Trotter 2015). The experiment used two hammerstones for removing the material; grooves were created in the stones using chisels and the stones were suspended from rope handles (Trotter 2015). The hammers suspended from handles were effective tools for breaking up the already fire-cracked basalt due to the force generated by swinging the stones but the rope frequently had to be replaced (Trotter 2015). At times the handles on the stones were not used and the stones were held in the hand because this increased the accuracy when striking so that a certain spot on the

rock could be repeatedly hit (Trotter 2015). The hammers were not examined for wear patterns at the end of the experiment because they were not the focus of the experiment (Trotter 2015). However, the 2014 experiment did indicate that a combination of handled and unhandled hammers were likely used if handles were used at all in the Lake Superior Basin.

Prehistoric mining experiments conducted in other areas of the world offer additional insight into the use of hammerstones, even if the experiments did not focus on the hammerstones themselves. Three prehistoric mining experiments utilizing firesetting were conducted in Great Britain in 1989 and each utilized hammerstones in some form for material removal. One experiment used one mining cycle with a fire roughly ninety minutes long and used hammerstones suspended from withy handles (Crew 1990). Researchers commented that the flexible handles made the stones more maneuverable and could be used easily in places where space was restricted (Crew 1990). 536kg of material was removed over the course of the experiment (Crew 1990). The second experiment was longer than the Crew experiment and consisted of three mining cycles (Lewis 1990b). After the completion of the project, 1,042kg of material had been removed over the course of the three fires (Lewis 1990b). Two different types of hammerstones were used, small handheld ones without handles and larger ones that were attached to a rope swing and suspended over the user’s shoulder and then swung into the target rock (Lewis 1990b). In the area where the experiment took place, early hammerstones did not appear to have handles so the majority of the stones the researchers used were not given handles unless they were too large to wield comfortably by hand (Lewis 1990b). The hammerstones that were given slings did not appear to have been altered with grooves for attaching the rope slings. The researchers did not indicate that the stones came out of the slings frequently, so it is possible that hafting was attached to some stones without grooves. The smaller hammerstones were

deemed to be easier to use than the larger stones with slings but both types were effective for material removal (Lewis 1990b). The last experiment was performed around Cwmystwyth, Wales and built upon previous work that the experimenters had done (Timberlake 1990b). The experiment took place in the same area as the previous one but consisted of only one fire and water quenching was used to cool the rock face (Timberlake 1990b). When the experiment was complete, 1.5 tons of rock had been removed from the mine (Timberlake 1990b). Researchers experimented with antler picks to determine if mining could be done using only the antler tines (Timberlake 1990b). They tried to force the tines into cracks in the rock and pry the rock away without first using hammers to loosen the cracked material (Timberlake 1990b). The tines frequently broke and dulled but broken antler tine tips were useful as wedges when hammered into small cracks in the rock (Timberlake 1990b). Hammerstones were used for material removal in addition to antler picks and wedges. The researchers used two types of hammerstones for the experiment: hand held hammers with no type of modification and hammers that were lightly grooved and were attached to hazel wood handles using tanned leather ties (Timberlake 1990b). The handles were made to emulate mining hammers found in Northern Chile that had wood bent once around the stone and rawhide ties securing the stone to the handle around multiple points (Bird 1979: 114; Timberlake 1990b). The leather ties stretched quite easily while the hammers were used and adjustments to the handles had to be made throughout the mining process (Timberlake 1990b). Beyond comments about the leather stretching and the final report of the material removed from the experimental mine, no mention was made of how effective the hammers were during their use, nor was wear pattern development mentioned. For the most part, prehistoric mining experiments used preexisting archaeological knowledge to construct hammerstones but rarely used stones with multiple forms of hafting or a combination

of hafted and non-hafted stones, even if there was evidence for multiple types of hammerstones likely being used at the same time in the study areas. Moreover, except for the 1990 Craddock experiment where hammerstones were the primary focus, the other experiments provided very little information on the relative performance effectiveness of the mining tools and their construction. Even though mining hammerstones were an important part of the prehistoric mining process, very little systematic research has been done investigating their construction, usability, and durability. This thesis provides additional data relevant not only to understanding the effectiveness of hammerstones with various types of hafting in the Keweenaw but to other areas of preindustrial mining worldwide.

Chapter 3: Methodology

Hammerstone Collection Analysis

This project had two primary components. The first component was a macro-use-wear analysis of three different collections of hammerstones from the Keweenaw. Fifty-six hammerstones were analyzed for this project, twenty with grooves and thirty-six without grooves (Table 3.1).

Table 3.1: Hammerstone collections and sample sizes

Collection	Institution	Date Collected	Hammerstone Sample	Modification
Chynoweth (C)	MTU	1897	17	Yes
Chynoweth (C)	MTU	1897	6	No
Drier (D)	MTU	1953-1954	14	No
Drier (D)	MTU	1953-1954	3	Yes
Massee (M)	MPM	1928	16	No

Three steps were used to document the hammerstone collections. First, each stone was photographed from six angles to ensure that all wear from mining use was clearly documented. The images were then compiled into a catalogue found in Appendix A. Secondly, diagrams of wear patterns for each stone were created so that the depth of wear and the percentage of wear surface area could be compared (Figure 3.1). Scans of the drawings can be found in Appendices A-C of this report together with the photo catalogues. Finally, the approximate dimensions, location and extent of wear, and extent of the groove carved into the stone, were recorded and added to the written description.

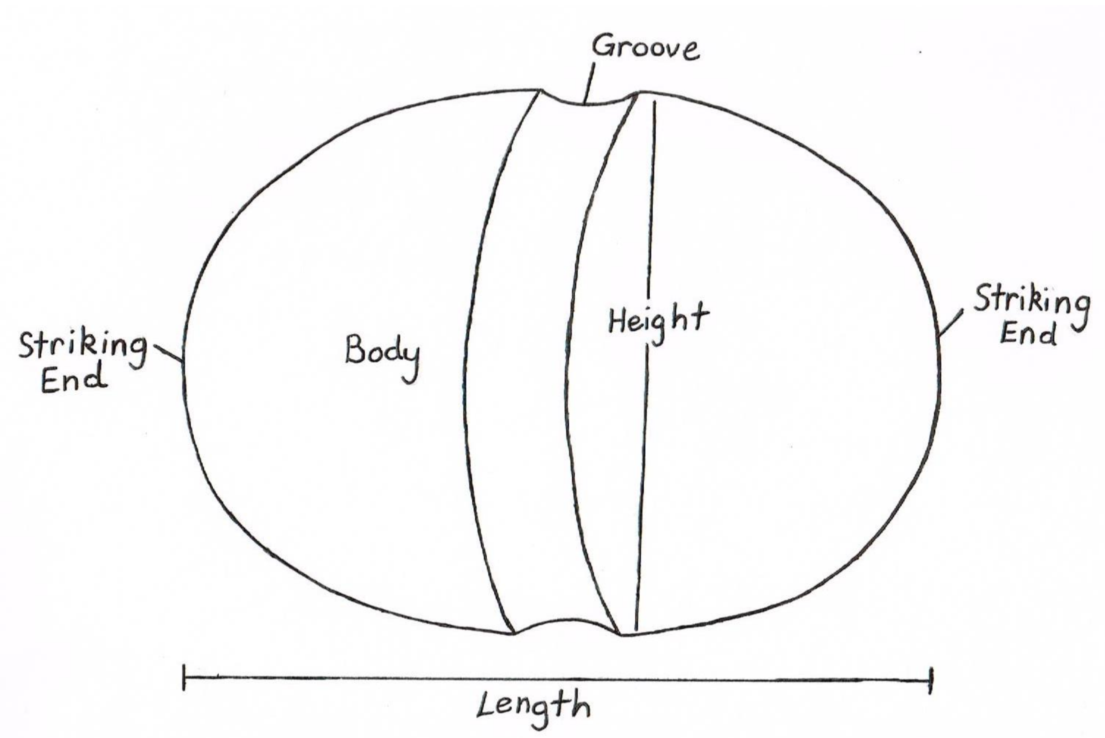


Figure 3.1: Schematic representation of a hammerstone

The variables recorded included whether there was there striking wear on only the primary end of the stone or on both the primary and secondary ends; whether strike wear covered 1% to 25%, 26% to 50%, 51% to 75% or 76% to 100% of the worked surface with the primary and secondary ends being examined separately; whether a stone had no grooving, partial grooving, or full grooving and the depth of the grooving; the presence of any indentations where hafting might have been attached but no deliberate grooving was visible; and whether the percentage of overall material loss of the stones was documented using the same scale as the strike wear analysis (Table 3.2). Material loss was estimated by comparing more complete stones to less complete ones and using what was left of the original surface of the stones to create a projection of the original dimensions of the hammers.

Table 3.2: Variables recorded for the project

Grooving	None	Notching	Partial	Full
Strike wear presence	Both ends	One end	Undetermined	

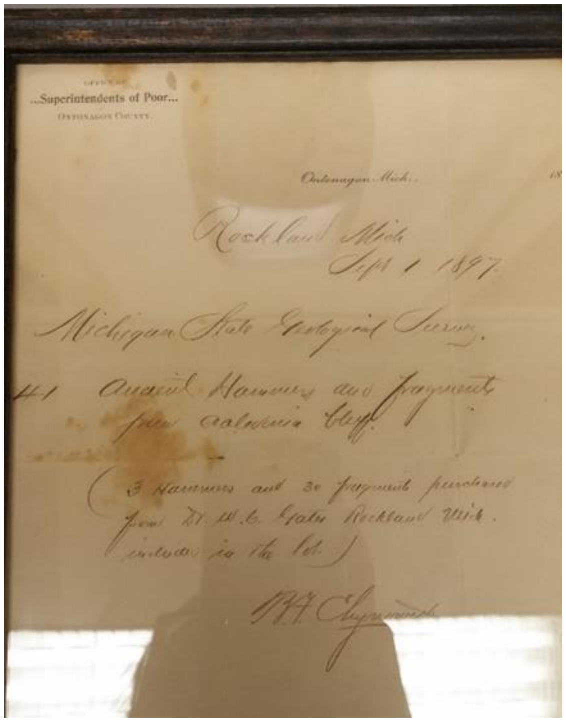
Hafting indentations	Present	Not present		
% strike wear coverage on primary end	1-25%	26-50%	51-75%	76-100%
% strike wear coverage on secondary end	1-25%	26-50%	51-75%	76-100%
% estimated material loss	<15%	15-25%	26-35%	36-50%

The Massee Collection is housed at the Milwaukee Public Museum (MPM) and consists of approximately 80 hammerstones collected from Isle Royale in 1928 as a part of the McDonald Massee expedition before the establishment of Isle Royale National Park in 1940. The expedition traveled around the island, visiting various sites with evidence of Native American mining activity (West 1929: 26). The expedition was meant to be an archaeological survey that would lay the groundwork for future research and excavation on Isle Royale and it did not focus on artifact collection (West 1929: 20). It also set out to determine what group(s) was/were responsible for the mining sites on the island, including whether indigenous populations from the surrounding areas were responsible, or if foreign groups such as the Norse were the miners (West 1929: 20). It was ultimately determined that the mine pits were the result of activity by Native Americans based on the material evidence found around the mines and across Isle Royale both during the expedition and through the analysis of museum collections (West 1929). The hammerstones were collected from the Minong Mine, also called the Old Mine, but not much information was provided about the collection process (West 1929:26) (Figure 3.2). Hammerstones appear to have been the only artifacts collected at the Minong Mine during the survey but other artifacts were collected as well (West 1929). Artifacts included stone arrow points, stone axes, and pottery sherds (West 1929). A sample of sixteen hammerstones was analyzed from the Massee Collection (Table 3.1). The collection consisted of hammer cores and

large chips that had come off the cores. Only hammerstone cores were selected for study because they provide the most information about wear on hammers, presence and completeness of grooves, and more accurate estimations of material loss due to hammering. After excluding the stones that were not hammerstone cores, the sample was selected based on how regularly shaped the cobbles were. Beyond looking for hammers that were oval in shape and 50% or more complete, the sample was chosen at random from the collection. Hammers ranged between 11 centimeters and 18 centimeters in length and weighed between 2 kilograms and 4 kilograms. This selection process was used for each collection. No grooved hammerstones were present in the Massee Collection. The first two days spent with the collection involved creating the image catalogue and producing the hammerstone diagrams. The third day involved finishing the diagrams and creating the written description. The two additional collections examined are both housed in the Social Science Department at Michigan Technological University (MTU).

Figure 3.2: Map indicating locations of Minong (A) and Caledonia Mines (B) (Google Maps)

The Drier Collection was assembled when Roy Drier conducted excavations on Isle Royale during the summers of 1953 and 1954 (Drier 1961: 1). It contains at least 134 hammerstones based on the labels on the stones themselves but a catalog for the collection could not be located. One box of Drier Collection material appears to be missing as well. The accession number on the hammerstones present ranged from 89-5-30 to 89-5-134; 89-5-1 to 89-5-32 not present in the boxes containing the collection. As a result, the exact number of stones the collection originally contained could not be determined. However, enough hammerstones were still present for the purposes of this project. Drier was a professor of metallurgical engineering at the Michigan College of Mining and Technology, now known as Michigan Technological University, and leader of the dig at the time of the expedition (Drier 1961: 1). He was not an anthropologist but did have an interest in the subject and in the prehistoric copper mines found on Isle Royale and in the Keweenaw (Drier 1961). The 1953 and 1954 digs largely took place at the Minong Mine but excavations were carried out in other areas of the island including settlement sites near mines (Drier 1961: 5-6). The hammerstones and hammerstone fragments collected by the dig teams were found in association with mine tailings and charcoal (Drier 1961: 3-6) (Figure 3.2). In addition to hammerstones, pottery sherds, pieces of worked copper, complete copper objects, floral and faunal remains, and stone tools were collected (Drier 1961). A sample of fourteen hammerstones without grooves from this collection as well as three hammerstones with grooves representing the rare examples of this type of hammerstone from the island were included in the analysis presented here (Table 3.1). The stones ranged from 9 centimeters to 20 centimeters in length and weighed between .9 kilograms and 4 kilograms. As with the Massee Collection, three days were spent with the Drier Collection, the first two photographing and drawing and the last spent creating the written descriptions and finishing the drawings.


...Superintendents of Poor...

Ontonagon Mich.,

Rockland Mich
Sept 1 1897

Michigan State Geological Survey.

41 Ancient Hammers and fragments from Caledonia Cliff.

(3 Hammers and 30 fragments purchased from Dr. W. C. Gates Rockland Mich. included in the lot.)

Figure 3.3: Letter of donation from Chynoweth Sr. associated with the Chynoweth Collection

The Chynoweth Collection was donated to MTU in 1897 after a geological survey of the Keweenaw was performed by Benjamin Chynoweth (Chynoweth 1897). Unfortunately, a copy of the geological survey could not be located nor could information be found on Benjamin Chynoweth. A letter of donation was provided with the collection but no other documentation is associated with the procurement of the collection (Figure 3.3). However, Chynoweth's son, Benjamin Chynoweth Jr., did write a manuscript focusing on Isle Royale indigenous copper mining that was never published. The manuscript is housed in the MTU archives. The hammerstones were largely taken from an area surrounding a later industrial mine known as the Caledonia Copper Mine in Ontonagon, Michigan (Chynoweth 1897). The collection was made up of core hammerstones, large hammerstone chips, and a few ground stone tools that appear to have had a purpose other than mining for a total count of 101 artifacts. A sample of seventeen grooved and six ungrooved hammerstones was selected from this collection (Table 3.1). All of the ungrooved hammerstones in the Chynoweth collection were included in this study. The stones ranged from 10 centimeters to 23 centimeters in length and weighed between 2 kilograms and 4.3 kilograms. No other verifiable collections of Keweenaw Peninsula hammerstones could be tracked down for study during the time allotted for this project. A privately-owned collection of hammerstones from multiple mines in the Keweenaw exists but no other museum collections of Keweenaw hammerstones could be identified for this project. The

Chynoweth Collection had to be studied over the course of multiple trips, the first of which resulted in a photo catalogue, diagram catalogue and written descriptions for the grooved hammerstones from the sample being created and additional trips to document the ungrooved stones. After all three collections were studied, the stones examined were given project numbers. The hammerstones from each collection were placed in order based on the original numbers assigned to each collection. The project number of each stone began with the first letter of the original collection name followed by G or U to indicate grooved or ungrooved then H for hammerstone (Table 3.3).

Table 3.3: Hammerstone collections and sample sizes

Collection	Accession Number	Groove/No Groove	Project Number
Chynoweth	Maul/Hammerstone 29	Partial groove	CGH1
Chynoweth	Maul/Hammerstone 33	Full groove	CGH2
Chynoweth	Maul/Hammerstone 35	Full groove	CGH3
Chynoweth	Maul/Hammerstone 42	Full groove	CGH4
Chynoweth	Maul/Hammerstone 44	Full groove	CGH5
Chynoweth	Maul/Hammerstone 47	Partial groove	CGH6
Chynoweth	Maul/Hammerstone 52	Full groove	CGH7
Chynoweth	Maul/Hammerstone 60	Full groove	CGH8
Chynoweth	Maul/Hammerstone 61	Full groove	CGH9
Chynoweth	Maul/Hammerstone 64	Full groove	CGH10
Chynoweth	Maul/Hammerstone 65	Full groove	CGH11
Chynoweth	Maul/Hammerstone 70	Full groove	CGH12
Chynoweth	Maul/Hammerstone 73	Full groove	CGH13
Chynoweth	Maul/Hammerstone 74	Full groove	CGH14
Chynoweth	Maul/Hammerstone 89	Partial groove	CGH15
Chynoweth	Maul/Hammerstone 91	Full groove	CGH16
Chynoweth	Maul/Hammerstone 97	Partial groove	CGH17
Chynoweth	Maul/Hammerstone 8	No Groove	CUH1
Chynoweth	Maul/Hammerstone 16	No Groove	CUH2
Chynoweth	Maul/Hammerstone 23	No Groove	CUH3
Chynoweth	Maul/Hammerstone 24	No Groove	CUH4
Chynoweth	Maul/Hammerstone 30	No Groove	CUH5
Chynoweth	Maul/Hammerstone 93	No Groove	CUH6
Drier	89-5-56	No Groove	DUH1
Drier	89-5-57	No Groove	DUH2
Drier	89-5-83	No Groove	DUH3
Drier	89-5-89	No Groove	DUH4
Drier	89-5-95	No Groove	DUH5
Drier	89-5-96	No Groove	DUH6
Drier	89-5-97	No Groove	DUH7

Drier	89-5-99	No Groove	DUH8
Drier	89-5-105	No Groove	DUH9
Drier	89-5-116	No Groove	DUH10
Drier	89-5-120	No Groove	DUH11
Drier	89-5-121	No Groove	DUH12
Drier	89-5-122	No Groove	DUH13
Drier	89-5-130	No Groove	DUH14
Drier	89-5-33	Notching	DGH1
Drier	89-5-62	Full groove	DGH2
Drier	89-5-134	Notching	DGH3
Massee	28067-7137	No Groove	MUH1
Massee	28071-7137	No Groove	MUH2
Massee	31684-8334	No Groove	MUH3
Massee	31687-8334	No Groove	MUH4
Massee	31688-8334	No Groove	MUH5
Massee	31697-8334	No Groove	MUH6
Massee	31700-8334	No Groove	MUH7
Massee	31701-8334	No Groove	MUH8
Massee	31704-8334	No Groove	MUH9
Massee	31707-8334	No Groove	MUH10
Massee	31709-8334	No Groove	MUH11
Massee	31711-8334	No Groove	MUH12
Massee	31712-8334	No Groove	MUH13
Massee	31729-8334	No Groove	MUH14
Massee	31735-8334	No Groove	MUH15
Massee	31736-8334	No Groove	MUH16

Creation of Experimental Hammerstones and Handles

The second phase of the project consisted of an experimental attempt to recreate wear patterns seen on a subset of hammerstones from the three collections. Seven hammerstones in total were produced and used. The cobbles used for the hammerstones came from Isle Royale. A research permit for use of park resources was filled out, and twelve beach cobbles were collected by park personnel. The stones were selected for use based on how similar in size and shape they were to the stones in the prehistoric collections and to each other. The prehistoric hammerstones after use ranged from 9cm to 24.3cm in length and weighed between .9kg and 4.9kg. The majority weighed between 2kg and 4kg. The archaeological hammerstones were made of basalt, gabbro, diabase, and granite.

The experimental hammerstones ranged from11.5cm to 21cm before use, had a weight range of 2.2kg to 4kg and were made of either basalt or diabase/gabbro. Stones were also selected based on the absence of visible flaws that might render them unsuitable for use, including the presence of hairline fractures or brittleness of the rock. These could cause the stones to break apart into

Figure 3.4: Researcher working on grooving for EGH3

pieces too small to be used for mining when grooving was added and mining began. Despite attempts to select stones without internal flaws, not all flaws were visible on the surface of the stones. For the experimental portion of the project, six hammerstones were initially made; three were grooved and three were not. Construction of the grooved hammerstones began on April 15, 2017 and ended on May 20, 2017. The technique used to create the grooves involved striking the hammerstones repeatedly with a smaller, harder stone to chip away at the hammerstone until a groove was formed (Figure 3.4). The smaller stones were angled to strike glancing blows in order to slowly take material way without creating cracks in the body of the stone. The pieces that came off the hammer using this technique were mainly small particles and chips, the largest of which was only about a centimeter long. A dust mask was worn during hammering to prevent the inhalation of stone dust, and goggles were worn to keep stone shards from flying into someone’s eyes (Figure 3.4). The technique was consistent with how archaeologists believe grooved hammerstones found throughout the Keweenaw Peninsula were made. Experimental grooved hammerstones #1 and

#2, henceforth referred to as EGH1 and EGH2, took three hours each to complete over the course of two nonconsecutive days. Experimental grooved hammerstone #3, henceforth referred to as EGH3, took four and a half hours to complete over the course of three nonconsecutive days. Images were taken of the grooved hammerstones before grooving took place at the beginning of each day and after each groove was completed. One person could work on a stone for an hour to an hour and a half before the striking became too taxing on the hand.

Table 3.4: Experimental hammerstone project numbers and handle types

Project Number	Modification	Handle Type
EGH1	Full Groove	Rawhide Handle
EGH2	Full Groove	Wooden Handle
EGH3	Full Groove	None
EUH1	None	Wooden Handle
EUH2	None	Rawhide Handle
EUH3	None	None
EUH4	None	Wooden Handle

After the grooves were completed, handles for the hammerstones were made, two of rawhide and two of hardwood from the Keweenaw. One grooved and one ungrooved stone were given wooden handles and two stones, one grooved and one ungrooved, stone were given rawhide handles. The rawhide used to construct the handles was made of deer hide. To construct the handles, the rawhide was first soaked in water for over twenty-four hours to soften it and make it more pliable than in its dried state. Strips were then cut from the larger piece of rawhide using scissors. The strips of rawhide were wrapped around the stones, and a cobra knot was used to construct the base of the handles (Figure 3.5). Because of the way the cobra knot is constructed, it has a central core that can be pulled to tighten the sling the hammers rest in if the rawhide begins to stretch. Due to the dimensions of the sheet of rawhide used, the maximum length of the handles were roughly six inches, but they were long enough to function (Figure 3.6A). Longer handles would have been preferred so that they would be more comfortable for individuals with larger hands but they were not necessary.


Figure 3.5: Researcher constructing a rawhide handle

The rawhide handles were then left to dry before use. After drying, the rawhide did not stretch. Initial designs for the wooden handles involved using thin strips of hardwood from the Keweenaw soaked in water for over twenty-four hours in order to make the wood softer and more pliable. Attempts were made to bend the sticks around the stone to create handles, but the wood splintered. The second design for the wooden handles used hardwood saplings split partially down the middle (Figure 3.6B). One sapling was three feet long with a diameter of about one inch and the other was four feet long and an inch and a half in diameter. A wedge and a hammer were used to split the saplings partially in half to the point where a stone could be inserted between the two halves. Strips of softened rawhide were used to secure the split ends so that the stones would be secured in the handles. The rawhide was allowed to dry and harden before use, and the wooden handles were cut down to close to two feet in length for easier use. The last two hammerstones were not given any form of handle and were instead wielded in the hand by researchers during the experimental mining activity.

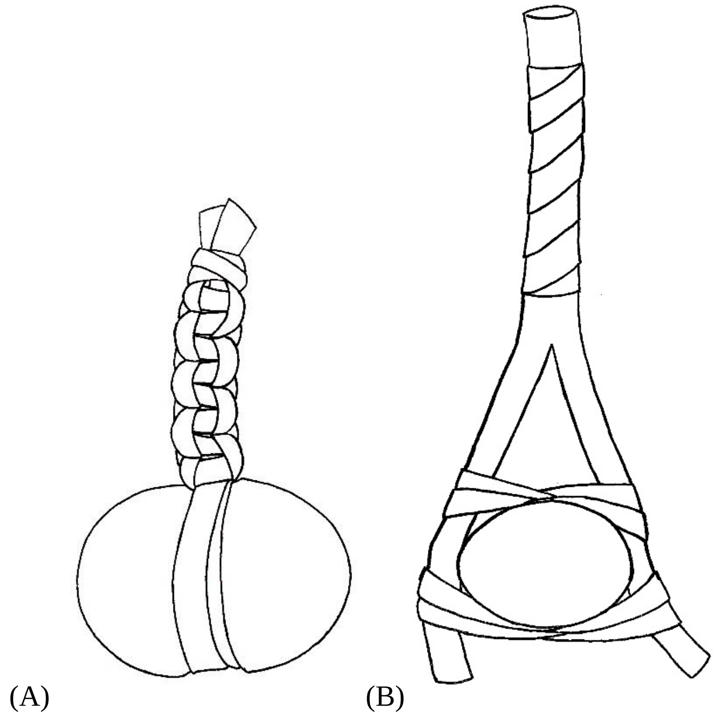
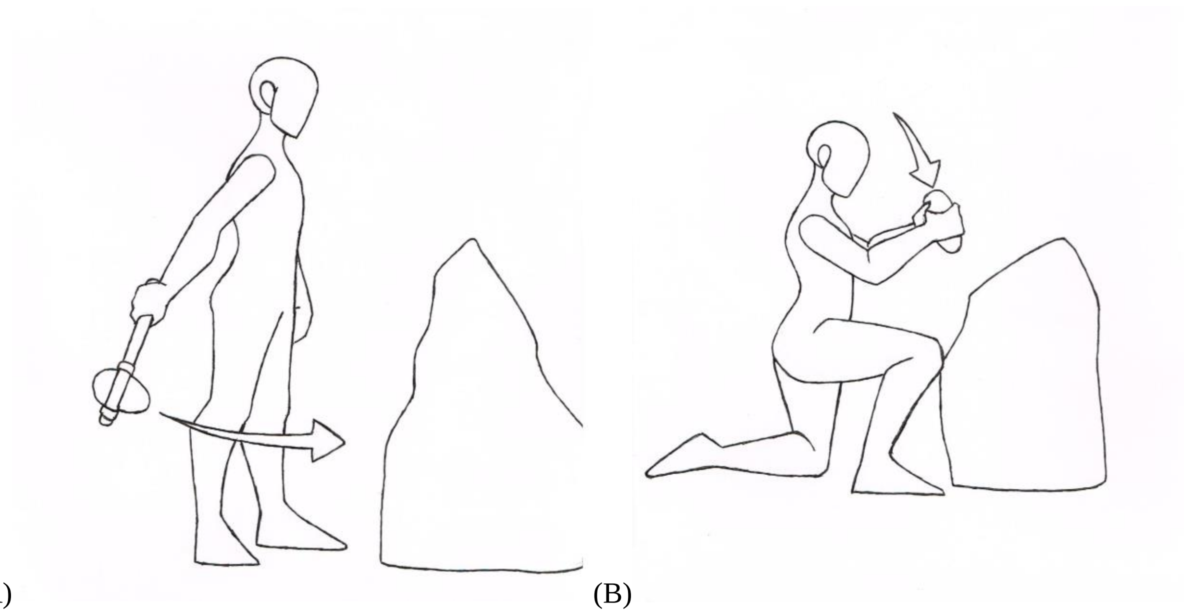


Figure 3.6: Rawhide handle design (A) and wooden handle design (B)

Hammering began on July 17 and took place in the area of Cliff Mine, an industrial copper mine located in the Keweenaw Peninsula. The majority of the rock at Cliff Mine is basalt consistent with the source rock indigenous populations mined for copper in other areas of the Keweenaw and on Isle Royale. The basalt used was not fire-cracked before hammering took place nor did it appear to have copper visible in it. The seven hammers were wielded by two individuals, one male and one female, with differing strengths and heights. The handled hammers were swung underhand to avoid any accidental hits to the wielder's head, and experimenters wore eye protection and hardhats (Figure 3.7A). Care was taken not to stand behind or around anyone using the hammers in case the hammerstones themselves or debris was sent flying. The two handheld hammers were wielded using one or two hands and struck against the basalt overhand (Figure 3.7B). Each hammer was used until sufficient wear patterns were

developed on the stones, usually signified by extensive chipping of the stones to the point where they were no longer useful as hammers.



(A) (B)
Figure 3.7: Handled hammer in use (A) and hand-held hammer in use (B)

EUH1 had internal flaws, and it broke into three pieces after only a few strikes against the basalt. As a result, no usable wear patterns were developed on that stone. The wooden handle and the rawhide binding for the handle were still intact and could be used again with a backup hammerstone. The handle was taken apart and a new stone was placed into it so that further testing with the handle could be carried out. The handle and rawhide were soaked overnight to make them pliable. A new stone was placed between the two halves of the handle and the rawhide strips were tied to secure the stone. Experimenters went back out to the same spot to test the new hammerstone on September 1st. Images of the hammers after use were taken to record the damage resulting from hammering. Drawings of the stones used in the experiment were made for comparison.

Chapter 4: Results

The hammerstone samples selected from the prehistoric collections were picked based on the general size and shape of each stone. Stones tended to be between 9 centimeters and 23 centimeters in length after material loss and were generally oval in shape, though irregularly shaped stones were present in every collection examined. After material loss, the stones ranged in weight from .9kg to 4kg but most were between 1.5kg and 3kg in weight. There was minimal difference in weight for grooved and ungrooved stones of similar size and material. Stones were also selected based on how much of the original stone was estimated to still be present. A stone that was less than 50% complete would not have yielded as much useful information and could have been pieces of the hammer and not the hammer core. Materials used in making the stones were mainly granite, basalt, diabase, and gabbro. The material CGH10 was made from could not be identified. The areas of the stones without strike wear present varied in smoothness based on the type of stone: basalt and granite tended to be smooth while stones made from gabbro and diabase had a rougher texture. Strike wear present on the hammers appeared in two different forms: 1) roughness from striking that resulted from repeated impacts slowly wearing away the ends of the stones and 2) chipping, ranging from small chips repeatedly removed from the striking ends of the stones to large pieces of stone that could stretch from one end of the stone to the middle or even the other end of the stone. Larger chips removed from the stone could be the result of internal flaws that existed in the stone before mining, flaws that developed over the course of mining, or from the concussive force of striking the mining surface. The primary striking ends of the hammerstones were the ones with the most strike wear present on the stone and the secondary ends were the ends with less strike wear. If each end had similar amounts of strike wear, the primary end was designated by the researcher as the right end. For the purposes

of this project, if a hammer had an end missing, the present end was labeled the primary end even if no strike wear was present. For the analysis of the stones when only one end was present, the present end was not treated as a primary end; instead discrepancies in material loss differences between primary and secondary ends were not recorded for stones with an end missing.

Experimental Hammerstones

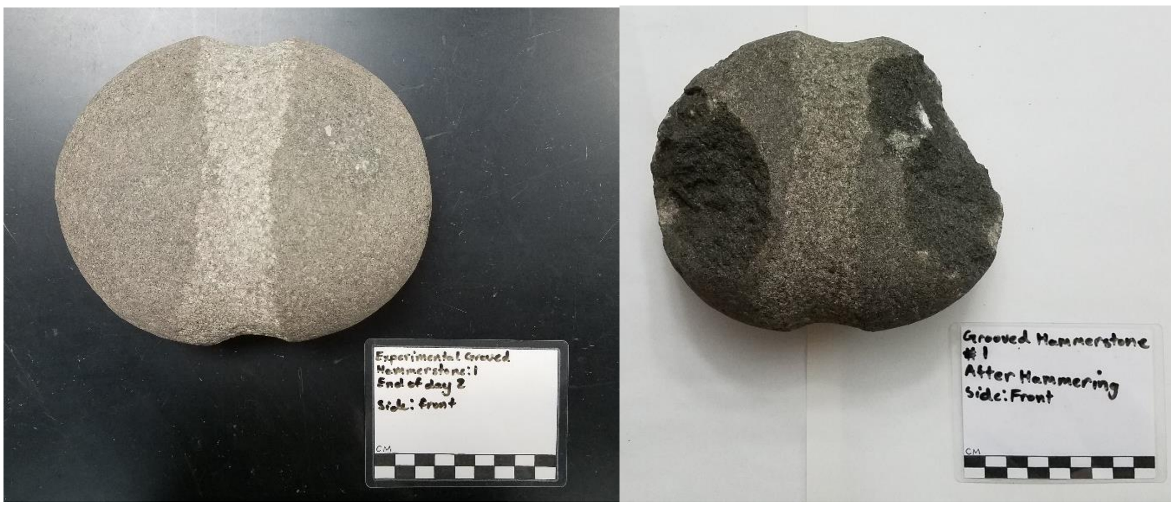
EGH1 and EUH2 were the two hammerstones with rawhide handles. EGH1 had an overall approximate material loss of 20% after use. The primary striking end of the hammer exhibited some form of strike wear covering between 51% and 75% of the hammering surface while the secondary end has strike wear on 26% to 50% of the hammering surface (Table 4.1).

Table 4.1: Material loss and strike wear in the experimental hammers

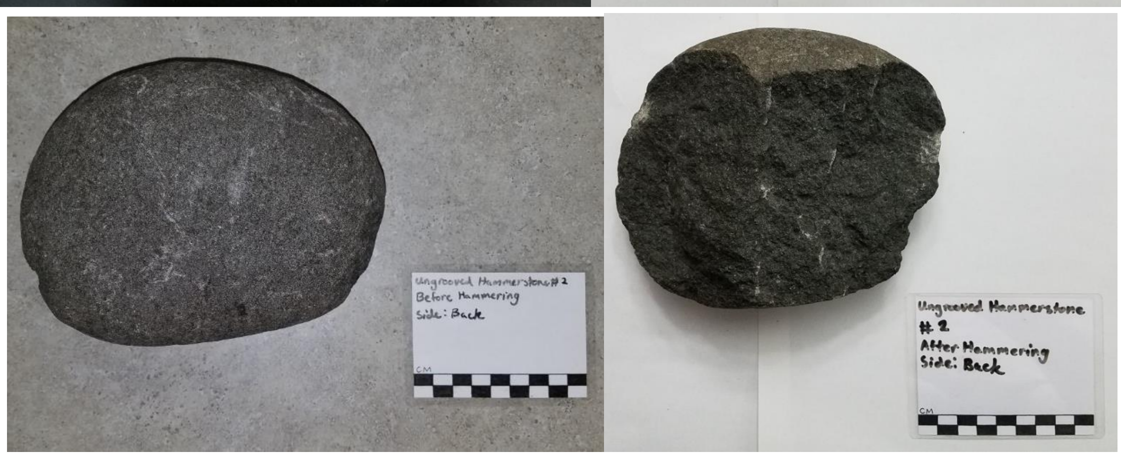
Hammerstone	% overall material loss	Ends present	% strike wear on the primary end	% strike wear on the secondary end	Difference in wear coverage between ends
EGH1	15-25%	Primary and secondary	51-75%	26-50%	26-50%
EGH2	26-35%	Primary and secondary	51-75%	26-50%	1-25%
EGH3	15-25%	Primary and secondary	76-100%	1-25%	51-75%
EUH1	26-35%	Secondary	N/A	0%	N/A
EUH2	36-50%	Primary and secondary	51-75%	51-75%	1-25%
EUH3	<15%	Primary and secondary	51-75%	51-75%	1-25%
EUH4	15-25%	Primary and secondary	51-75%	26-50%	26-50%

The majority of the chipping from hammering for EGH1 can be seen on the front of the hammerstone with minimal chipping seen on the back (Figure 4.1A). EUH2 had an overall material loss of approximately 40% to 45% after hammering. Both primary and secondary

hammering surfaces of EUH2 had strike wear covering 51% to 75% of the overall surface area (Table 4.1). The majority of the chipping from hammering seen on EUH2 is on the back of the hammerstone (Figure 4.1B). Chipping stretches from the primary end of the hammerstone to the secondary end and is responsible for nearly all the material loss that resulted from hammering.



(A)



(B)

Figure 4.1: Before and after images of EGH1 (A) and EUH2 (B)

Overall, the rawhide handles held up very well during hammering; on EGH1, the rawhide had to be soaked overnight to loosen it enough to remove it from the hammerstone and appears to have suffered no wear and tear as a result of hammering. The handle on EUG2 stayed on the hammerstone nearly as well as its grooved counterpart. The hammer could be taken out of the handle after the rawhide dried and before hammering with some wriggling and maneuvering of

the stone. Despite this, the handle held the stone quite well during hammering. The stone came out of the handle once during hammering but was placed back into the handle and hammering continued. The handle only failed completely when the stone lost too much material to fit securely into it. The handle itself suffered little to no damage. The rawhide from both handles could be soaked in water overnight and remade into new handles for stones or for some other purpose. Accurately hitting the same specific area on the rock used for simulating mining wear was difficult with the rawhide handles. The handles were pliable, which resulted in difficulty aiming. However, hitting in the general vicinity of the target area was possible and quite easy. The handles absorbed a significant amount of the impact force from striking, which resulted in less strain on the user's arms and hands.

EGH2, EUH1, and EUH4 were the three hammerstones paired with the wooden handles. EGH2 had an approximate material loss of 25% to 30% after hammering. The primary striking end of EGH2 had strike wear covering 51% to 75% of its surface while the secondary striking end had wear covering 26% to 50% of its surface (Table 4.1). Strike wear on the primary end of EGH2 was primarily chipping with minimal roughness from striking while the secondary hammering end had more equal amounts of chipping and roughness. Chipping from both ends of the stone extended toward the center and into the groove though the chipping from either end did not meet (Figure 4.2A). EUH4 had an overall material loss of about 15% to 20%. EUH4 had strike wear covering 51% to 75% of its primary striking end and 26% to 50% of its secondary striking end (Table 4.1). Chipping made up the majority of the strike wear on both ends of the stone with minimal roughness from striking. A large chip stretched across the front of the hammerstone toward the center from the primary striking end. No large chips came off the secondary striking end (Figure 4.2C). EUH1 cannot provide much information about how strike

wear patterns develop over time because it fell apart almost immediately after hammering began but it can provide information about what might have caused hammers from the Massee and Drier Collections to be missing ends (Table 4.1) (Figure 4.2B). The hammers could have fallen apart due to internal flaws that were not apparent until hammering began. The pieces of hammer could have still been utilized after breaking apart as handleless hammers.

(A)
(B)
(C)

Figure 4.2: Before and after images for EGH2 (A), EUH1 (B), and EUH4 (C)

Both wooden handles held up very well over the course of hammering, exhibiting minimal wear. The grooved hammerstone stayed more secure in the handle than the ungrooved hammerstone. Both hammers did come out of the handles but it was easier to wedge and secure the grooved stone back into the handle for further use than it was to put the ungrooved stone back into the handle. The ungrooved hammerstone repeatedly came out of the wooden handle and eventually hammering had to be stopped with it because it would not stay in the handle. Accurately striking the same spot on the rock repeatedly with the wooden handles was difficult but the rigidity of the handles did allow for slightly more accuracy than the rawhide handles. The handles also absorbed a significant amount of the impact from striking which resulted in less force travelling into the user's arms and hands.

EGH3 and EUH3 were the two hammerstones used without a handle. EGH3 had a material loss of approximately 15% to 20% after hammering while EUH3 had an overall material loss of approximately 10%. The primary striking end of EGH3 had strike wear covering 76% to 100% of its surface and the secondary striking end had strike wear covering 1% to 25% of its surface (Table 4.1). EGH3 had a large chip taken from the front of the stone that stretches toward the middle of the stone and just touches the groove (Figure 4.3A). Chipping makes up the majority of the strike wear seen on the primary end of EGH3 while roughness from striking makes up the majority seen on the secondary end. EUH3 had strike wear covering 51% to 75% of both the primary and secondary striking ends of the stone (Table 4.1). Chipping from striking makes up the majority of the strike wear on both ends of the stone but more roughness is seen on the primary end than the secondary end. Chipping stretches from both ends of the stone toward the middle of the stone but the chips do not meet or span the entirety of the stone (Figure 4.3B). The hand-held hammers were the most taxing on the hand because there was no handle to absorb

the impact from striking. On the other hand, they were easiest to accurately aim and the same spot could be consistently hit by the experimenters.

(A)
(B)

Figure 4.3: Before and after images for EGH3 (A) and EUH3 (B)

A difference of opinion about which hammerstone without a handle was easier to use arose between the two testers. One preferred the hammerstone without the grooving while the other preferred the one with the grooving. This difference in opinion could have resulted from multiple factors including placement of the groove, size of the groove, and size of the hammerstone. The ungrooved stone was smaller than the grooved stone and it was the preferred stone of the female tester because she found it easier to use. The size was more comfortable for her to manage and she liked that it did not have the groove. The male experimenter preferred the grooved hammerstone because the size of the stone was easier for him to manage and he felt having the groove improved his grip on the stone. While personal preferences did affect which

handheld hammerstones the testers preferred, both hammers could be utilized effectively by the experimenters. Personal preferences arose for handle type as well. The female experimenter preferred the wooden handles over the rawhide, despite how frequently EUH4 came out of the handle, because she felt the wooden handles allowed her to generate more force behind her swings with less effort than the shorter rawhide handles. She also felt that the wooden handles gave her more control over where the swing landed. The male experimenter preferred the rawhide handles because they were lighter and more mobile than the wooden handles.

The McDonald-Massee Collection

Sixteen hammerstones in the McDonald-Massee Collection were examined (Table 4.2).

Table 4.2: Material loss and strike wear in the Massee Collection

Hammerstone	% overall material loss	Ends present	% strike wear on the primary end	% strike wear on the secondary end	Difference in wear coverage between ends
MUH1	15-25%	Primary and secondary	76-100%	0%	76-100%
MUH2	26-35%	Primary and secondary	76-100%	76-100%	1-25%
MUH3	15-25%	Primary and secondary	76-100%	26-50%	51-75%
MUH4	26-35%	Primary and secondary	76-100%	1-25%	51-75%
MUH5	<15%	Primary and secondary	76-100%	26-50%	51-75%
MUH6	15-25%	Primary and secondary	76-100%	0%	76-100%
MUH7	26-35%	Primary and secondary	76-100%	26-50%	26-50%
MUH8	36-50%	Primary and secondary	76-100%	26-50%	26-50%
MUH9	36-50%	Primary and secondary	76-100%	0%	76-100%
MUH10	26-35%	Primary and secondary	51-75%	1-25%	51-75%
MUH11	15-25%	Primary and secondary	76-100%	51-75%	1-25%

MUH12	36-50%	Secondary	N/A	0%	N/A
MUH13	26-35%	Primary and secondary	51-75%	51-75%	1-25%
MUH14	15-25%	Primary and secondary	51-75%	0%	51-75%
MUH15	15-25%	Primary and secondary	76-100%	0%	76-100%
MUH16	15-25%	Primary and secondary	26-50%	0%	26-50%

One hammerstone had only about 10% missing. seven had between 15% and 25% of the estimated original mass missing, five of the hammerstones had between 26% and 35% of the overall mass missing, and three had about 36% to 50% missing; one appears to have cracked down the middle due to an internal flaw in the same way that EUH1 did during hammering. Seventy-five percent of the sample had between 15% and 35% of original volume missing; approximately six percent had less than 15% of their overall mass missing due to use, and nineteen percent had 35 to 50% of their mass missing (Figure 4.4).

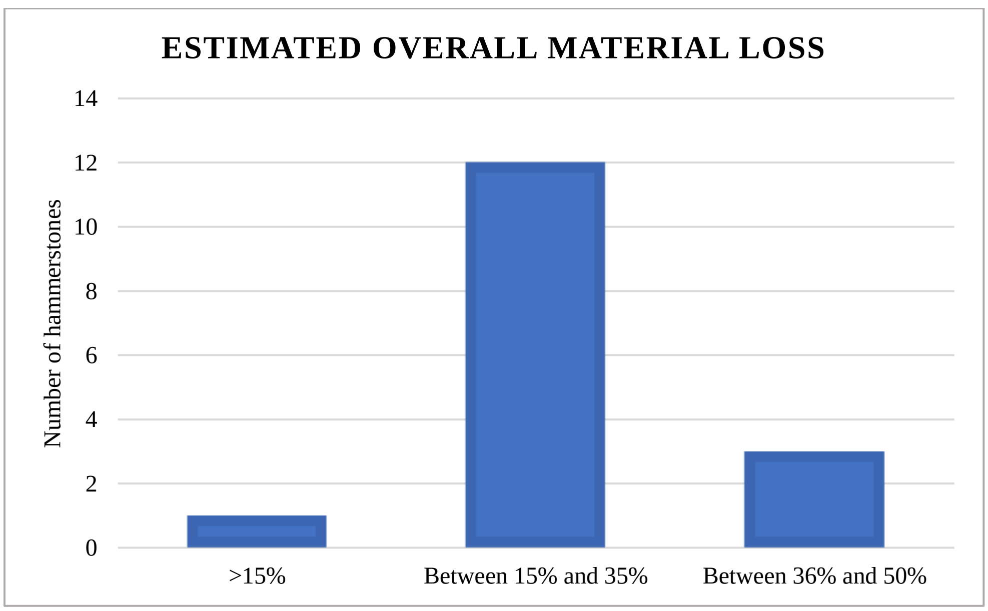


Figure 4.4: Estimated material loss for the Massee Collection

Fifty-six percent of the sample had some form of strike wear on both their primary and secondary ends, while forty-four of the sample had strike wear only on one end of the stone (Figure 4.5). MUH12 was missing its primary striking end but no strike wear was present on its remaining end.

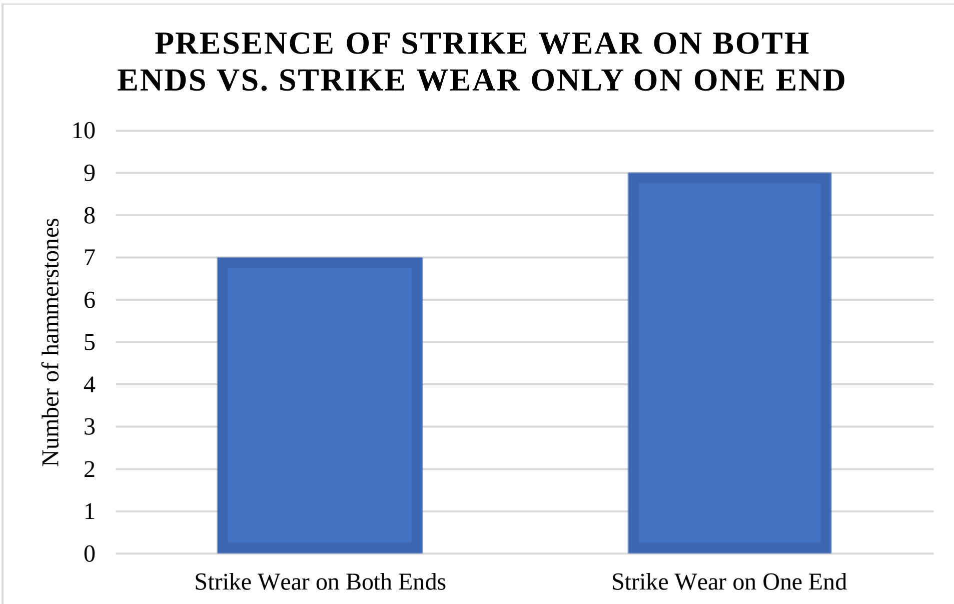


Figure 4.5: Percentage of hammerstones in the Massee Collection with strike wear on both ends vs. one end

Nineteen percent of the sample had a 25% or less difference in the amount of surface area worked between the primary and secondary striking ends. Nineteen percent of the sample had a strike wear difference of 26% to 50% between the strike wear on the primary and secondary ends of the stone; MUH16 had strike wear on only one end of it but strike wear only covered 35-45% of its used end. Thirty-one percent of the sample had a strike wear coverage difference between the primary and secondary ends of 51% to 75%, while twenty-five percent of the sample had a strike wear difference of 76% to 100% between the primary and secondary ends. All four hammerstones only had strike wear on one end of the stone. The strike wear difference between ends on MUH12 could not be determined because one end was missing (Figure 4.6).

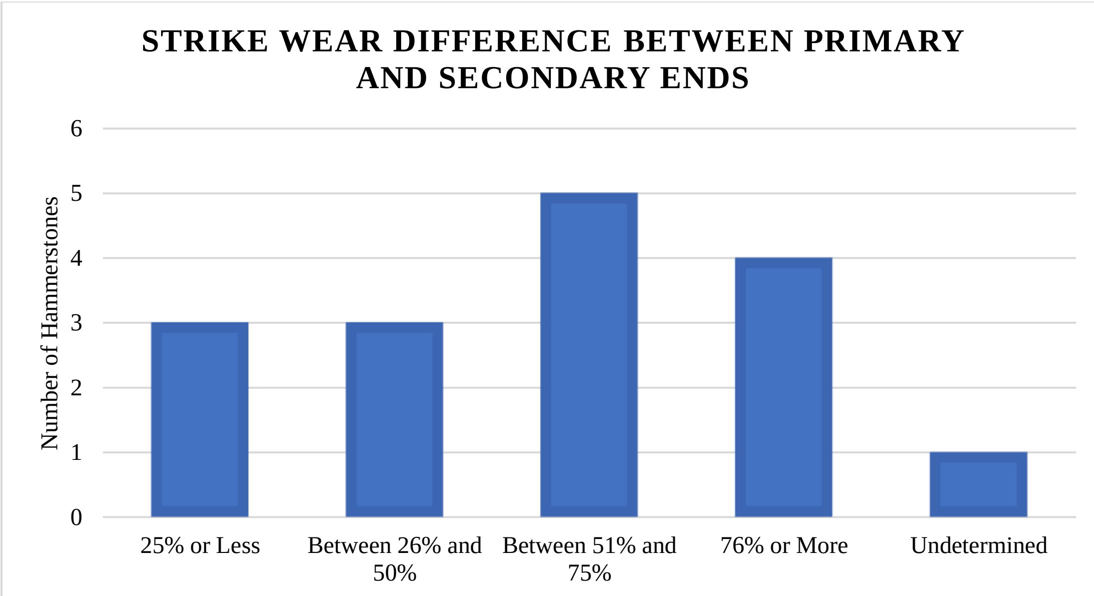


Figure 4.6: Strike wear differences between primary and secondary hammerstone ends in the Massee Collection

Approximately sixty-nine percent of the sample had strike wear covering 76% to 100% of the worked surface of the primary end of the stone, nineteen percent had strike wear covering 51% to 75% of the worked surface, six percent of the sample had strike wear covering 26% to 50% of the worked surface and strike wear coverage on MUH12's primary work surface could not be determined because one end was missing (Figure 4.7).

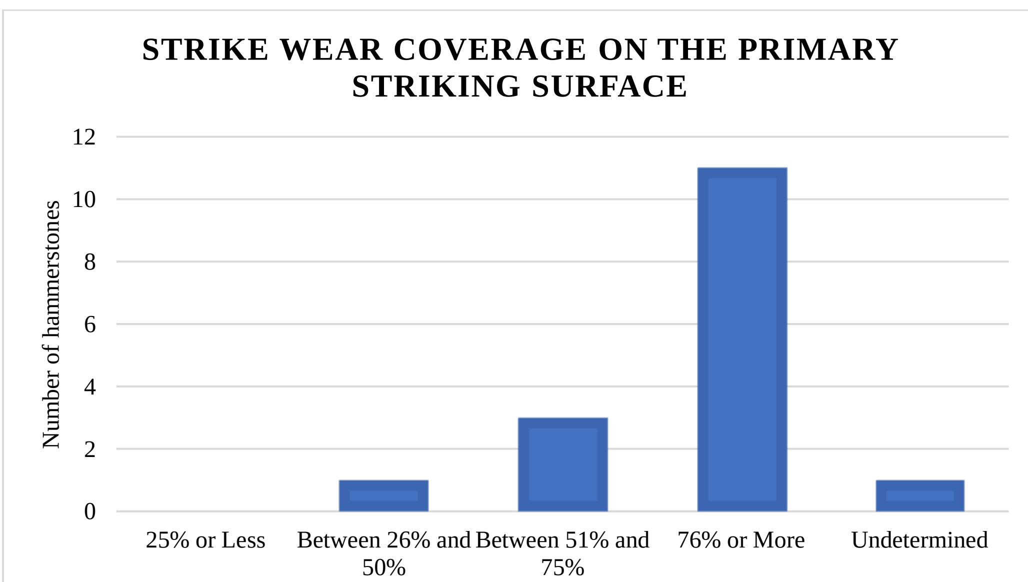


Figure 4.7: Percentage of strike wear coverage on the primary striking surfaces of hammerstones in the Massee Collection

Approximately seven percent of the sample had strike wear covering 76% to 100% of the secondary striking surface, twelve percent had strike wear covering 51% to 75% of the striking surface, twenty-five percent had strike wear covering 25% to 50% of the striking surface, twelve percent have strike wear covering 1% to 25% of the secondary striking end, and forty-four percent had no strike wear on the secondary end (Figure 4.8).

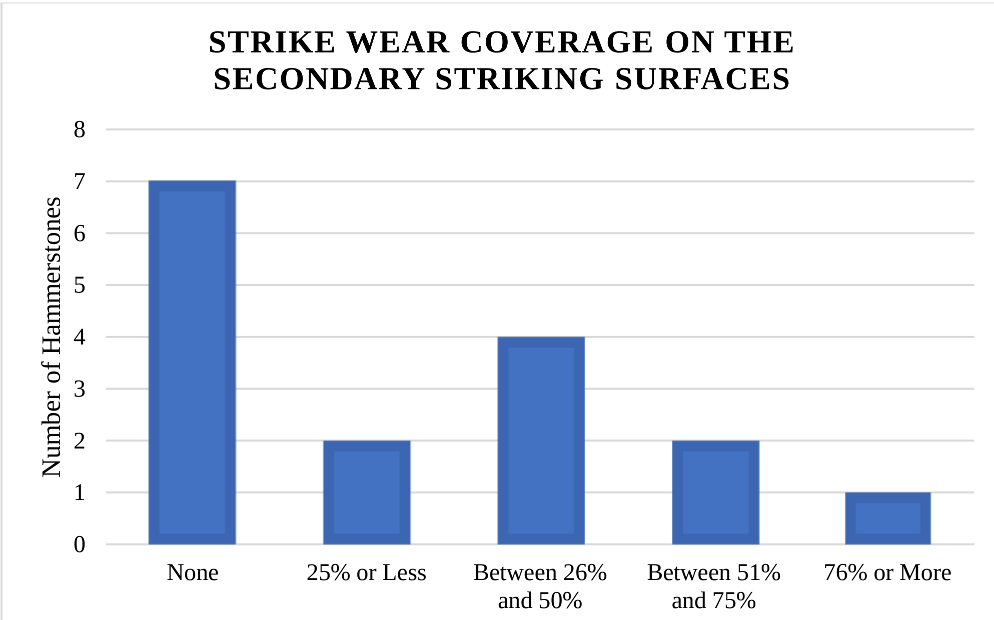


Figure 4.8: Percentage of strike wear coverage on the secondary striking surfaces of hammerstones in the Massee Collection

As a whole, the sample stones taken from the Massee Collection display strike wear on the primary and secondary ends of the hammerstones in the majority of the stones. However, the difference between the two halves of the sample is not startling, represented by only twelve percent, or two stones. Moreover, sixty-seven percent of the stones with strike wear on the primary and secondary ends only had wear covering less than 50% of the secondary surface. The sample appears to indicate that the hammerstones were primarily worked only on one end until that end became chipped to the point of reduced uselessness and was either discarded immediately or the secondary end was used for a little while before the stone was discarded. The stones could have also been discarded at the end of the mining season or for some other reason.

The majority of the hammerstones sampled from the Massee collection appear to be basalt, while three appear to be diabase or diabase/gabbro. The material the stones are made from does not appear to have played a part in wear pattern development.

The Roy Drier Collection

Seventeen hammerstones from the Roy Drier Collection were examined (Table 4.3); eighteen percent of the total sample have what appears to be evidence for some sort of modification while eighty-two percent of the sample exhibit no apparent modifications for use.

Table 4.3: Material loss and strike wear in the Drier Collection

Hammerstone	% overall material loss	Ends present	% strike wear on the primary end	% strike wear on the secondary end	Difference in wear coverage between ends
DUH1	<15%	Primary and secondary	26-50%	1-25%	26-50%
DUH2	<15%	Primary and secondary	26-50%	1-25%	1-25%
DUH3	26-35%	Primary and secondary	76-100%	76-100%	1-25%
DUH4	26-35%	Primary	1-25%	N/A	N/A
DUH5	15-25%	Primary	76-100%	0%	76-100%
DUH6	26-35%	Primary	1-25%	N/A	N/A
DUH7	15-25%	Primary and secondary	76-100%	26-50%	51-75%
DUH8	26-35%	Primary and secondary	76-100%	76-100%	1-25%
DUH9	26-35%		51-75%	51-75%	1-25%
DUH10	36-50%	Primary	26-50%	N/A	N/A
DUH11	36-50%	Primary	51-75%	N/A	N/A
DUH12	26-35%	Primary and secondary	76-100%	76-100%	1-25%
DUH13	36-50%	Primary	76-100%	N/A	N/A
DUH14	26-35%	Primary and secondary	76-100%	51-75%	26-50%
DGH1	<15%	Primary and secondary	26-50%	1-25%	1-25%
DGH2	36-50%	Primary and secondary	26-50%	1-25%	26-50%
DGH3	<15%	Primary and secondary	76-100%	76-100%	1-25%

DGH3 has a small notch pecked into the top of the stone that seems to have resulted in chipping down part of the stone. The second modified stone, DGH1, was somewhat triangular in shape width and height wise and notching was visible on the corners while DGH2 appears to have had a full groove pecked around the circumference of the stone but due to significant chipping this cannot be confirmed. DGH1 and DGH3 appear to have had an overall material loss of less than 15% and DGH2 had a material loss of 36% to 50%. Sixty-two percent of the ungrooved sample had an estimated material loss of 15% to 35%, fourteen percent had an estimated material loss of less than 15%, and twenty-four percent had an estimated material loss of 36% to 50% material loss. Thirty-six percent of the unmodified sample also appeared to have had internal flaws that resulted in one end of the stone breaking off from the larger body of the hammer (Figure 4.9).

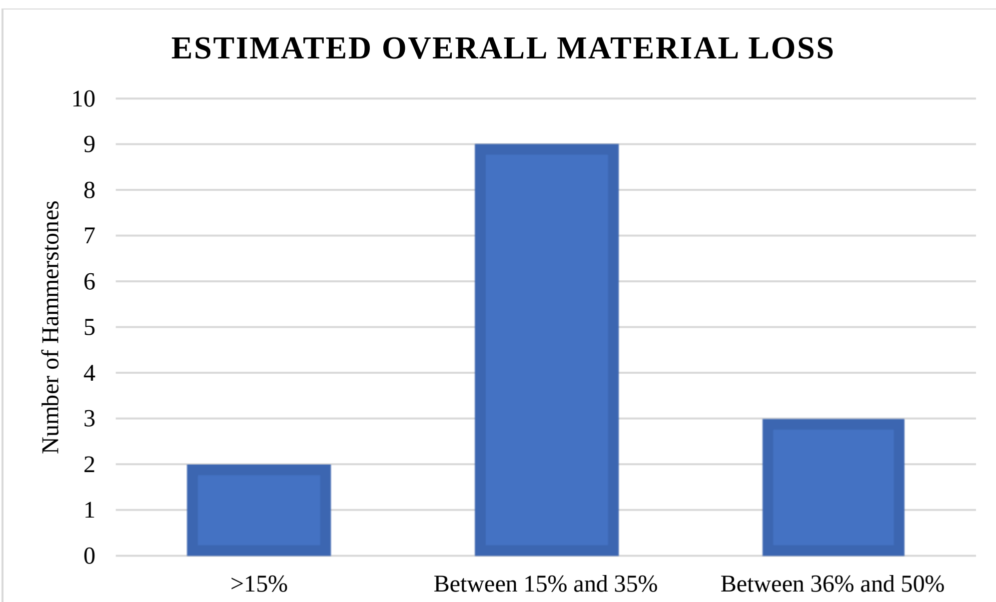


Figure 4.9: Overall estimated material loss for the ungrooved sample in the Drier Collection

All three examples of modified hammerstones from the Drier Collection have evidence of strike wear on the primary and secondary ends of the hammers. DGH3 exhibited less than a 25% difference in strike wear coverage on the primary and secondary ends of the stone and the

remaining two modified hammers had a difference of 26% to 50% in the amount of strike wear on the primary and secondary ends. On the primary end of DGH3, 76% to 100% of the striking surface showed wear while a similar amount of wear is seen on the secondary end. The primary ends of DGH2 and DGH1 display strike wear on 26% to 50% on their surface area. The secondary ends of DGH2 and DGH1 display strike wear on 1% to 25% of their surface areas. Thirty-five percent of the unmodified sample exhibits a 25% or less difference in the amount of strike wear seen on both the primary and secondary ends of the hammerstones; fourteen percent had a strike wear difference between 26% and 50%, seven percent had a difference between 51% and 75%, and seven percent had a difference between 76% and 100%. DUH5 had strike wear on only one end of the stone. Due to missing primary or secondary ends of five of the stones, determinations about the discrepancies between the amount of strike wear between the primary and secondary ends of those stones could not be made (Figure 4.10).

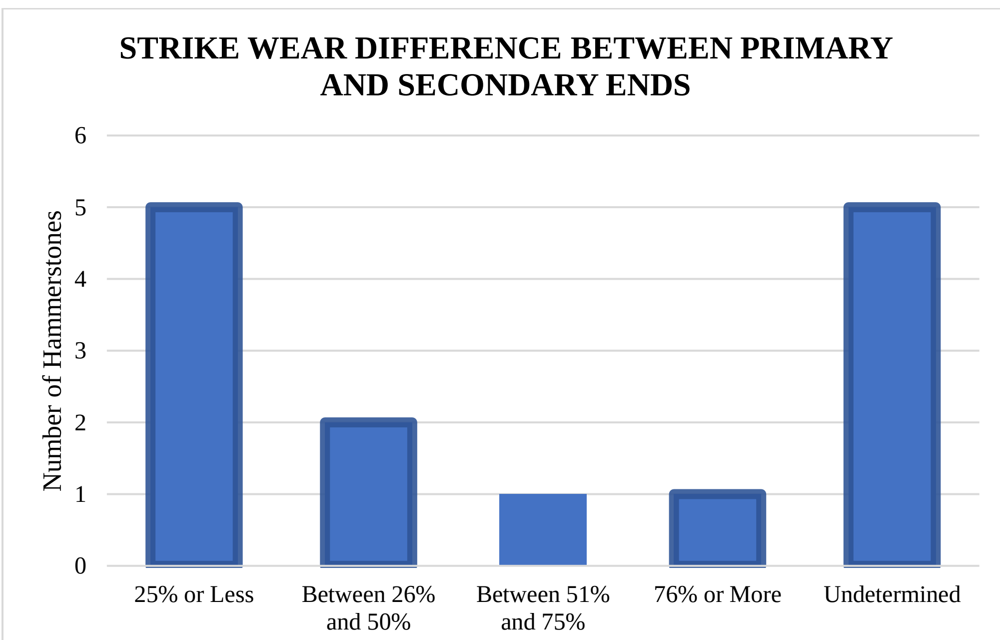


Figure 4.10: Strike wear differences between the primary and secondary hammerstone ends of the unmodified hammers in the Drier Collection

Fifty percent of the unmodified sample displayed strike wear covering 75% to 100% of what is assumed to be their primary working surface; DUH13 was missing an end. Seven percent displayed strike wear coverage of 51% to 75% of the primary work surface and seven percent displayed strike wear coverage 51% to 75% of the end present but, because the other end is missing, determinations about whether or not the present end was the primary end or merely a heavily worked secondary end cannot be made. Fourteen percent of the unmodified sample had strike wear covering 26% to 50% of their primary working ends and eight percent had strike wear coverage on 26% to 50% of the present striking surface but because the other end is not present determinations regarding whether the present end is the primary striking surface could not be made. Fourteen percent of the unmodified stones had strike wear on 1% to 25% of the striking surface of the only present end; the present ends may be the primary working surface if the stone broke almost immediately after utilization began but it is possible that the present ends are also the secondary ends that were used after the primary end fell away (Figure 4.11).

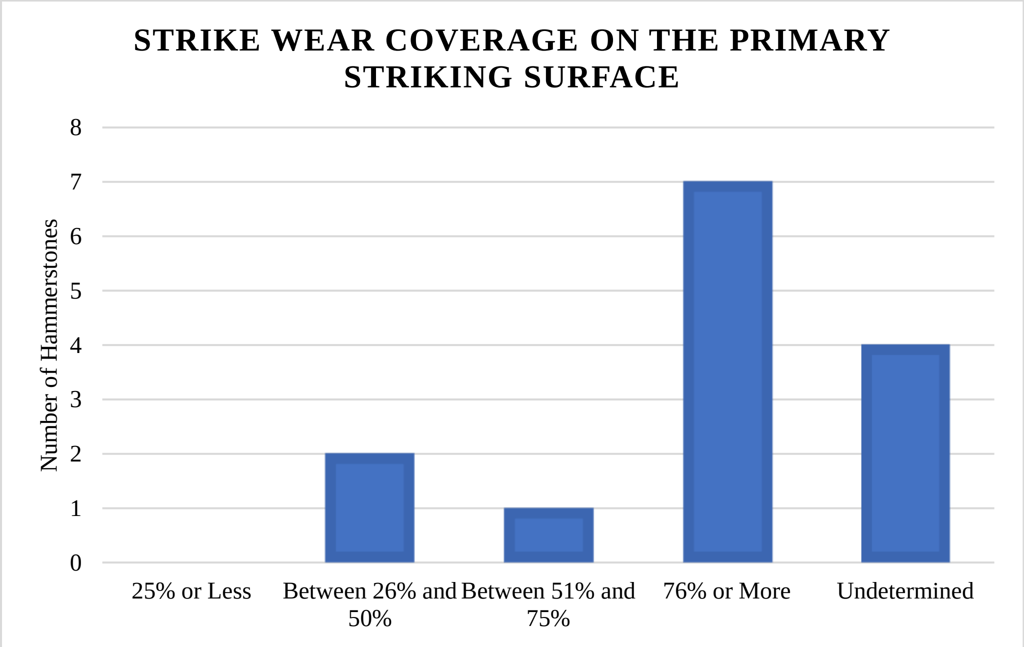


Figure 4.11: Percentage of strike wear coverage on the primary striking surfaces of unmodified hammerstones in the Drier Collection

Twenty-two percent of the unmodified sample had strike wear on the secondary end covering 76% to 100% of the striking surface. Fourteen percent had strike wear covering 51% to 75% of the striking surface of the secondary end and seven percent of the sample had strike wear covering 26% to 50% of the striking surface of the secondary end. Fourteen percent of the sample had strike wear covering 1% to 25% of the striking surface of the secondary end of the hammerstone, seven percent had strike wear only on one end of the hammer and thirty-six percent only had one end present (Figure 4.12). The hammers from the Drier Collection were largely basalt but a few were gabbro and diabase. The material did not appear to effect wear pattern development.

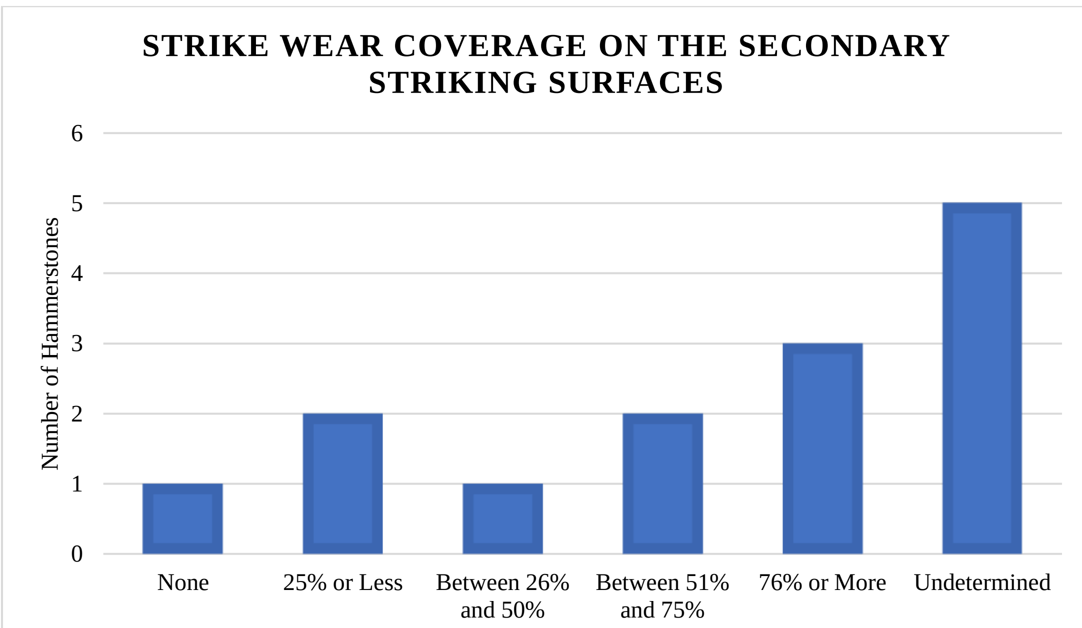


Figure 4.12: Percentage of strike wear coverage on the secondary striking surfaces of unmodified hammerstones in the Drier Collection

The Chynoweth Collection

Twenty-three hammerstones from the Chynoweth Collection were examined; seventeen of the hammers had modifications for use in the form of partial or full grooving and six hammerstones in total from the collection were not modified before use (Table 4.4).

Table 4.4: Material loss and strike wear in the Chynoweth Collection

Hammerstone	% overall material loss	Ends present	% strike wear on primary end	% strike wear on secondary end	Difference in wear coverage between ends
CGH1	<15%	Primary and secondary	26-50%	26-50%	1-25%
CGH2	<15%	Primary and secondary	26-50%	1-25%	1-25%
CGH3	26-35%	Primary and secondary	76-100%	76-100%	1-25%
CGH4	26-35%	Primary and secondary	26-50%	26-50%	1-25%
CGH5	26-35%	Primary and secondary	76-100%	51-75%	1-25%
CGH6	15-25%	Primary and secondary	76-100%	26-50%	26-50%
CGH7	36-50%	Primary and secondary	76-100%	76-100%	1-25%
CGH8	<15%	Primary and secondary	76-100%	51-75%	1-25%
CGH9	36-50%	Primary and secondary	51-75%	26-50%	26-50%
CGH10	15-25%	Primary and secondary	51-75%	1-25%	51-75%
CGH11	26-35%	Primary and secondary	76-100%	76-100%	1-25%
CGH12	36-50%	Primary and secondary	76-100%	51-75%	26-50%
CGH13	<15%	Primary and secondary	51-75%	26-50%	1-25%
CGH14	26-35%	Primary and secondary	51-75%	26-50%	26-50%
CGH15	<15%	Primary and secondary	76-100%	76-100%	1-25%
CGH16	36-50%	Primary and secondary	76-100%	76-100%	1-25%
CGH17	<15%	Primary and secondary	51-75%	51-75%	1-25%
CUH1	26-35%	Primary and secondary	76-100%	76-100%	1-25%
CUH2	15-25%	Primary and secondary	76-100%	26-50%	26-50%
CUH3	15-25%	Primary and secondary	51-75%	51-75%	1-25%

CUH4	15-25%	Primary and secondary	76-100%	76-100%	1-25%
CUH5	26-35%	Primary and secondary	76-100%	76%-100	1-25%
CUH6	26-35%	Primary and secondary	76-100%	51-75%	26-50%

One hundred percent of the unmodified sample had a material loss of 15% to 35%. Forty-seven percent of the unmodified sample had an estimated material loss between 15% to 35%, twenty-four percent had an estimated loss between 36% and 50% and twenty-nine percent had an estimated material loss that was less than 15% of the overall volume of the stone (Figure 4.13).

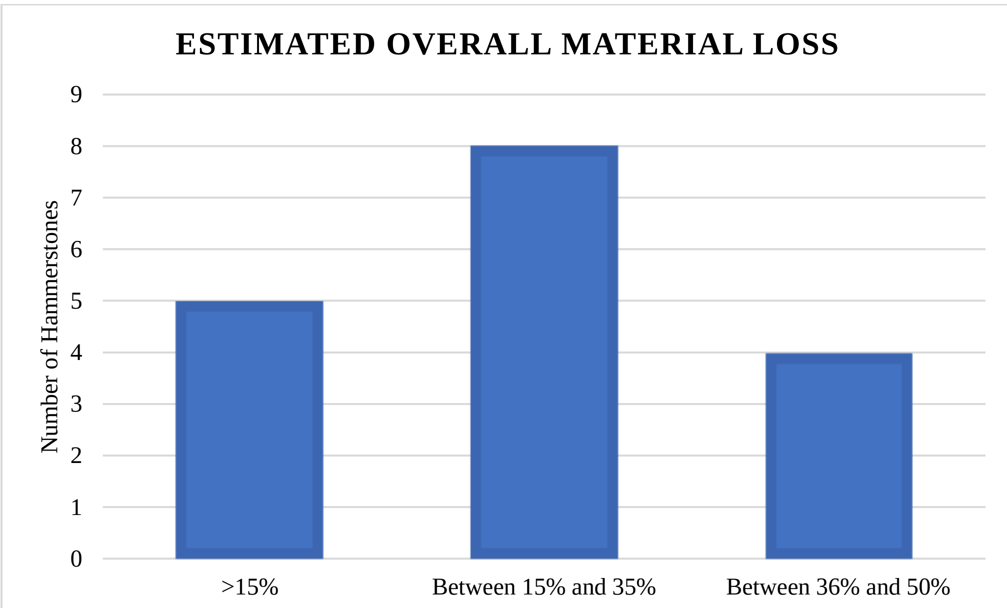


Table 4.13: Overall estimated material loss for the modified hammerstone sample in the Chynoweth Collection

Sixty-seven percent of the unmodified sample had less than a 25% difference between the amount of strike wear seen on their primary and secondary striking ends. Thirty-three percent had between a 26% and 50% difference in the amount of strike wear seen between their primary and secondary ends and seventy-one percent of the grooved sample had a difference of 25% or less in the amount of strike wear seen between the primary and secondary ends of the stones. Twenty-three percent of the modified sample had a strike wear difference of 26% to 50%

between their primary and secondary ends, six percent of the modified sample had a difference of 51% to 75% in the strike wear seen on its primary and secondary ends and every hammerstone from the Chynoweth collection had some strike wear on both their primary and secondary ends (Figure 4.14).

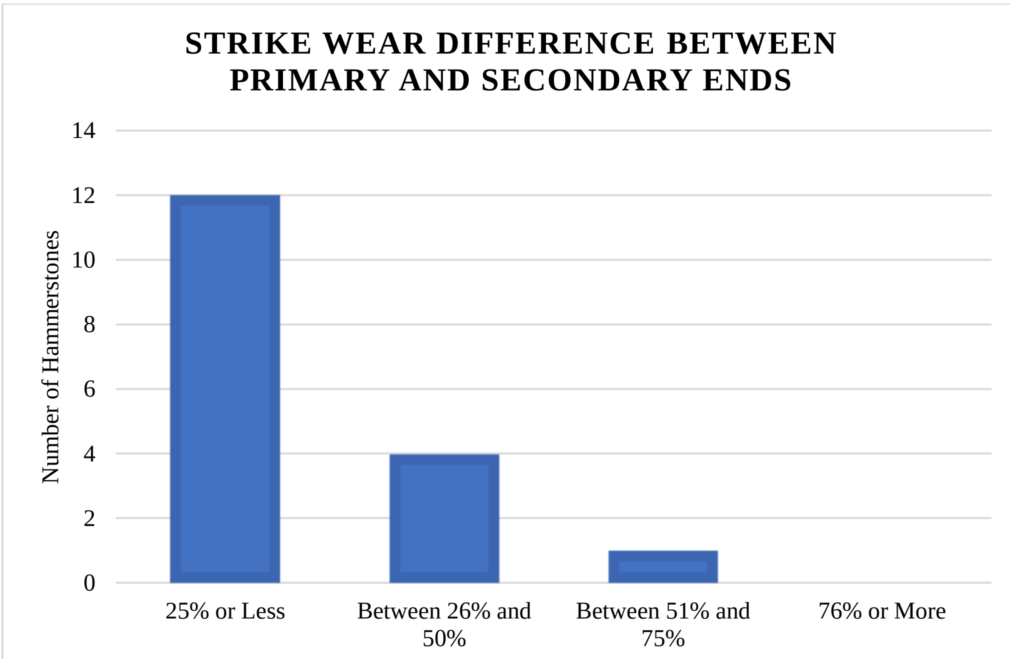


Figure 4.14: Strike wear differences between the primary and secondary ends of the modified hammers in the Chynoweth Collection

Eighty-three percent of the unmodified sample had strike wear covering 76% to 100% of their primary striking surface while seventeen percent had strike wear covering 51 to 75% of the primary striking end, sixty-seven percent had strike wear covering 76% to 100% of their secondary hammering surface, sixteen and a half percent had strike wear on 51% to 75% of the secondary hammering surface and sixteen and a half percent of the sample had strike wear covering 26% to 50% of the secondary hammering surface. Fifty-three percent of the modified sample had strike wear covering 76% to 100% of the primary striking surface, twenty-nine percent of the sample had strike wear covering 51% to 75% of the primary hammering surface,

and eighteen of the sample had strike wear covering 26% to 50% of the primary working surface (Figure 4.15).

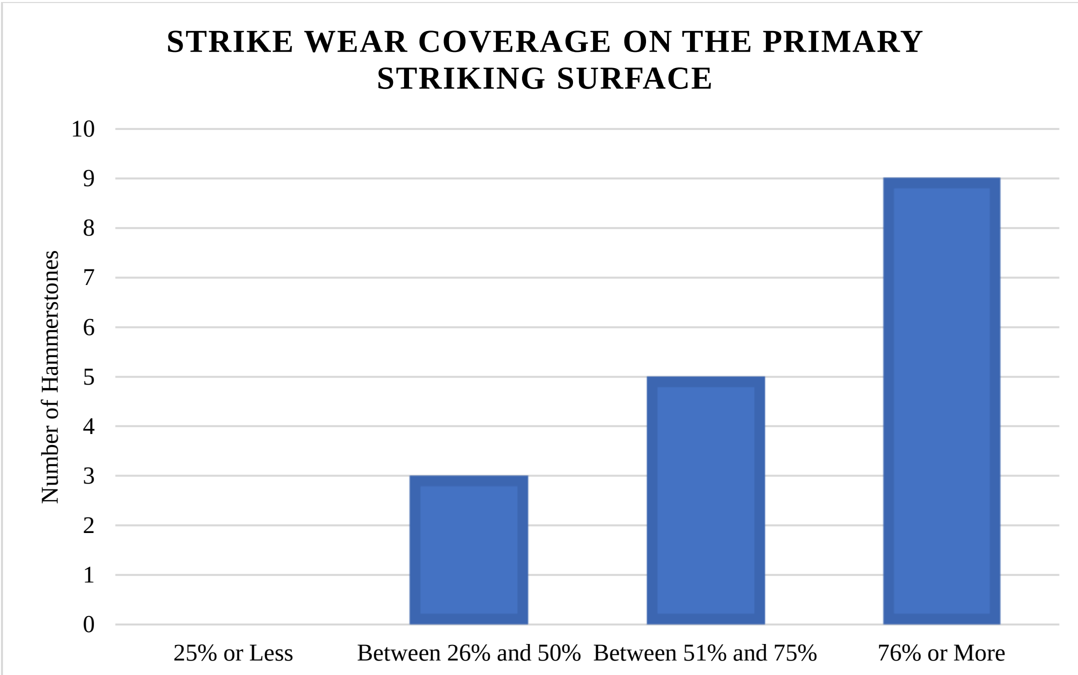


Figure 4.15: Percentage of strike wear coverage on the primary striking surfaces of modified hammerstones in the Chynoweth Collection

Twenty-nine percent of the modified sample had strike wear covering 76% to 100% of their secondary hammering surface, twenty-four percent of the sample had strike wear covering 51% to 75% of the secondary working surface, thirty-five percent had strike wear covering 26% to 50% of the secondary hammering surface, and twelve percent of the modified sample had strike wear covering 1% to 25% of the secondary hammering surface (Figure 4.16). The hammers from the Chynoweth collection were a mix of basalt, gabbro, diabase, and granite. As with the Massee and Drier Collections, material did not seem to effect the development of wear patterns.

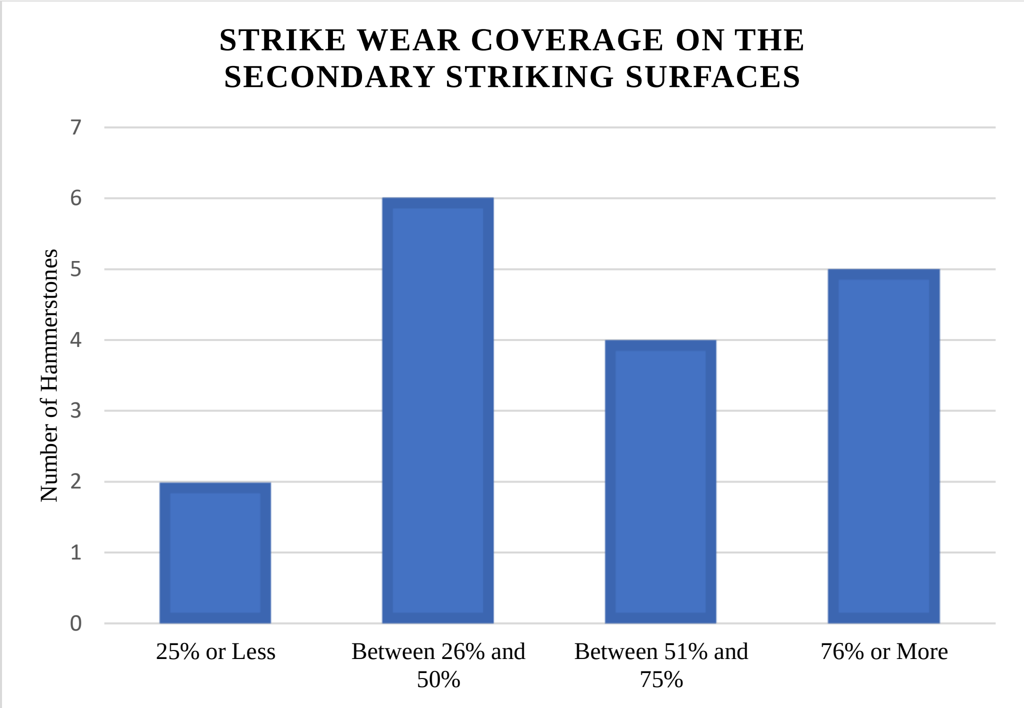


Figure 4.16: Percentage of strike wear coverage on the secondary striking surfaces of modified hammerstones in the Chynoweth Collection

In summary, material loss and strike wear coverage on the primary ends of the stones from each collection was similar. Most of the stones from each sample had a material loss between 15% and 35%. The majority of the strike wear coverage on the primary ends of the hammerstones was between 76% and 100% in all three collections. Presence of both ends of the hammers and strike wear coverage on the secondary working surfaces differed between collections. Hammers from the Massee and Drier Collections with both ends present had less strike wear on their secondary ends than the ones from the Chynoweth Collection. Several hammers from the island displayed no wear on secondary ends but every hammer studied from the peninsula had strike wear on both striking surfaces (Figure 4.17). Several hammerstones from the Isle Royale collections had ends missing as well.

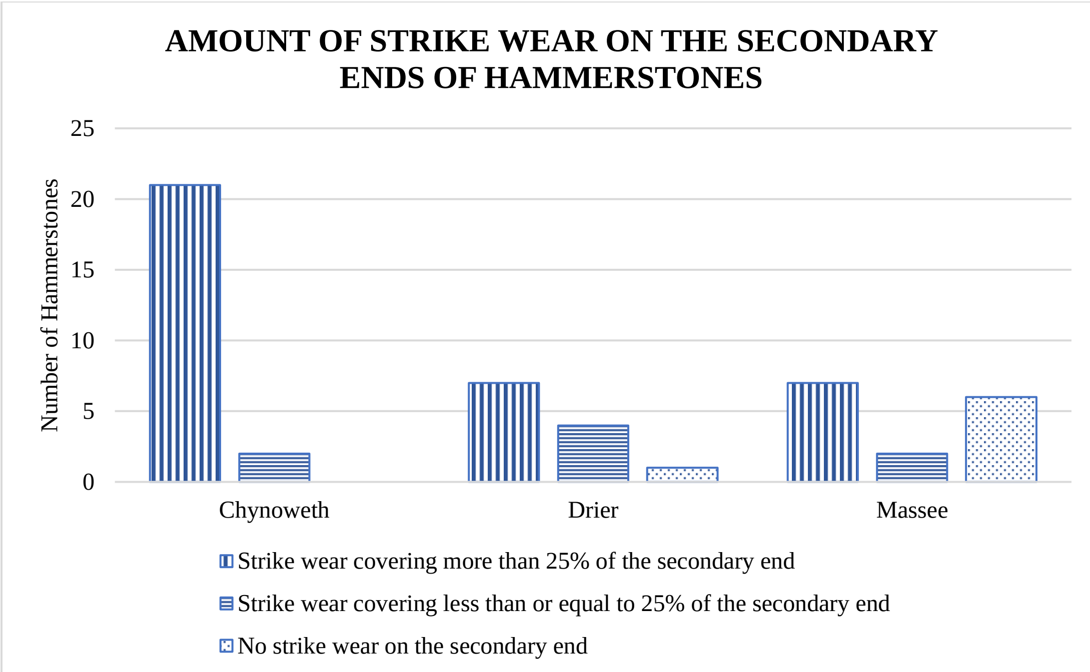


Figure 4.17: Amount of strike wear on the secondary ends of the total hammerstone sample with both ends present

Chapter 5: Discussion

Hammerstone Wear in the Collections

A pattern can be observed beyond the obvious difference in the frequency of modifications to the stones before hammering when the Isle Royale and Keweenaw Peninsula hammers are compared. Multiple hammers from Isle Royale appear to have lost their ends as a result of hammering. This could be due to internal flaws in the stones being aggravated over the course of hammering and may be a feature of the stone available on Isle Royale. Five hammers in the sample from the Drier Collection and one from the sample from the Massee Collection, all unmodified, are missing a significant portion of their overall mass but the surviving ends clearly exhibit strike wear. As stated in the previous section, material loss due to striking comes in two forms: chipping and roughness resulting from a wearing down of the striking surface from hammering. Striking breaks down the ends of the hammer over time by slowly crushing the striking ends into small pieces. Ends that have this form of strike wear are rough to the touch and can be relatively flat but there is no obvious breakage along the surface though chipping can occur on the same end (Figure 5.1A). Chipping from striking appears as pieces of the stone coming off over time and the chipped areas varies in size (Figure 5.1B).

(A)


(B)


Figure 5.1: Chipping from striking (A) and roughness from striking (B)

The chipping from striking builds up upon itself and layers of chips can be seen. The chipping also tends to develop an edge near the point of impact as material is percussed off across the body of the stone from one end to another (Figure 5.2). The majority of the stones studied from the three collections exhibit a combination of the two forms of strike wear seen on the ends of the stones still present. Many of the examples from the Isle Royale collections missing an end display little to no directional chipping radiating from the missing end that could account for so much material loss (Figure 5.3). Three hammers from the Drier collection have some additional chipping on the missing end but the chipping does not appear to be connected to the process of the end falling off beyond the fact that hammering resulted in aggravating flaws. The edges of the hammerstones missing ends are very similar in appearance to the experimental stone that broke apart due to internal flaws.

Figure 5.2: Edge as a result of percussive striking

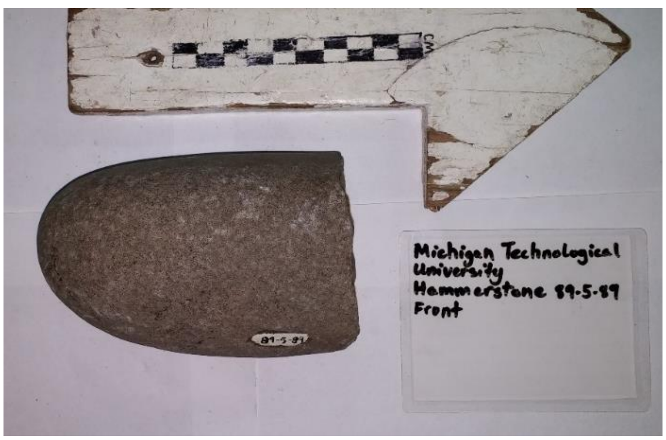


Figure 5.3: Hammerstone with end missing

No hammers examined from the Chynoweth Collection have ends missing in the same manner as the ones from the Isle Royale collections. This is likely due to the process of creating the grooving seen on most of the stones from the Keweenaw collection. The creation of the grooving acts as proofing for the rock. Repeatedly striking the hammers with smaller stones to

create notches or grooving in the stones probably would aggravate internal flaws in the rocks, causing them to break apart before hammering could begin. Because the sample of modified hammers from Isle Royale is so small, determinations about whether or not this pattern holds across the island cannot be made, but all of the modified hammers have both ends present. It is also likely that some of the unmodified hammers from the peninsula had ends break off due to internal flaws but because the sample in the Chynoweth collection is so small, none of the unmodified Keweenaw hammers display this feature. Hammers missing ends could have been subjected to selection bias during the collection process, accounting for the absence of this feature and the small number of unmodified hammers in the Chynoweth Collection.

Another difference between the hammers from the two geographic regions involves the amount of strike wear seen on the secondary ends of the stones. Only two of the hammerstones from the Chynoweth Collection, grooved and ungrooved, display strike wear coverage of 25% or less on the secondary striking ends and every hammer in the collection displays some strike wear on both ends (Figure 5.4C). In the Drier Collection, three of the nine unmodified hammers with both ends present have strike wear covering 25% or less of the secondary striking surface and one of the hammers has no strike wear on the secondary end. Two of the three modified hammers from the Drier Collection have less than 25% strike wear coverage on their secondary ends but each modified hammer does display some form of strike wear on both its primary and secondary surface (Figure 5.4B). Eight of the sixteen hammers examined from the Massee Collection display strike wear covering 25% or less of the secondary striking surface. Seven of those eight hammers have no strike wear on their secondary ends (Figure 5.4A). Many of the stones from Isle Royale appear to have been discarded after their primary ends became less

useful due to chipping. Alternatively, the stones may have been discarded because the mining season was over and the stones were not picked up the next season.

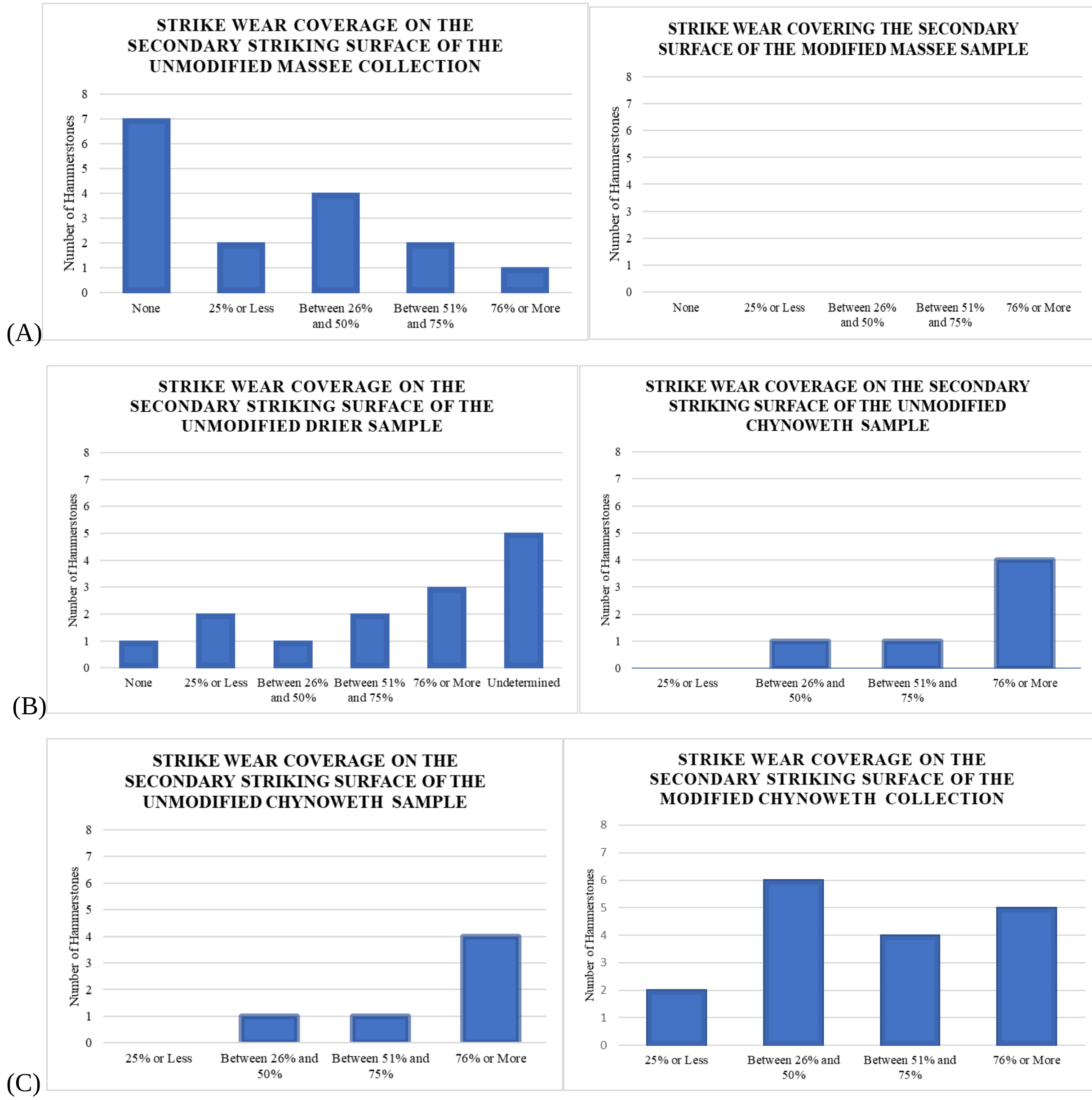


Figure 5.4: Strike wear on the secondary ends of the unmodified and modified samples from the Massee (A), Drier (B), and Chynoweth (C) collections

The primary striking surfaces of the hammers do not display significant differences in percentage of strike wear coverage across the collections. For the majority of the modified and unmodified

stones from each collection, strike wear covers 76% to 100% of the surface. No hammers have strike wear covering less than 25% of the primary striking surface (Figure 5.5).

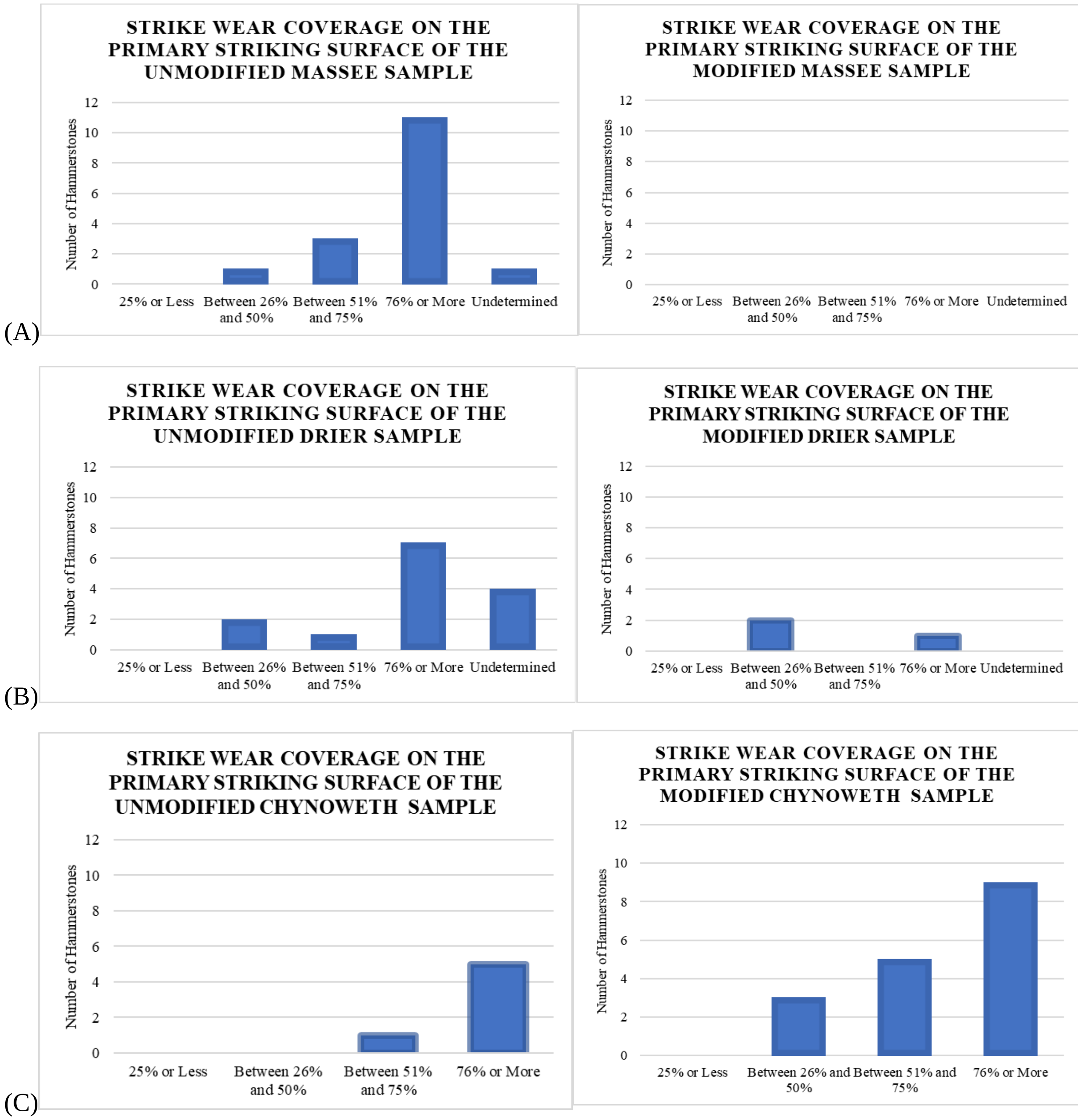


Figure 5.5: Strike wear on the secondary ends of the unmodified and modified samples from the Massee (A), Drier (B), and Chynoweth (C) collections

The difference in the amount of use seen on the secondary ends of the stones in both locations could have been due to a number of factors. One is that the supply of readily available

hammerstones was different in the two areas. On Isle Royale, rounded beach cobbles of the preferred size for the majority of the hammers seen in the collections could have been found in greater quantities near the mining sites. As a result, discarding a stone after one end was significantly broken down and finding a new one of similar size and shape would not have been difficult. On the peninsula, the sources of beach cobbles utilized by the miners were in areas that were not as close to the mines and thus they were a more scarce commodity during mining expeditions. This theory is supported by the unmodified hammers in the Chynoweth Collection, five of which have strike wear covering 51% to 100% of their secondary striking ends with only one with strike wear covering 26% to 50% of the secondary hammering surface. The unmodified hammerstone sample might be small but it does offer a nice contrast to the unmodified stones from the Drier and Massee collections. Nearly half of the unmodified stones from the Drier Collection with both ends still present have strike wear covering less than 50% of the secondary striking surfaces and twelve of the fifteen hammerstones from the Massee Collection with both ends intact have strike wear covering less than 50% of the secondary striking surface. Both hammerstone collections from the island were from the same mine but there is a possibility that hammerstones from other mines on the island without readily available sources of hammerstones had similar amounts of wear on both primary and secondary ends as the hammerstones seen from the Chynoweth Collection. Similarly, mines on the peninsula close to hammerstone sources may have less wear on the secondary ends of unmodified, or maybe even some modified stones, because miners could more easily acquire a new stone. Another possible explanation for this difference is that because the grooving on the stones took time to make, the grooved hammers had to be produced beforehand and a supply of them had to be built up and taken to the site. Grooved stones did not appear on the ground already modified,

someone had to make the modifications. The miners probably tried to get as much use out of the grooved stones as they could to maximize the time and energy invested in making the grooved hammers. Thus the secondary end was used more consistently on the Keweenaw hammerstones to maximize the amount of use from those stones. A third possible explanation for this difference is that it was a stylistic change over time. It is nearly impossible to date the hammerstone collections because the bulk of the collections were surface finds. Hammerstones in the same collection could have been made and used thousands of years apart. As a result, the grooved hammerstones from the Chynoweth and Drier collections may be a different age than the unmodified stones found in all three collections. Moreover, different groups were mining on Isle Royale and in the Keweenaw. Modified and unmodified hammerstone traditions could represent cultural/ethnic differences in the mining populations visiting the sites over time. In areas with a scarcer supply of hammerstones, both ends of the stone would have been used as long as possible to get the most utility out of a single hammer. The modified stones were the result of hours of time and energy investment, so the miners would have wanted to use those stones as long as possible, despite the availability of unmodified cobbles, so they would only have to create a minimum number of grooved stones. Temporal and cultural distance may have played a part in modification and use wear differences as well.

Implications of Experimental Hammerstone Wear Results

There was no significant difference between the strike wear seen in the hammerstones paired with the rawhide handles, EGH1 and EUH2, and the hammerstone paired with the wooden handle that was not frequently knocked out of the handle during hammering, EGH2. EGH1 and EGH2 both had an overall material loss of between 20% and 30%, EGH1 having slightly less material loss than EGH2. EUH2 had the most material loss of the three, 40% to

45% of its original volume. EGH1 and EGH2 exhibited chipping largely across the front of the stone and minimal chipping on the backs of the stone. The primary striking ends of the stones have strike wear covering 51% to 75% of the primary striking end and strike wear covering 26% to 50% of the secondary hammering ends. Both hammers display the two types of strike wear discussed previously in this section. EUH2 had strike wear covering between 51% and 75% of the primary and secondary hammering surfaces, making it the experimental hammerstone with the most strike wear. EUH2 and EGH1 display the most and least amount of strike wear, respectively, of the handled hammerstones most viable for mining. EGH2 exhibits an amount of material loss midway between the two other stones. Because the handled hammers with both the least and most amount of wear were paired with rawhide handles, there does not appear to be much difference in strike wear development and material loss as a result of handle material. However, the sample size of experimental hammers was small and further testing might result in pattern development specific to each handle type. While EUH4 did develop wear patterns, the stone exhibited the least amount of wear of the stones with handles, excluding the stone that broke immediately upon use, because it was the most inconvenient hammer to use. The stone had an overall material loss of between 10% and 15%, the primary striking end has strike wear covering 51% to 75% its surface, and strike wear covered between 26% and 50% of the secondary striking surface. The hammer had less material loss than the other three handled stones and less chipping on the body of the stone was seen when compared to the others.

There was some difference in wear level on hammers with handles and hammers without handles. The hammers without handles had an overall material loss of between 10% and 20%, which is not all that different from the handled stones, but the chips that came off the hammers without handles were smaller on average than the chips that came off the handled hammers.

Chipping did compound on itself so that the final material loss appeared similar to the handled stones, making it difficult to distinguish between the two types. With the handled hammers, large chips eventually fell off the stone as whole pieces. The resulting material loss appears similar to material loss that resulted from hammering with handles. An interesting observation derived from using the handheld hammers was that experimenters did alter the ways they held the hammers without handles as the hammers broke down. As one hammering end disappeared, the researchers were forced to move their hands back along the stone or switch from a two-handed grip to a one-handed grip. Eventually the end used for hammering had to be switched. When the secondary end of the stone was used, holding the stone was slightly more difficult because the body of the stone had already been shortened. Holding the stone by the primary hammering end was unpleasant due to the broken nature of that end. Having a more difficult time holding the hammers made hammering with the secondary ends more difficult and made researchers less inclined to work with that end. It was possible to continue to work with the secondary striking end especially if the user had some sort of hand protection. The larger handheld hammer had an advantage over the smaller stone when the secondary end was used because there was more stone to hold onto even when it broke down. This particular phenomenon may account for some of the hammerstones having less wear on their secondary hammering ends as opposed to their primary ends.

For the experimental stones, amount of strike wear on the primary and secondary ends was determined more by how long the hammer was used and how it broke down than by what material was used for the handle or if it had a handle at all. If large chips came out of the stone, it eventually became too broken to stay in the handle and had to be discarded. Holding the broken end of a stone made it more difficult to handle and that could have resulted in the

hammer being discarded as well. Patterns seen in the three collections may result from the ways in which the hammerstones were utilized in addition to scarcity of resources, temporal differences, and cultural differences. The sample size used for the experiment was small, however. Seven hammerstones does not appear to be enough to illustrate significant differences between hammerstones with different handle types and between hammerstones with handles and hammerstones without handles. Multiple variables could account for the differences seen between the collections. Moreover, only two handle styles were tested. Other handle styles may be more effective than the ones used for this experiment and could result in different patterns.

Handle Performance and Summary of Results

Both rawhide handles held the grooved and ungrooved stones quite securely during hammering, though the ungrooved stone came out once, and performed the best overall in terms of striking the rock face and holding onto the stone. The rawhide handles could generate more than enough force to aid in mining fire-cracked rock and were the safest handles for both grooved and ungrooved stones. When hammering with the rawhide handles, researchers could hammer with one end repeatedly until it broke down and became less useful before switching to the secondary end. The wooden handles performed less well than their rawhide counterparts. The grooved stone stayed in the handle fairly well if it was monitored. Researchers had to repeatedly switch hammering ends when it looked like the force of hammering was knocking the stone loose. Switching hammering ends for a few hits recentered the stone so that researchers could go back to using the primary striking end for a time before having to repeat the process. It did come out of the handle but could be wedged securely back into the handle so that hammering could continue. When hammering was switched primarily to the secondary end, the same process had to be used. For the ungrooved stone paired with the wooden handle, the stone was

knocked loose much more frequently than the grooved stone with the wooden handle making it difficult to hammer with it. A similar hammering process was used for the ungrooved wooden handled stone as was used with the grooved wooden handled hammerstone. If the stone looked as though it was coming loose the striking end was switched in an attempt to recenter the stone. Without the grooving around the stone to catch the wood and help secure the stone in place, it did not work as well. Eventually hammering with the ungrooved stone became too difficult to continue.

Both handle material types held up well over the course of hammering. The rawhide handles were very durable. After drying, the rawhide did not stretch during the process of hammering despite initial fears that this could be a possibility. There was also minimal wear and tear on the rawhide after hammering. The lack of wear could be attributed to the acceleration of the development of wear on the hammers due to hammering against an unfired rock face but it could also hold up well in the long term. Further experimentation should be carried out. The wooden handles themselves did hold up well over the course of hammering but as with the rawhide handles, this could be attributed to acceleration of wear development. Moreover, the grooved stones worked better for both handle types when compared to their ungrooved counterparts. The groove caught on the split pieces of wood and held the stone in place until hammering eventually knocked it lose and, because of the groove, after drying the rawhide looped around the hammerstone shrunk to a size too small to slip over the stone. Grooved hammerstones performed better than the ungrooved stones in terms of use with handles. Rawhide could be easily used to make handles for both grooved and ungrooved stones. The style of wooden handle used for the experiment worked with the grooved hammerstone but was

not well suited to the ungrooved hammers. Other styles of wooden handles may perform better when paired with ungrooved stones.

To summarize, there appear to be more regional or temporal differences between hammerstones from Isle Royale and the Keweenaw Peninsula than differences between hammers with different handle styles or hammers with or without handles. Isle Royal hammerstones have a higher probability of having significantly less or no wear on the secondary end of the hammerstone. Isle Royale hammerstones also have a higher probability of missing one end of the hammerstone, likely as a result of internal flaws being aggravated by hammering. Keweenaw hammerstones have more equal amounts of wear on their primary and secondary ends and none of the hammerstones studied from the Chynoweth collection appear to have had an end fall off. However, collection bias could have played a part in the selection of hammerstones. Rawhide handles did not produce wear patterns on hammerstones that differed significantly from those seen on hammerstones paired with wooden handles. The style of rawhide handle used for this experiment performed better overall than the style of wooden handle. Grooved hammers performed better with both handle types than the ungrooved handles. There was also no significant difference between the wear patterns that developed between the hammerstones with handles and those without. The sample size of experimental hammerstones was small, however, and more investigation must be carried out before conclusions can be drawn about whether or not different types of handles result in different wear patterns on hammerstones.

Implications for Future Research

Further experimentation and study of Lake Superior Basin mining hammerstones should take place in order to generate a more accurate picture of the patterns seen in prehistoric mining

equipment from the area and to determine how it compares to hammerstones from other areas of the world. The three hammerstone collections studied for this thesis contained a significant number of hammerstone specimens but the two Isle Royale collections were from one mine and the Keweenaw collection came from one peninsula mine. Mining took place in many areas around Isle Royale and the Keweenaw and additional hammerstone collections that can be authenticated and placed as originating from specific areas in the Lake Superior Basin should be studied. How do the patterns identified in the Drier and Massee Collections and in the Chynoweth Collection compare to other collections from the Keweenaw Peninsula and Isle Royale and how would an expanded sample from the larger region compare to the results presented here? The hammerstone sample studied for this report was quite small when compared to the total number of hammerstones in each collection. Studying a wider range of collections will help determine if the patterns observed in the Drier, Massee and Chynoweth Collections hold across multiple areas in the Keweenaw and on Isle Royale or if different patterns emerge between areas in the wider region. The Isle Royale National Park Service houses a hammerstone collection comprised of stones from the island and there are likely other collections in other museums and institutions. Moreover, comparisons between mining hammerstones from different regions of the United States and between the United States and other areas of the world would offer insight into how mining technologies and extraction techniques of copper and other resources differed from each other. The Ontario Archaeological Museum has a collection of hammerstone specimens that may have been used for pre-contact mining, for example. If the collection contains mining mauls, these should be examined and compared to the Isle Royale and Keweenaw hammerstones. Comparing hammerstone collections that were used for different types of mining, metallurgical mining as opposed to flint mining or mining on different types of

source material, for example, could result in the discovery of distinct patterns on different types of mining tools as well as stylistic differences in the development of the tools used for mining.

Experimental Research Directions

Research into the hammerstones themselves and different types of handles needs to be expanded in the experimental realm as well. The sample size for the experimental hammerstones was small. Seven hammerstones in total were used, three grooved and four ungrooved, and five were paired with some sort of handle. The sample was enough to get an idea of differences in the development of wear between hammerstones with and hammerstones without handles but there was not enough of a sample size to determine if different types of material for handles resulted in different patterns. Only two types of material were used to develop handles, rawhide and hardwood. The handles may have been made of other materials available to prehistoric miners. Experiments utilizing more materials, such as different types of wood or fibrous materials, for handles should be developed to determine if other materials or softer woods work better for handles than the materials used in the experiment. Different types of handle styles should be tested as well. A cobra knot was used to create the rawhide handles because it offered the possibility of pulling the central cords of the knot to tighten the sling around the stone if it stretched. The rawhide did not stretch so this feature was not necessary for the handle design. Other methods of constructing rawhide handles may be just as effective as the one used in the experiment or may work better. Different handle constructions may also result in longer handles using the same amount of rawhide which could make the handles slightly easier to use. The strips of rawhide used in the experiment were also fairly thick, close to an inch in width before drying. Thinner strips of rawhide might be just as effective as the thicker strips with the added benefit of maximizing the number of usable strips that can be taken from a hide. The wooden

handles used in the experiment worked alright when paired with the grooved hammerstone but the design failed when paired with the ungrooved stone. Using a different design for the wooden handles may make them better suited for use when paired with both grooved and ungrooved hammers so that they perform on a similar level to the rawhide handles. Changes to the wooden handle might include using more rawhide strips to lock the stone in place or to wrap around the arms of the handle to create a surface more resistant to slippage. Using a softer wood may also make bending the handle around the stone easier. A handle with the wood bent around the stone, when paired with rawhide to secure the handle, might be a better technique for securing the stone than the design used in this experiment. Further experimentation may also reveal that wooden handles are not well suited to being paired with ungrooved hammerstones no matter the design of the handle or the amount of rawhide used to secure it.

Only one size range of hammerstones was examined over the course of this project despite evidence of hammers that range from less than 8cm to upwards of 38cm in length being used by prehistoric miners. In the Chynoweth Collection, grooved stones that appear to be hammers are found that are much too large to be wielded easily by one person. These larger hammers might have been used as wrecking ball equivalents to help loosen large quantities of material at once and smaller more precise hammers would then be used to target and strike specific areas. The large hammers were probably suspended using some sort of sling, as there seems to be no other practical way to have used them, but what the hammers were then suspended from is not known. Were the slings slung over the shoulder of one of the miners, as they were in the Lewis experiment in 1990, or were the stones suspended from some sort of built structure like a bipod? Experiments should be conducted using larger hammerstones in order to determine what their role might have been in prehistoric copper mining and how the larger

hammers might have impacted the rate or process of mining. Hammers smaller than the ones studied for this project do appear as well, both grooved and ungrooved. The use of smaller hammers may have been merely a personal preference for some of the miners, such as the personal preferences that arose between the two experimenters during the process of hammering, or younger miners may have used the smaller stones because the larger ones were not easy for them to use. The possible implications for the organization of labor, including the presence of women and children, in connection with the smaller stones remains to be explored. Ethnographic sources from other areas of the world indicate that it was probably not only men who traveled on a seasonal basis so the Keweenaw Peninsula and Isle Royale to mine copper, but this remains to be tested (Kowarik et al. 2012). Smaller hammerstones might have also been useful in confined spaces where larger stones were impractical. Experiments should be conducted looking at circumstances where different sized hammerstones might be utilized.

The hammerstones used in this project were not used on fire-cracked basalt and were instead used on unfired basalt. The lack of fire-cracked material accelerated the development of wear on the hammers and as a result, measurements about how long it took wear patterns to develop and for a stone to wear down may not be consistent with prehistoric use. The durability of handle materials could not be accurately measured due to this. As a result, any estimations about reusing handle materials for multiple stones may not be accurate despite the condition of the experiment materials. Experiments should be conducted on fire-cracked rock to see how long handle materials last if the stones do not break down as quickly as they did during this project. The handle materials may prove to be durable and may be able to be used with multiple stones but it is equally likely that the handle materials might only be viable for one or two hammers. Moreover, the length of time one hammerstone could have been used while mining

cannot be determined based on this experiment alone. Fire-cracking makes basalt more brittle than basalt that has not been superheated. As a result, less force is needed to break apart the rock being mined and the hammers would likely be less prone to rapid chipping and wear. The stones would probably last much longer on a fire-cracked rock face than the ones used for this experiment. Testing the length of time needed to wear down hammerstones when using them on fire-cracked basalt would give archaeologists a better idea of how long one stone could be used and how many stones might be needed for over a given mining season depending on the size of the project being undertaken. A project investigating wear development on hammerstones used on fire-cracked basalt could be paired with an experiment exploring other aspects of fire-cracking as well.

Conclusion

This project set out to answer three research questions. Is it possible to determine whether or not hammerstones used in pre-contact copper mining had some form of hafting or handle? If the stones did have hafting, is it possible to tell what type of hafting was most likely used? Can experimental replication provide new insights into the question of copper extraction before European contact in North America? Three hammerstone collections were examined: the McDonald Massee Collection, the Roy Drier Collection and the Ben Chynoweth Collection. Both the Massee and Drier Collections came from the Minong Mine on Isle Royale while the Chynoweth Collection came from a prehistoric mine that was destroyed by later European industrial mining operations near Ontonagon, MI in the Keweenaw Peninsula. Results regarding whether or not studying wear patterns on hammerstones could indicate a hammer had a handle or not were inconclusive. Possible regional or temporal differences between hammerstones from Isle Royale and the Keweenaw Peninsula became apparent during the analysis of the three

different hammerstone collections. The most obvious difference between the Isle Royale and Keweenaw collections is that Keweenaw hammerstones are more likely to have modifications made to them before use in the form of full or partial grooving around the center of the stone. However, other differences between the hammers from the two regions were noted. Hammers collected from Isle Royale were more likely to display instances of lost ends, likely as a result of hammering aggravating flaws in the stones that were not obvious to the miners when the stones were picked up for use. The hammerstones in the Keweenaw sample do not display this trait. Keweenaw hammerstones were largely modified for use by the creation of grooves around the center of the stone. The process of making the grooves in the stone could have aggravated internal flaws in the stones before hammering began, causing the stones to break apart before hammering even started. Further study and experimentation need to take place before definitive conclusions can be drawn.

Another difference that emerged in the comparison of the hammerstone collections was that Isle Royale hammerstones have a larger probability of significant differences between wear seen on their primary and secondary ends than Keweenaw hammerstones. Isle Royale hammerstones appear to have been largely discarded after their primary striking ends broke down and had reduced utility. Secondary ends were used but the strike wear seen on the secondary ends was on average lighter than the primary ends. Multiple hammerstones from the island displayed no strike wear on their secondary ends and appear to have been discarded in favor of a fresh stone when the user decided the primary end had been depleted. Hammers from the peninsula on average exhibit fewer differences in the amount of strike wear seen on their primary and secondary ends. There are several possible explanations for the differences observed in strike wear of the primary and secondary ends on hammerstones from the island and

the peninsula. One the availability of hammerstones near the mining sites. The area around the Minong Mine may have had a more readily available supply of beach cobbles suitable for use as hammerstones at or near the mine while the prehistoric mine associated with the Chynoweth Collection may not have had an easily accessible supply of potential hammerstones. Another reason for the difference may be the forethought and planning needed to create a supply of grooved stones for use as hammers. Creating grooving in the hammers required time and energy investment by the miners that merely grabbing a stone off the ground to use did not. As a result, miners would have tried to get as much use out of a hammer as they could before discarding it. The presence or absence of grooving may have been the result of temporal distance between when the unmodified hammers were made and used and when the modified hammers were made and used. The presence or absence of modification also could have been the result of differing hammerstone traditions between the two regions. Because the hammerstones were surface collected, there is no way to be sure of the time periods during which they were used or if all the hammerstones in one collection were used around the same time period. Most likely, a combination of availability of hammers, the energy investment that went into creating the modified hammers, and temporal differences in when the hammers were used resulted in the regional differences seen in strike wear.

Seven hammers were constructed in order to examine what kind of wear patterns would develop with or without handles made of rawhide and wood. Three of the experimental stones were grooved and four were not. Rawhide from a deer and hardwood saplings from the Keweenaw were used to create handles for the hammerstones. Hammerstones with and without handles were repeatedly struck against unfired basalt in order to simulate mining. After hammering was complete, wear on the experimental hammers was compared to the

hammerstones in the collections studied. With a sample size of seven experimental stones, there was not enough data to definitely determine if distinct wear patterns develop as a result of different materials used for hammers or if definitive patterns develop between hammers with and without handles. During the mining process, larger chips came off the handled hammers than came off the handheld hammers but the chipping on the handheld hammers eventually built up on itself to the point where the wear looked similar to handled hammers. In terms of usability, the rawhide handles performed better than the wooden handles. The rawhide held onto the grooved handle very well after it dried and the stone never came out of the handle. The rawhide held onto the ungrooved stone well and it only came out of the handle once but could be placed back into the handle for further use. The wooden handle worked fairly well with the grooved stone but the stone did come out of the handle. With both types of handles, hitting the same precise spot on a surface was difficult though the same general area could be struck accurately. The handled hammerstones had an advantage over the handled stones in that they could be wielded more accurately. The handled hammerstones had an advantage in that they offered the user the ability to generate more force behind a strike than the handheld stones. The ungrooved stone came out of the wooden handle repeatedly, which made it impractical for use as a mining tool. Only two styles of handle were tested during the experiment and more handle styles should be tested before conclusive determinations about what kind of handles may have been used with Lake Superior Basin hammerstones can be drawn.

Copper mining and copper working have been a significant part of Lake Superior Basin history for thousands of years. Rich deposits of native copper can be found throughout the region lodged within the abundant basalt flows in the area. The oldest known examples of worked copper from the area are over 7,000 years old. The indigenous populations utilized

pieces of float copper to create tools and ornaments for use within their society and for trade goods. Later populations began to mine copper as the demand for the material increased over time. Production of copper ornaments and tools increased over time in as mining and trade networks expanded further across the present day United States. Camp sites near mines indicate that miners processed the extracted copper and lived in the area while mining occurred. Copper extraction was an activity that both men and women, even children, would have been able to do. The more labor present to aid in the extraction process and to support the miners, the more successful an operation would have been. The indigenous populations in and around the Lake Superior Basin utilized copper up until the historic period, at which time European metals were introduced to the area. Many of the prehistoric mines found in the Keweenaw were destroyed after European industrial mining operations began. Prehistoric mines on Isle Royale largely escaped destruction, though industrial mining operations did destroy several there. Surviving mines on the island and on the peninsula can tell archaeologists about the activities and processes that went into mining and that occurred around the mines. The tools used by preindustrial miners in all areas of the world are similar to each other and the study of these mining remnants can tell archaeologists quite a bit about the processes and social systems required for this activity to be successful. Comparisons of regions with evidence for preindustrial mining will allow archaeologists to identify similarities between how different cultures developed their mining practices as well as the differences that developed.

Through studying prehistoric mines from the Lake Superior Basin, the associated activity sites, and material remains left behind, archaeologists can piece together what kind of investment mining was for the first copper miners in the region. Preindustrial copper mining on the scale seen in the Lake Superior Basin would have been an intensive activity. Miners would have

planned in advance both in terms of material and the amount of work that could be done before the harsh winter weather began to set in. Copper mining in the region was very much a seasonal activity both in the Keweenaw and on Isle Royale because of the harsh winters of the Lake Superior Basin. Through studying intact mine sites archaeologists can learn what kind of activities occurred in and around the mines. Mining itself, processing copper, tool construction for mining, and other non-mining related activities, would have taken place around the mines and by studying the area, archaeologists can build a picture of how the miners lived and worked when they came to mine copper. Studying the tools and techniques used for mining, both in the context of how they relate to the other artifacts, ecofacts, and features found at sites and in terms of experiments to gauge the practicality of the tools/processes used and to better understand the time and energy investment that went into mining, helps archaeologists build a more complete picture of the ways of life of Lake Superior Basin prehistoric copper miners. Comparisons between the tools and techniques used for prehistoric mining in the Lake Superior Basin region and in other areas of the world can also help archaeologists build a more complete picture of the lives of miners across the world and develop a more complete picture of regional differences that arose while utilizing similar techniques and tools. The copper miners of the Keweenaw Peninsula are one of the groups that can contribute to that effort, as this thesis has demonstrated.

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Image Sources

Figures 1.1& 3.2:

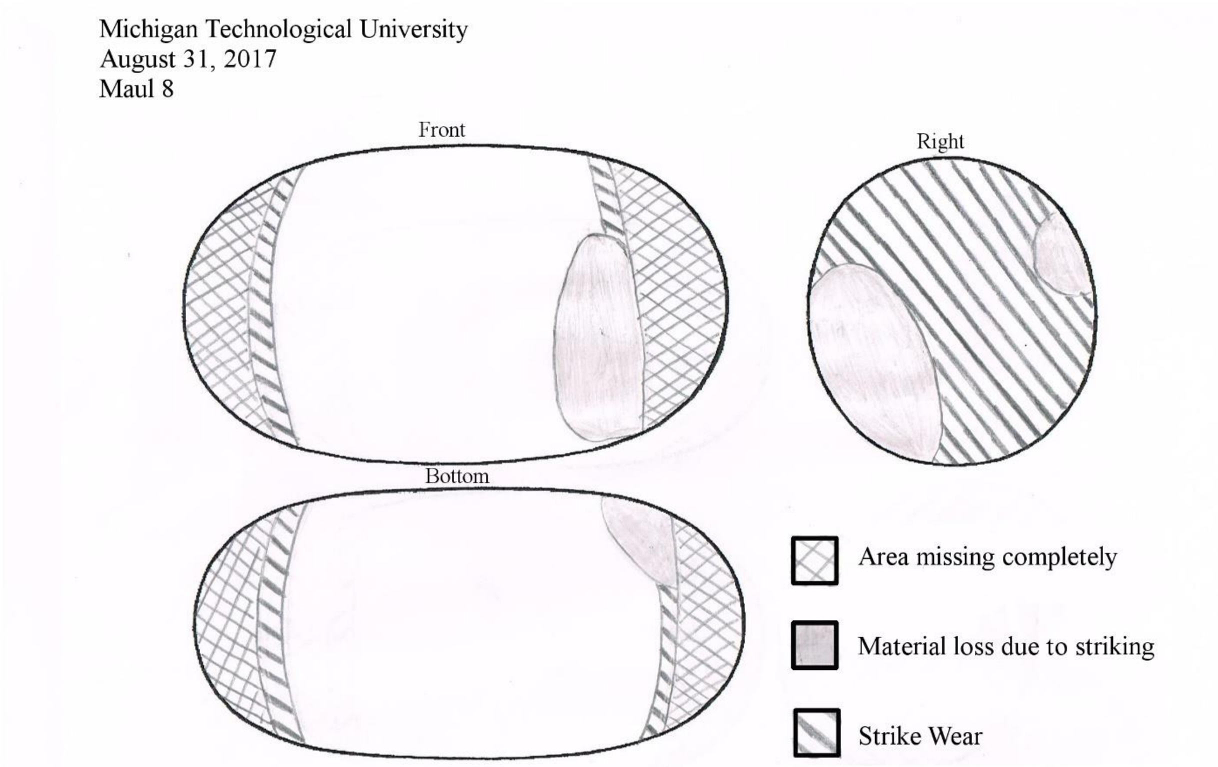
Google Maps. 2017. California: Google Inc.

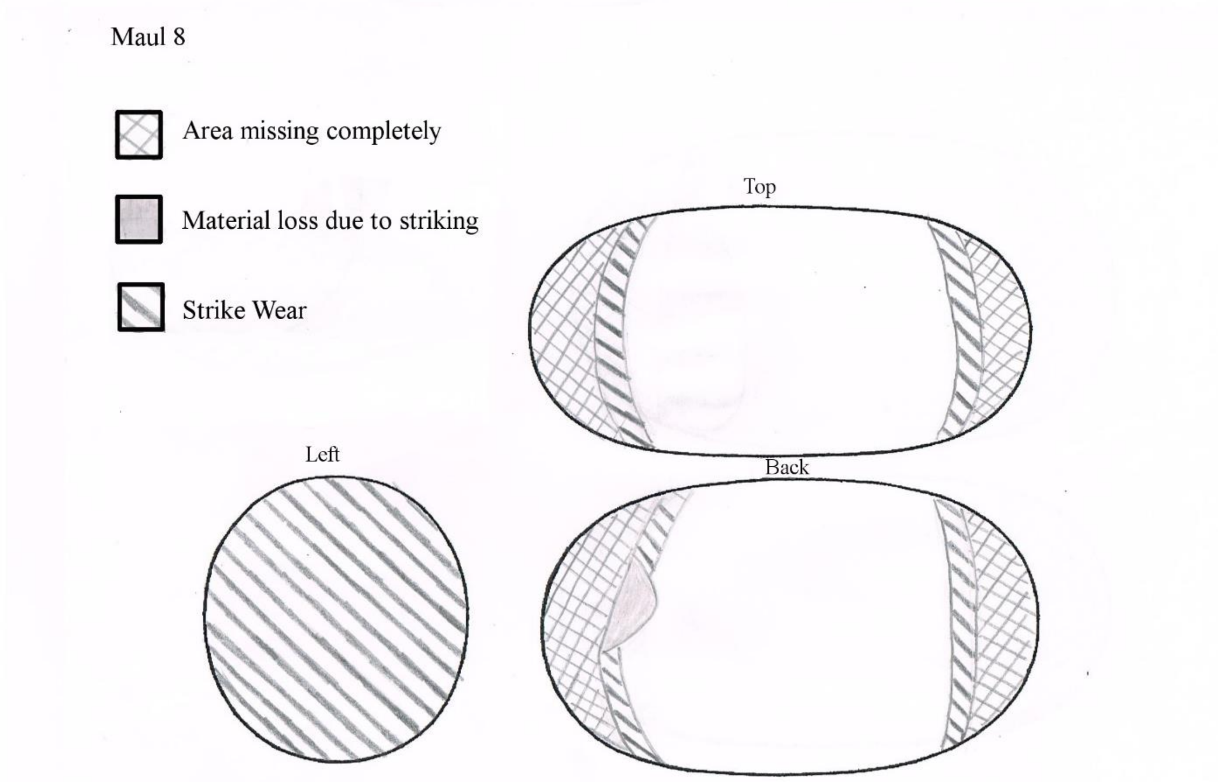
Figure 2.1:

Schaetzl, R. 2017. Michigan’s Copper Deposits and Mining. East Lansing: Michigan State University.

Appendix A: The Chynoweth Collection

Chynoweth Collection Maul 8—CUH1





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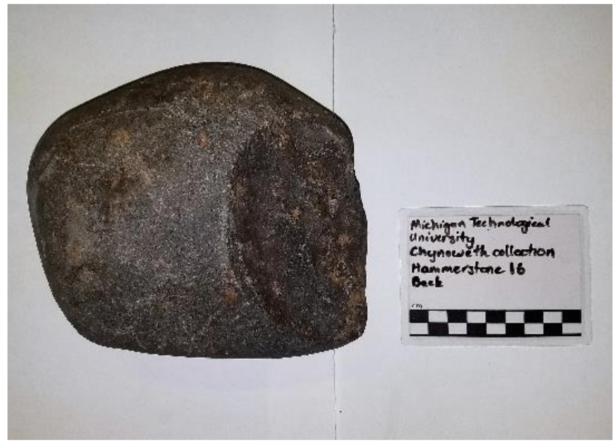

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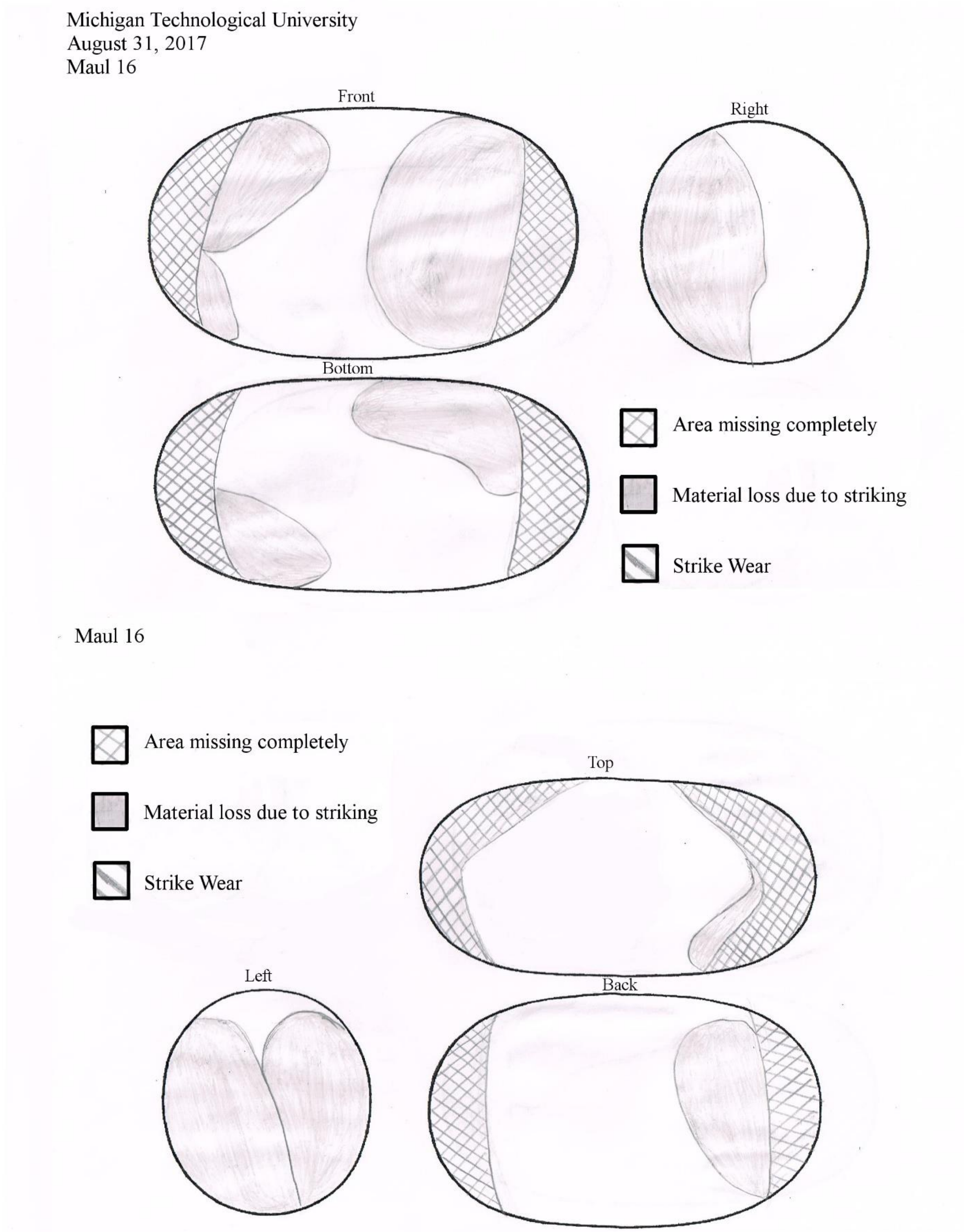

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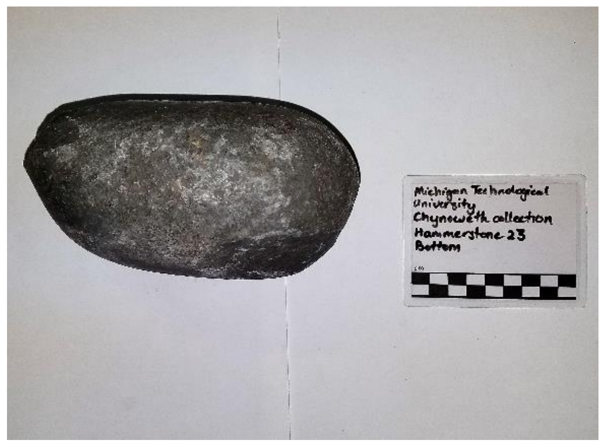

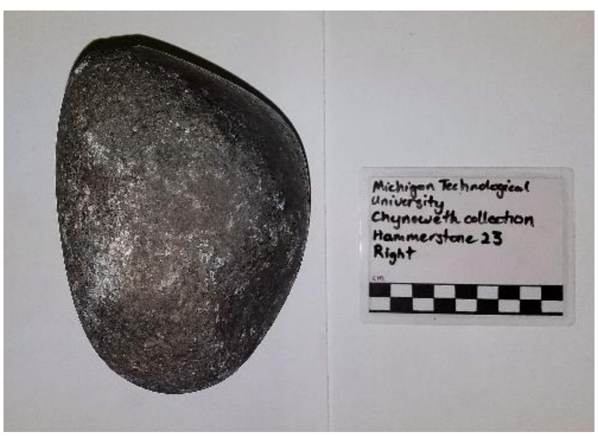

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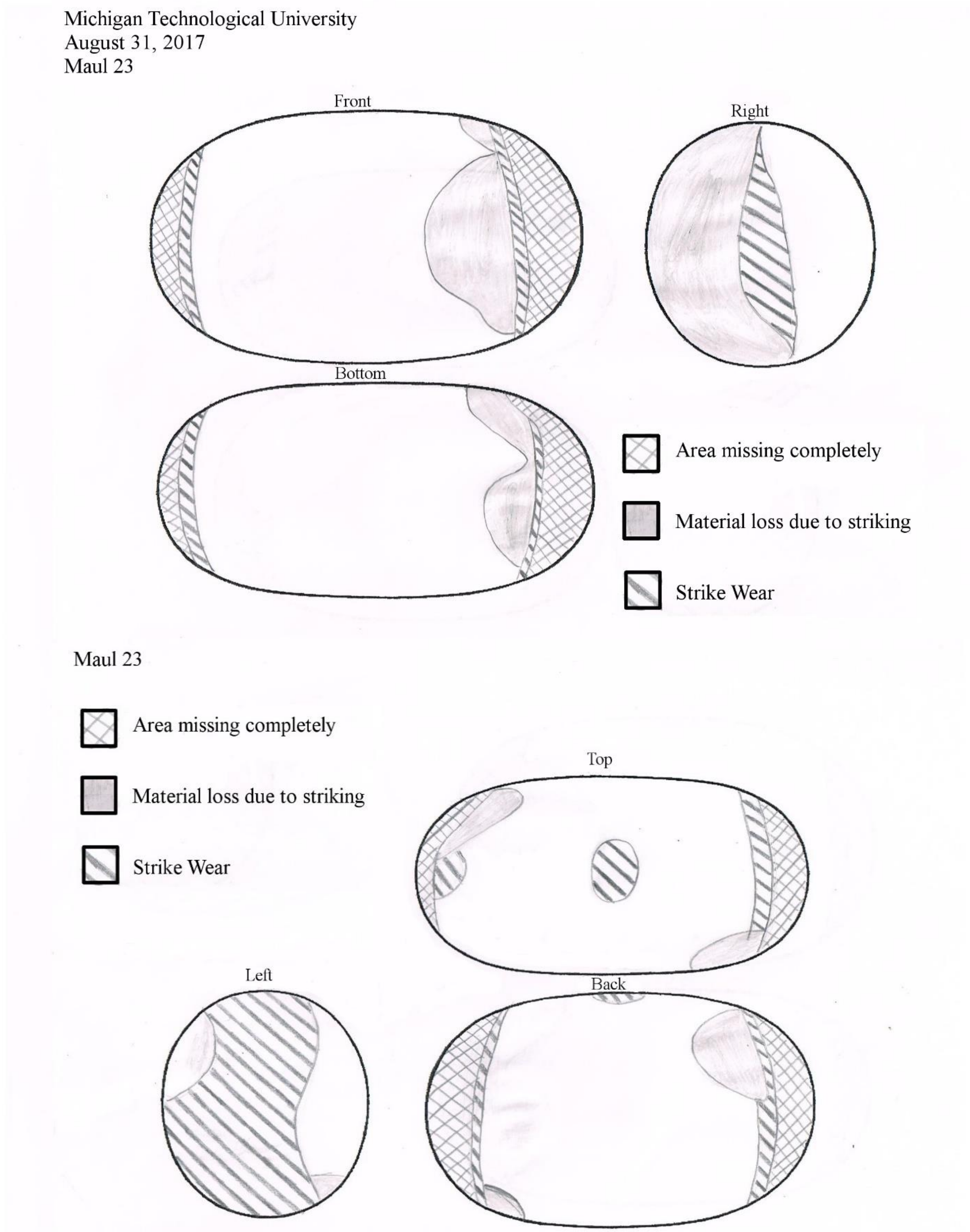

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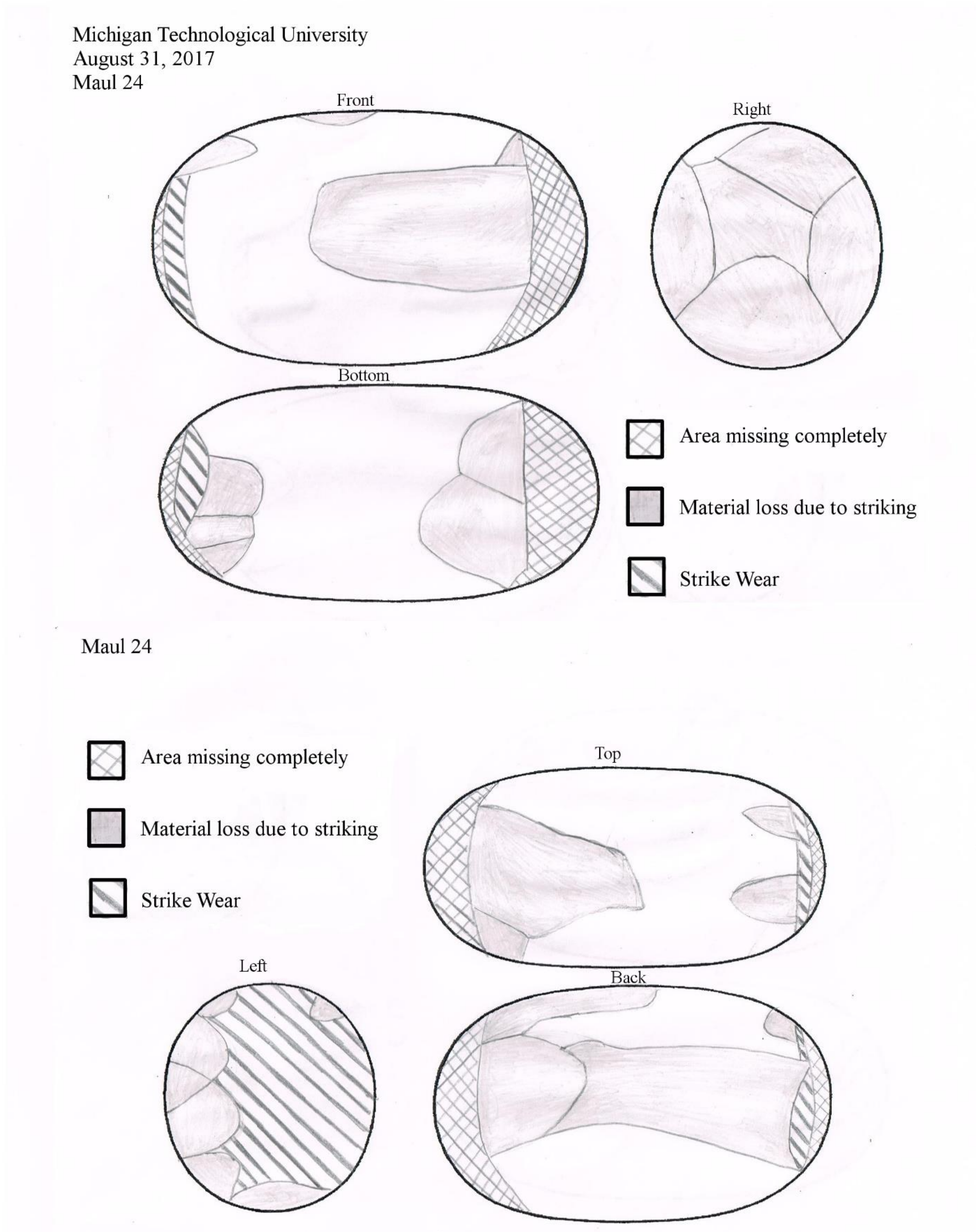

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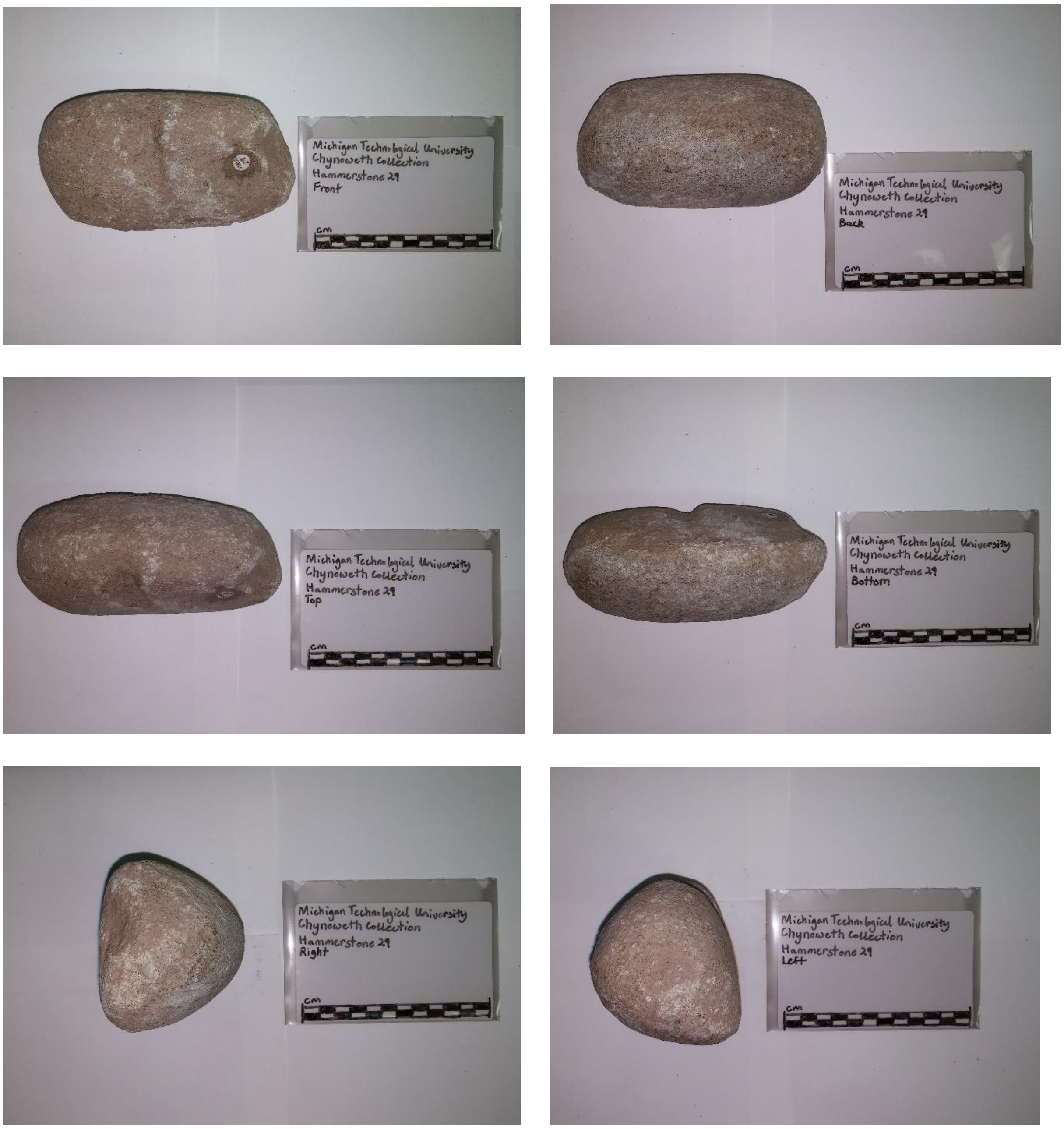

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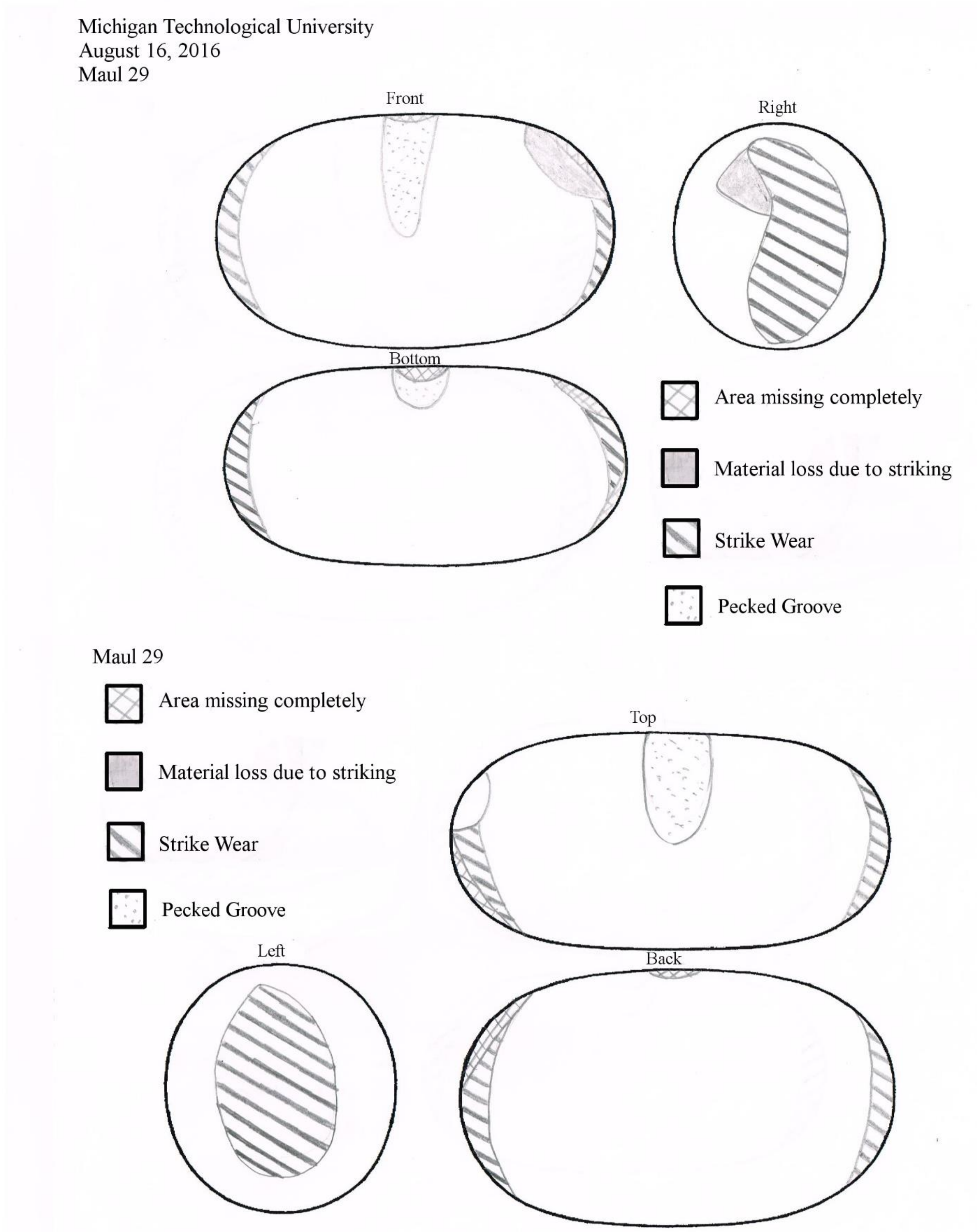

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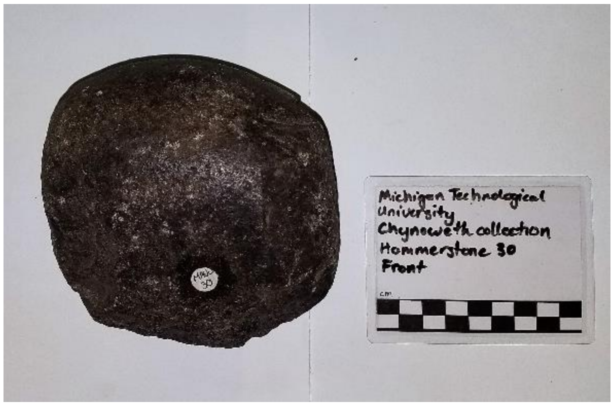

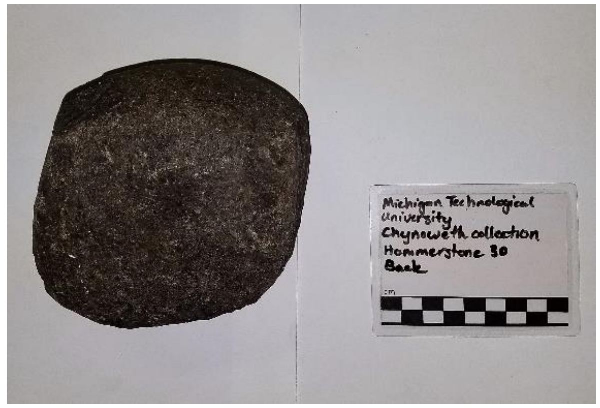

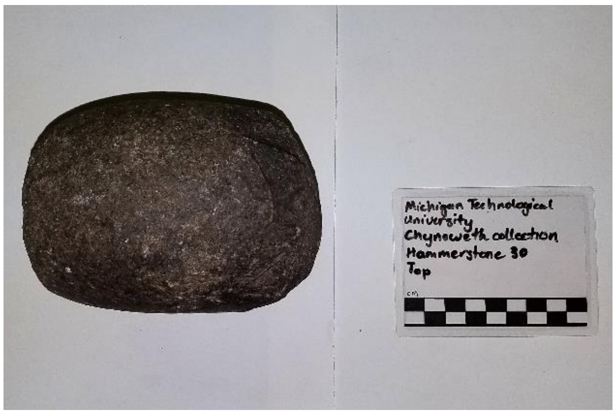

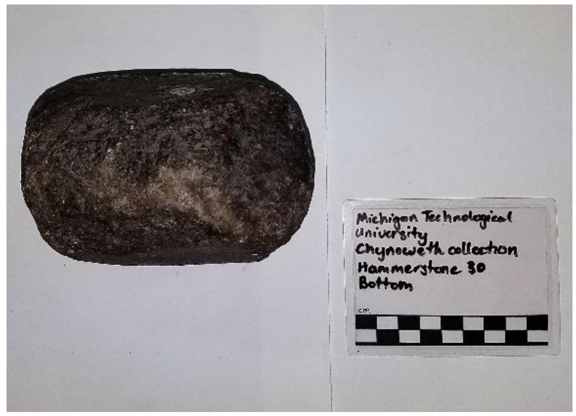

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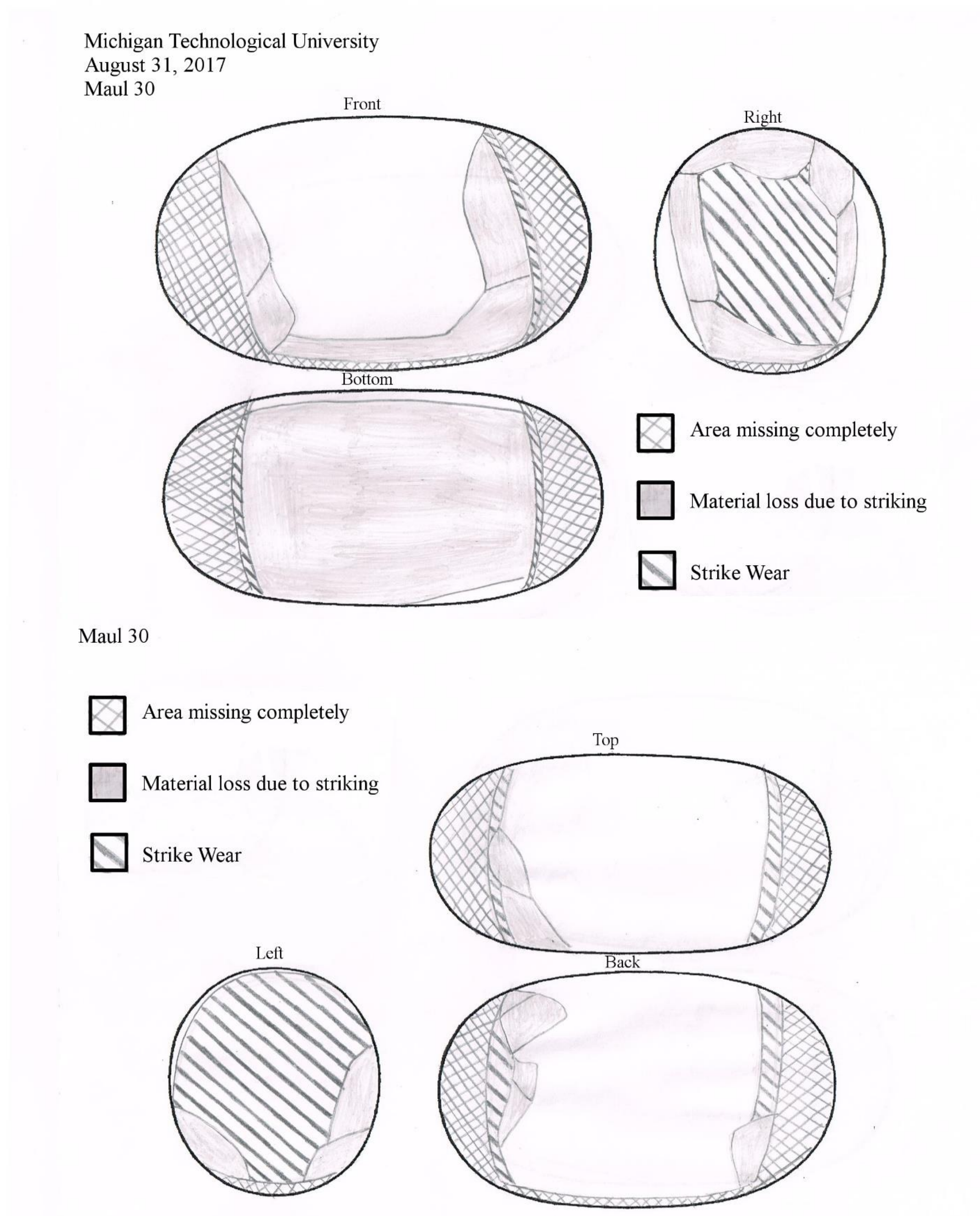

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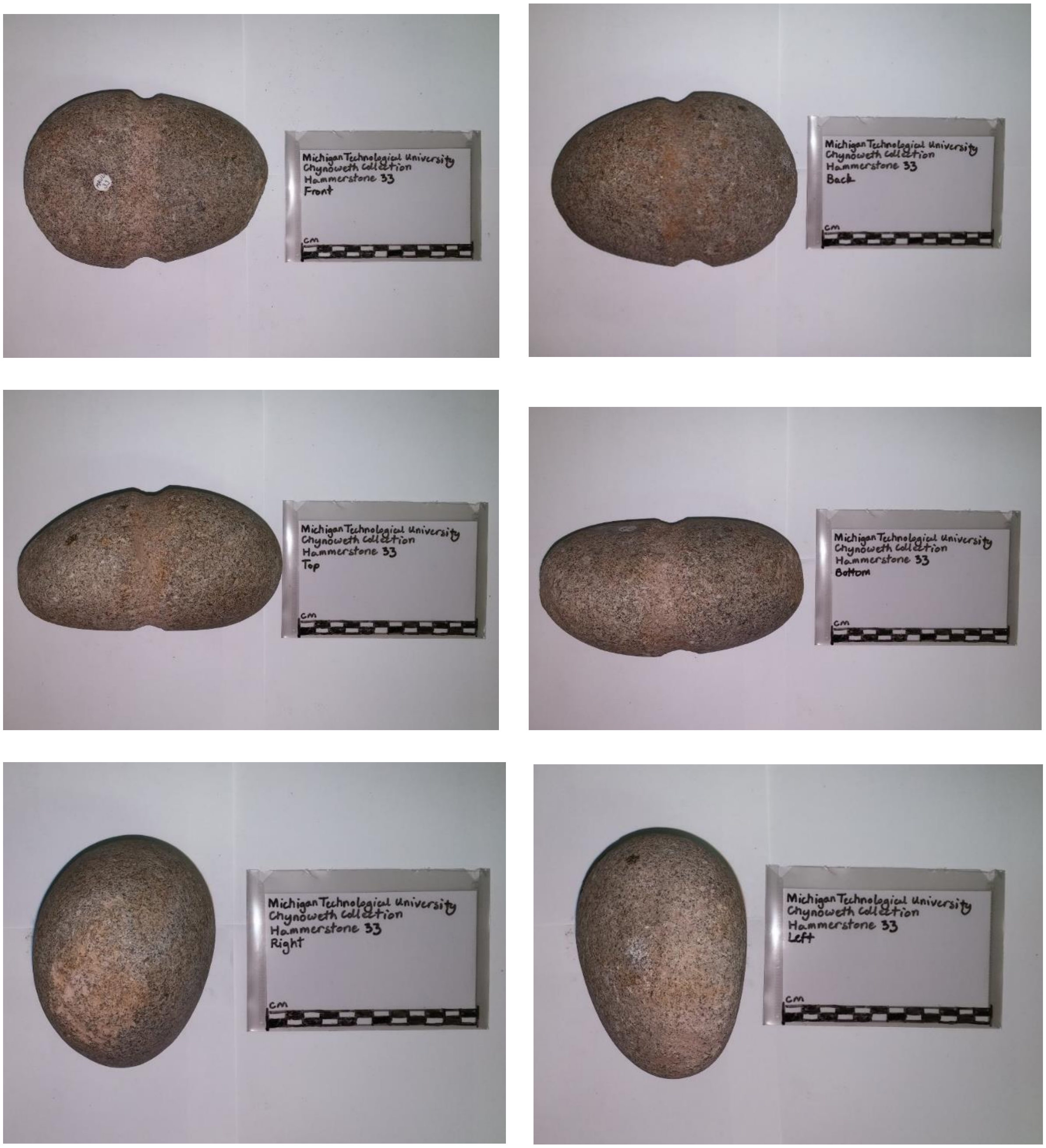

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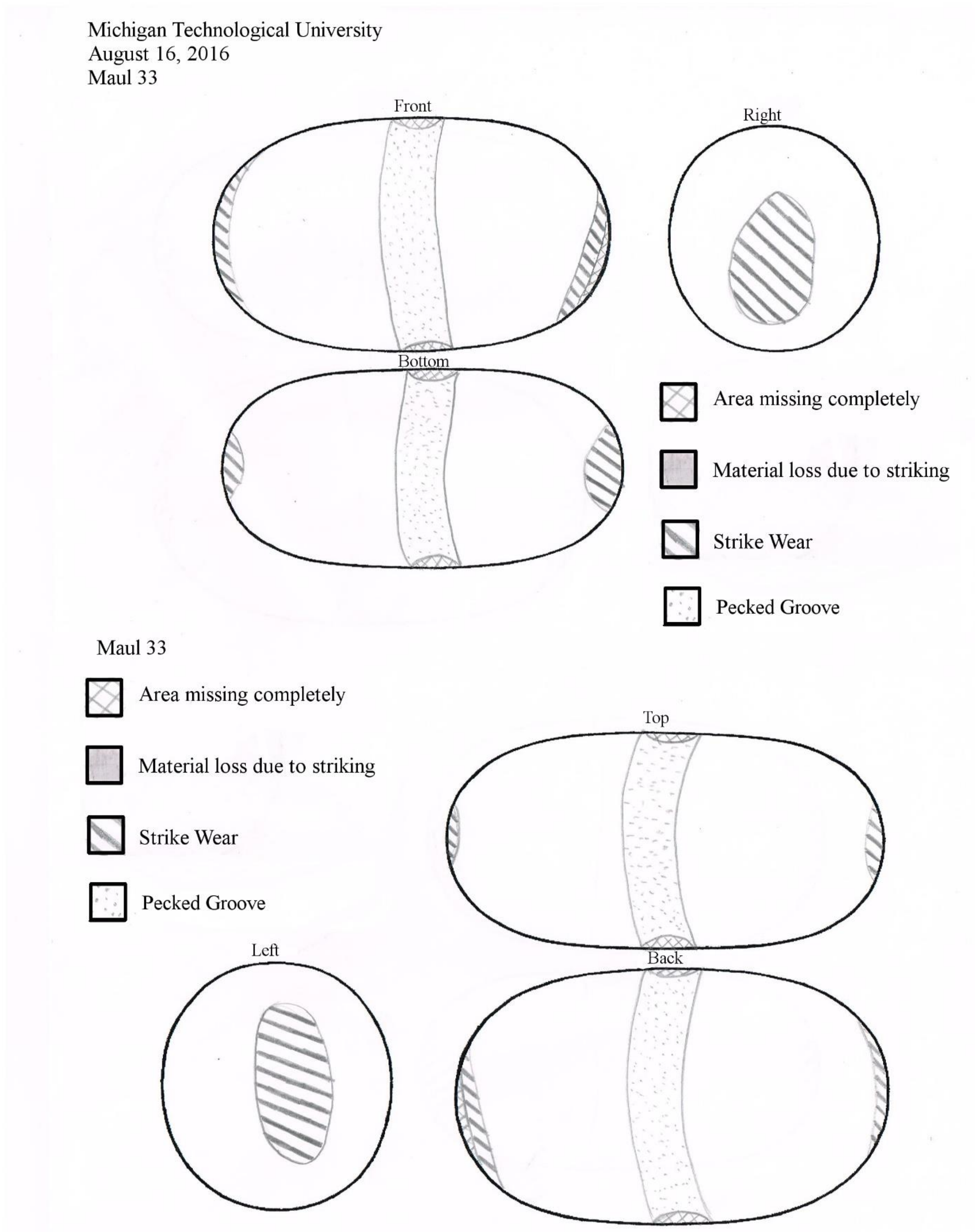

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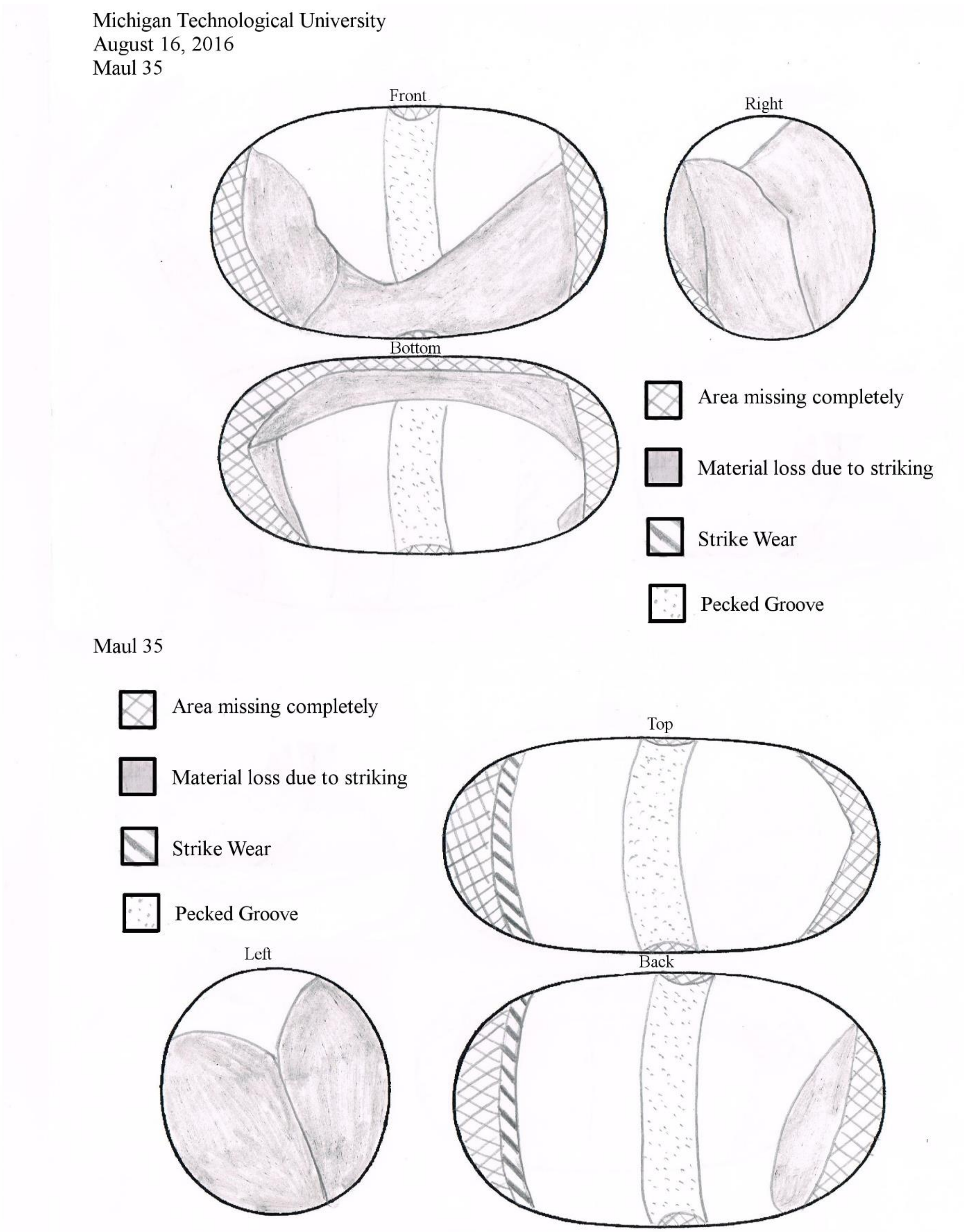
Chynoweth Collection Maul 35—CGH3



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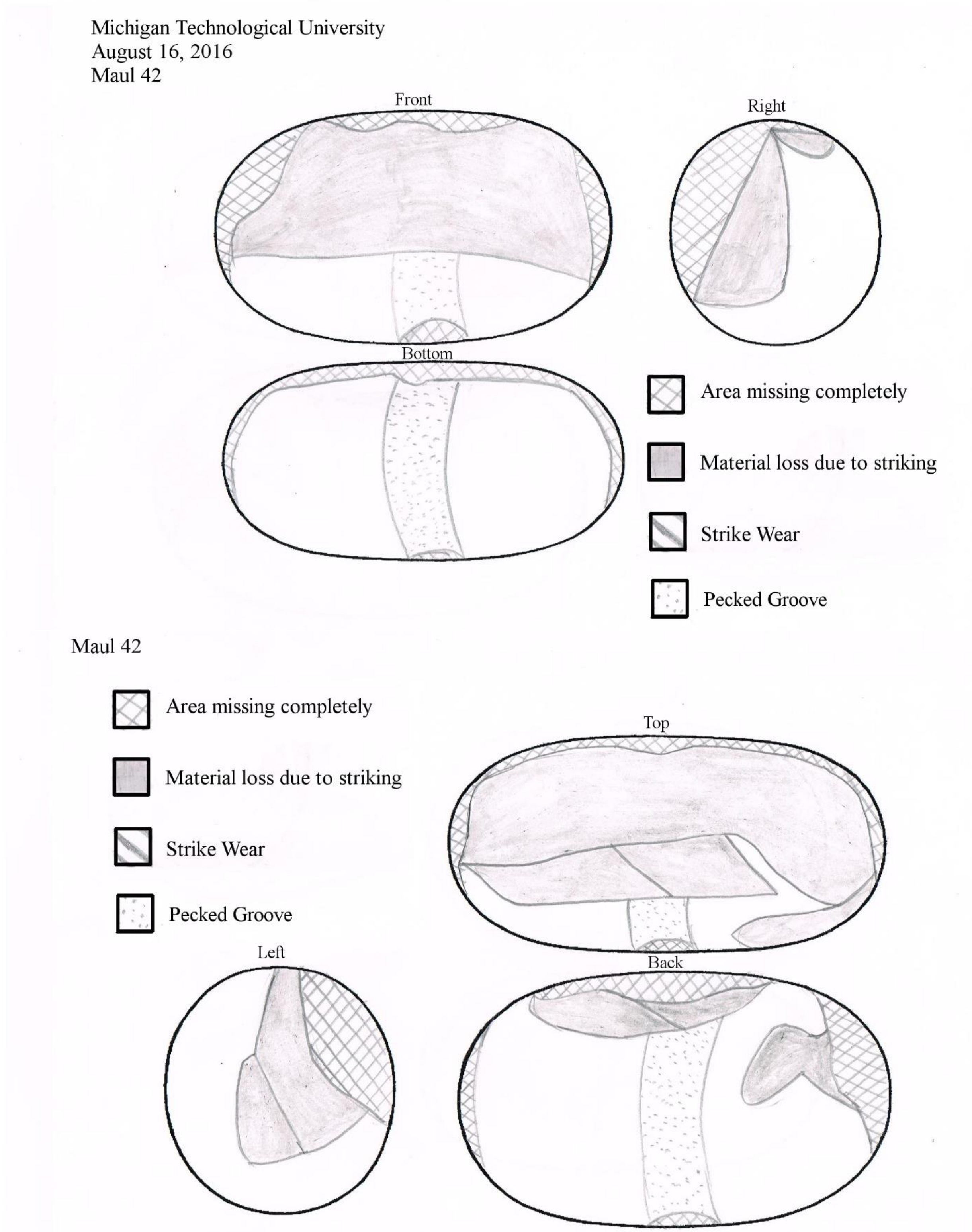
Chynoweth Collection Maul 42—CGH4



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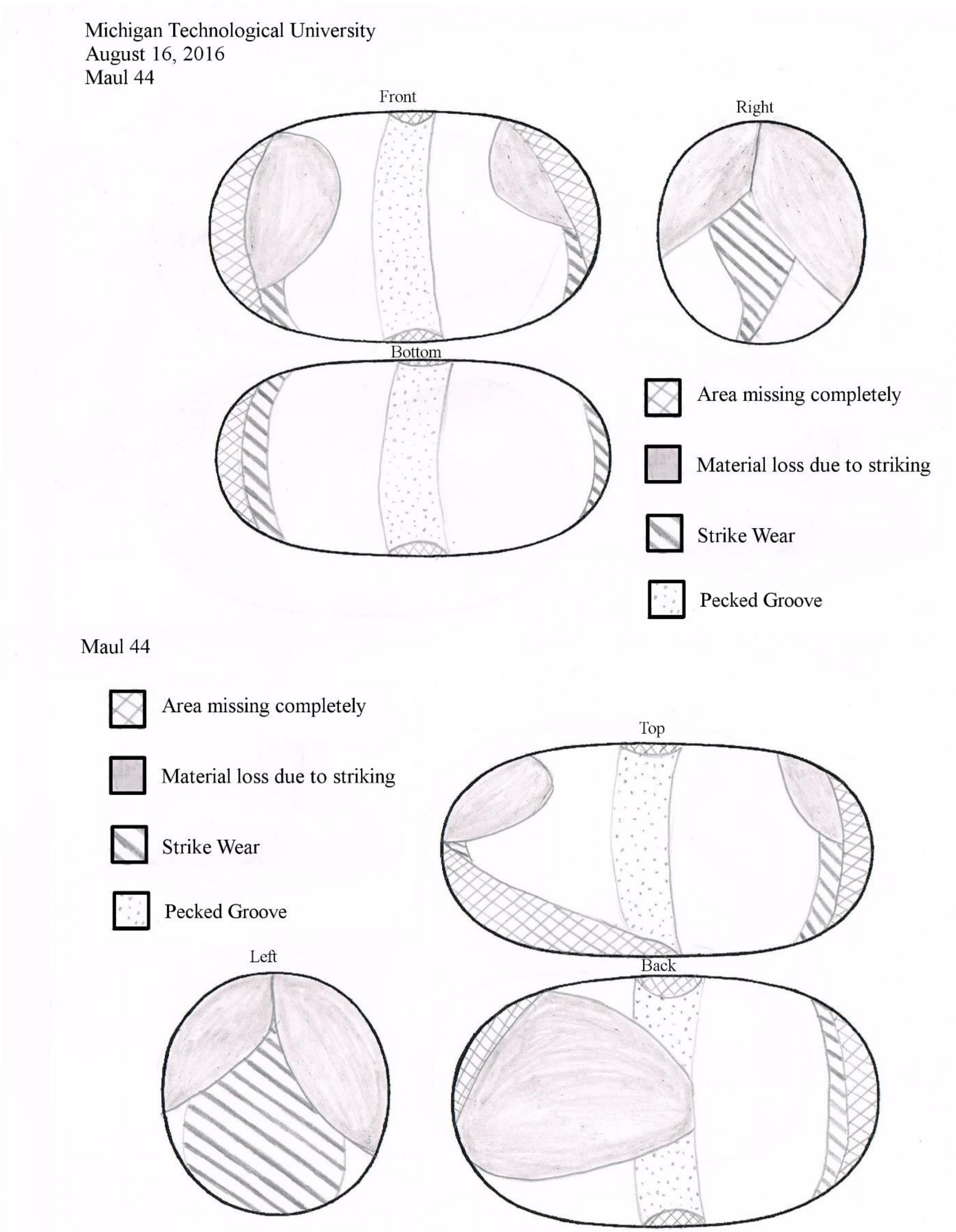
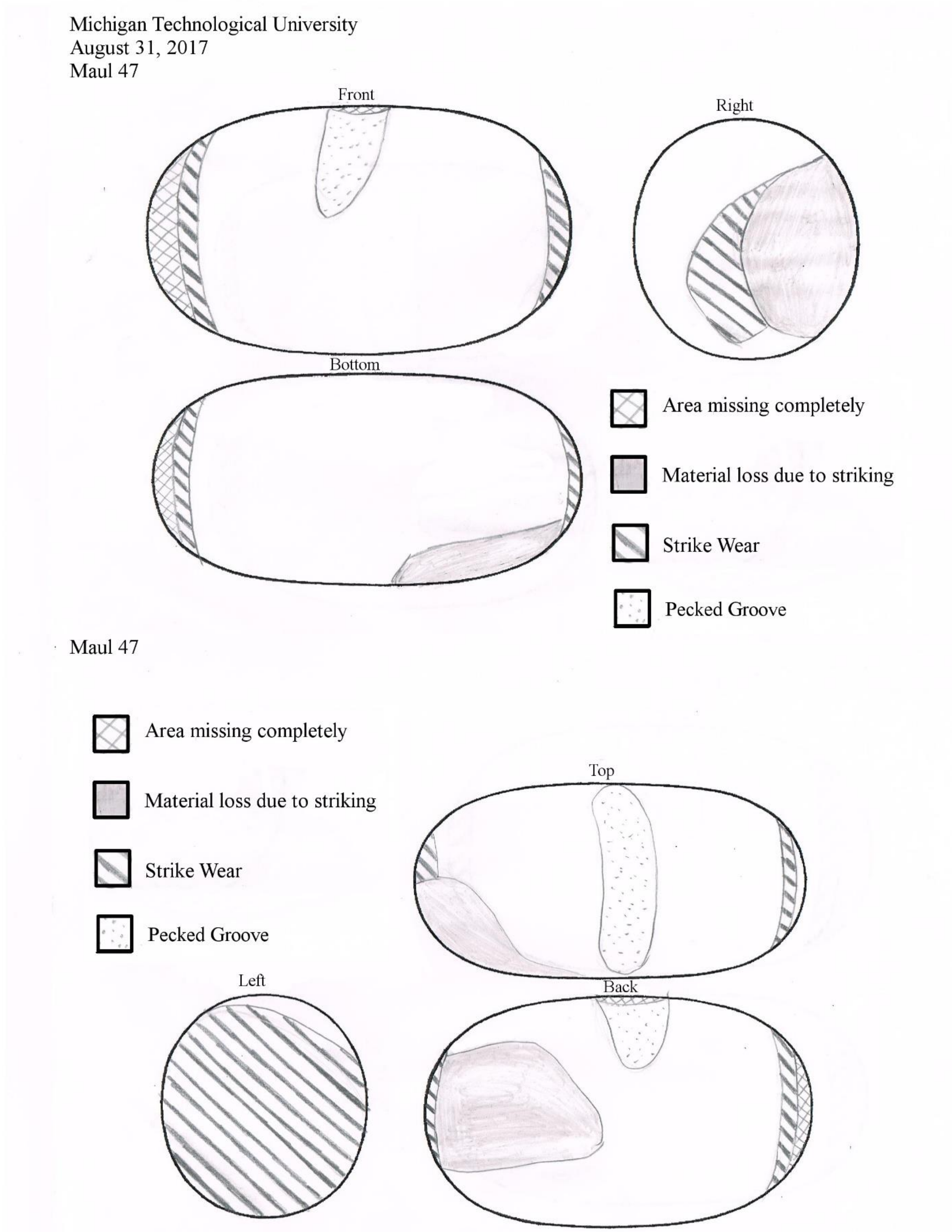
Chynoweth Collection Maul 44—CGH5



Chynoweth Collection Maul 44—CGH5

Chynoweth Collection Maul 47—CGH6



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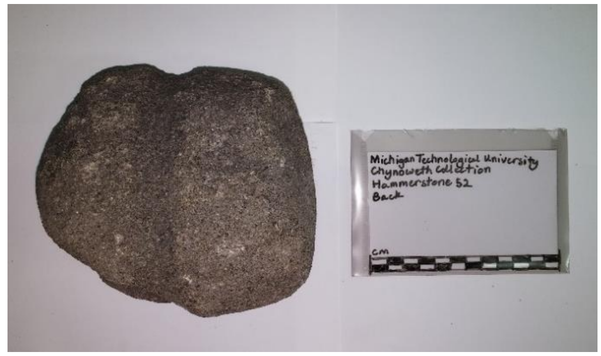

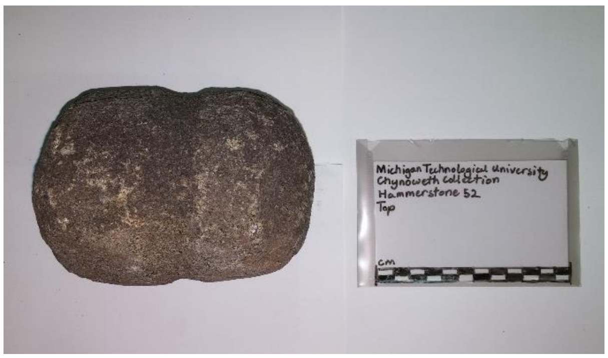

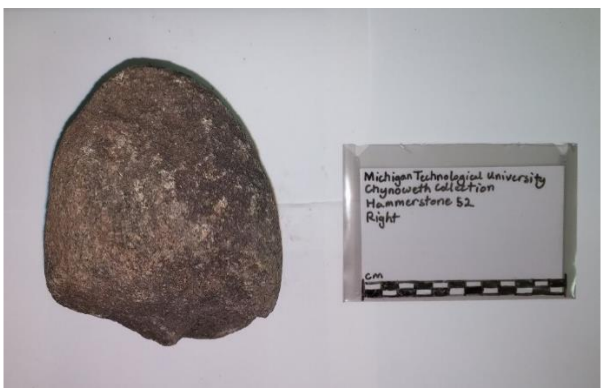

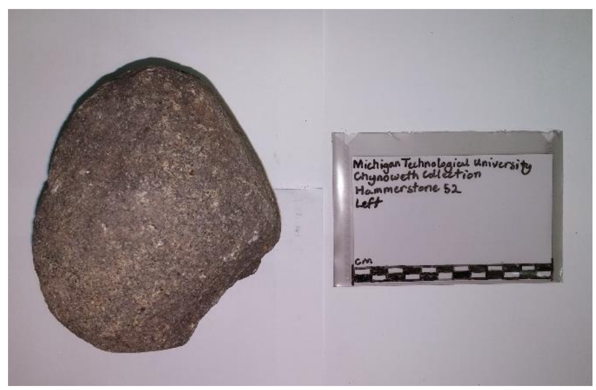

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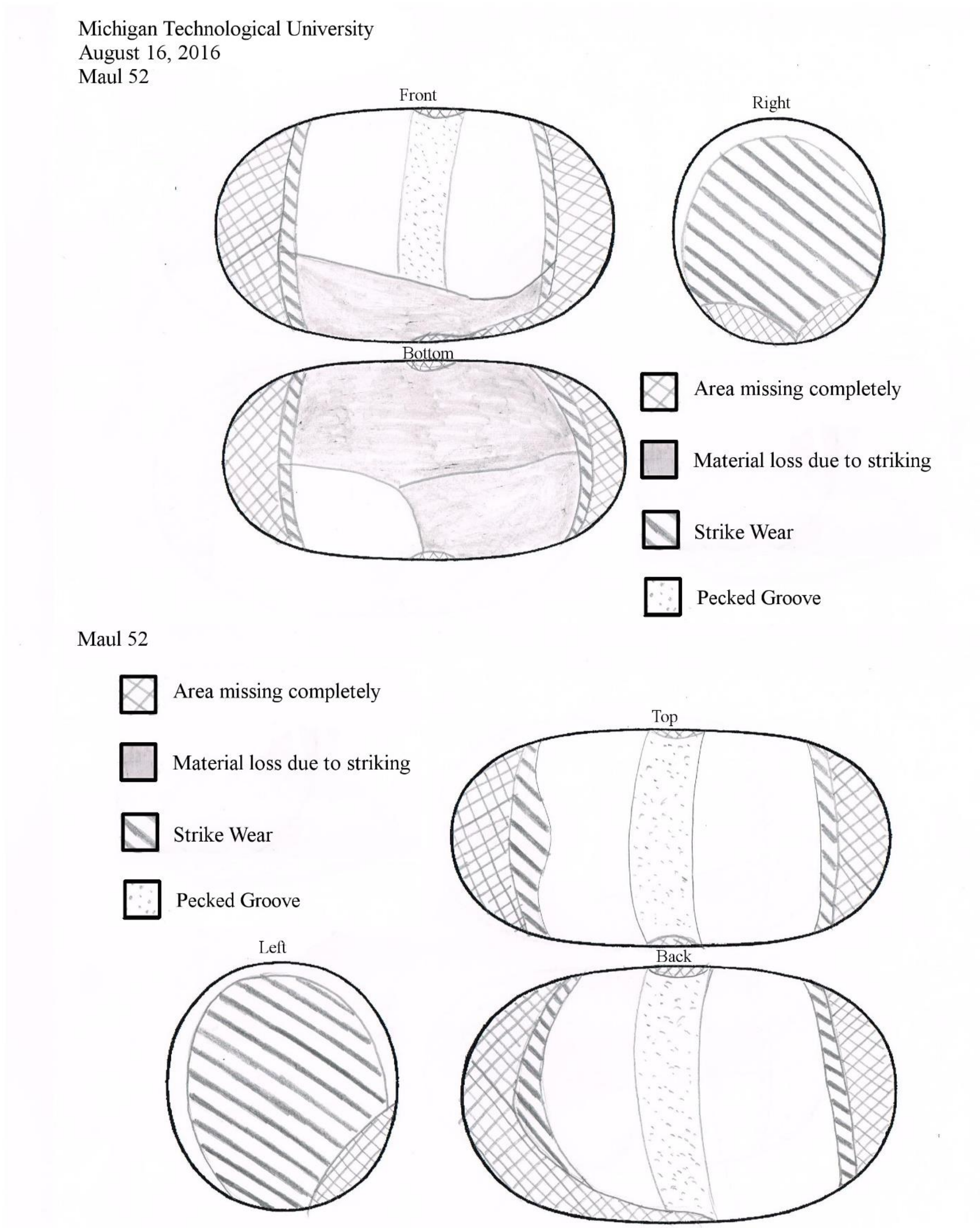

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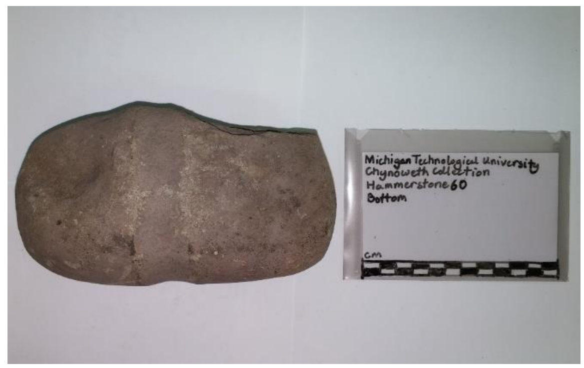

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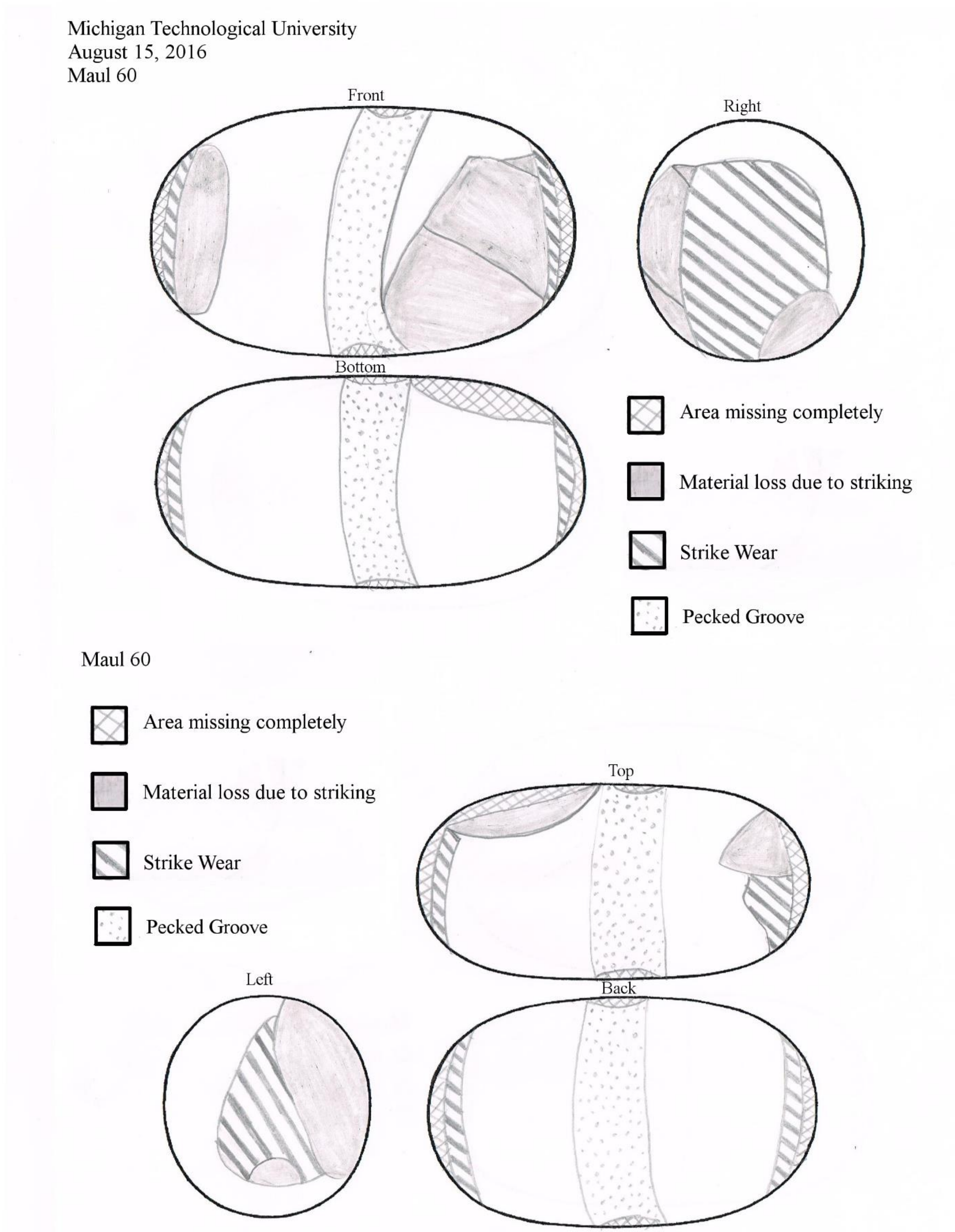

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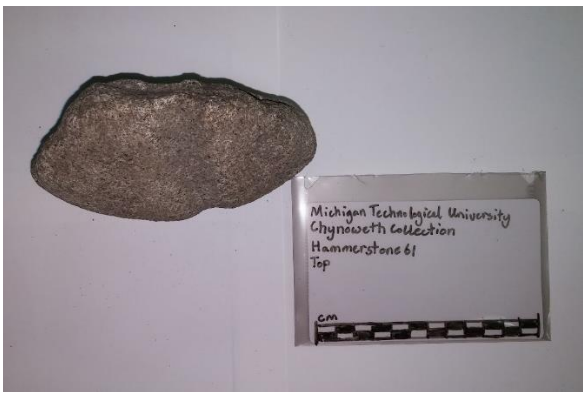

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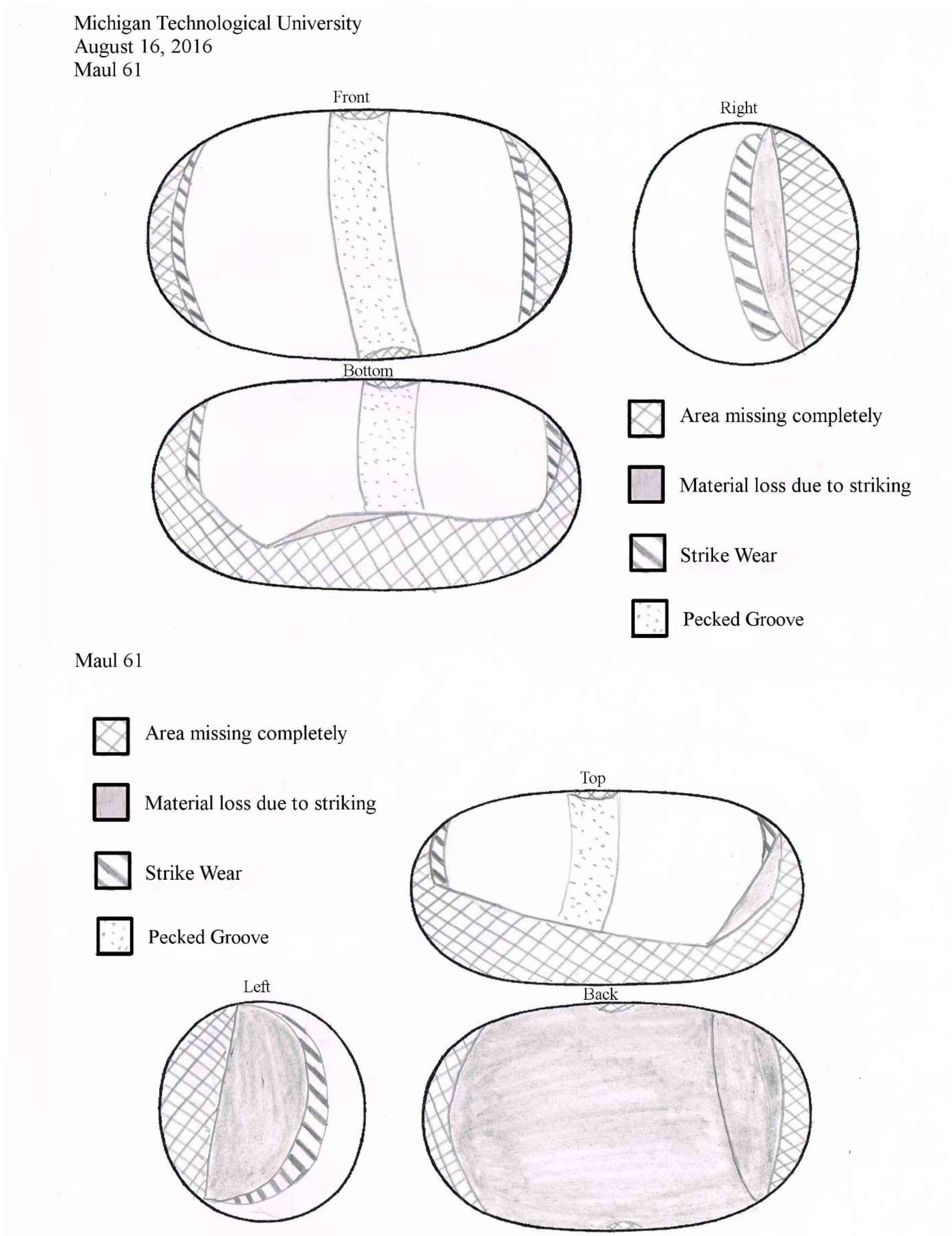
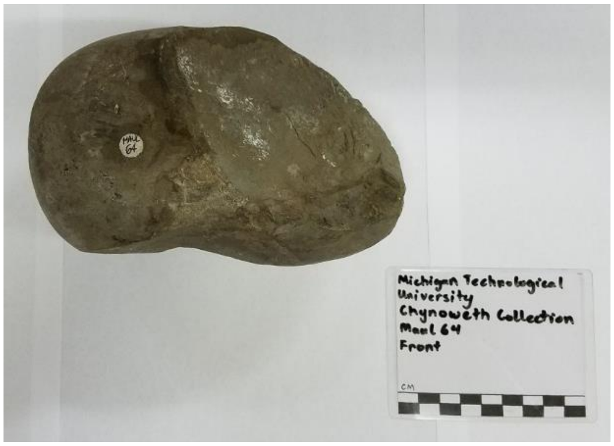
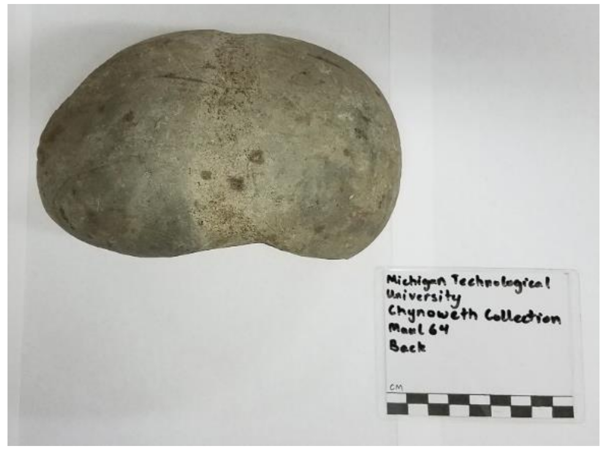
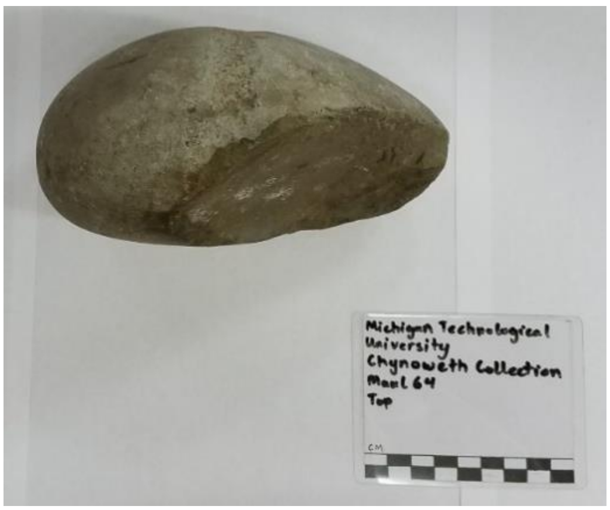
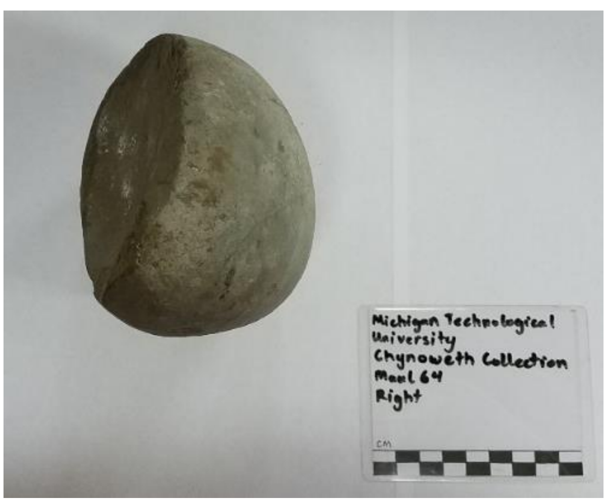


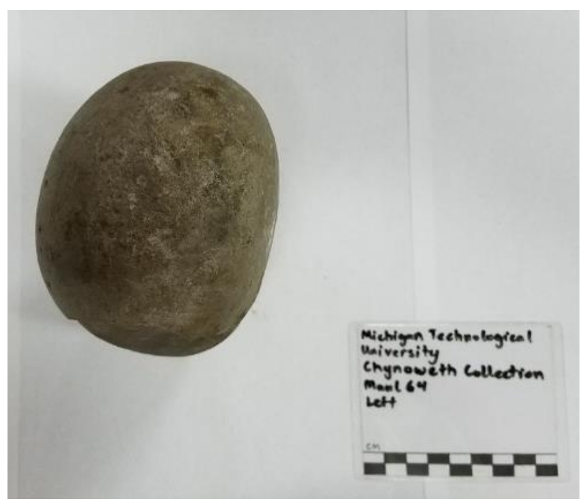
Chynoweth Collection Maul 61—CGH9











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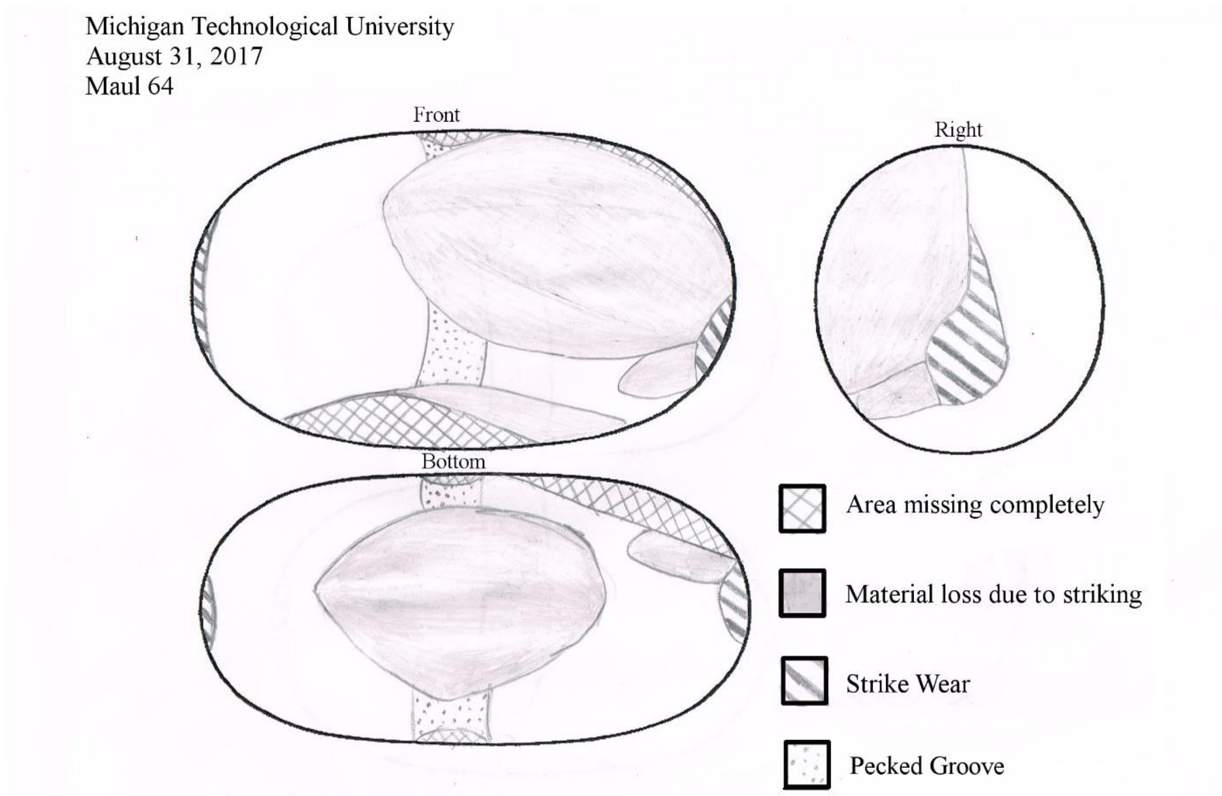

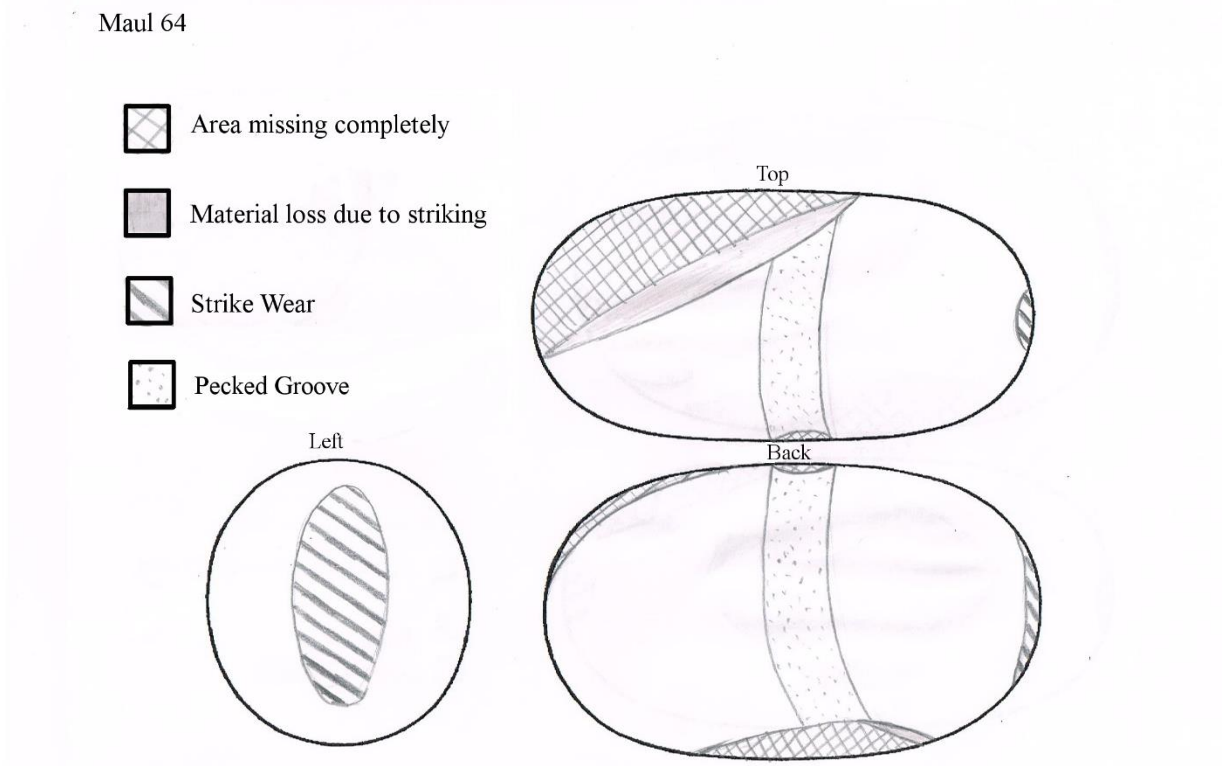

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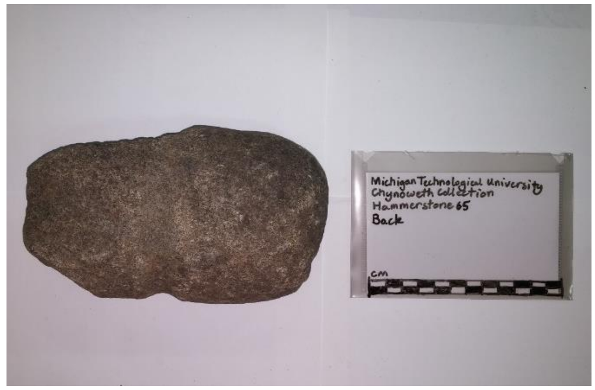
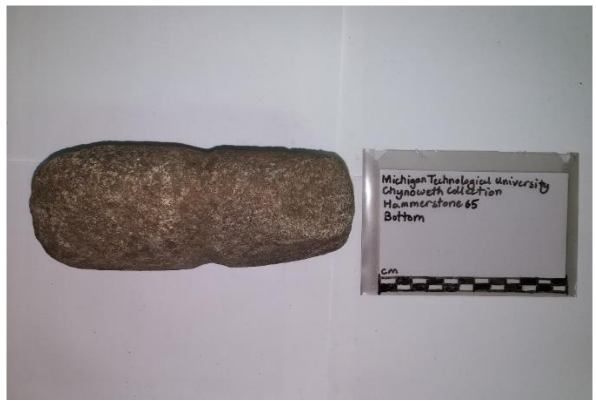
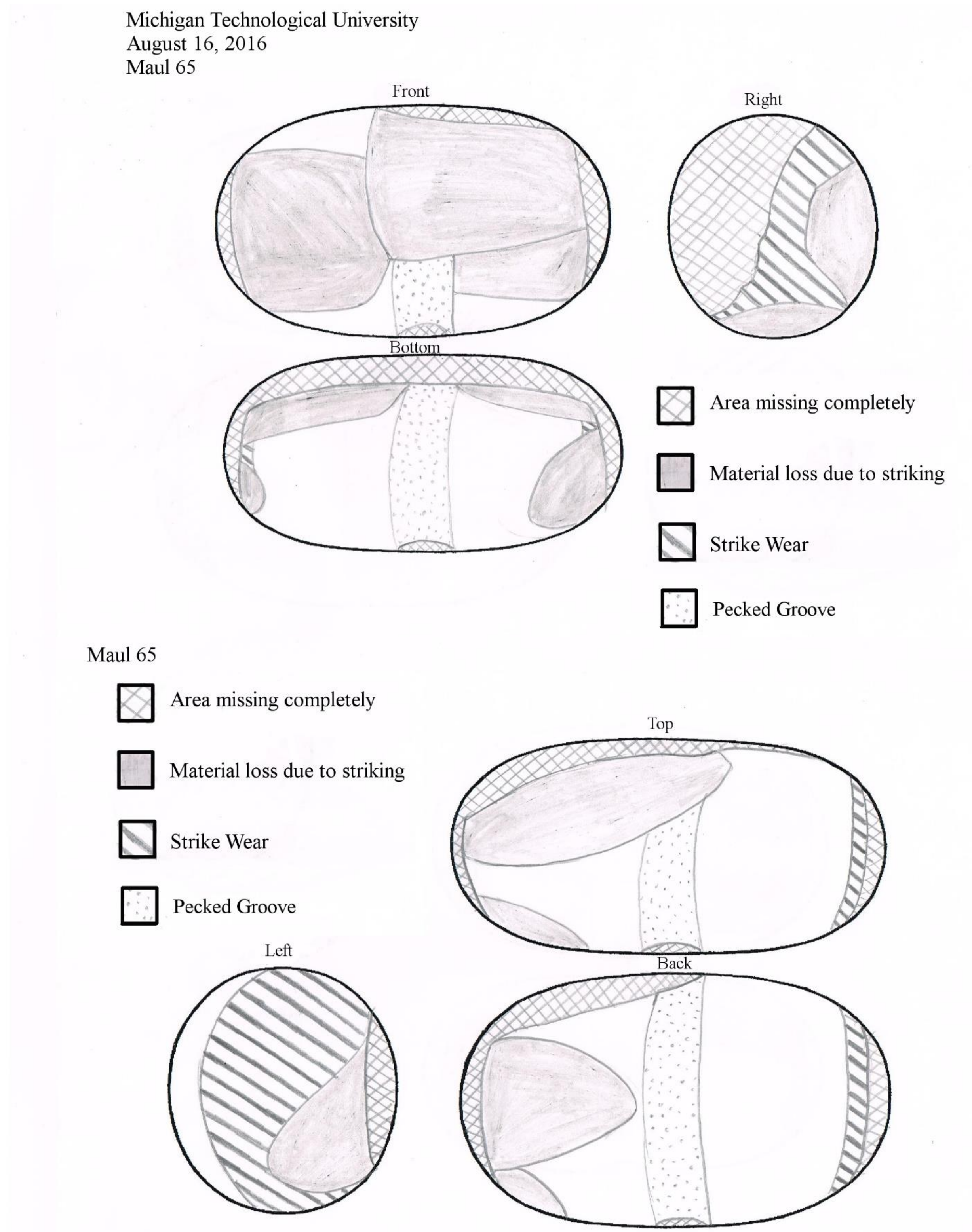


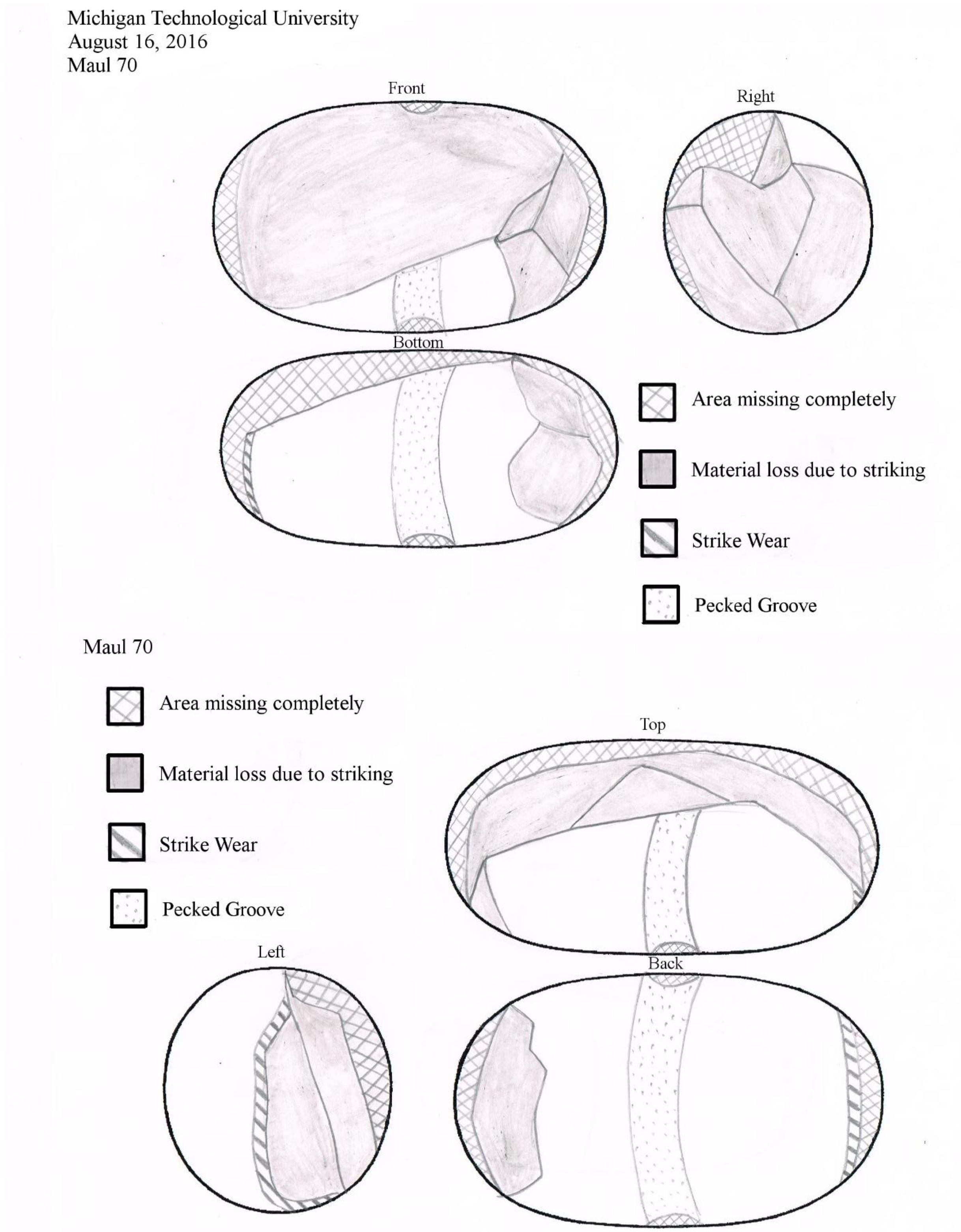


Chynoweth Collection Maul 65—CGH11

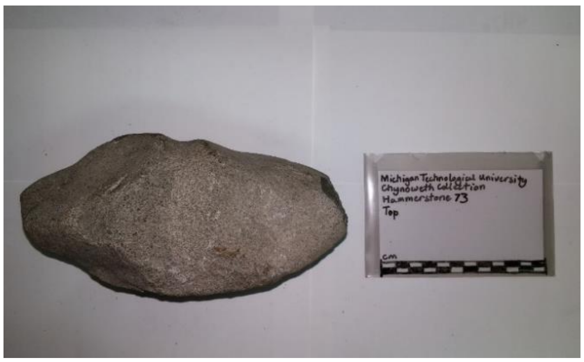


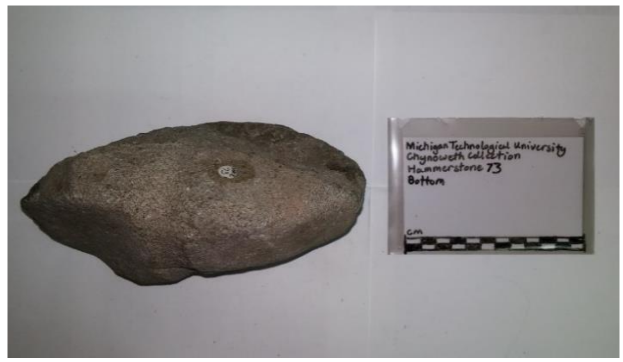
Chynoweth Collection Maul 65—CGH11

Chynoweth Collection Maul 70—CGH12



Chynoweth Collection Maul 70—CGH12





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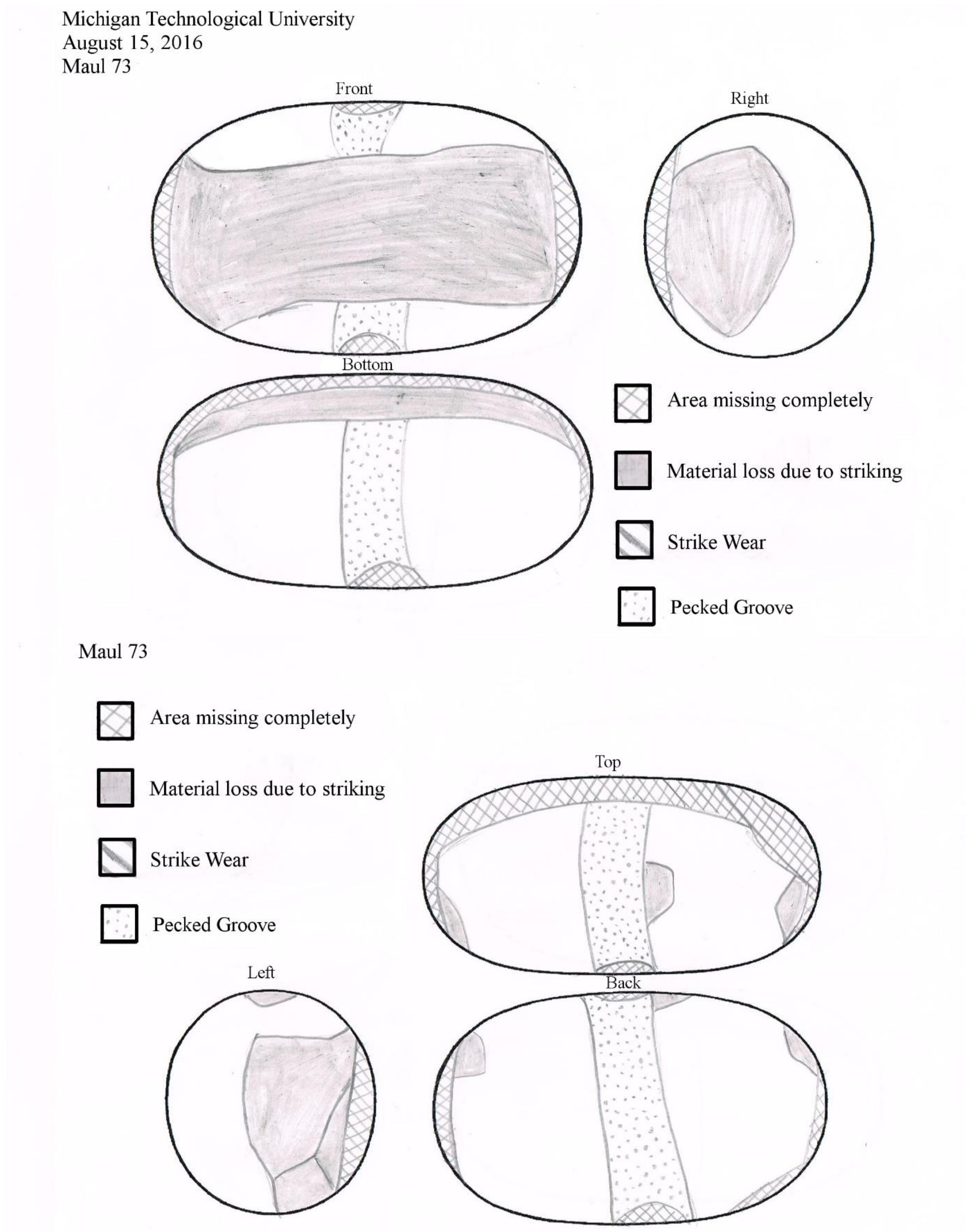

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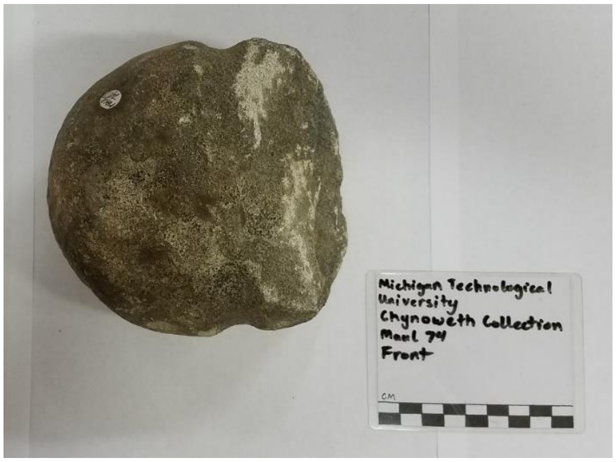

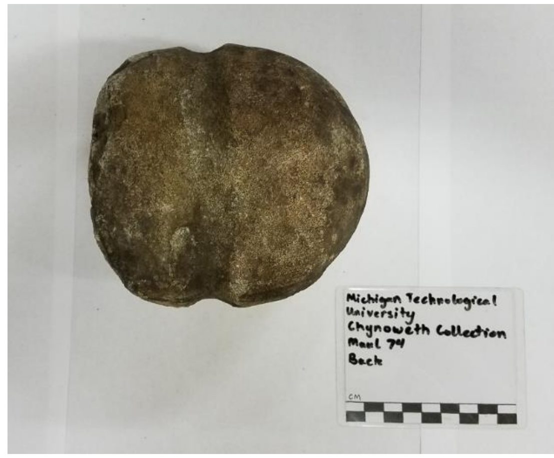

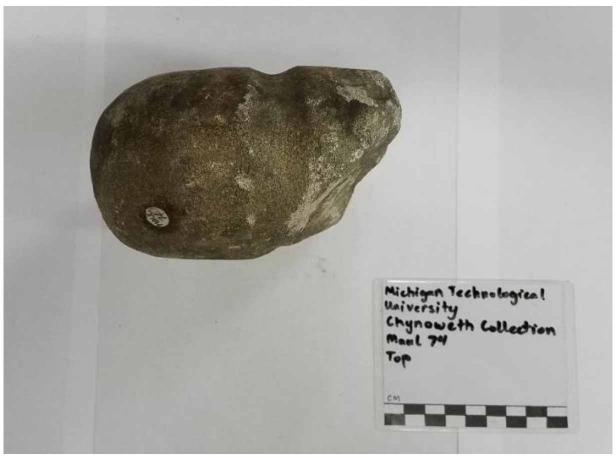

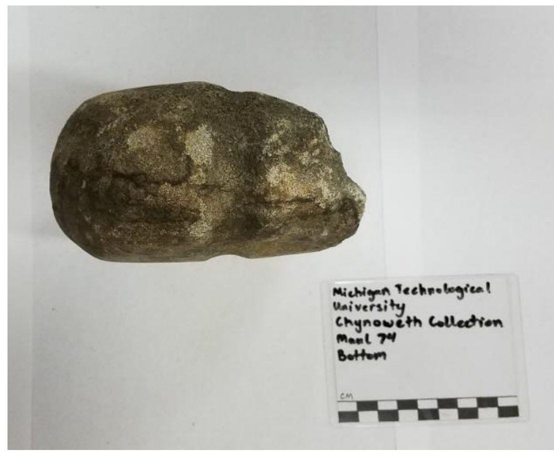

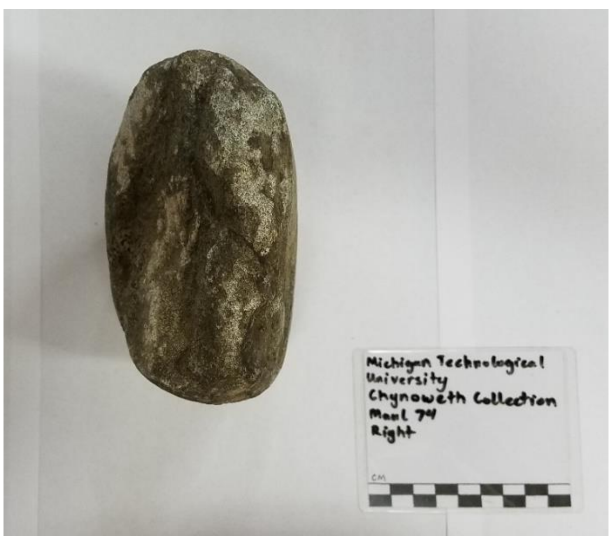

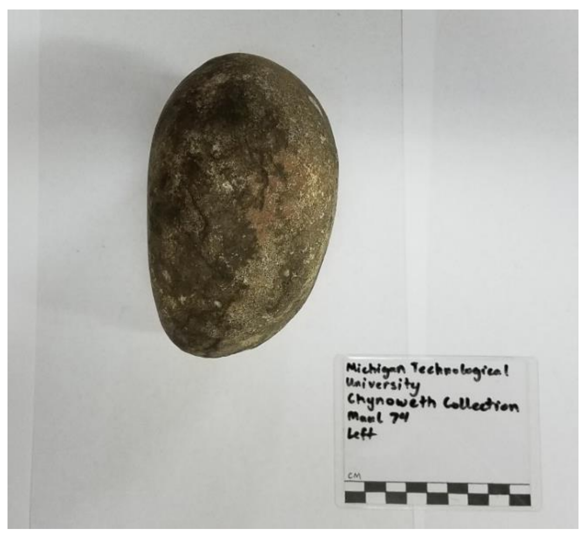

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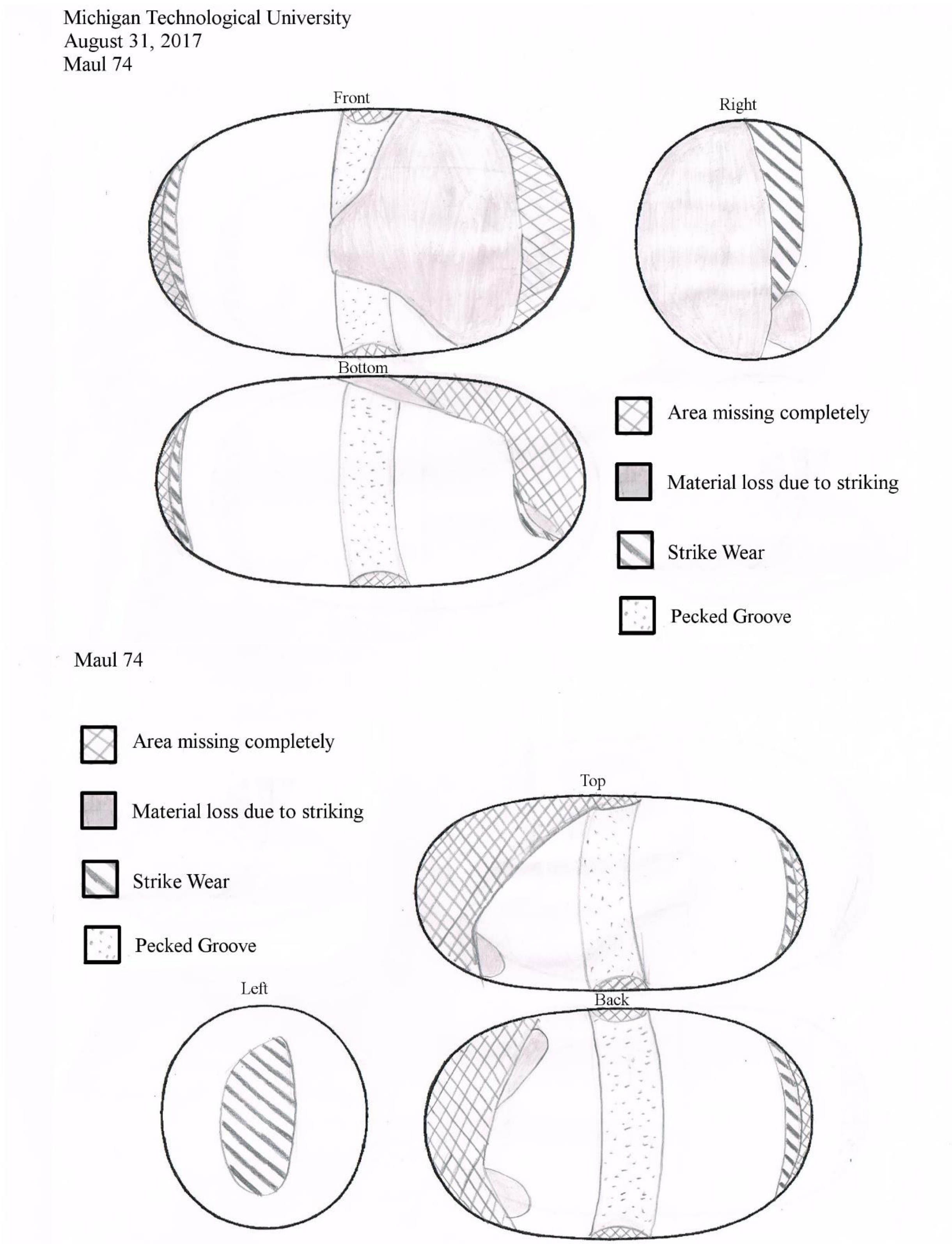
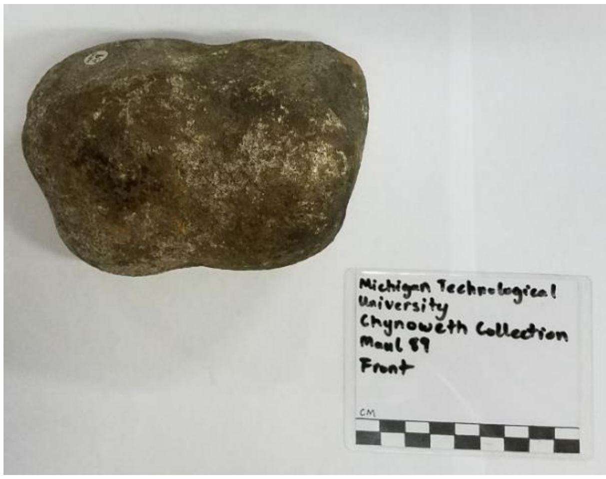
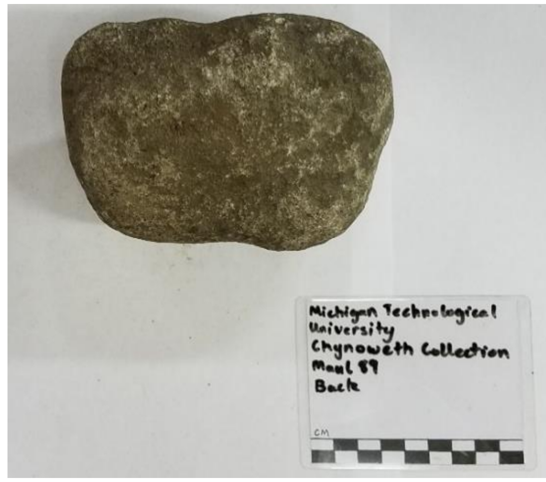
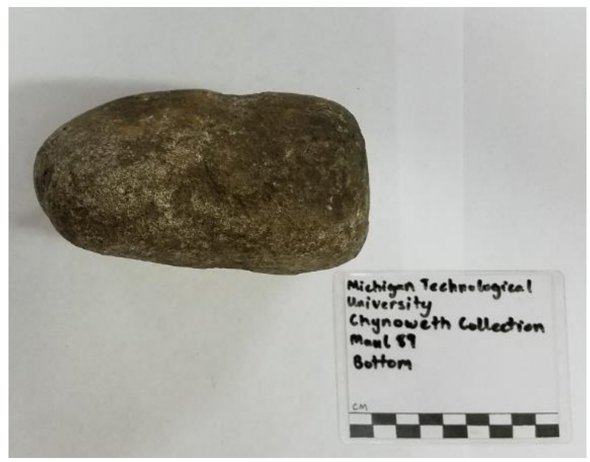
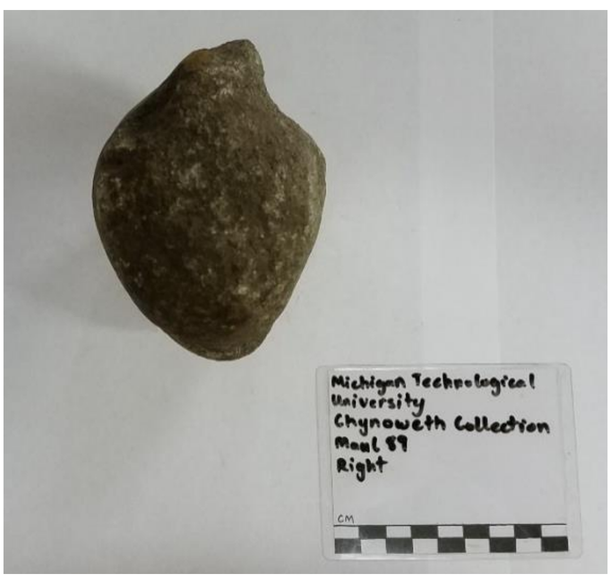


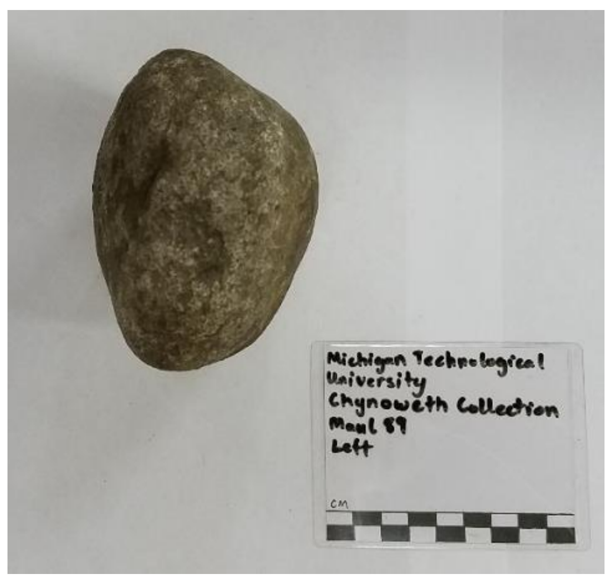
Chynoweth Collection Maul 74—CGH14



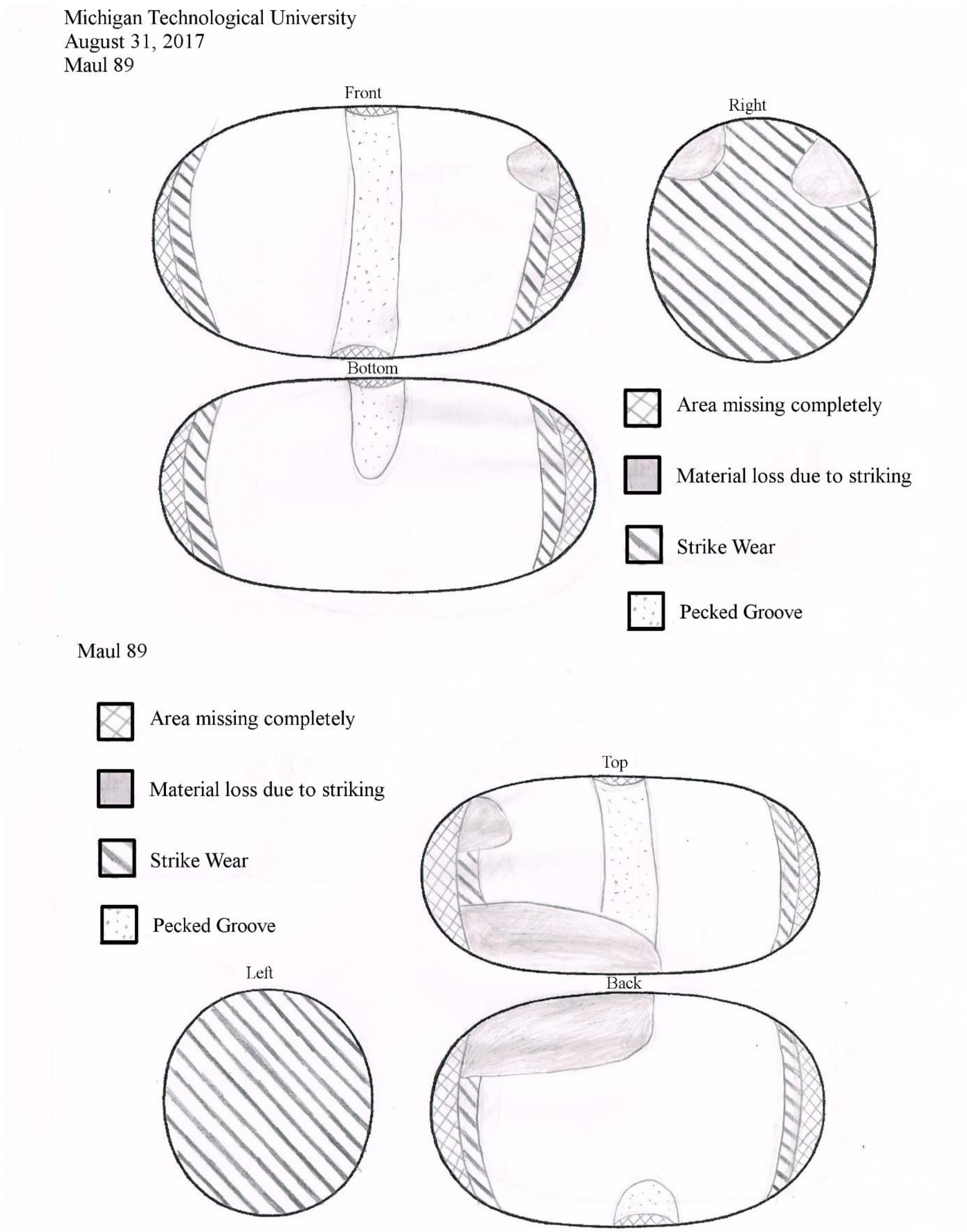








Chynoweth Collection Maul 89—CGH15



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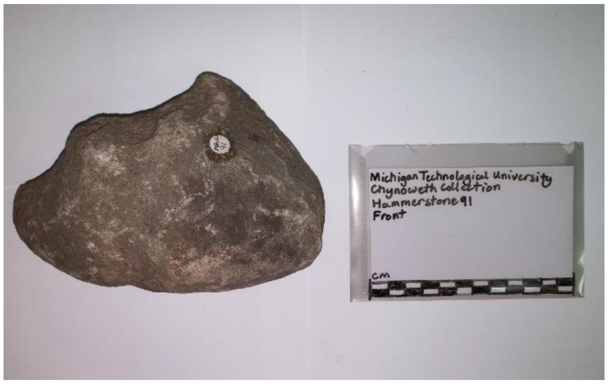

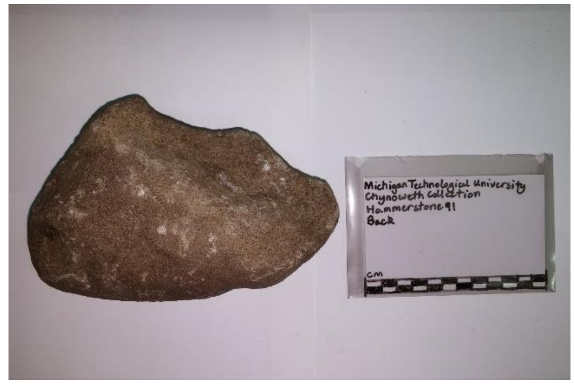

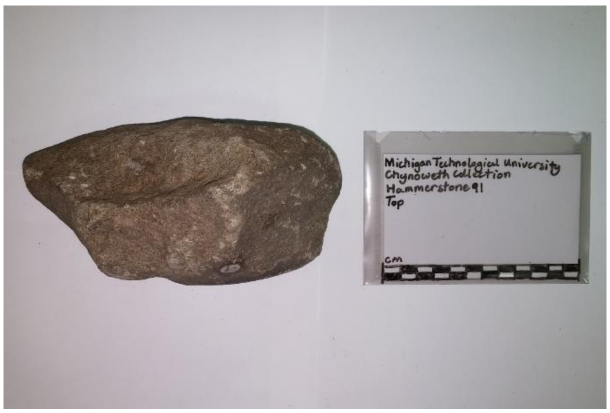

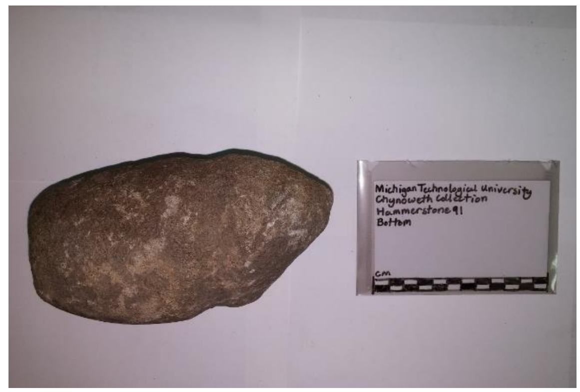

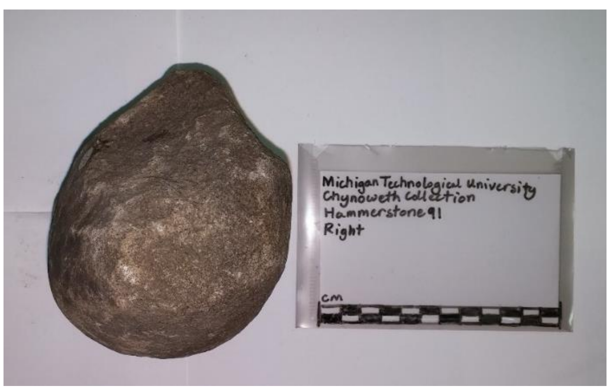

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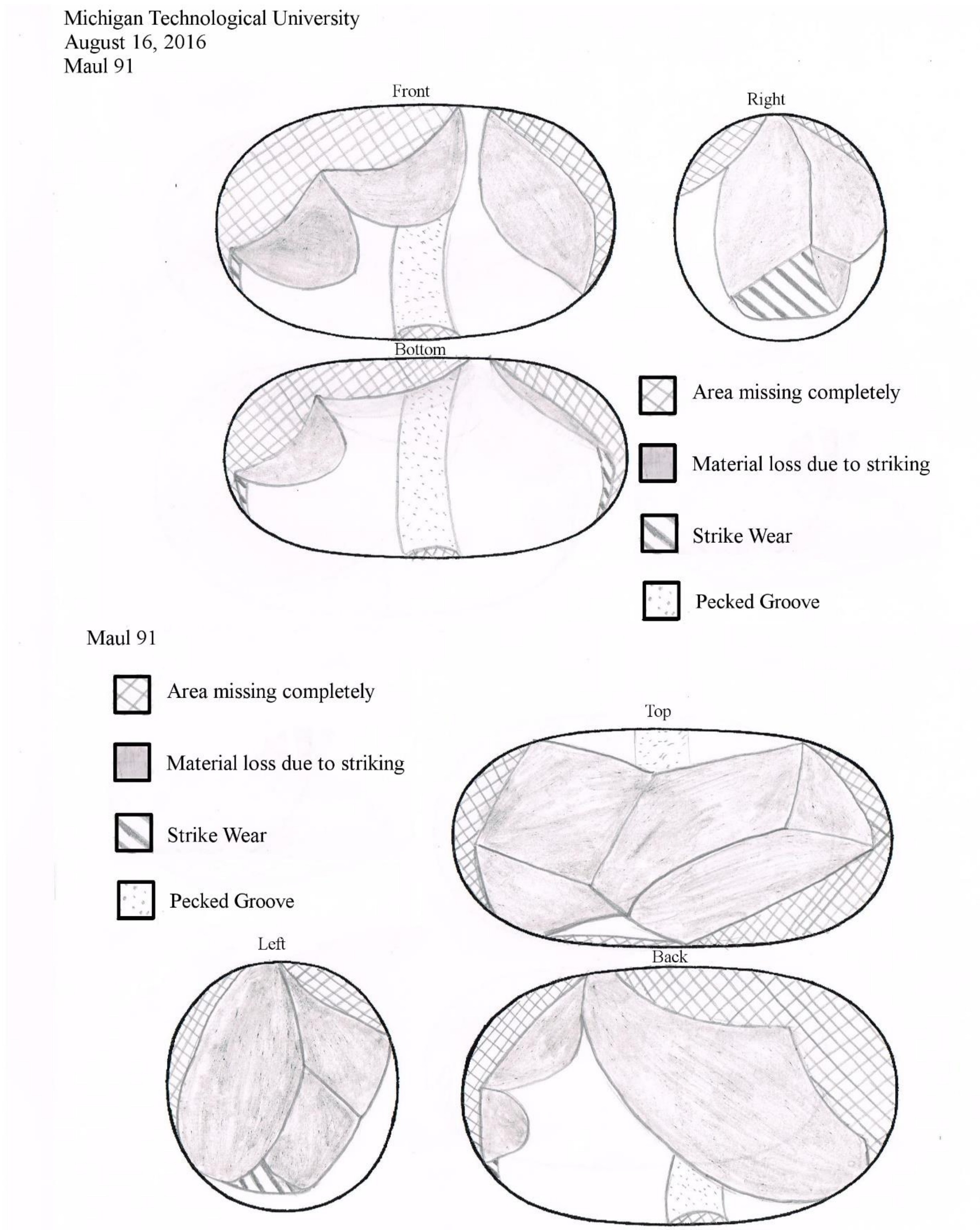

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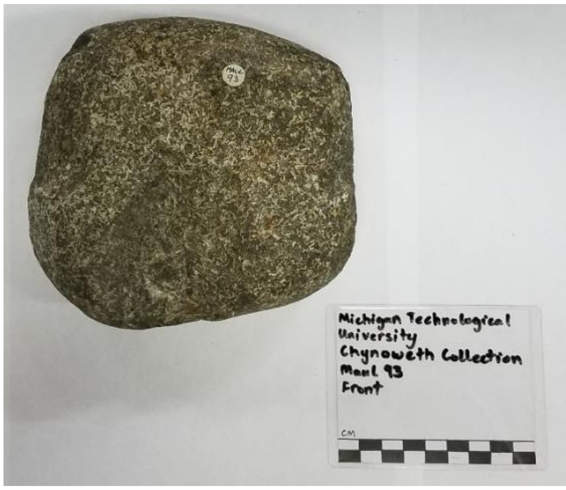
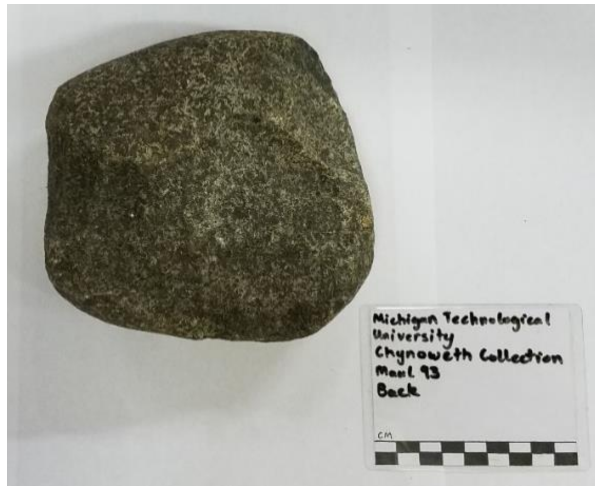
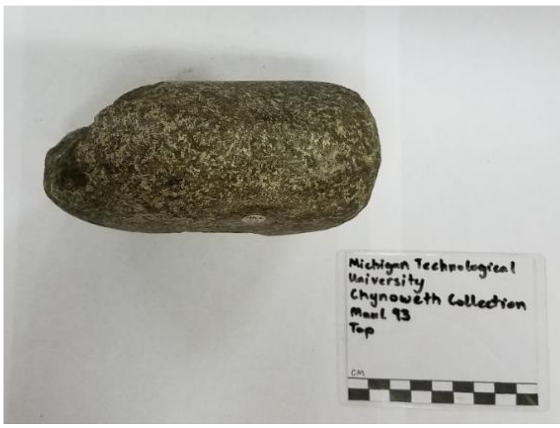
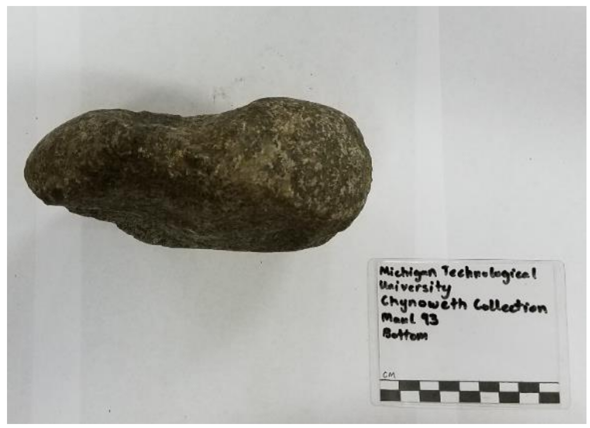
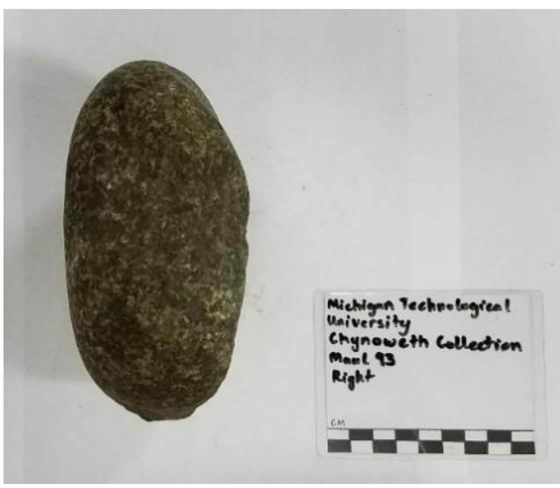
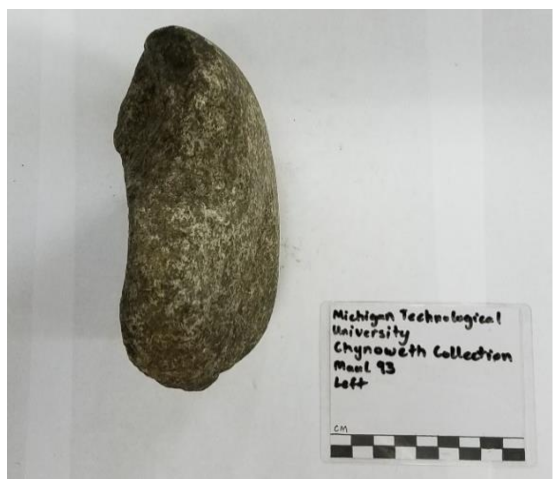




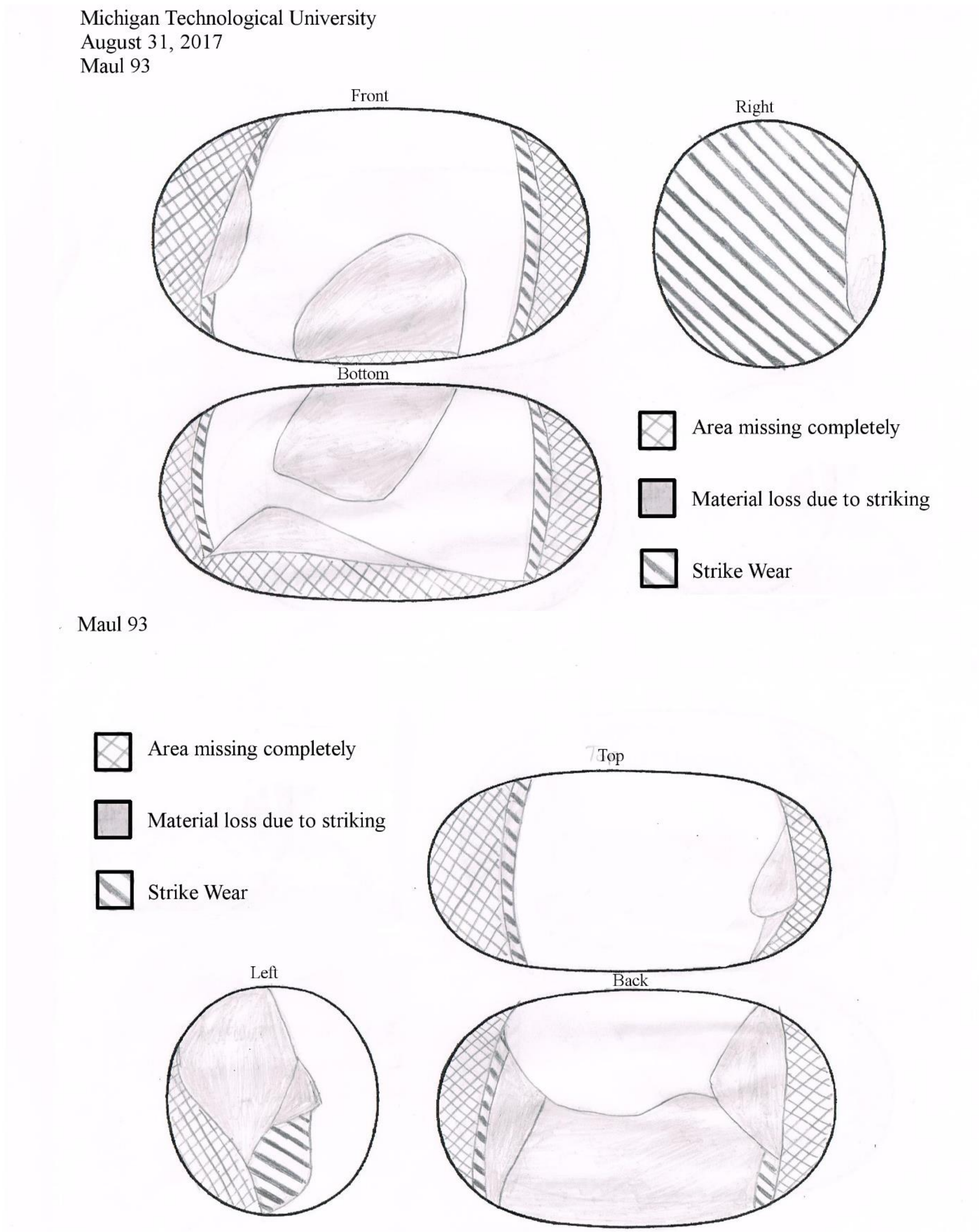




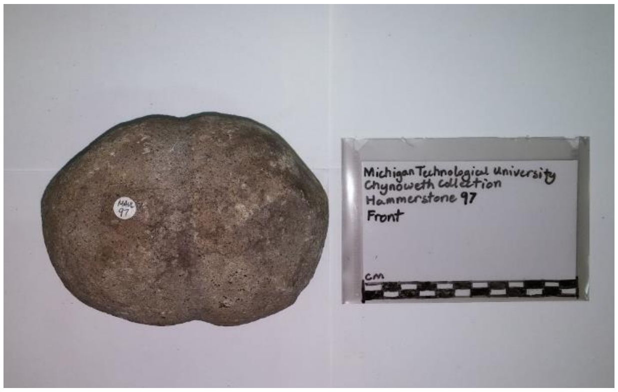


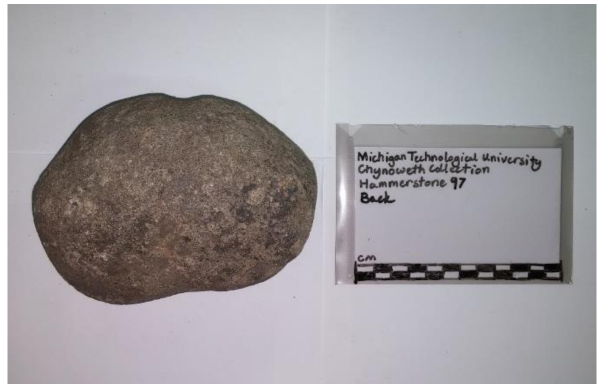


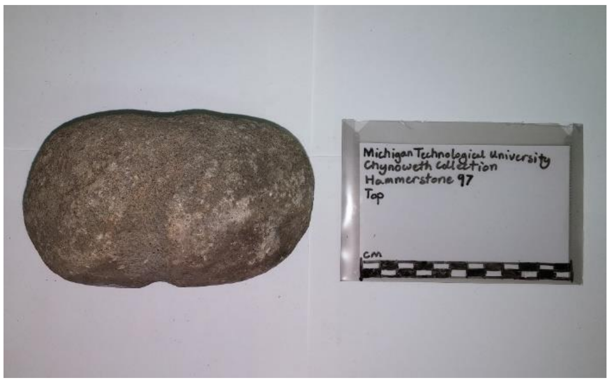
Chynoweth Collection Maul 93—CUH6

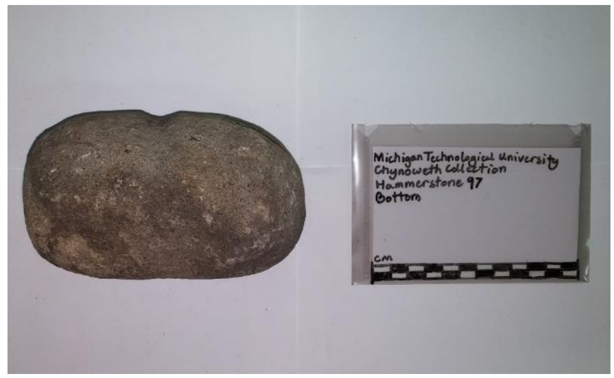


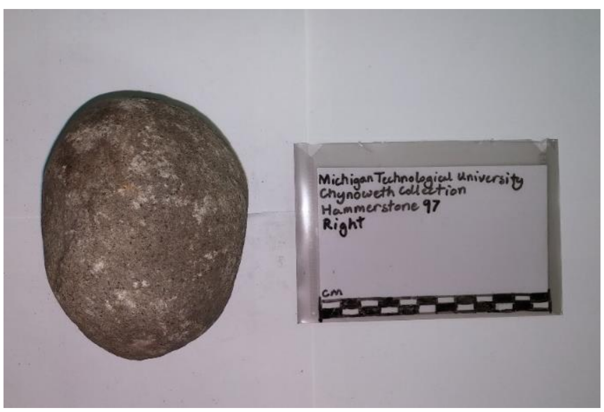
Chynoweth Collection Maul 93—CUH6

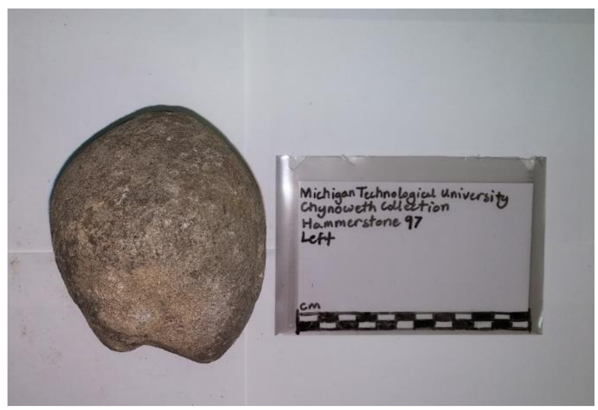












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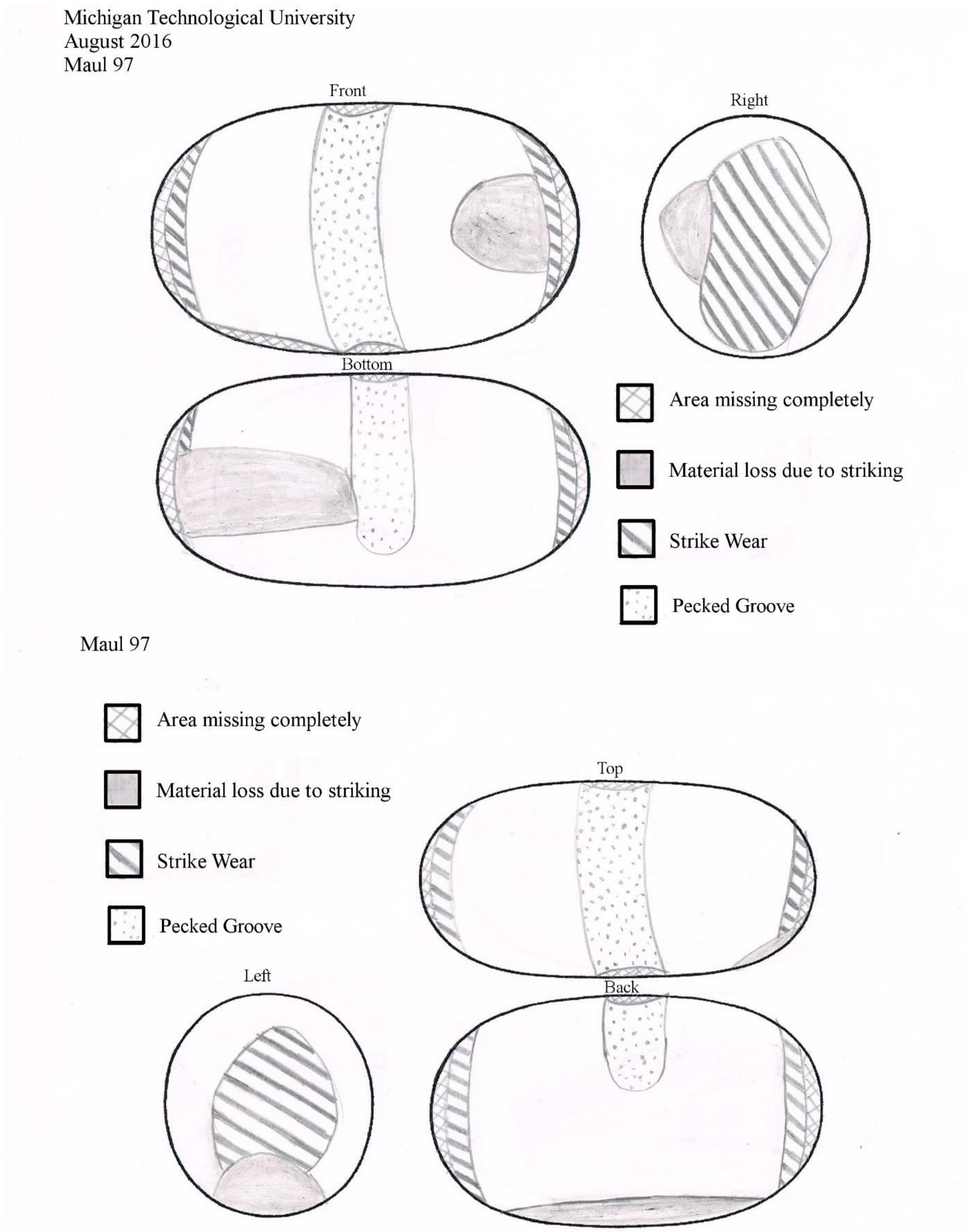
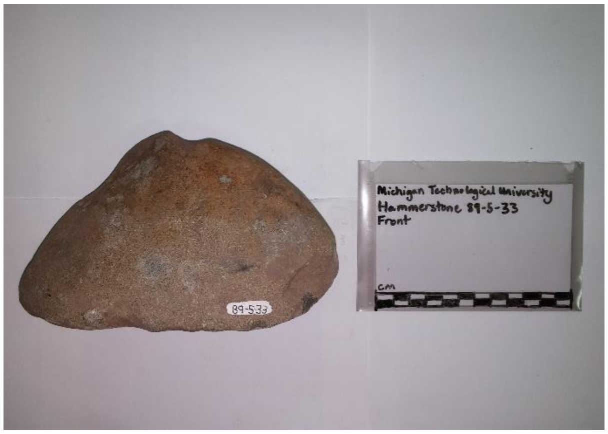
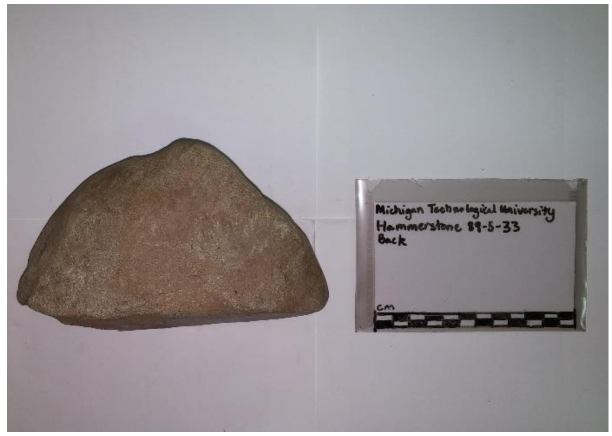
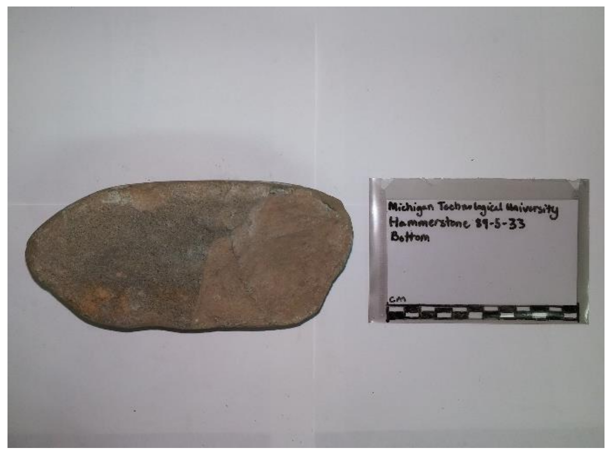


Chynoweth Collection Maul 93—CGH17

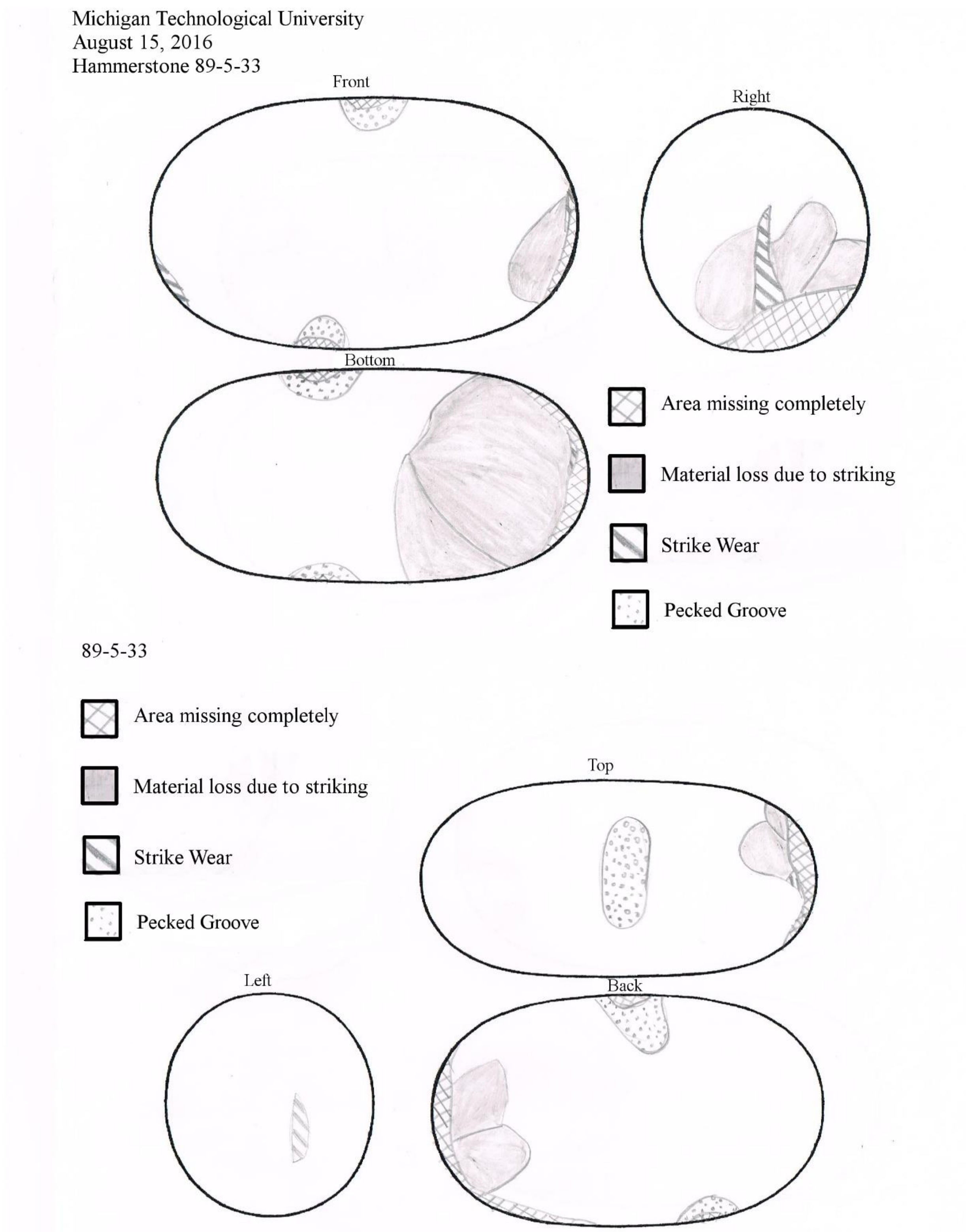
Appendix B: The Drier Collection



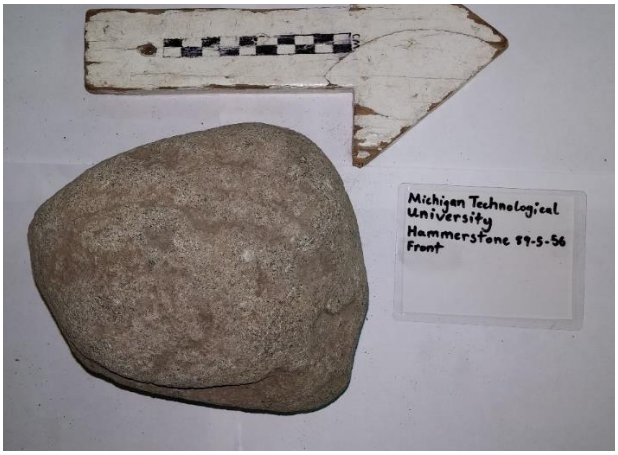


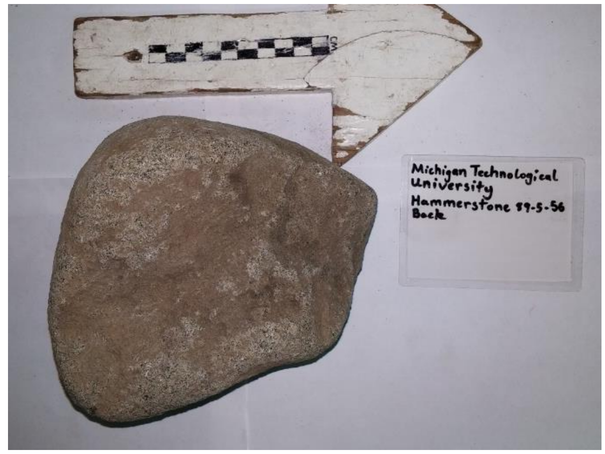


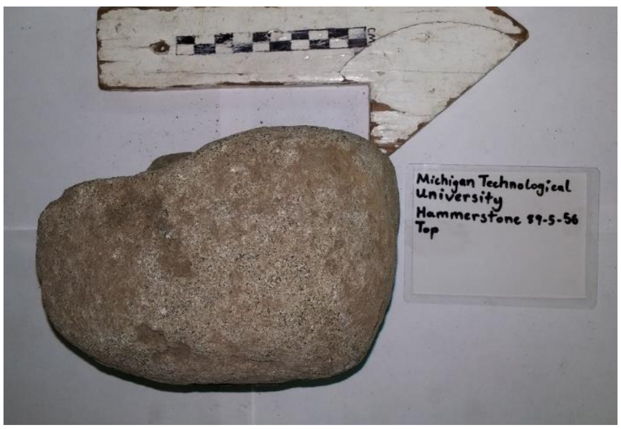
Drier Collection 89-5-33—DGH1



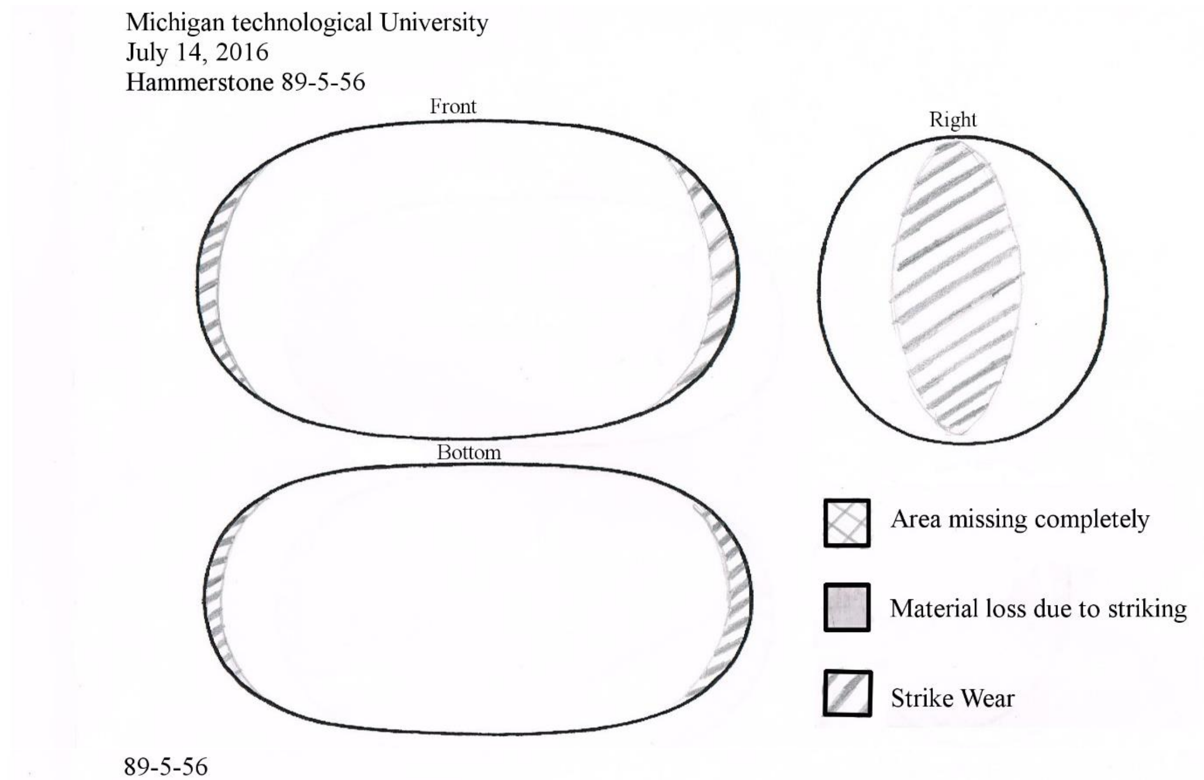
Drier Collection 89-5-33—DGH1

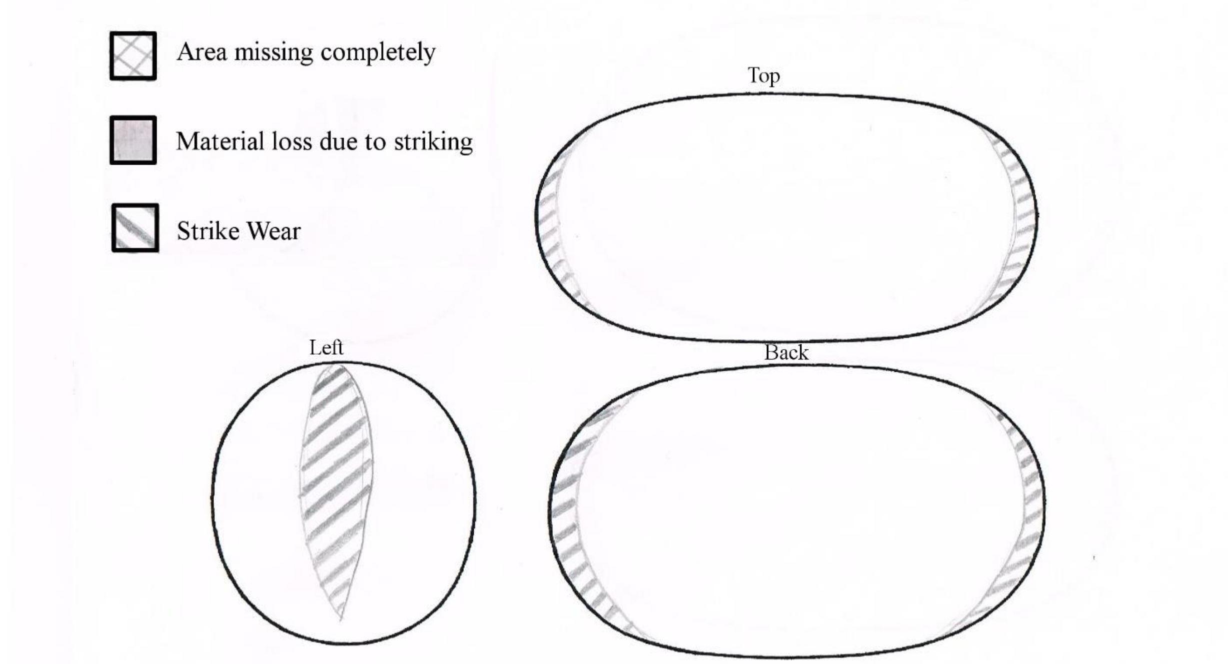




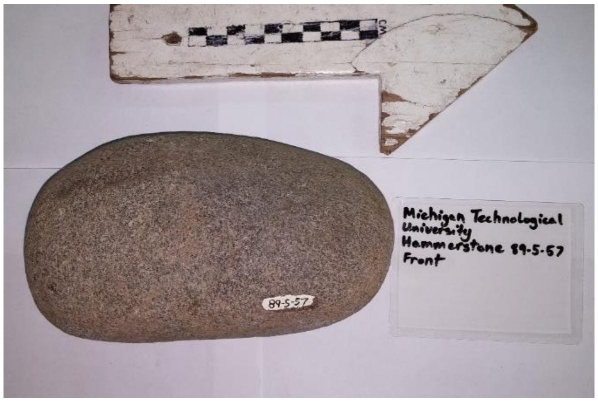


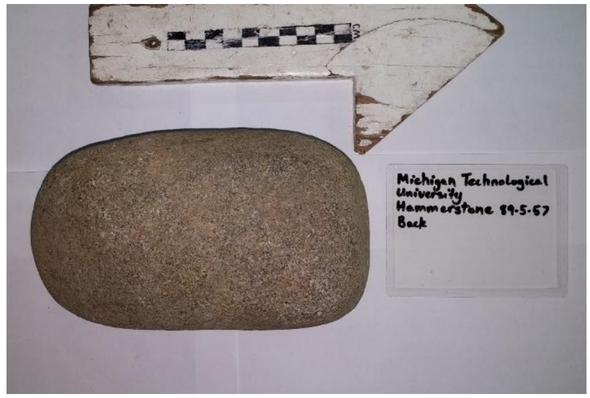
Drier Collection 89-5-56—DUH1

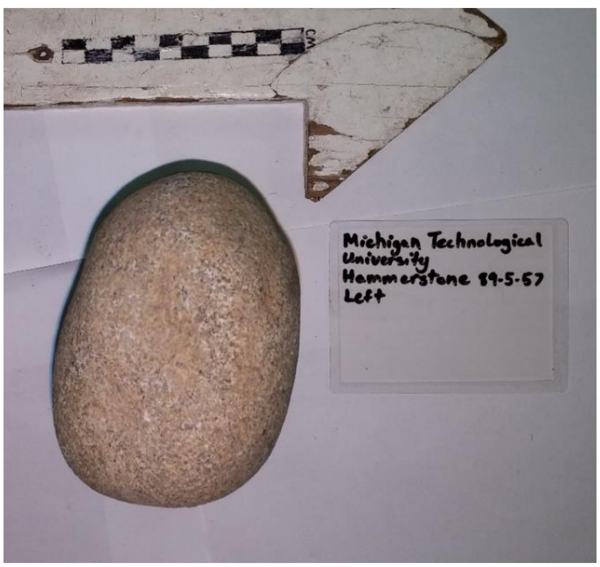


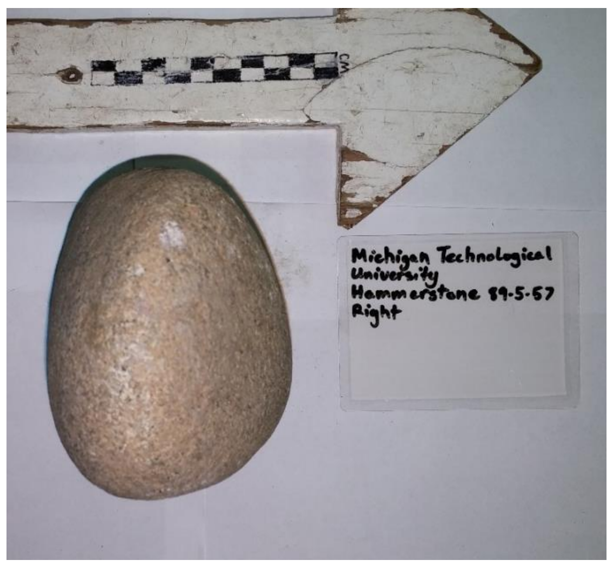


Drier Collection 89-5-56—DUH1

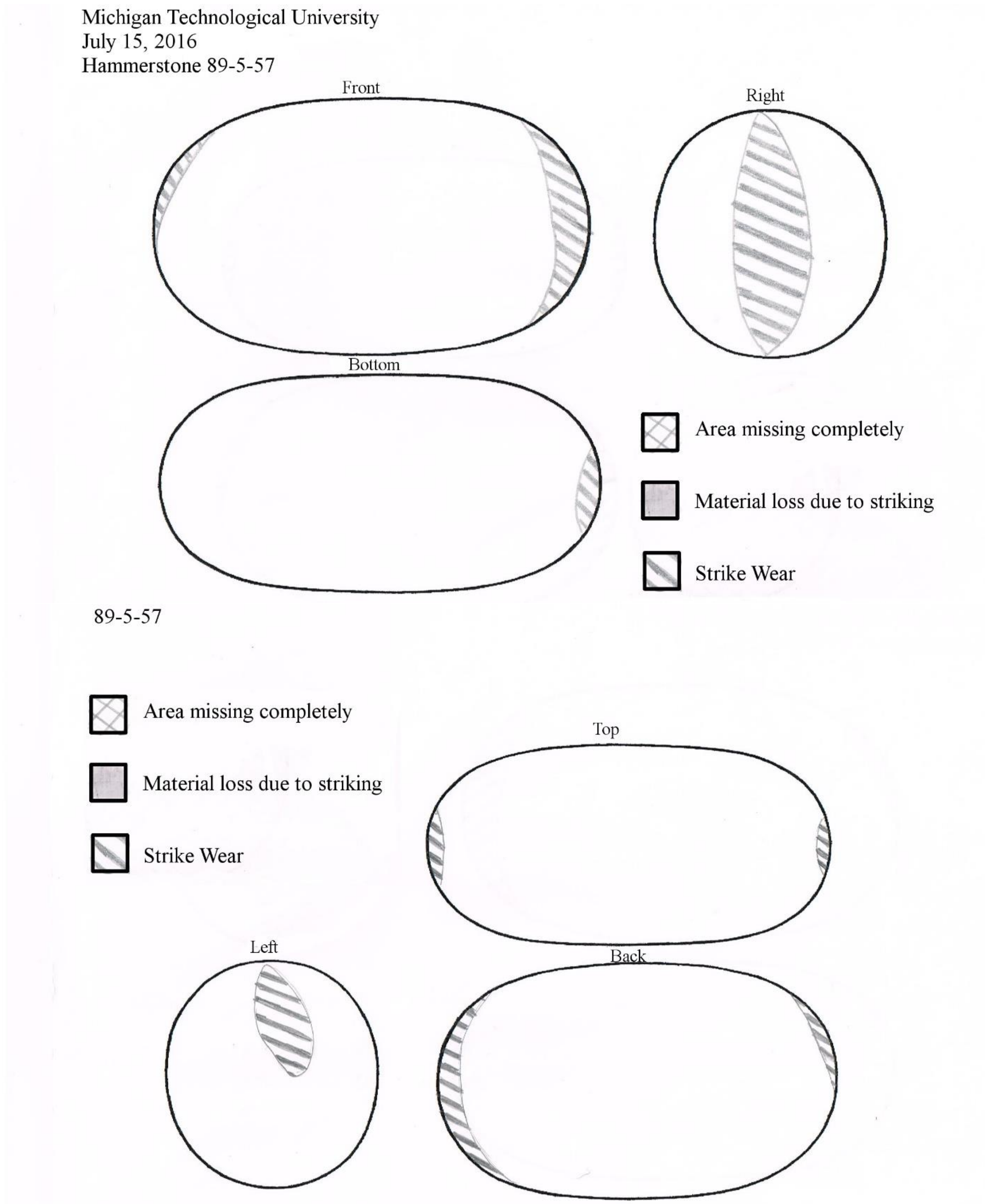




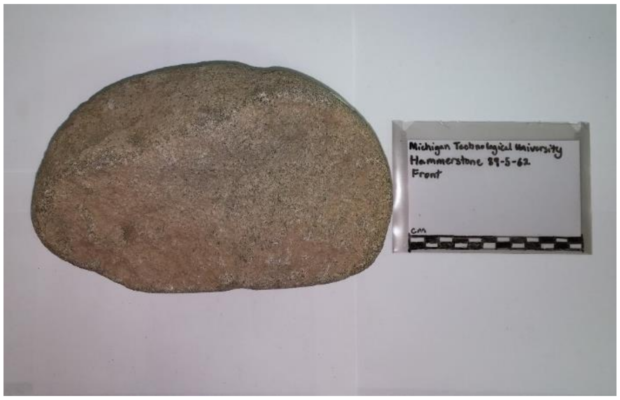


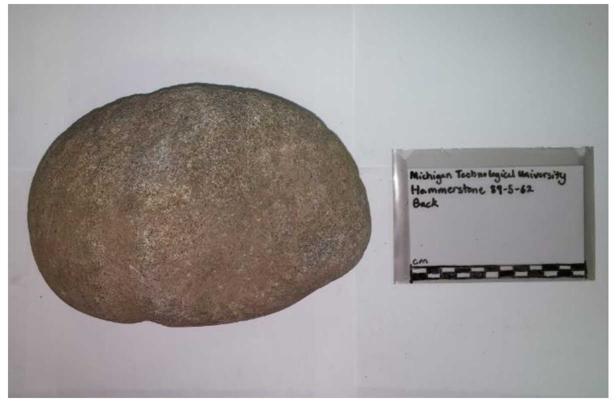


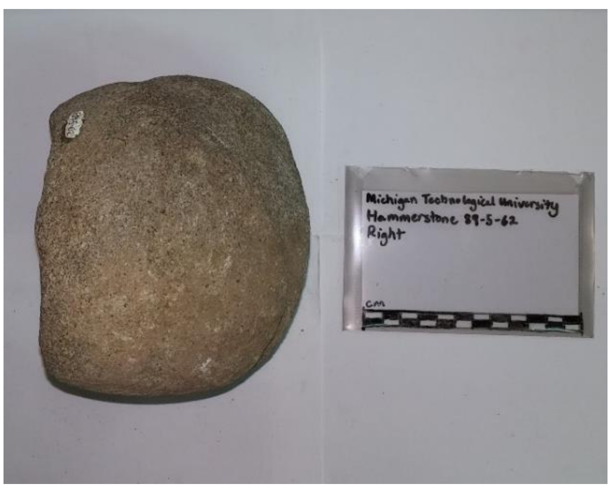
Drier Collection 89-5-57—DUH2

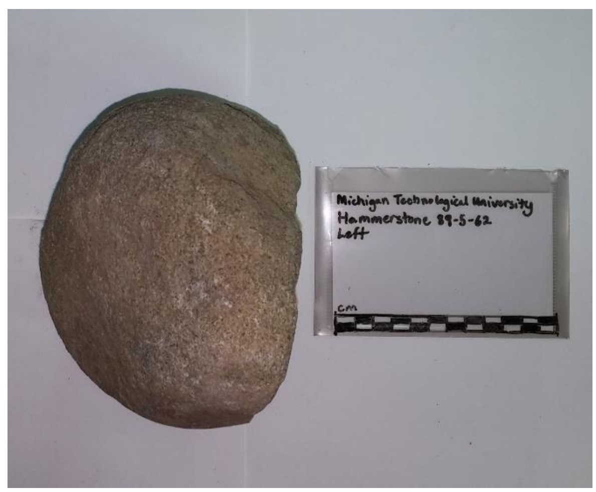


Drier Collection 89-5-57—DUH2

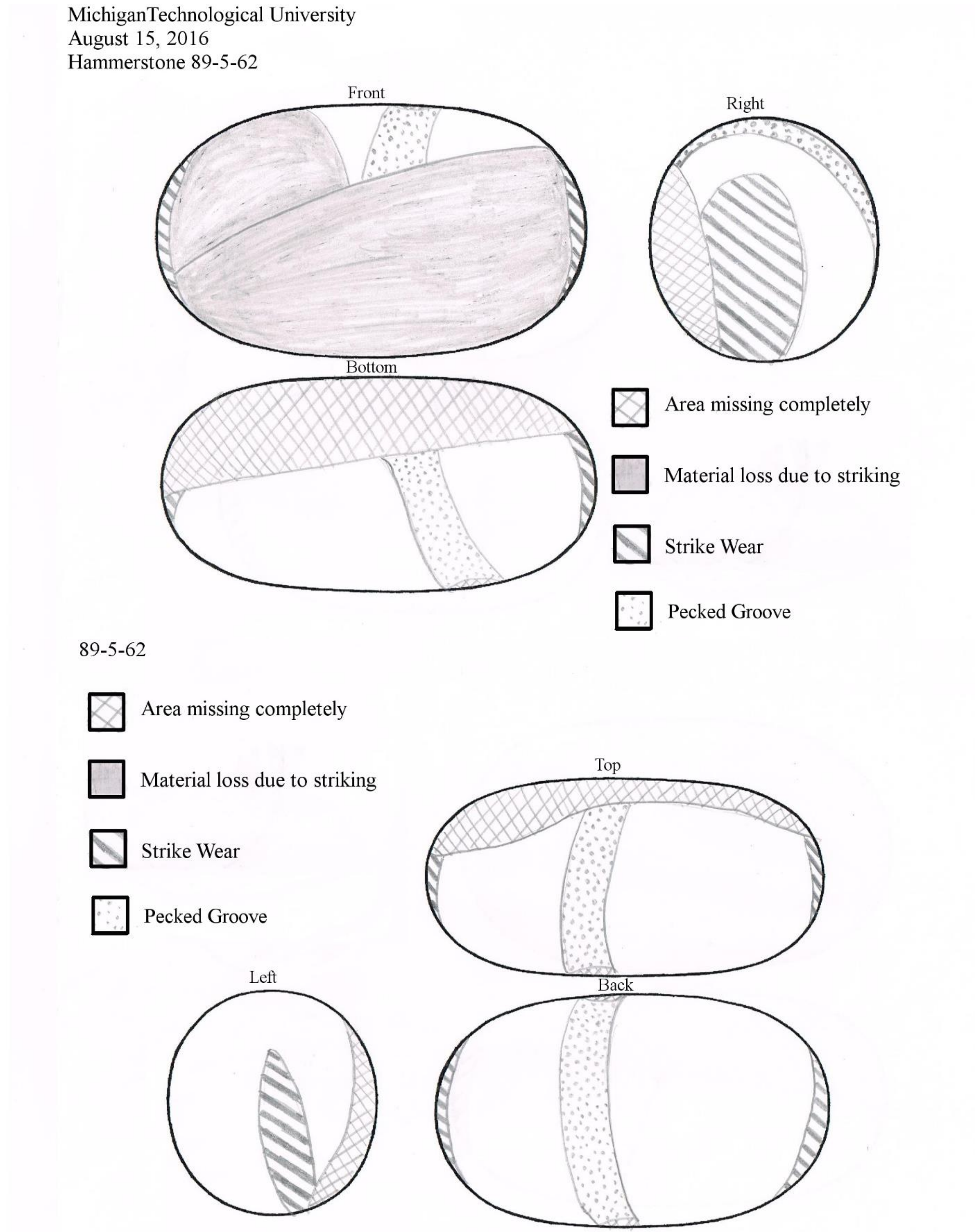




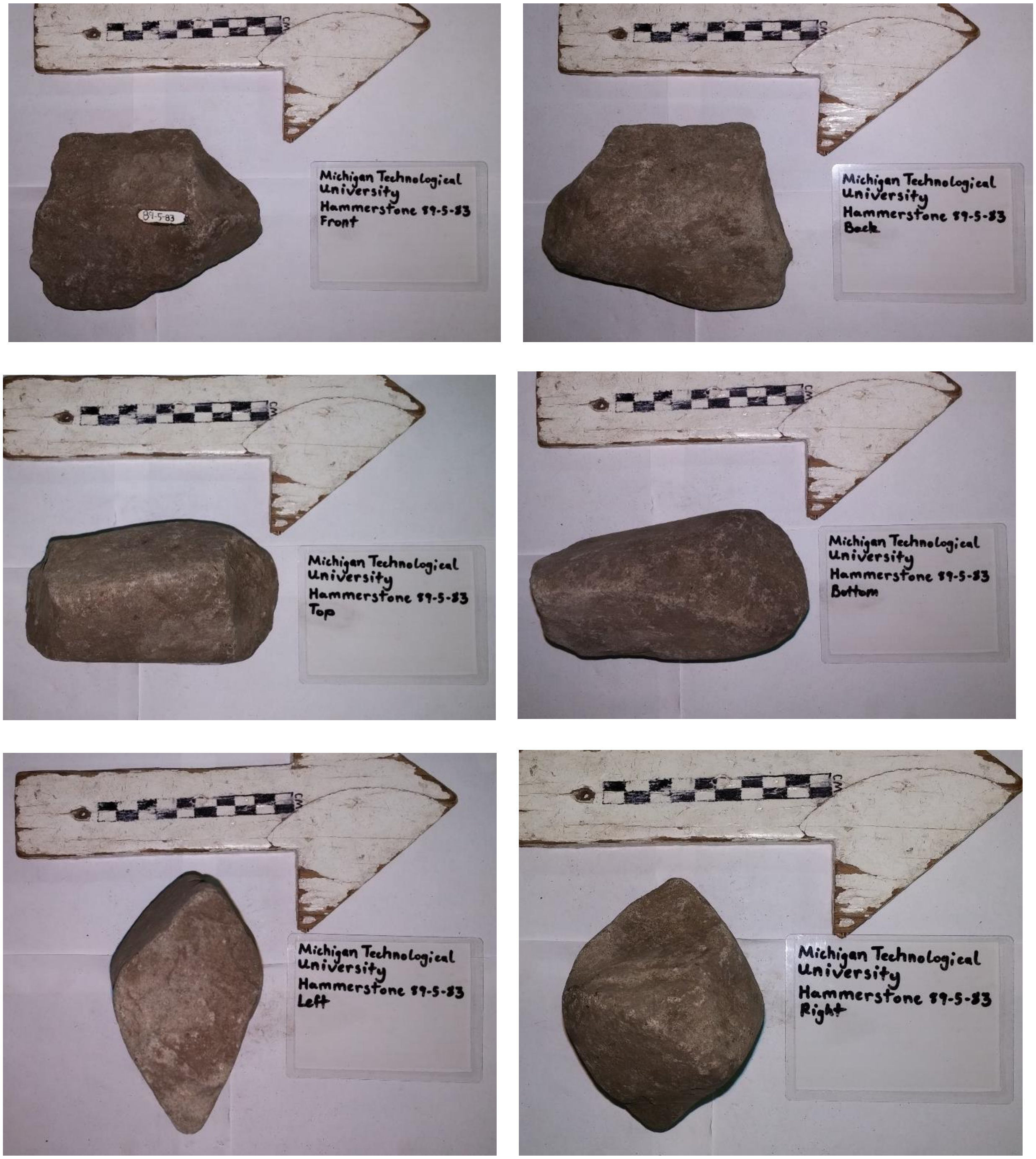




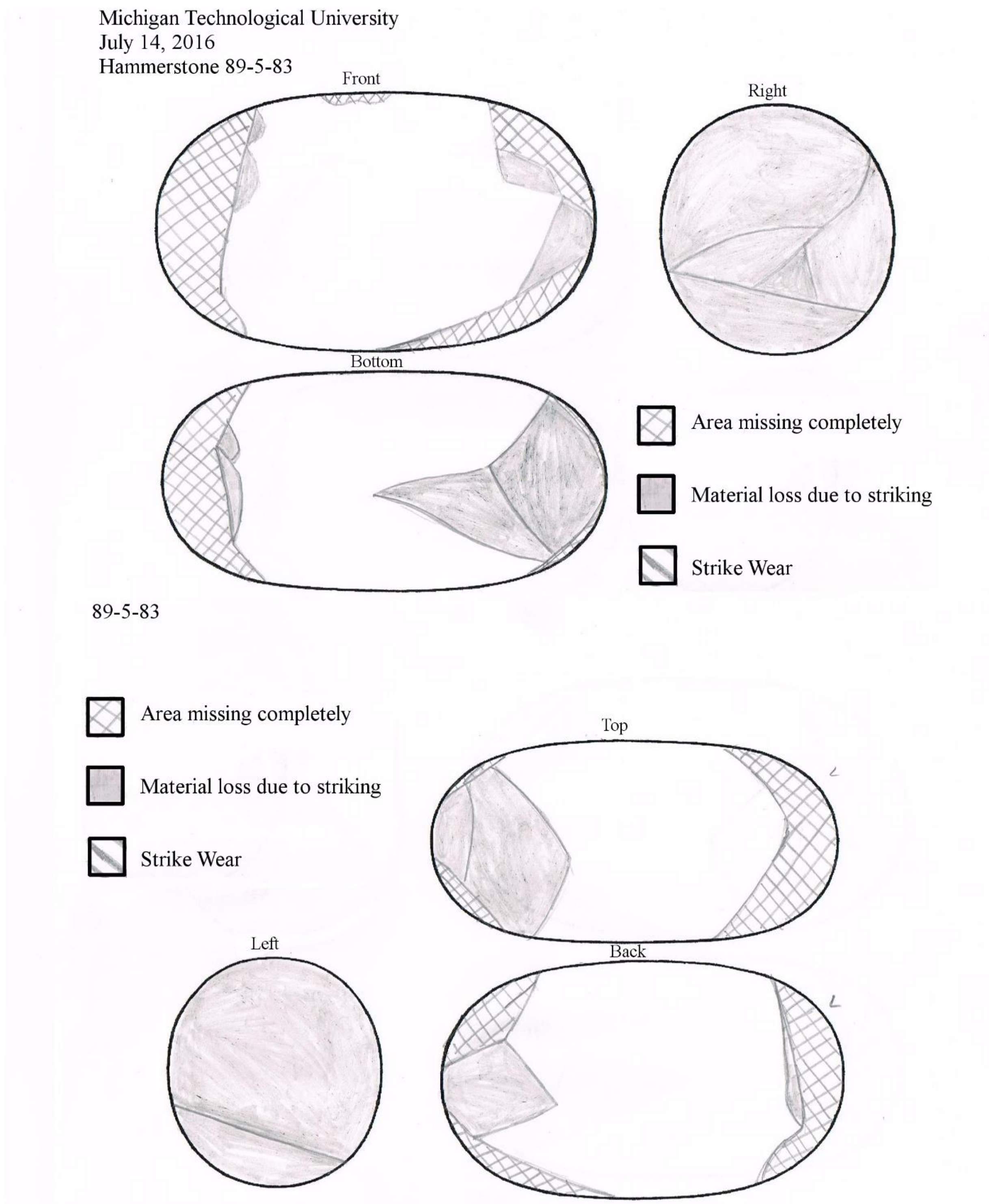
Drier Collection 89-5-62—DGH2



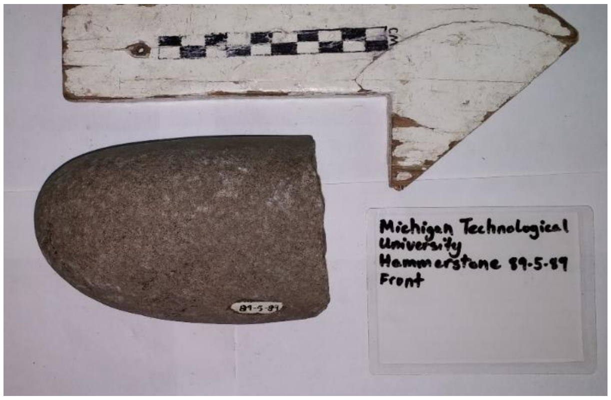
Drier Collection 89-5-62—DGH2

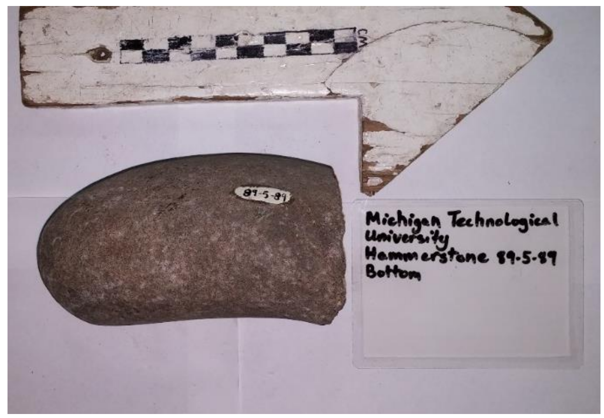


Drier Collection 89-5-83—DUH3

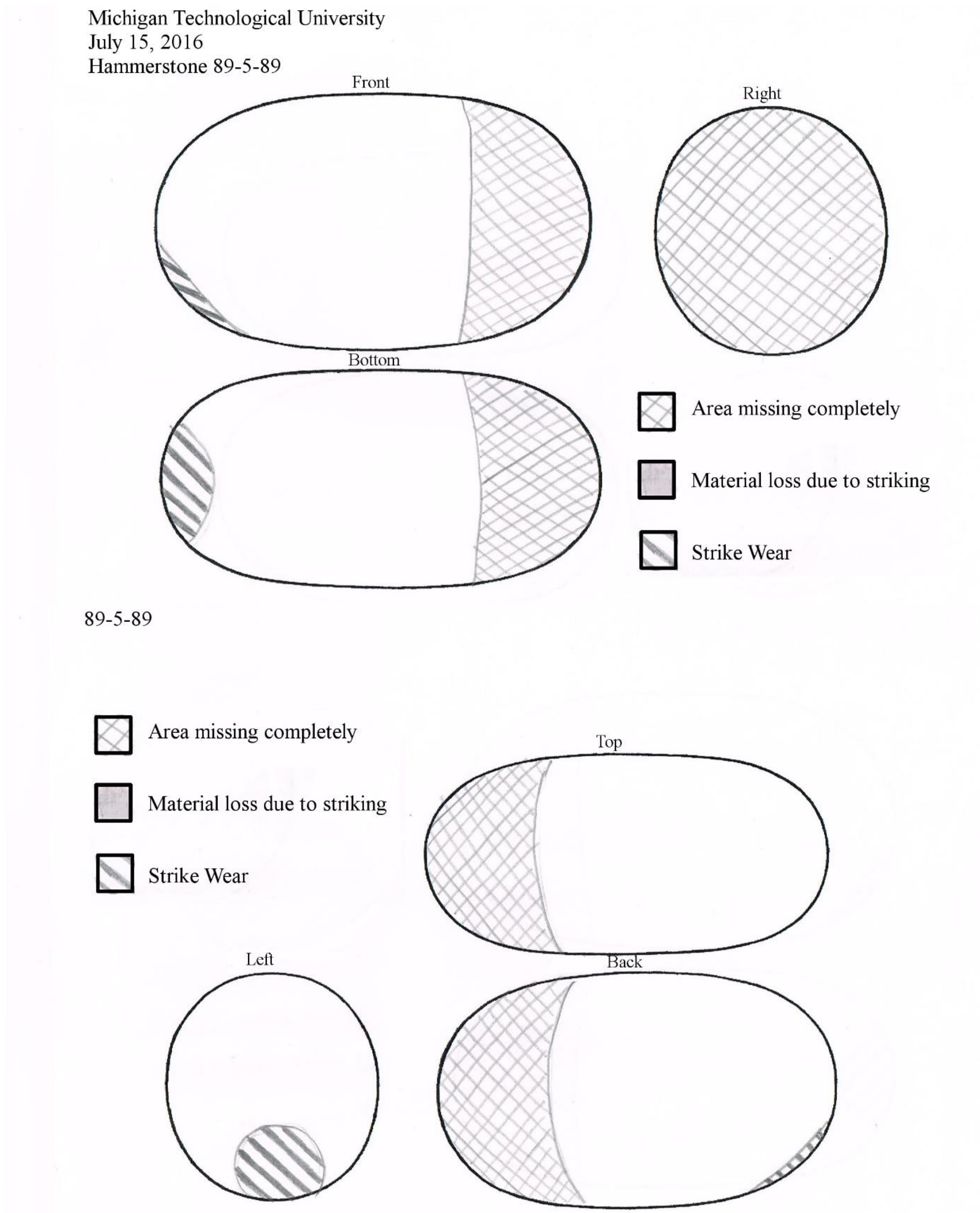


Drier Collection 89-5-83—DUH3



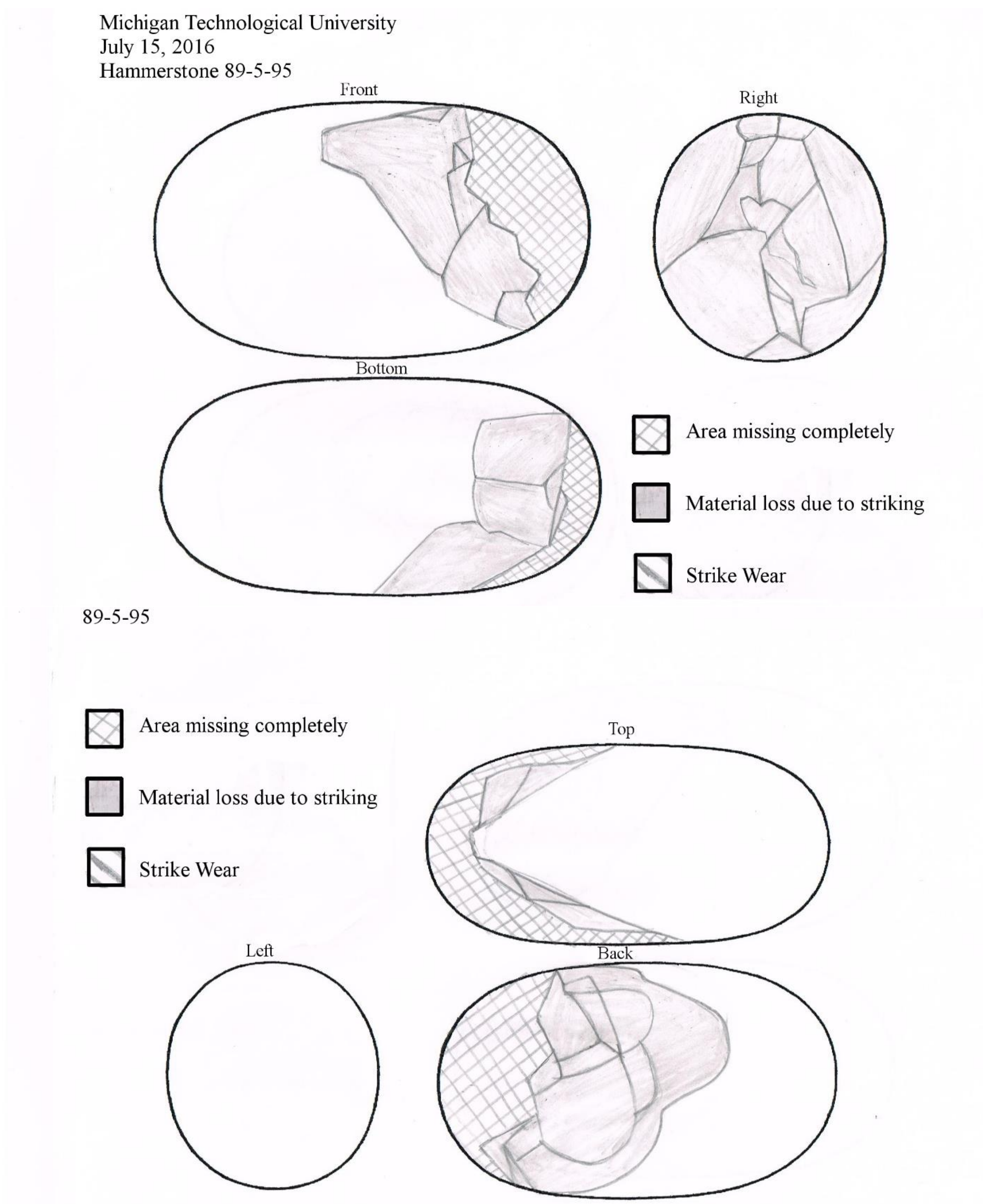


Drier Collection 89-5-89—DUH4

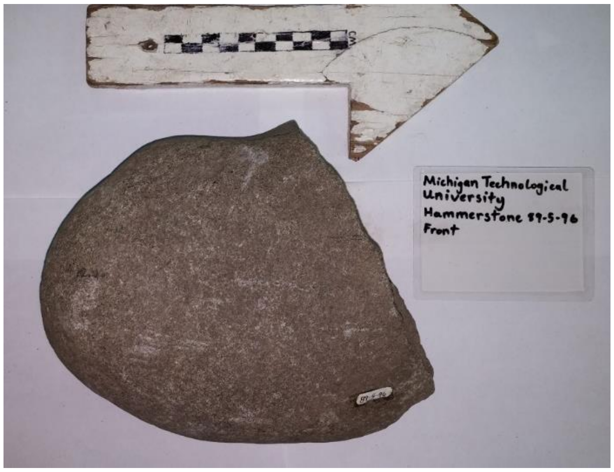


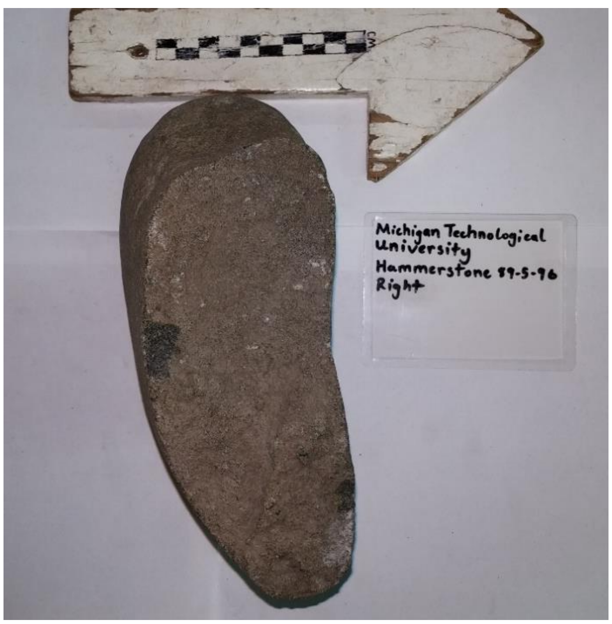
Drier Collection 89-5-89—DUH4

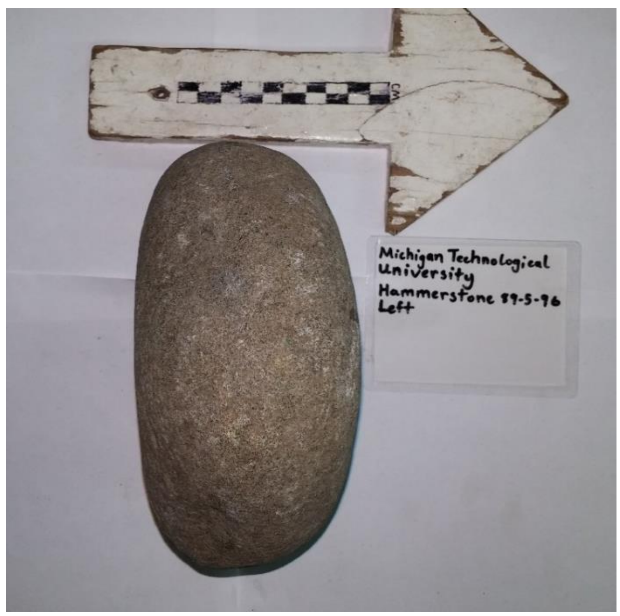
Drier Collection 89-5-95—DUH5



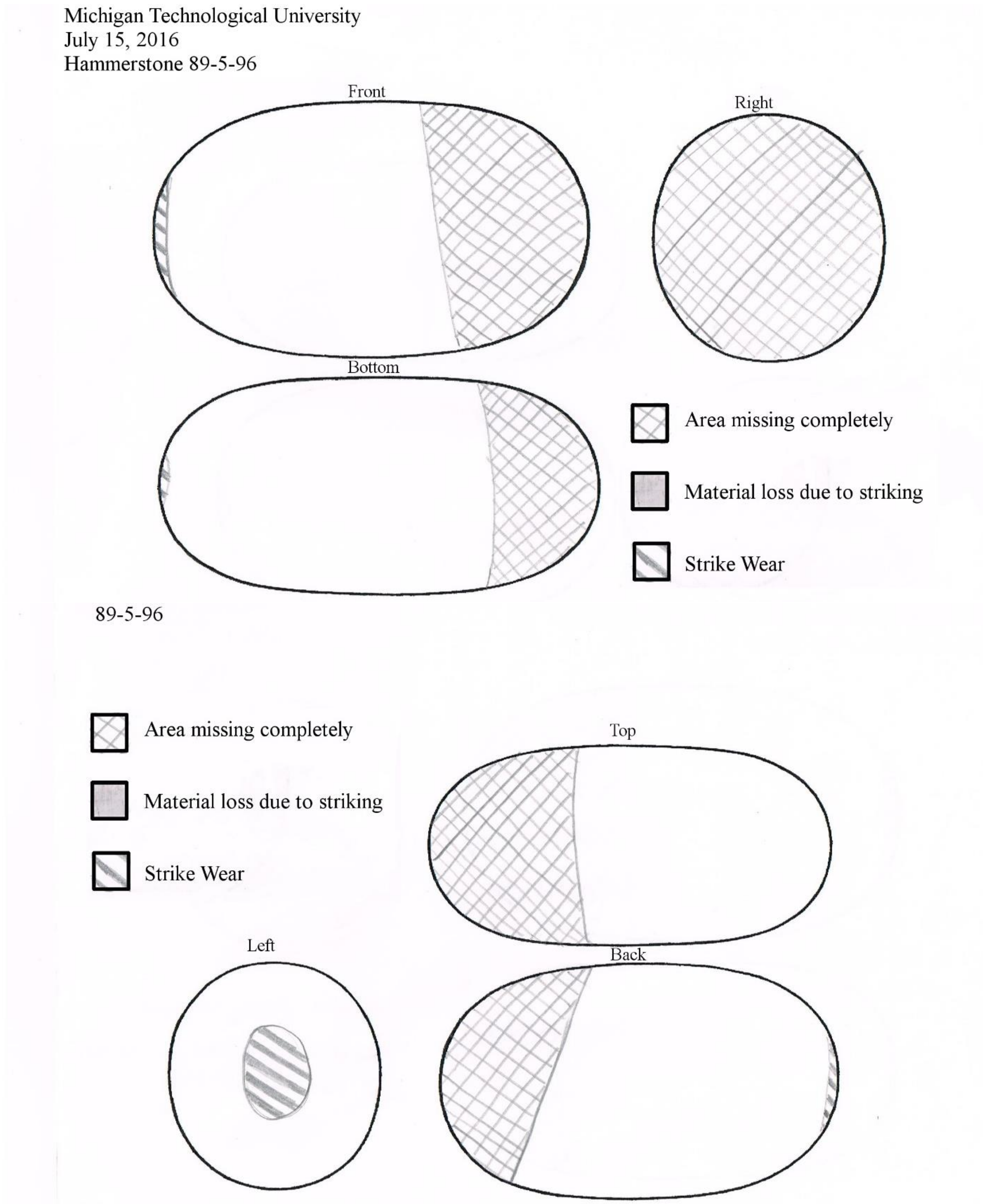
Drier Collection 89-5-95—DUH5







Drier Collection 89-5-96—DUH6



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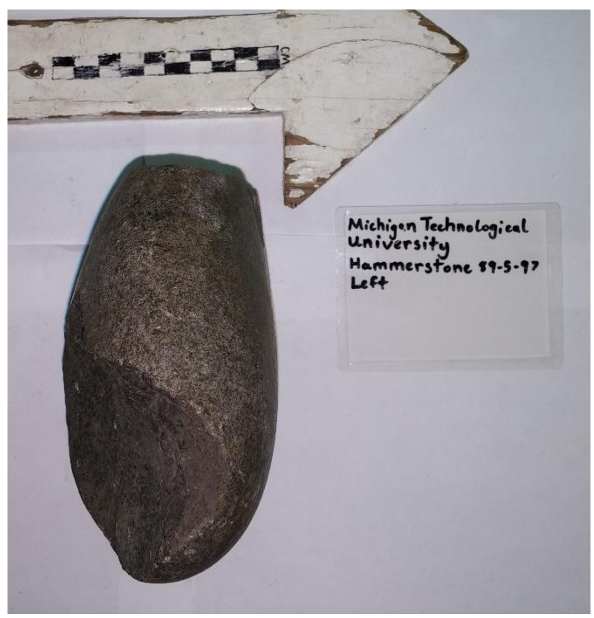

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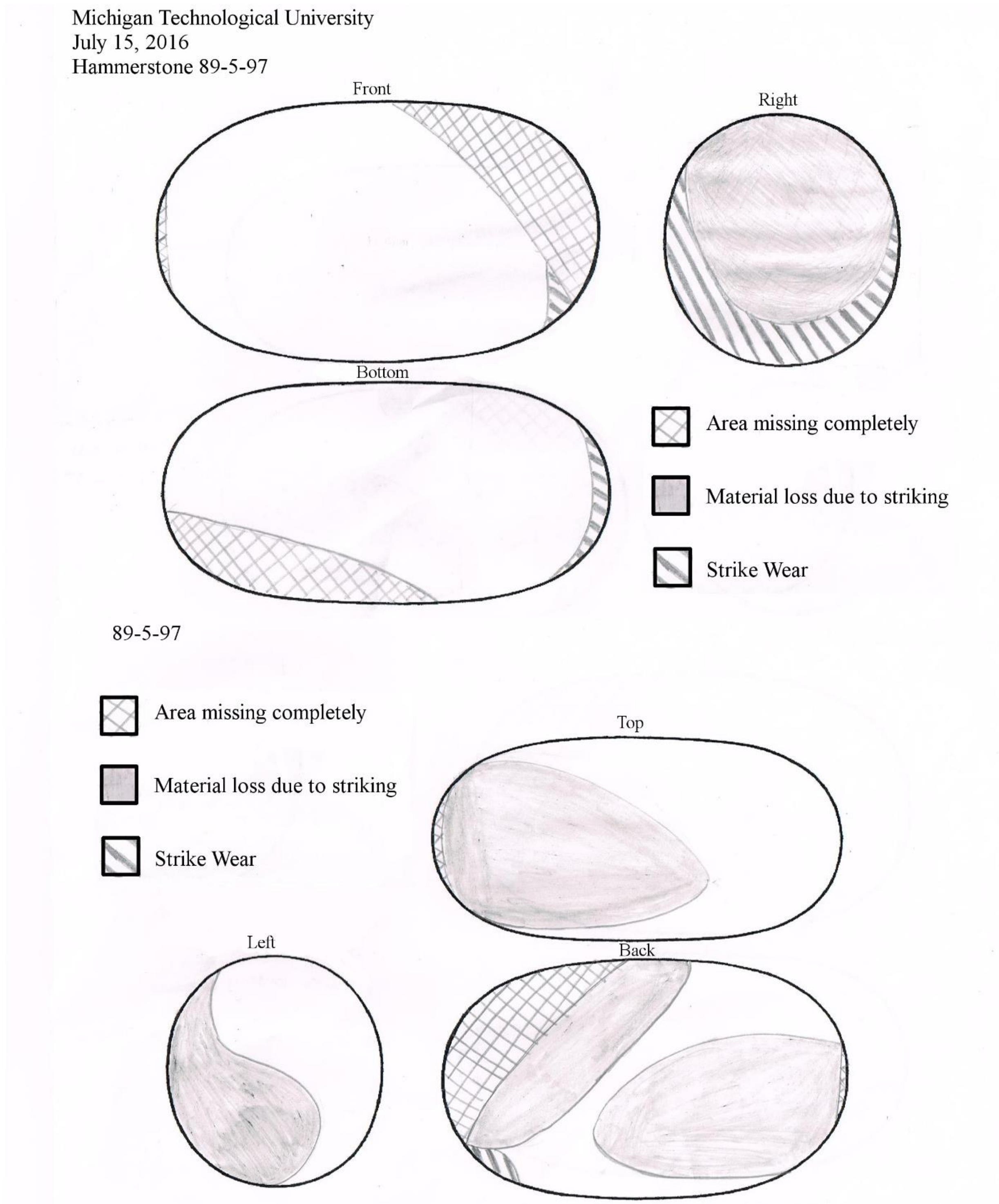

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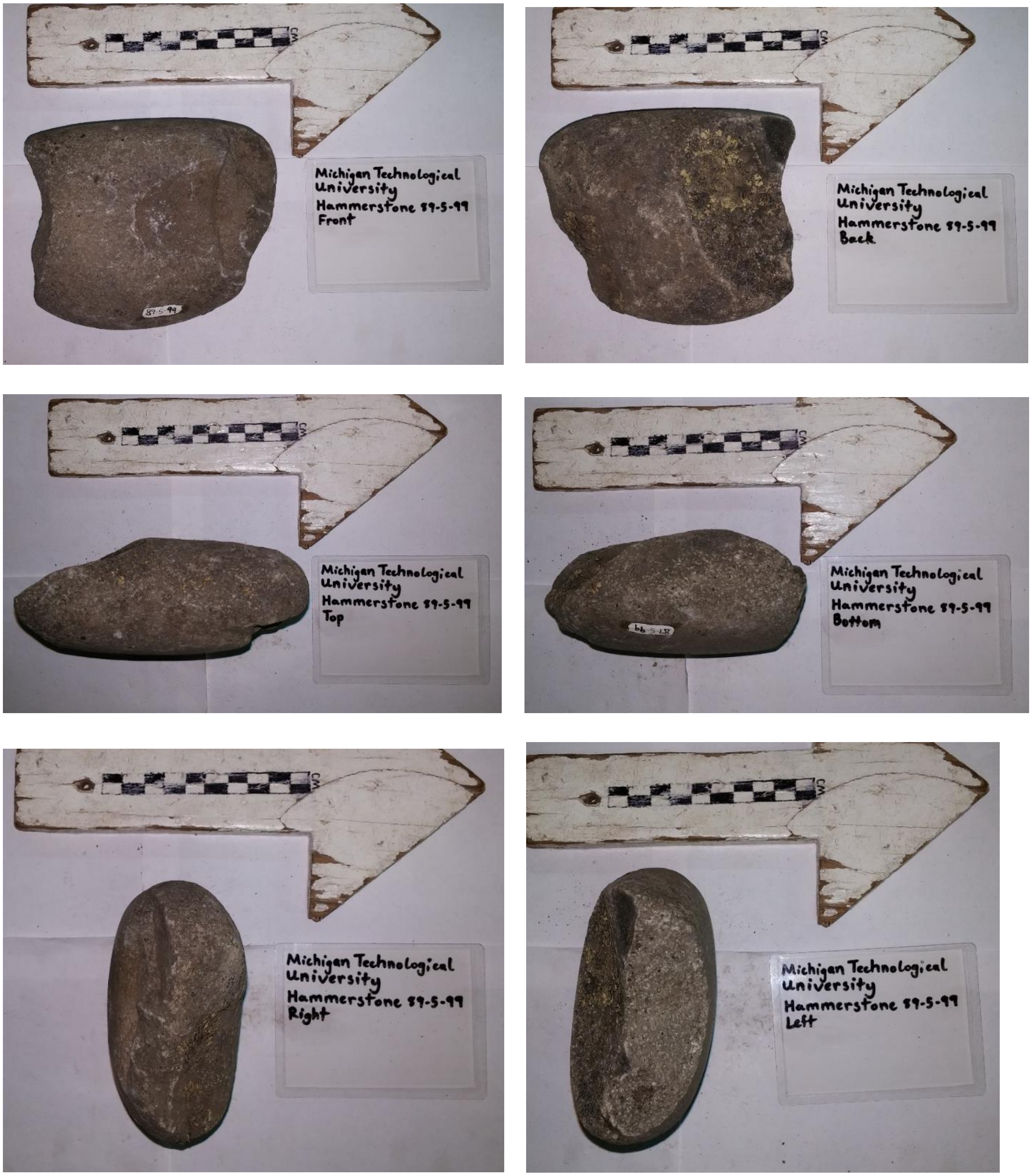

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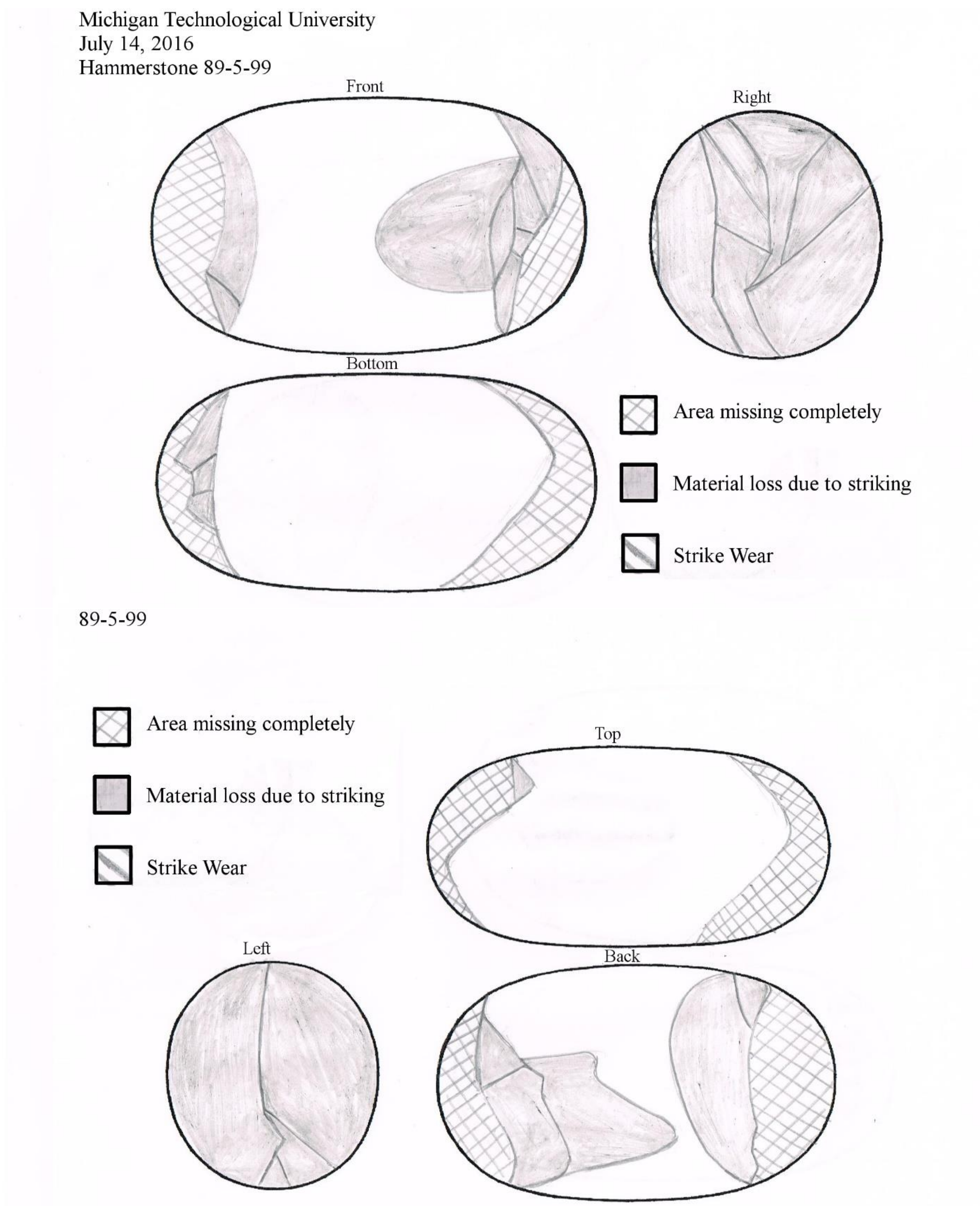

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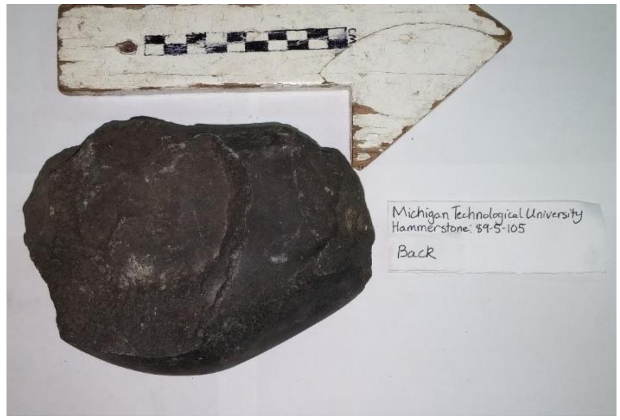

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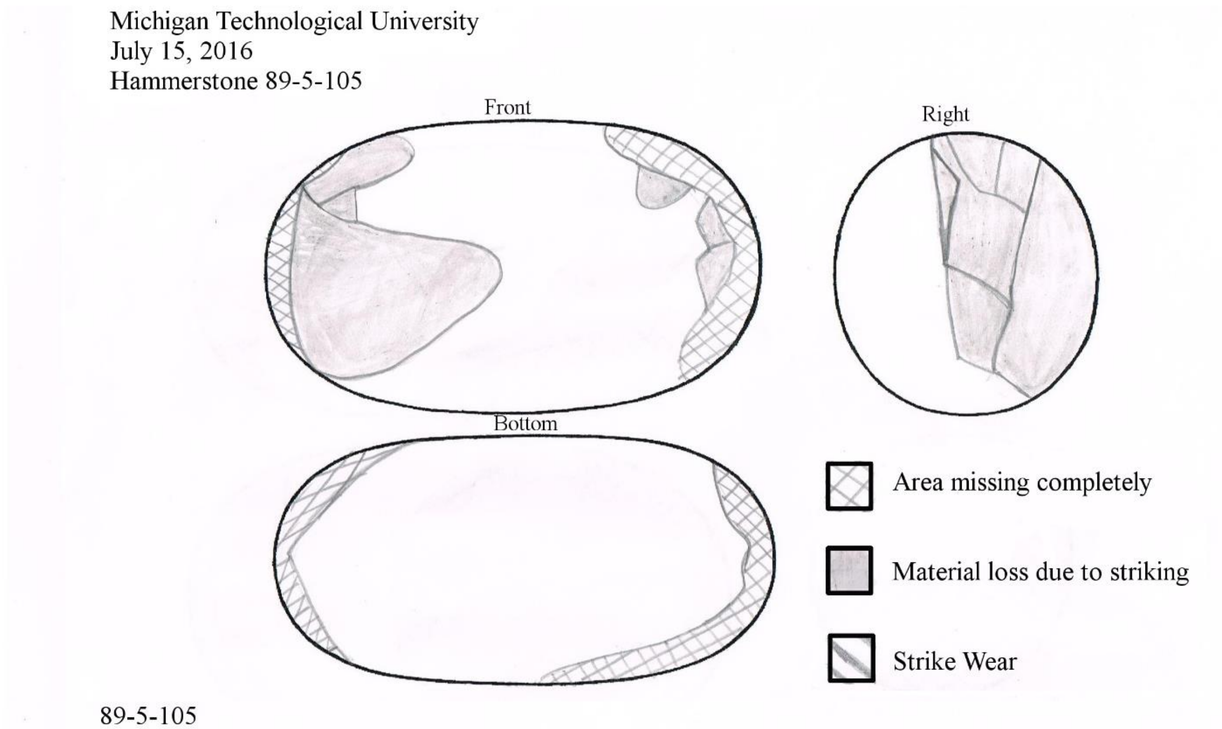
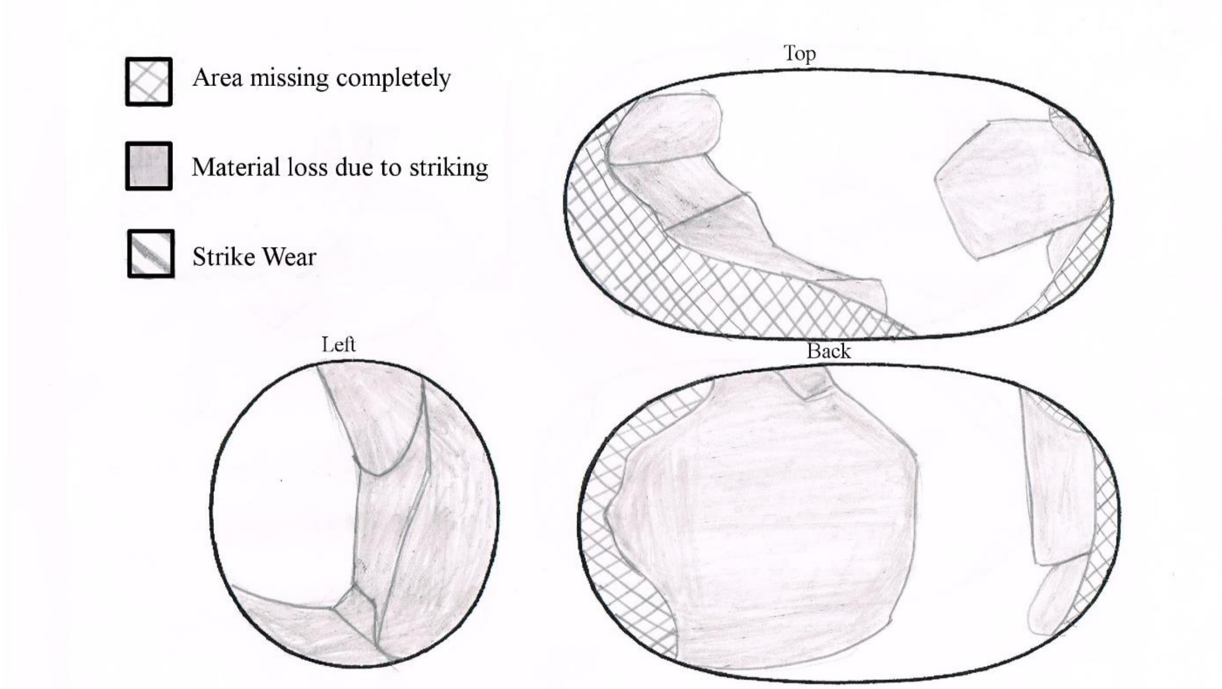
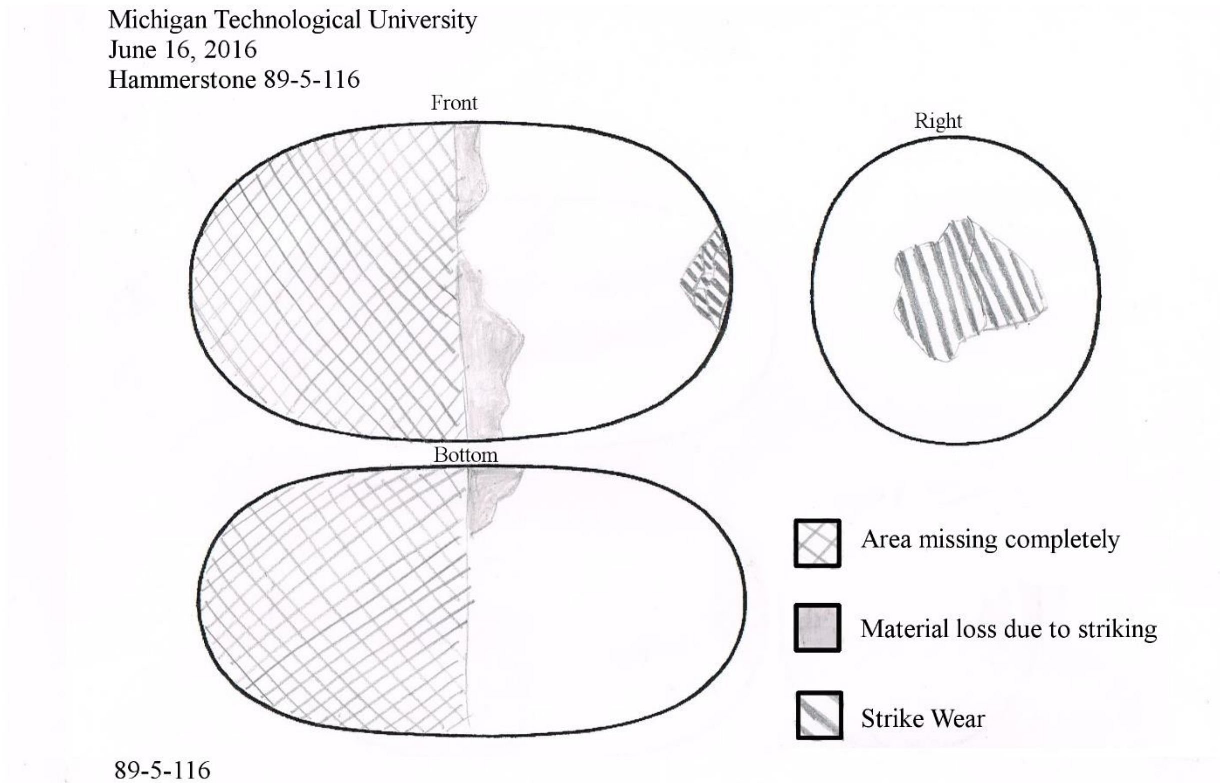
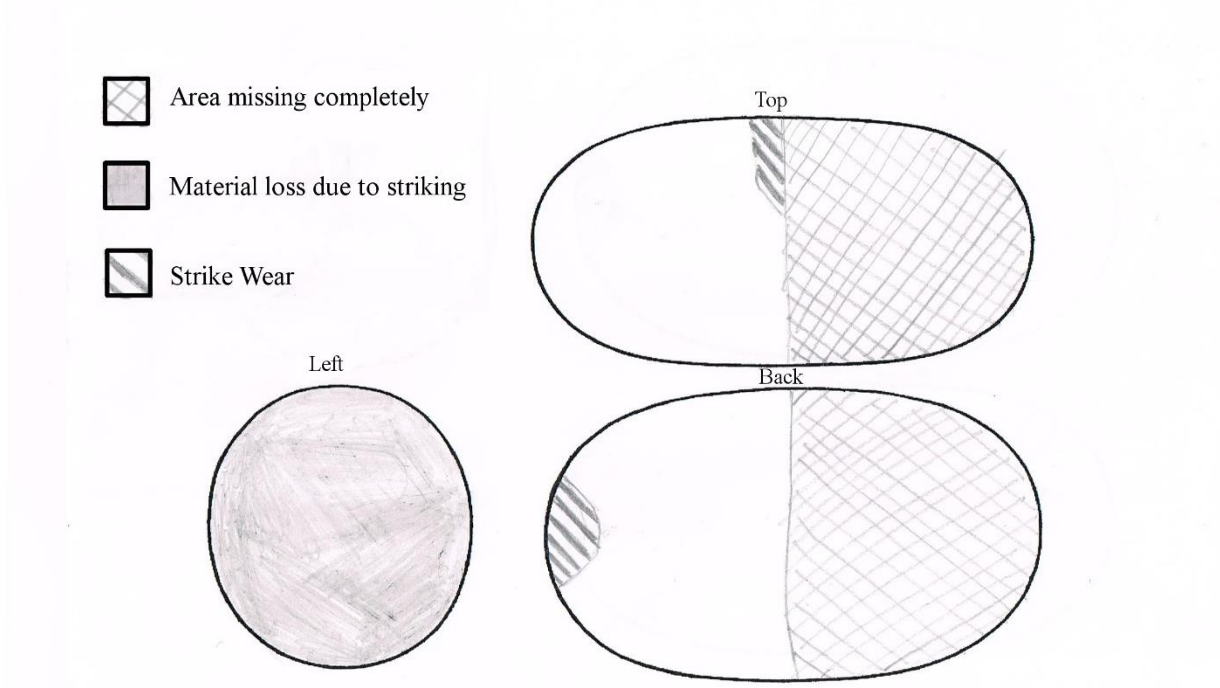




Drier Collection 89-5-105—DUH9

Drier Collection 89-5-116—DUH10





Drier Collection 89-5-116—DUH10

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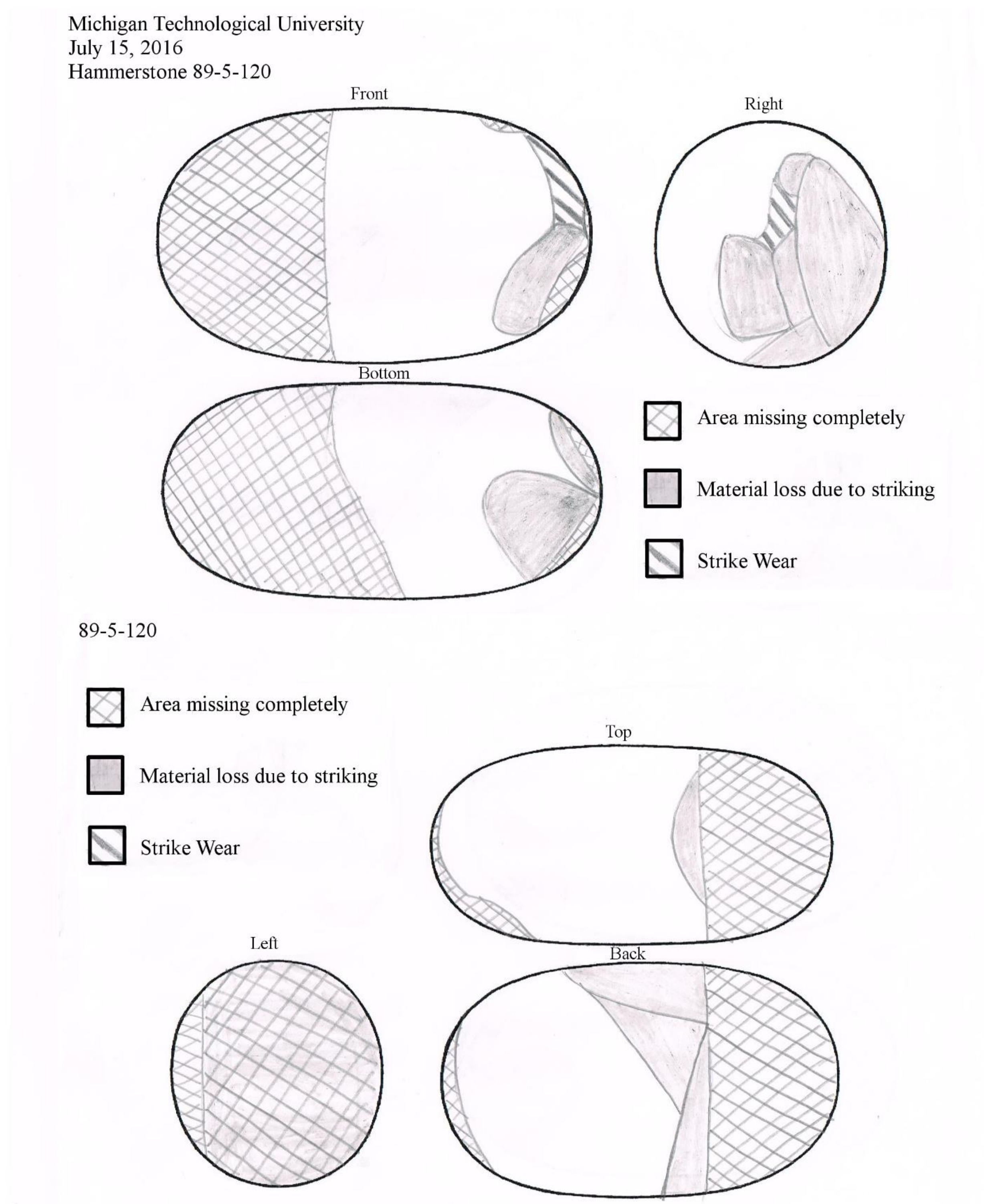

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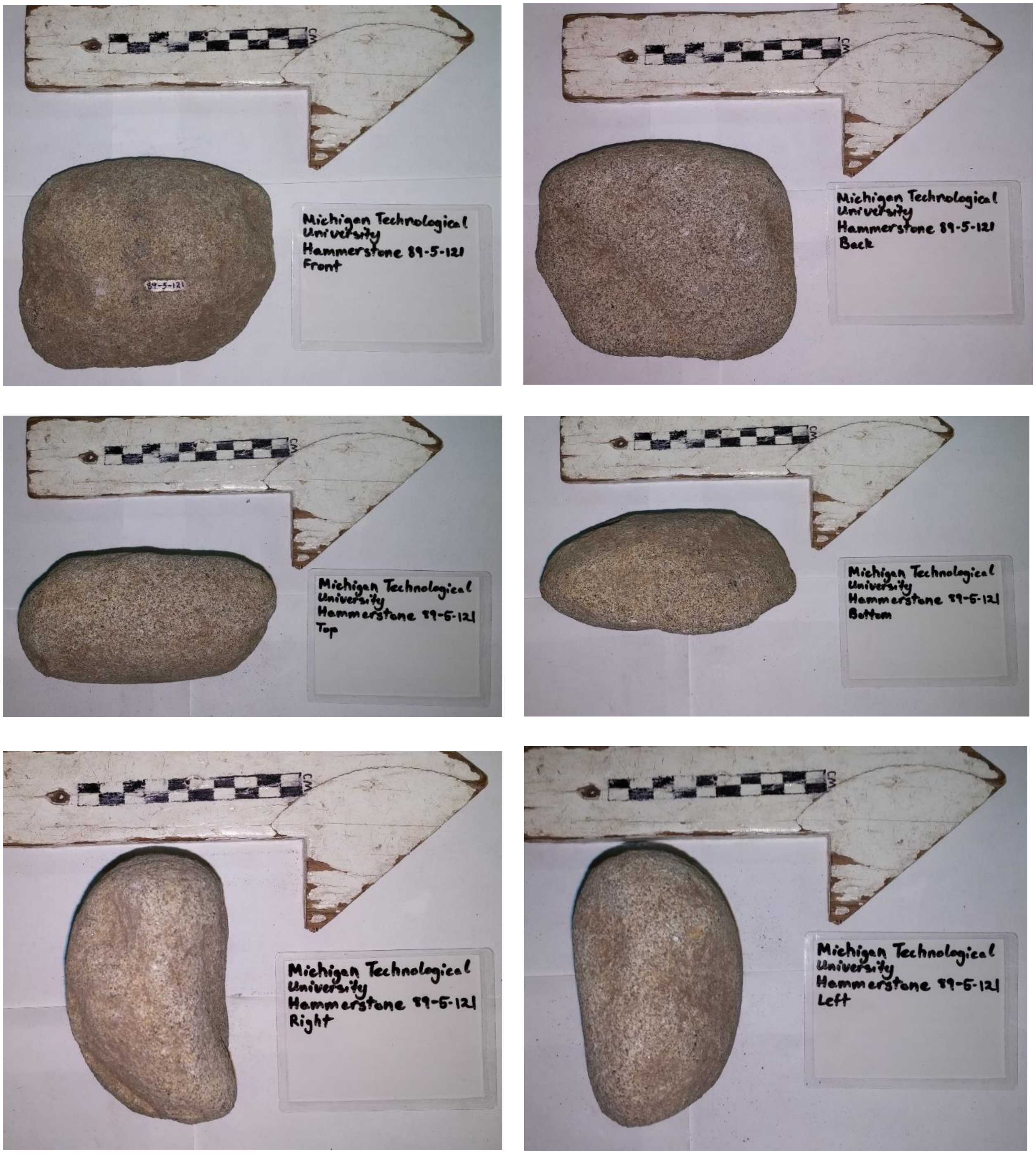

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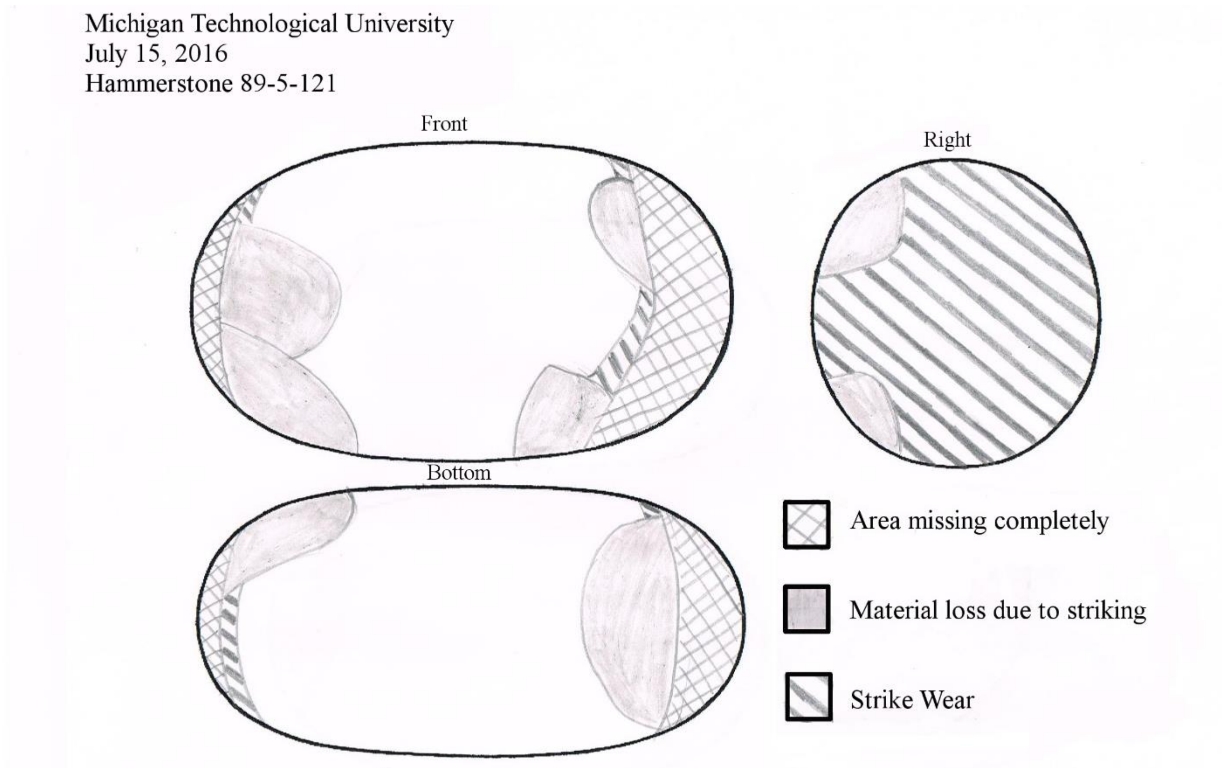
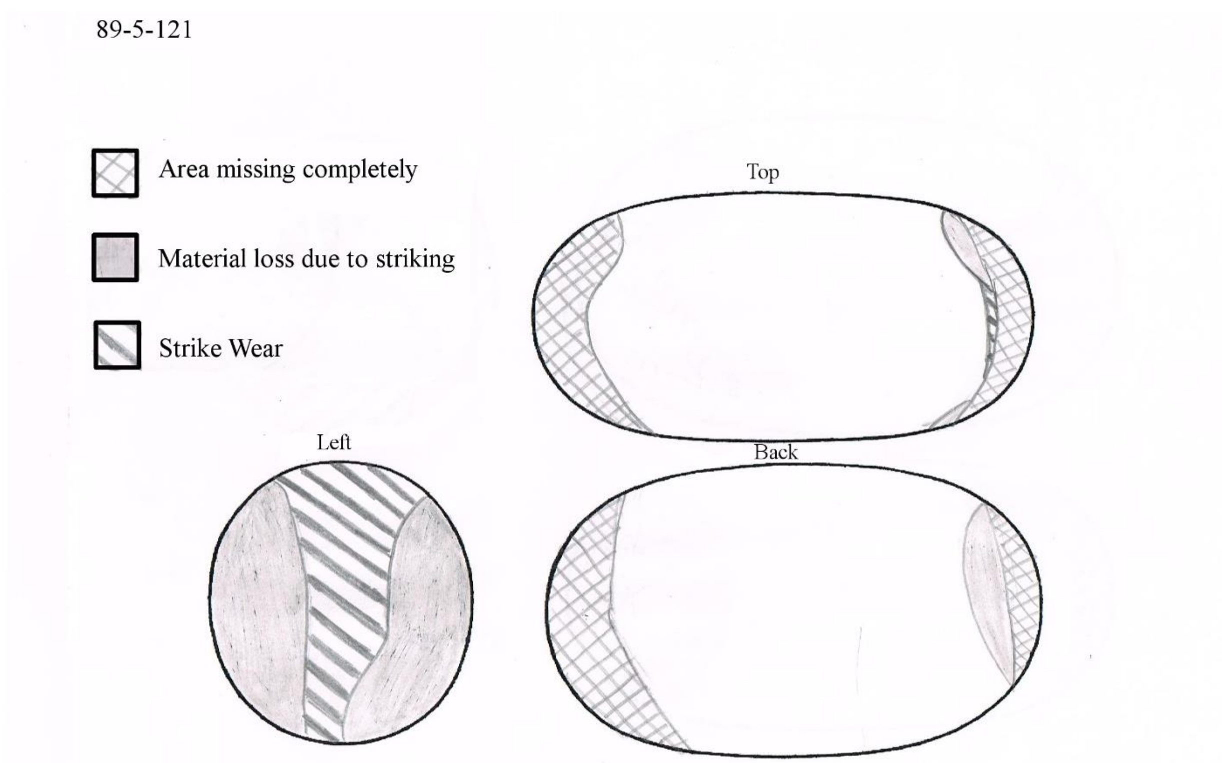
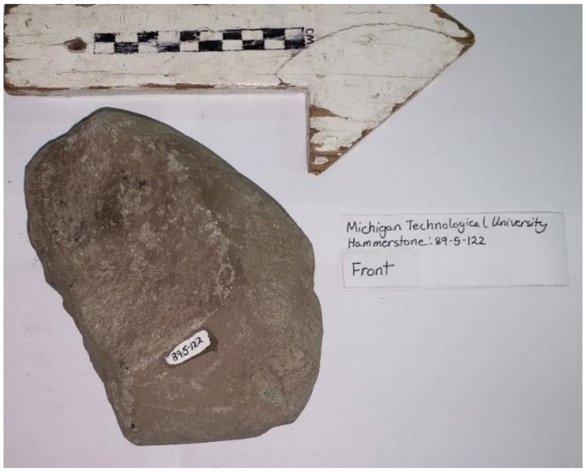




Drier Collection 89-5-121—DUH12



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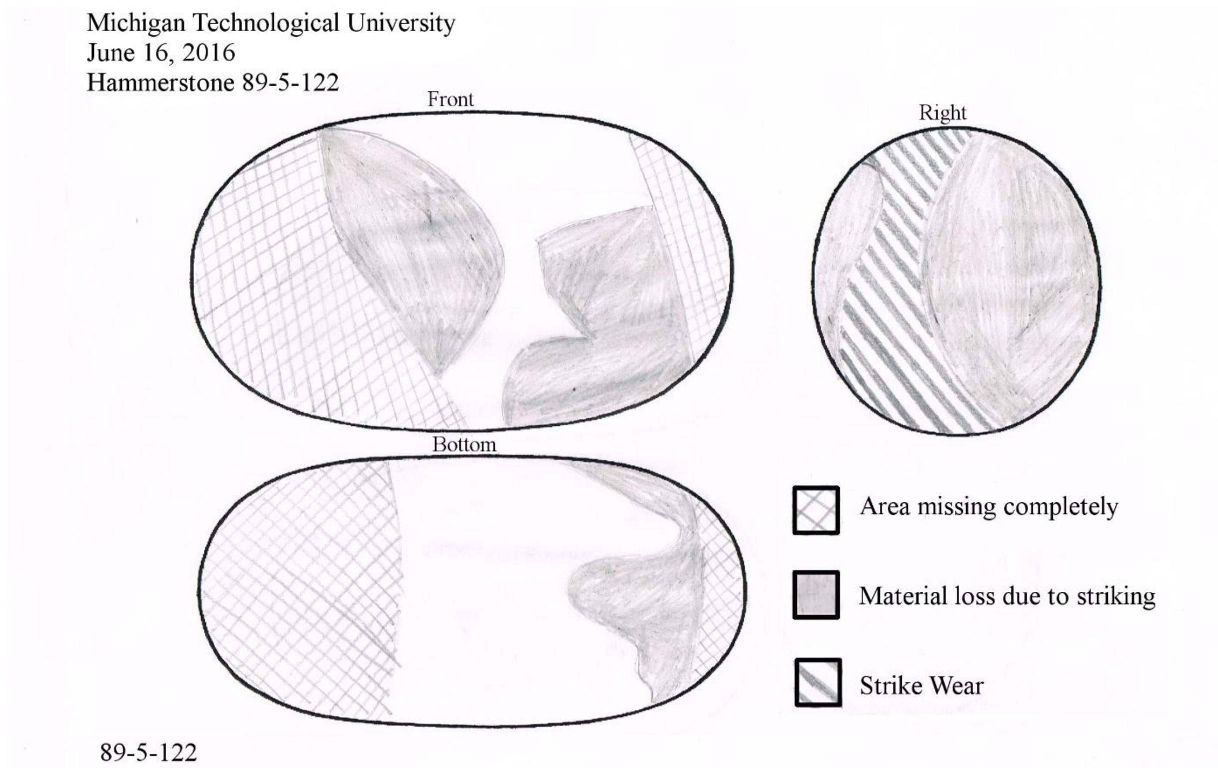
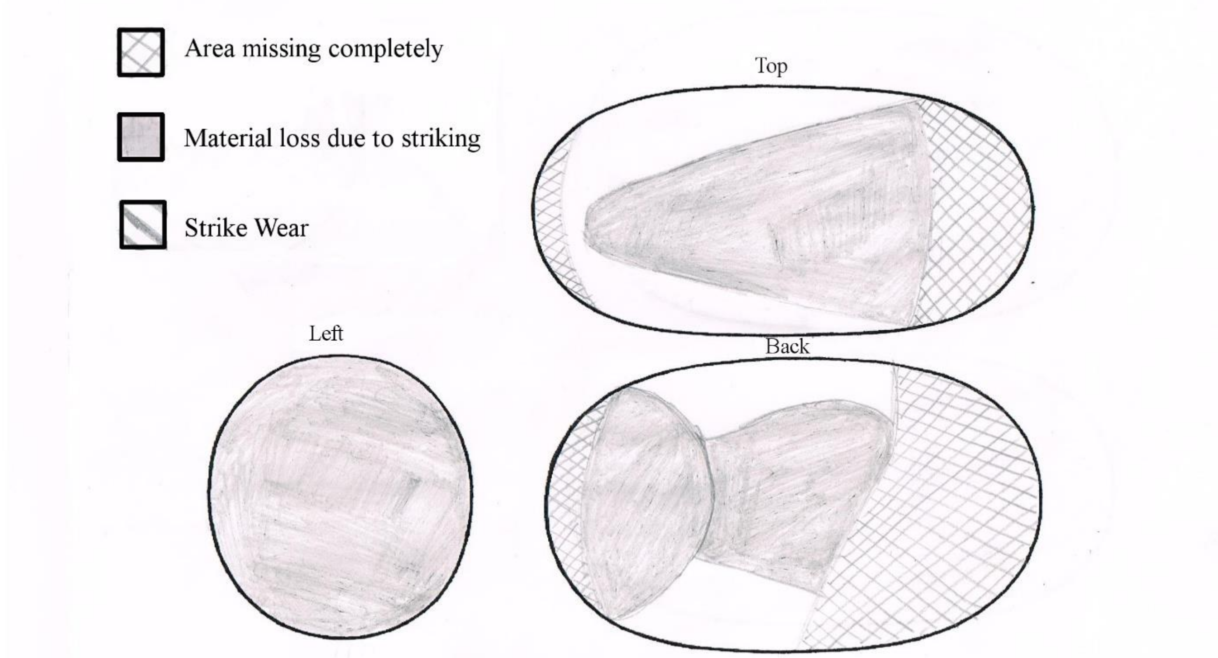
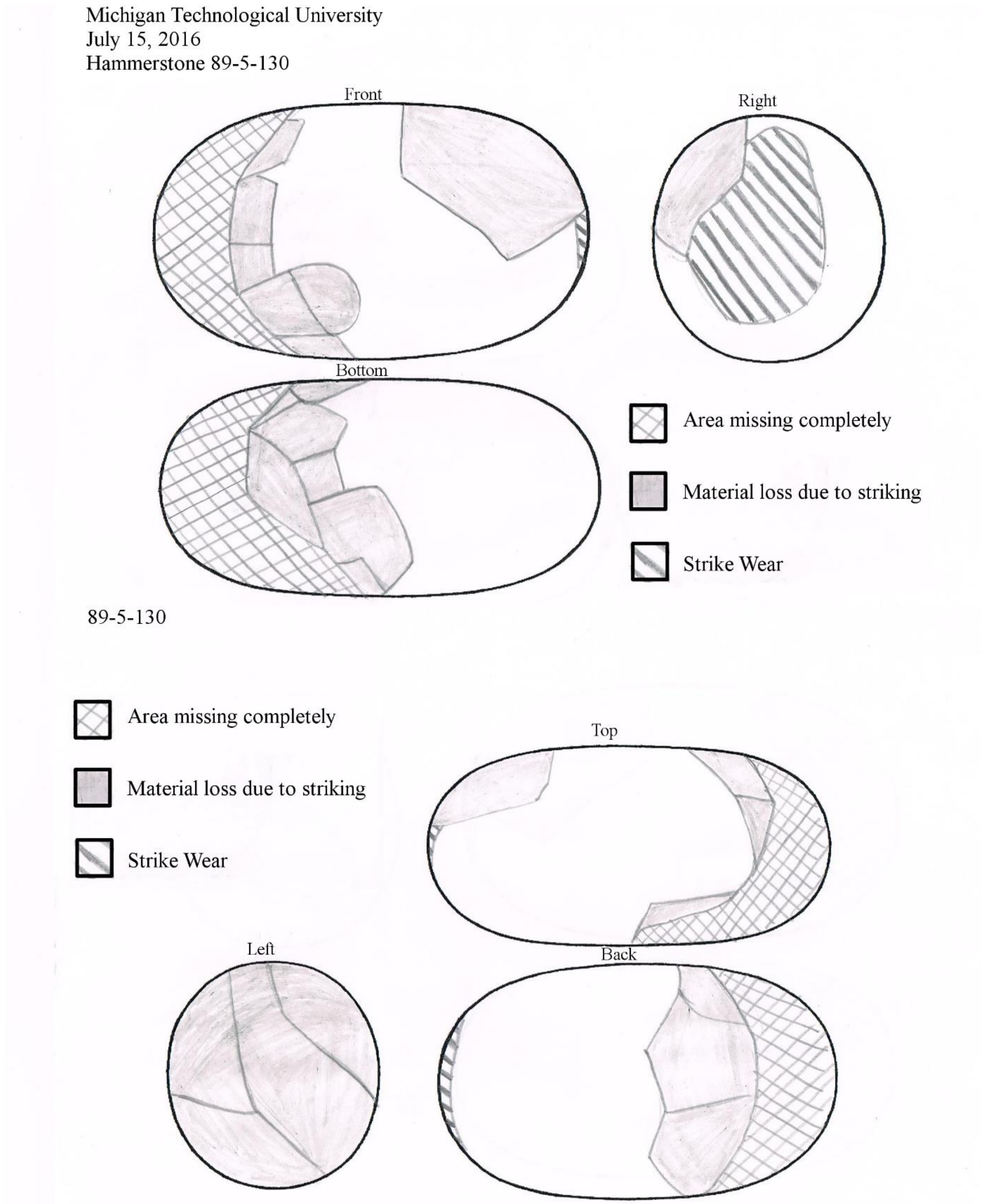




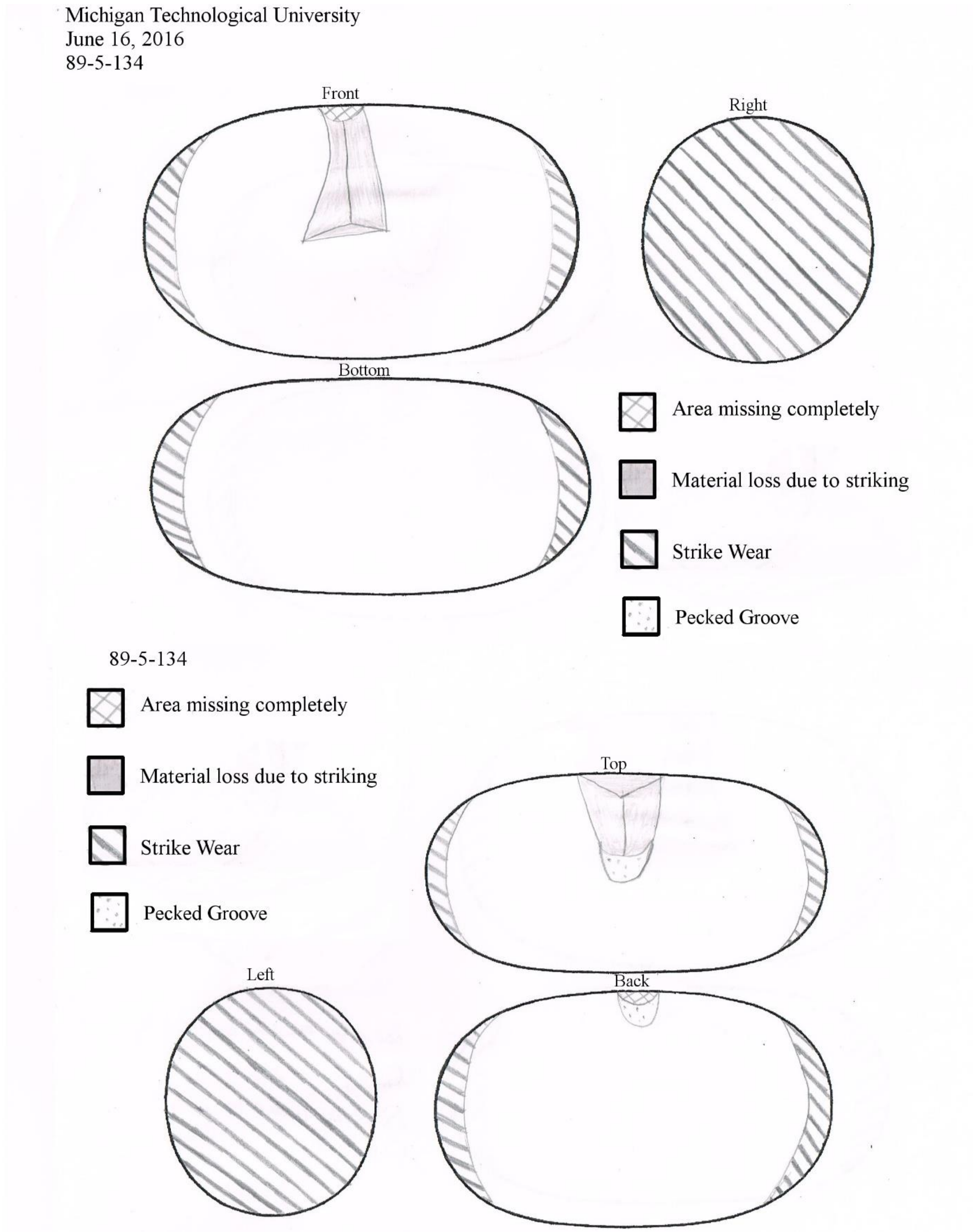
Drier Collection 89-5-122—DUH13

Drier Collection 89-5-130—DUH14



Drier Collection 89-5-130—DUH14

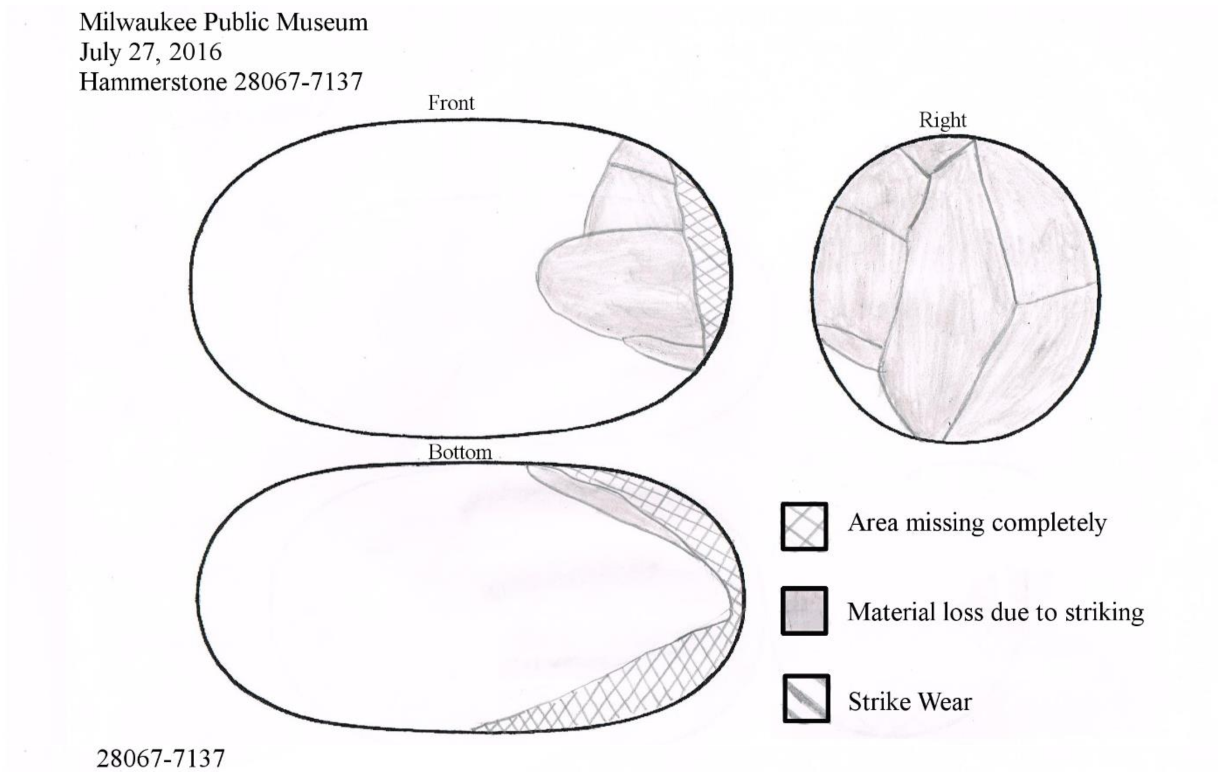
Drier Collection 89-5-134—DGH3

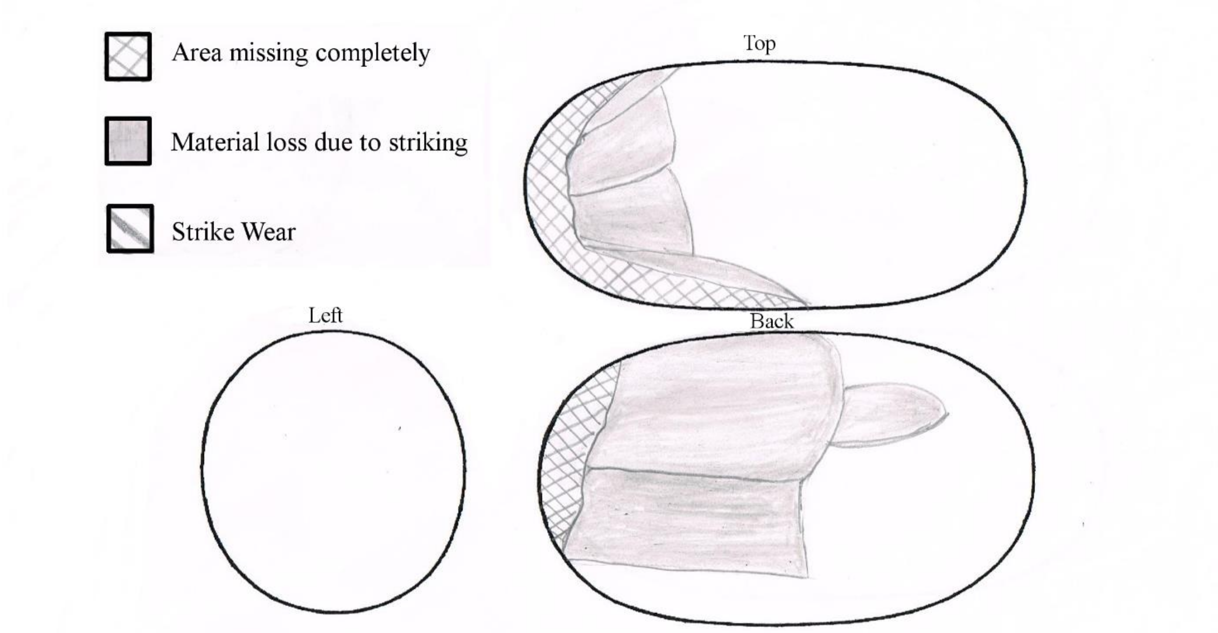


Drier Collection 89-5-134—DGH

Appendix C: The Massee Collection

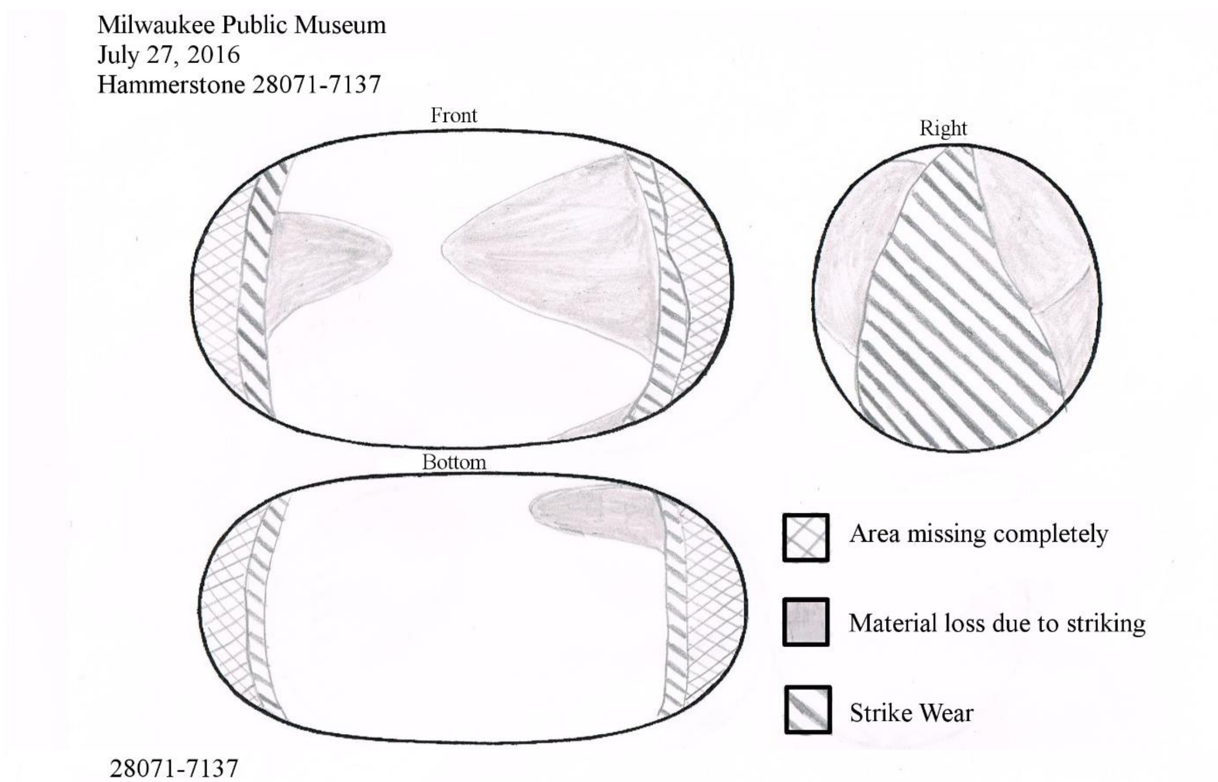
Massee Collection 28067-7137—MUH1

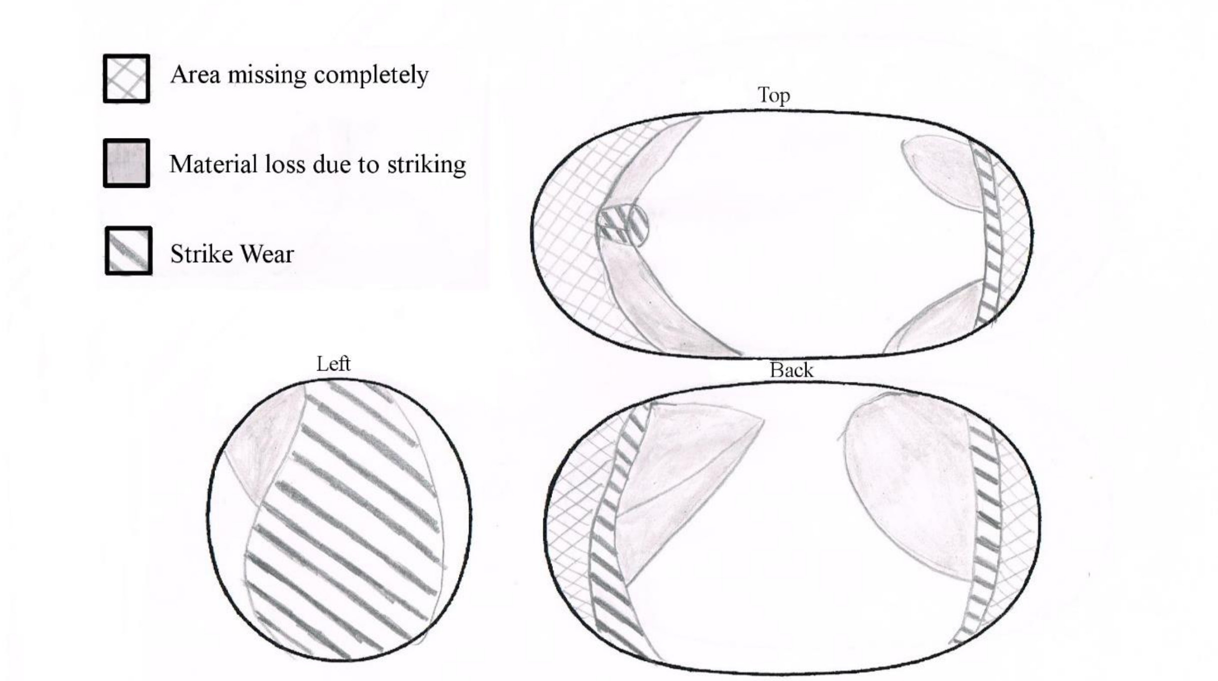




Massee Collection 28067-7137—MUH1

Massee Collection 28071-7137—MUH2





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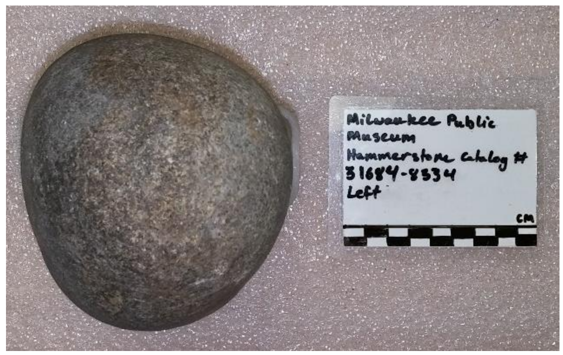
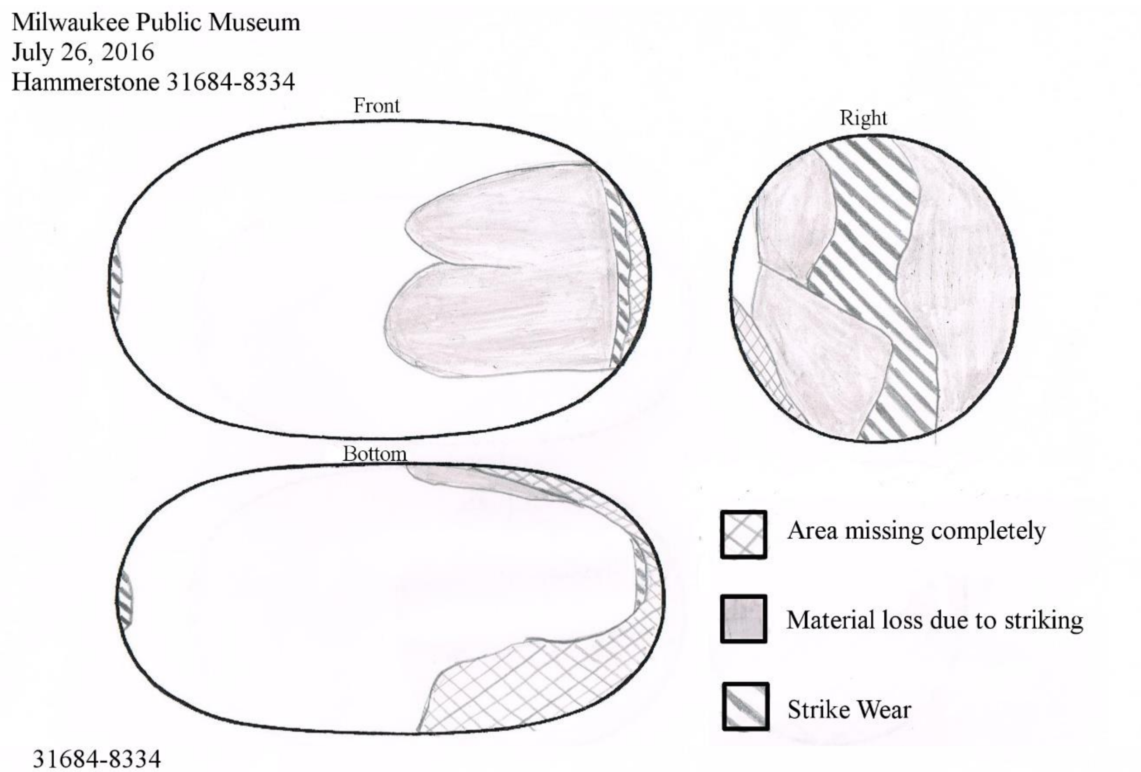
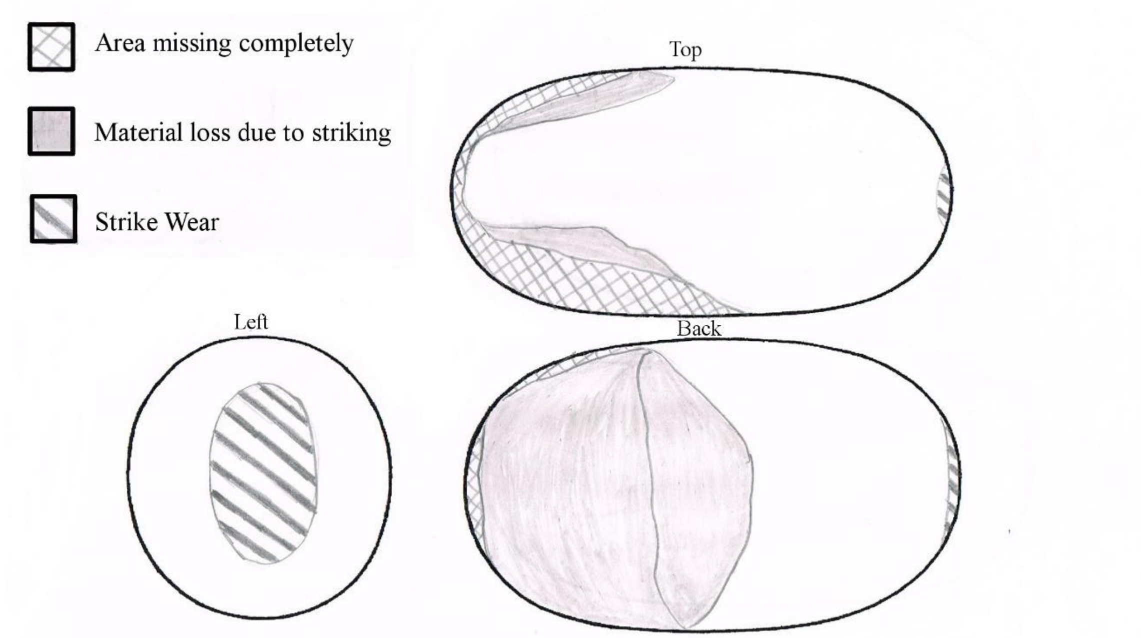


Massee Collection 31684-8334—MUH3





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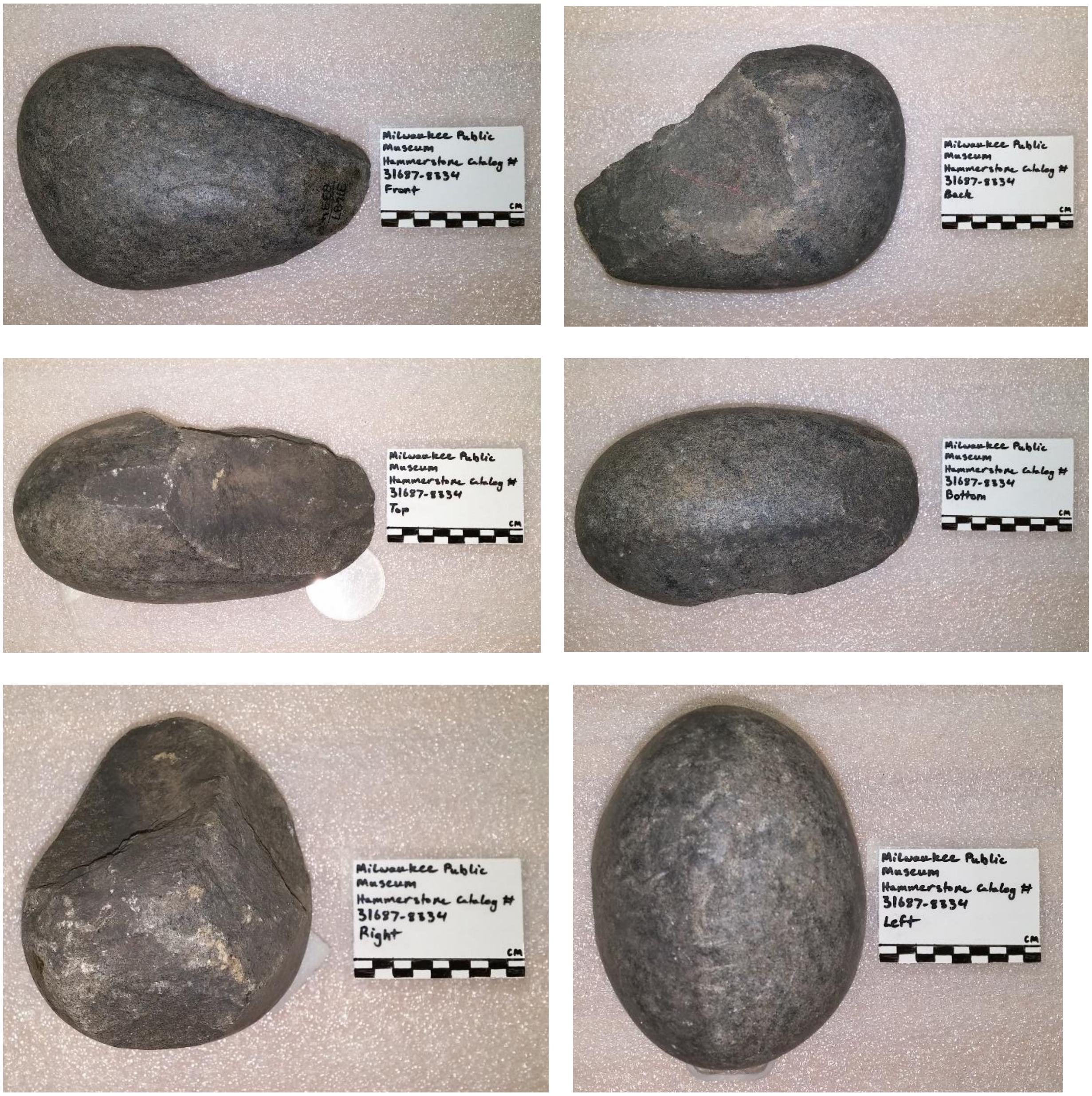

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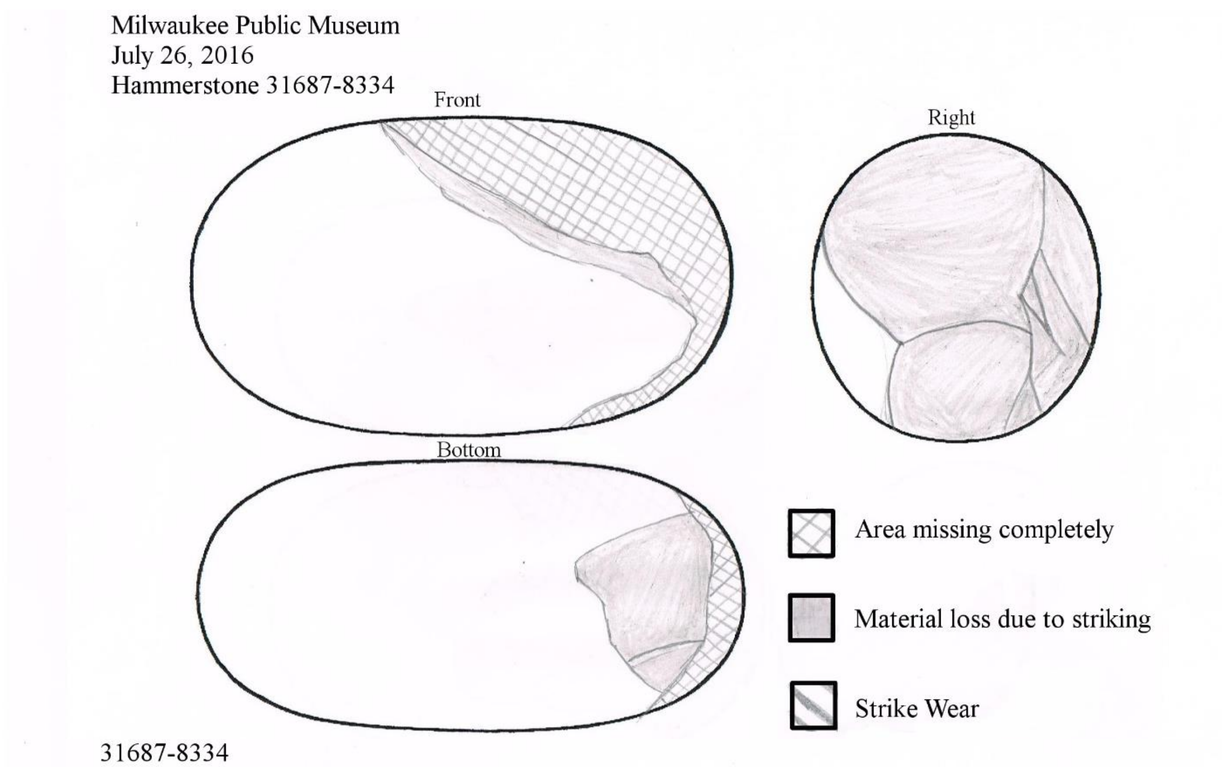
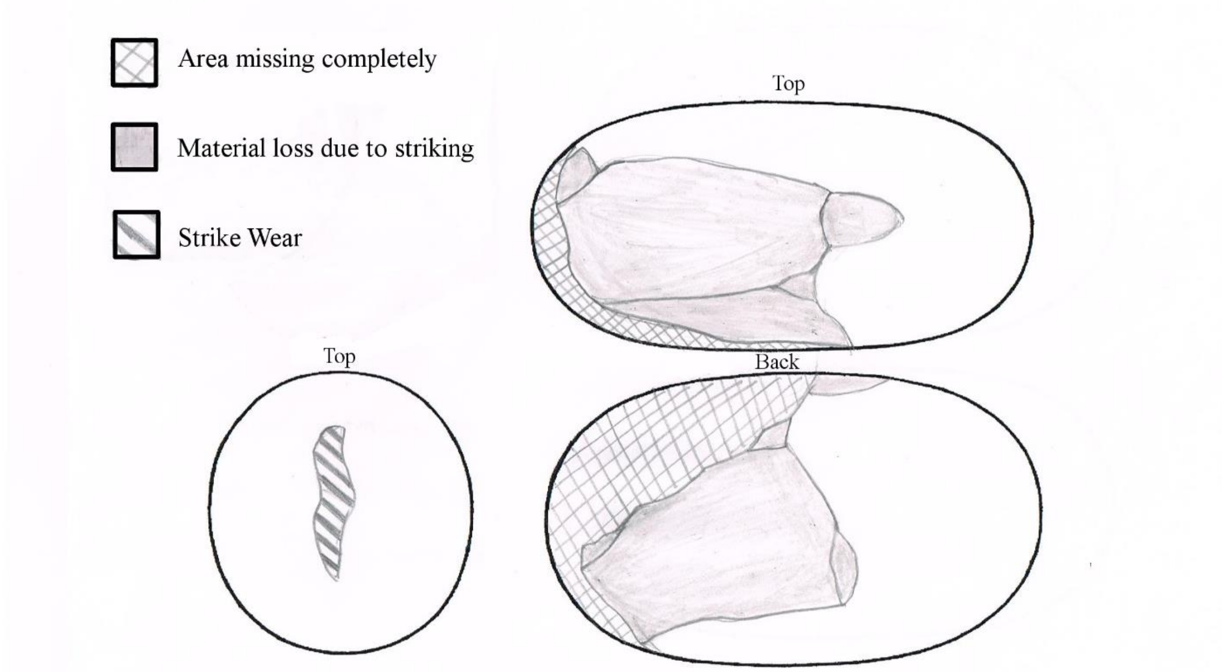
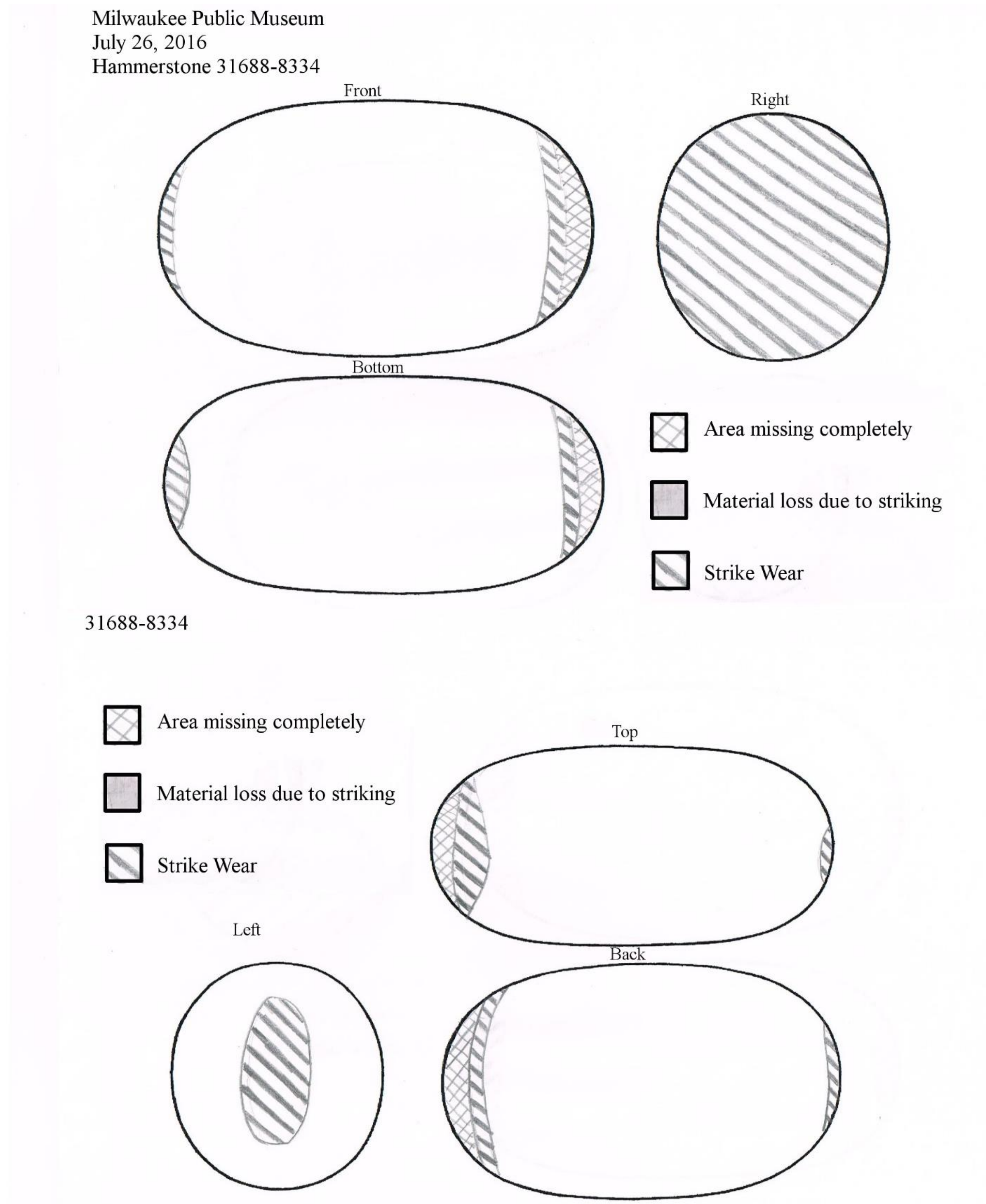




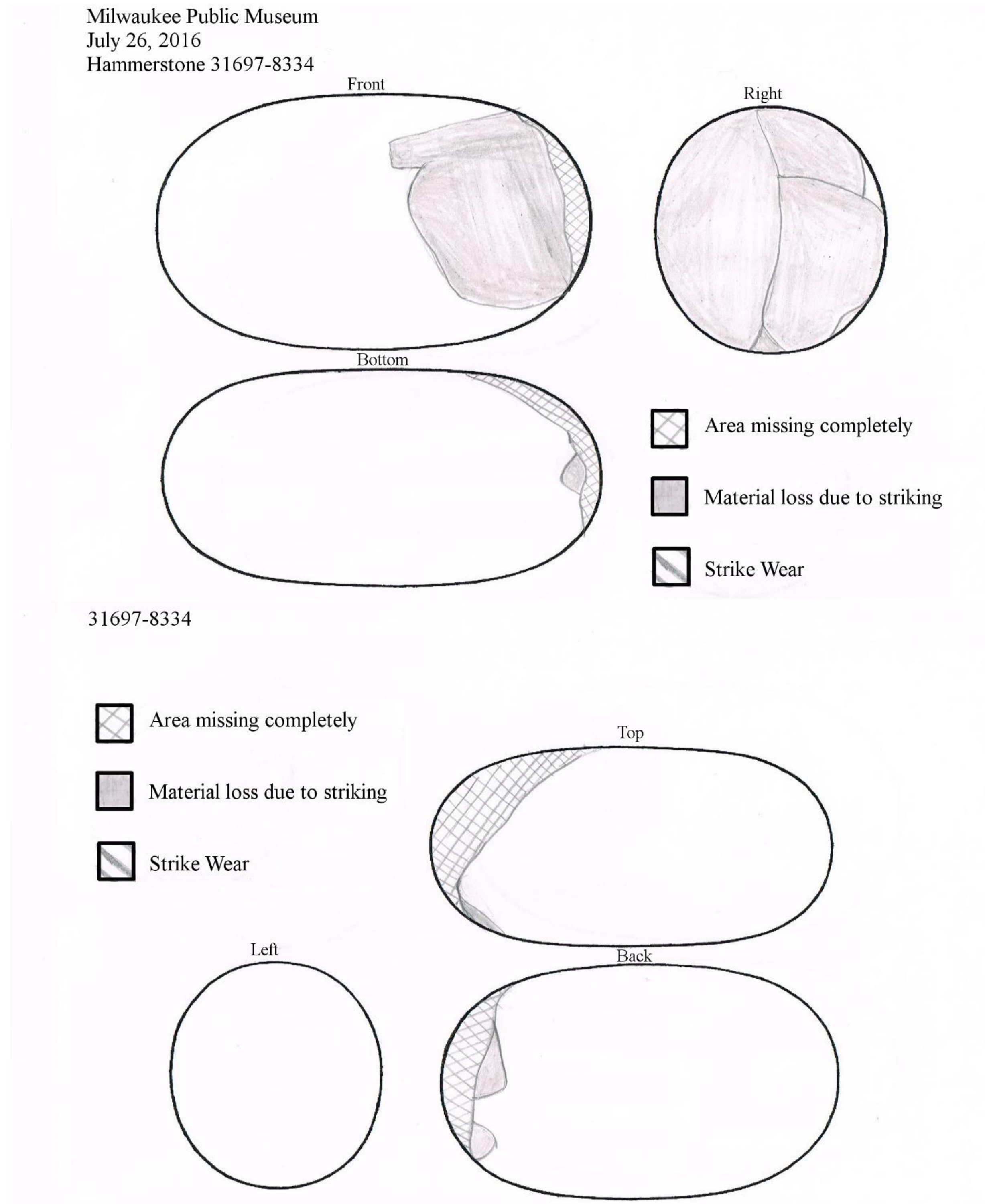
Massee Collection 31687-8334—MUH4

Massee Collection 31688-8334—MUH5



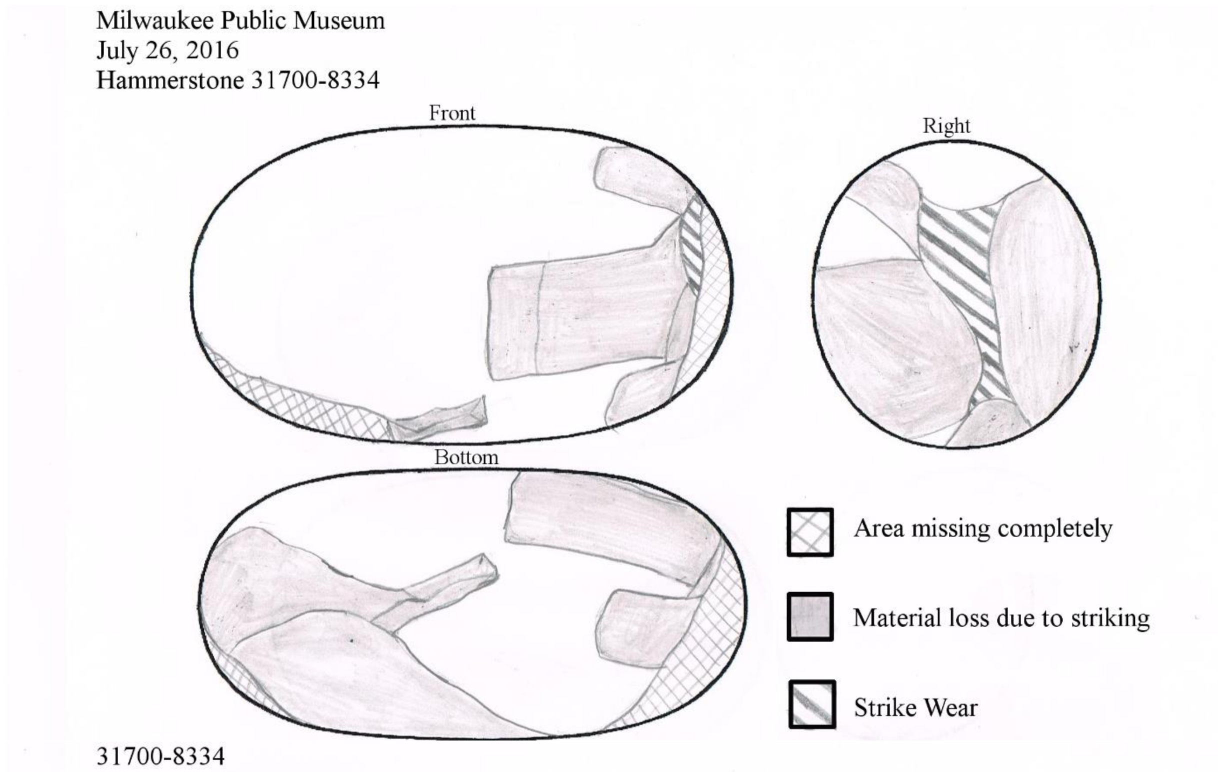
Massee Collection 31688-8334—MUH5

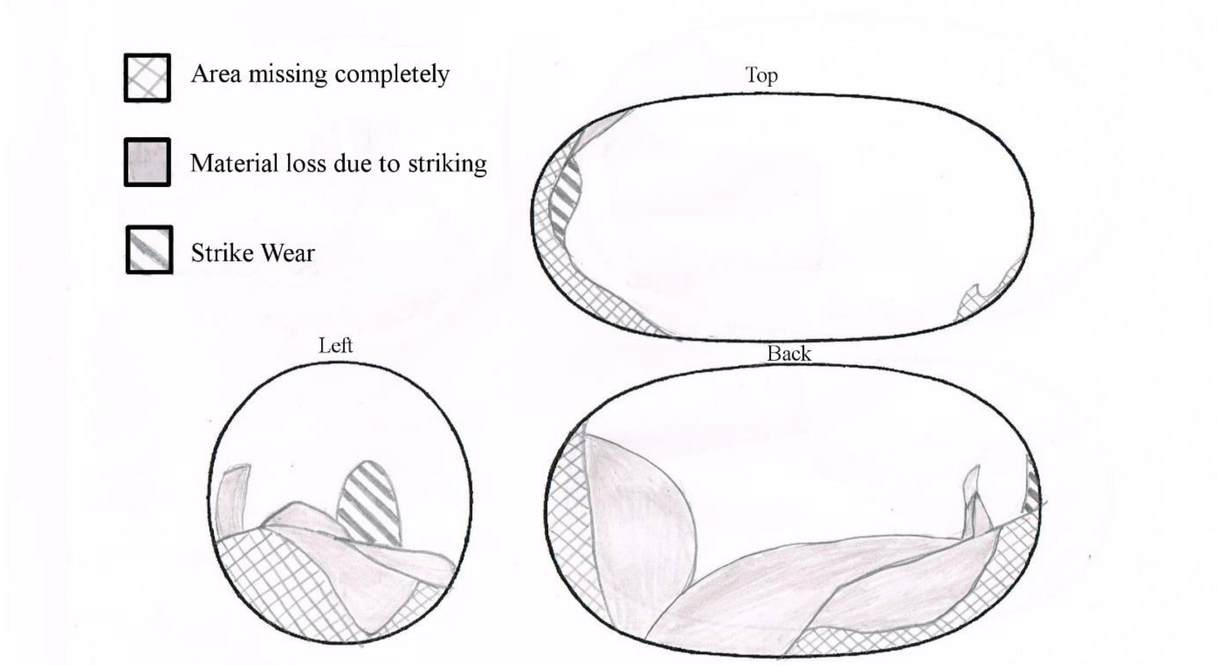
Massee Collection 31697-8334—MUH6



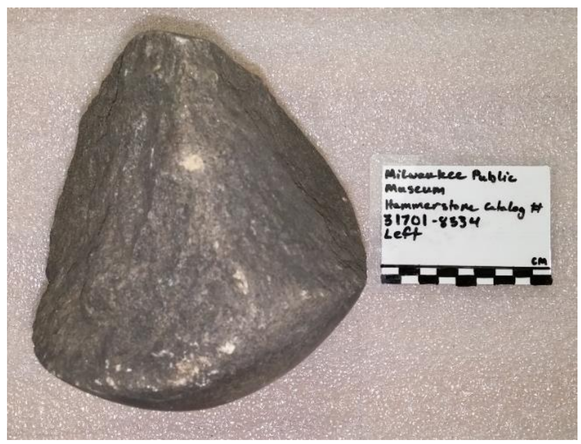
Massee Collection 31697-8334—MUH6

Massee Collection 31700-8334—MUH7





Massee Collection 31700-8334—MUH7



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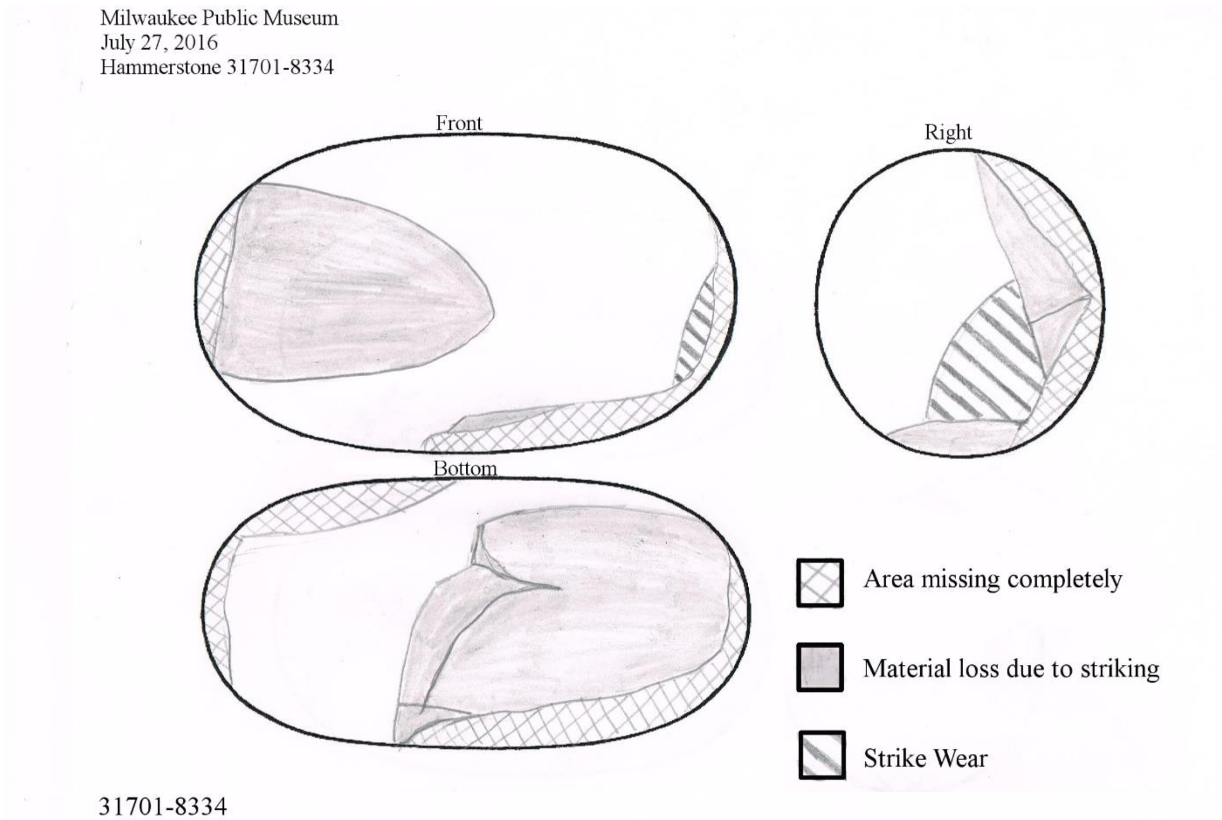
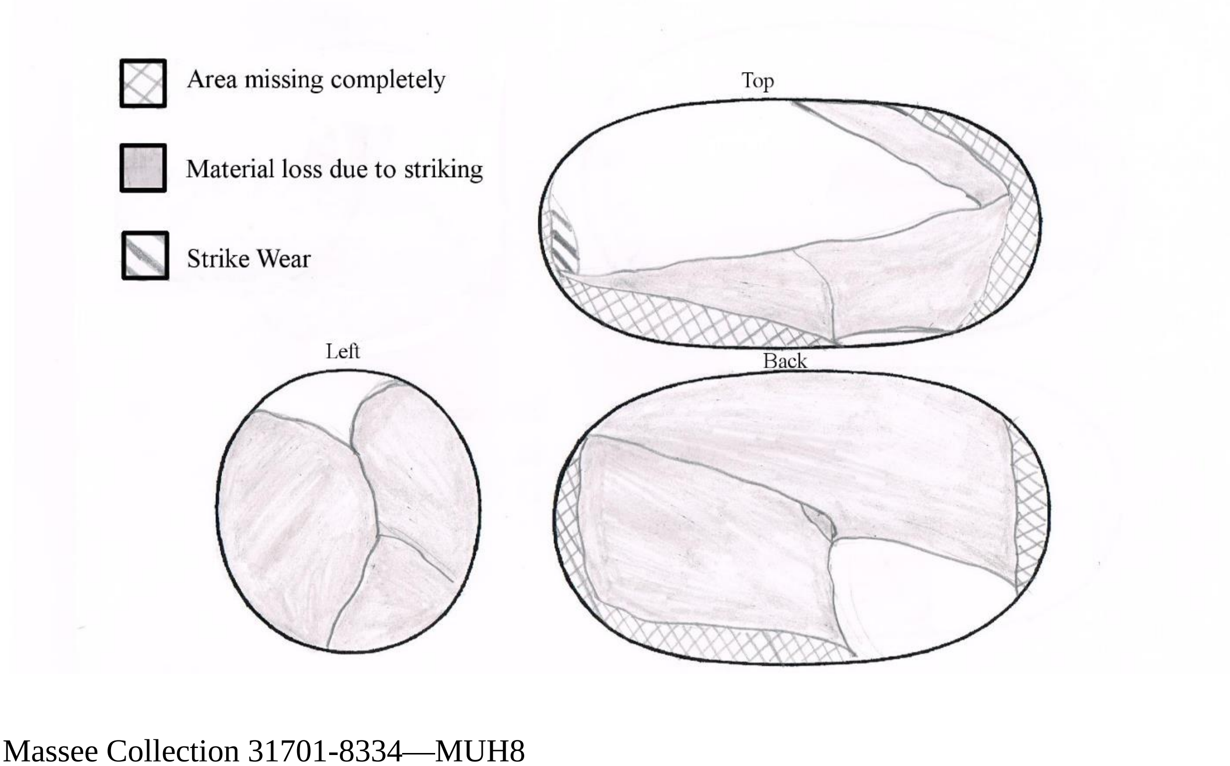
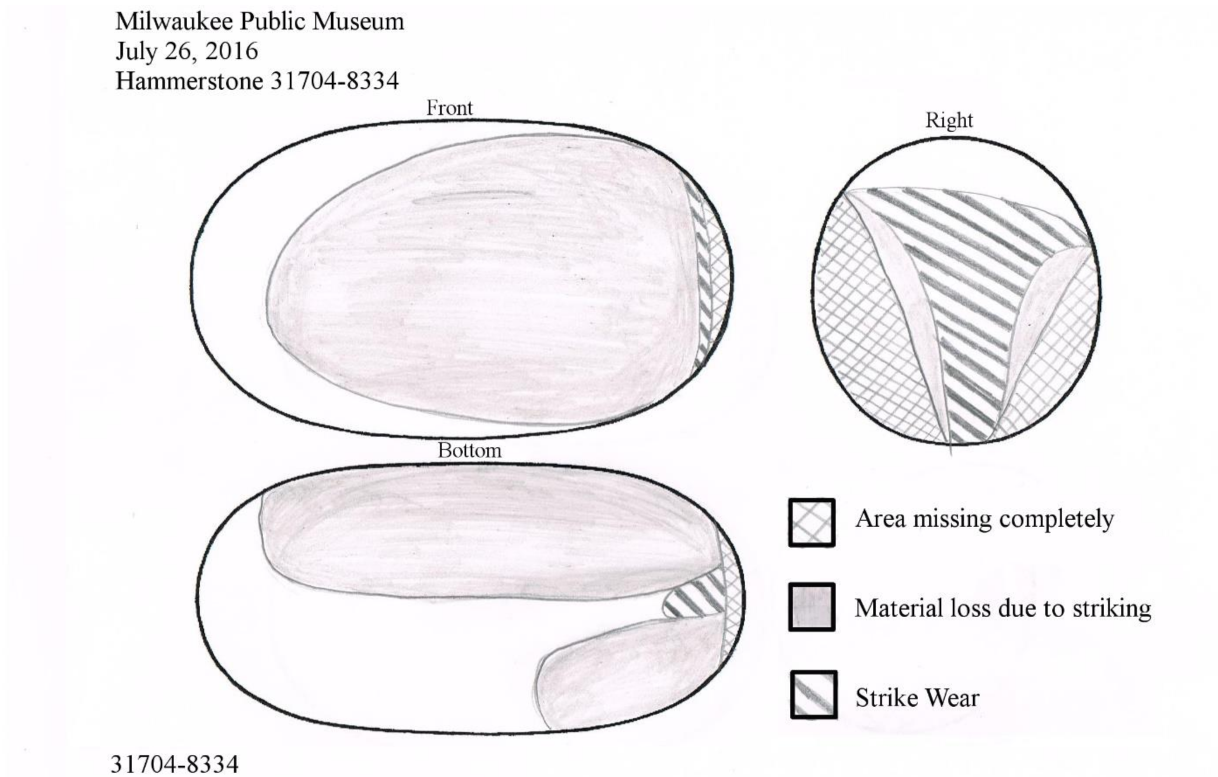
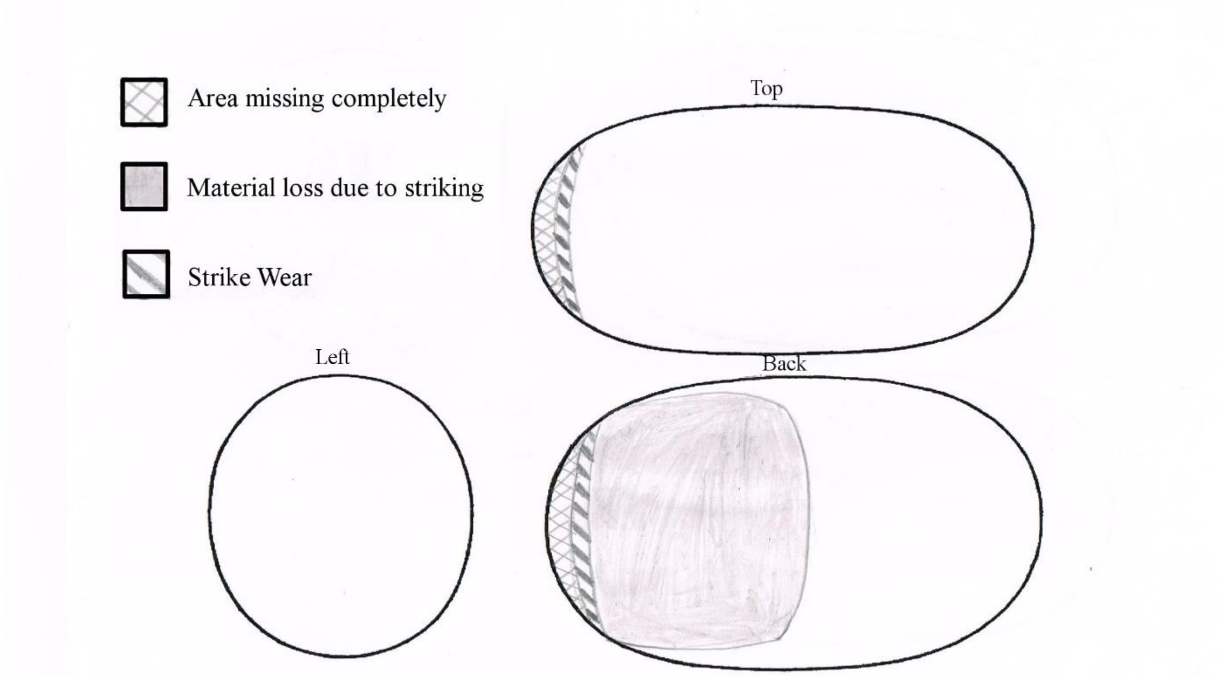




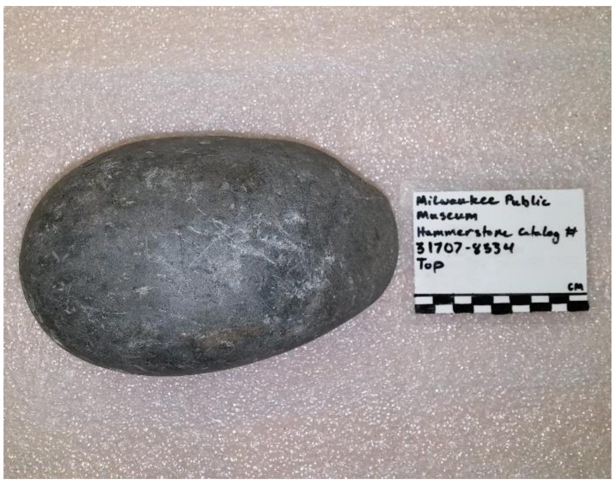
Massee Collection 31701-8334—MUH8

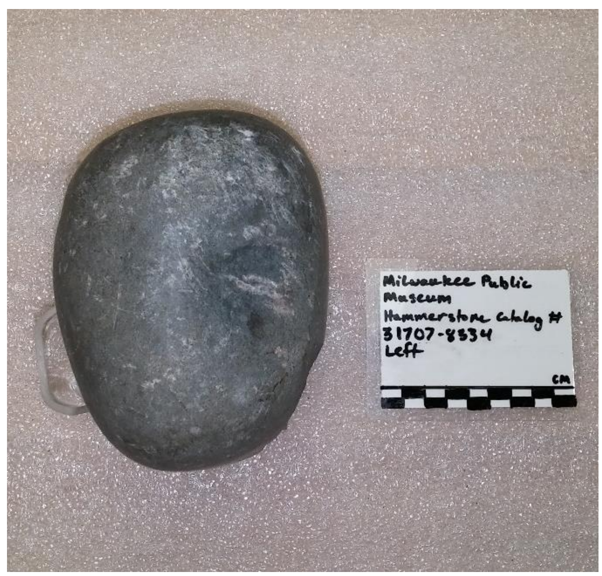
Massee Collection 31704-8334—MUH9





Massee Collection 31704-8334—MUH9





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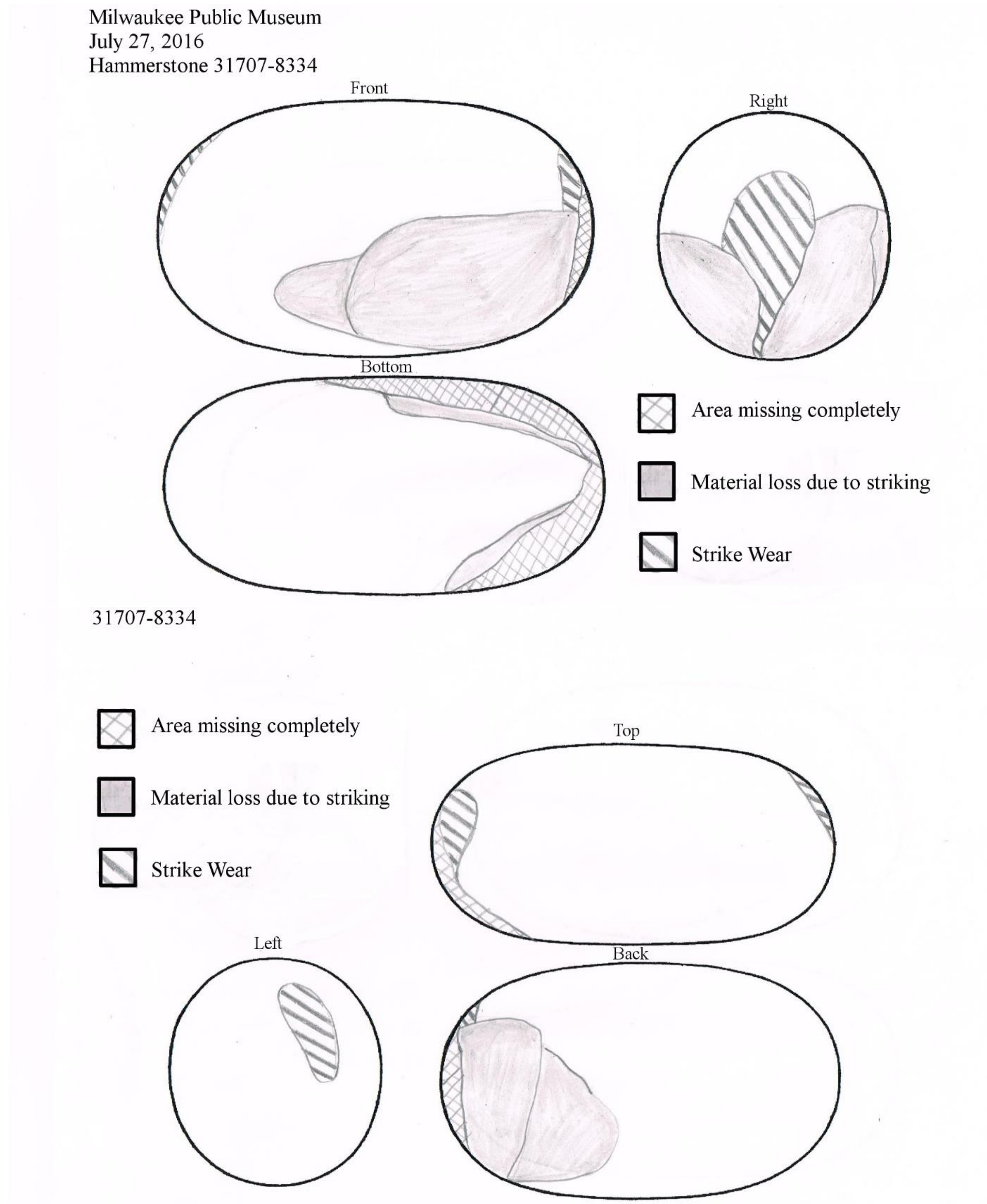

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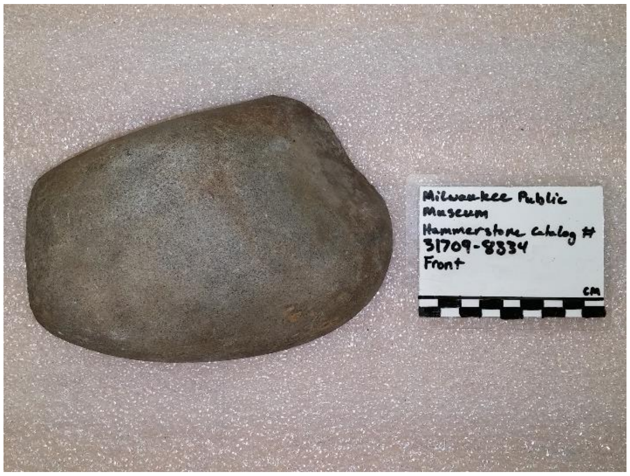

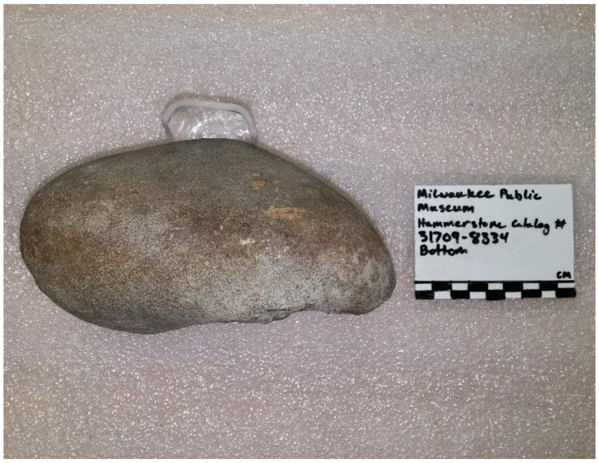

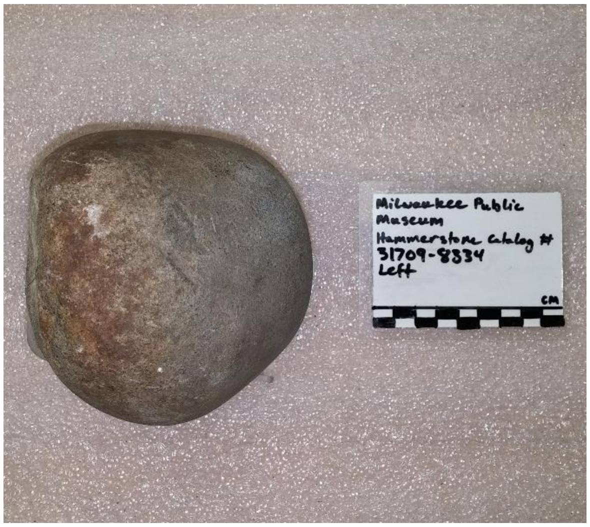

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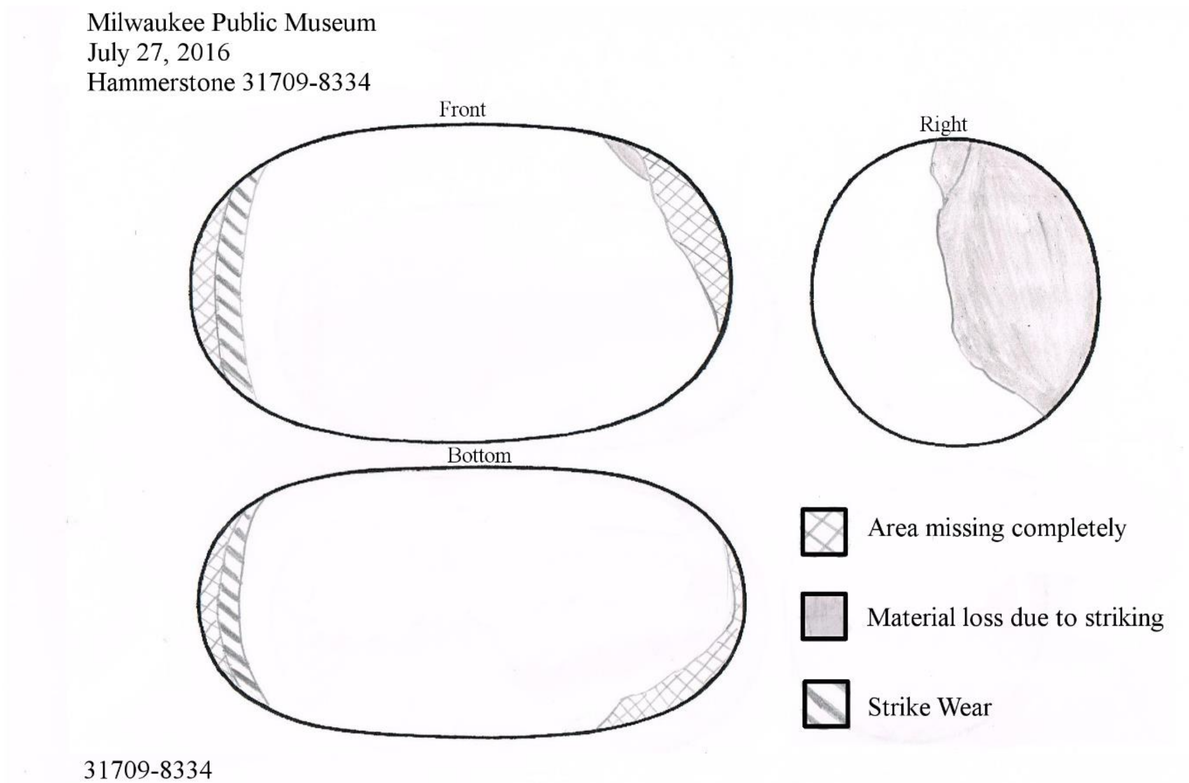
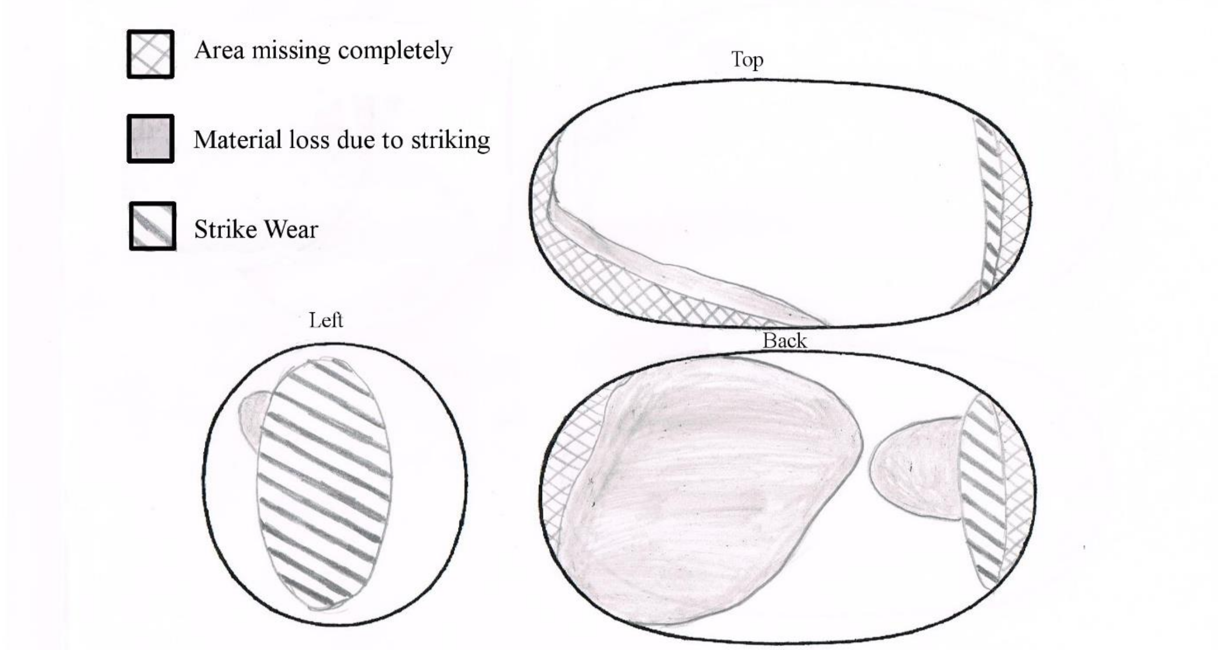
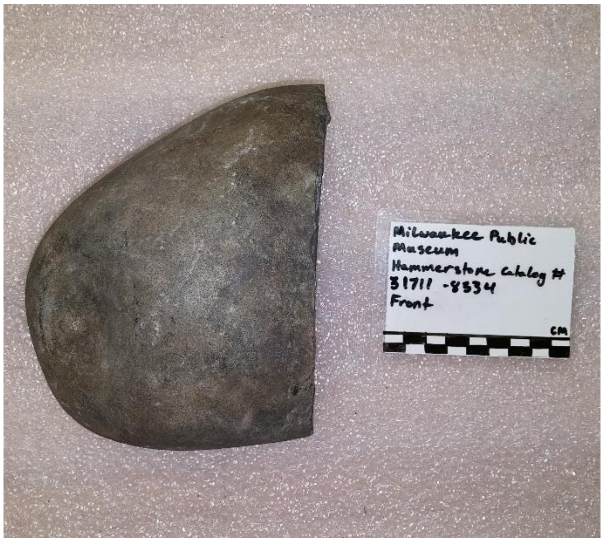




Massee Collection 31709-8334—MUH11



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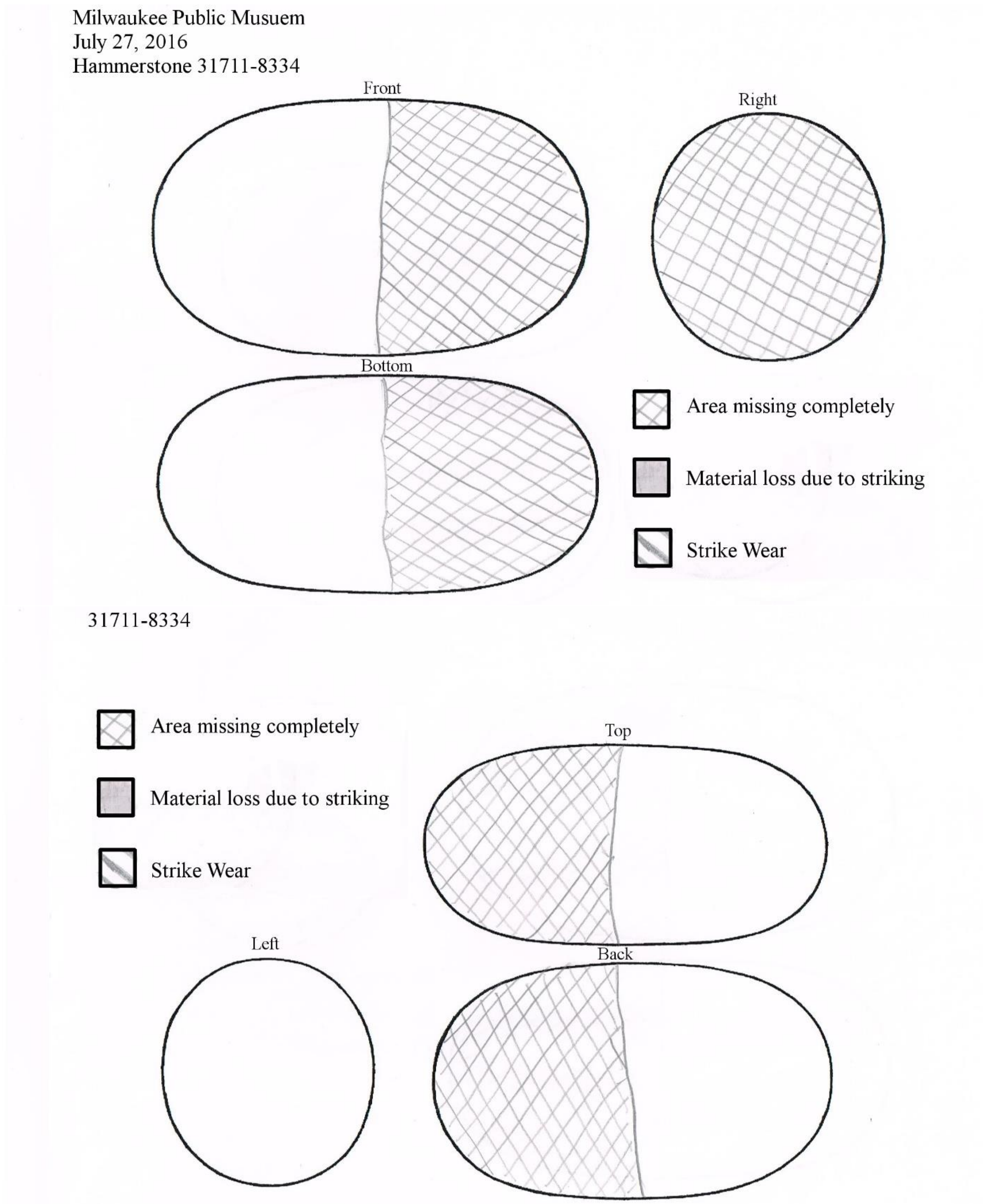
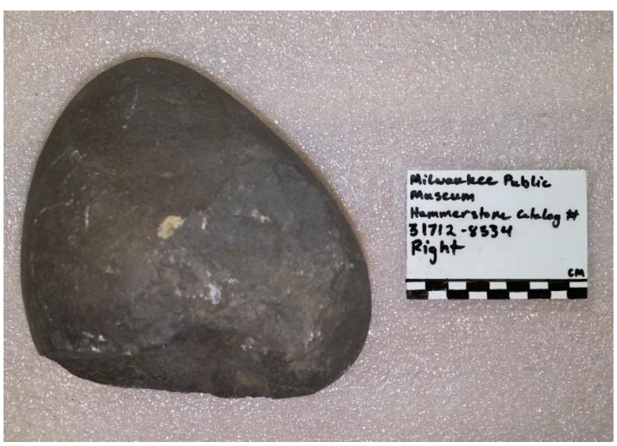


Massee Collection 31711-8334—MUH12



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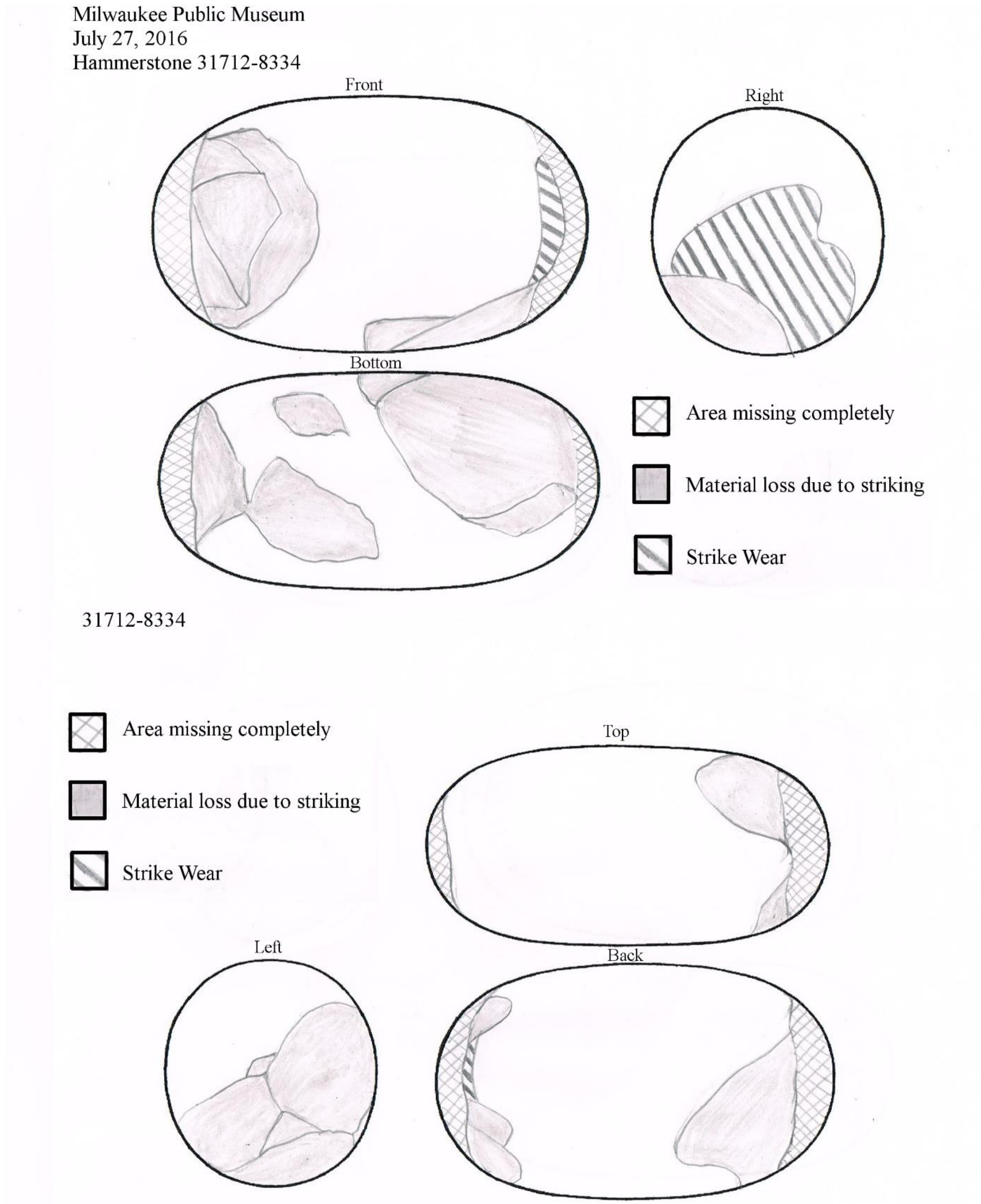

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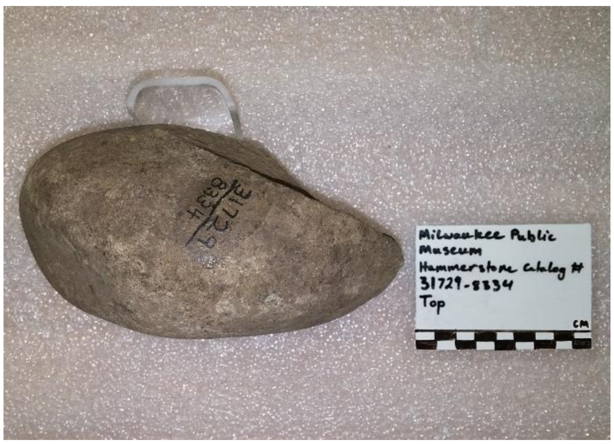
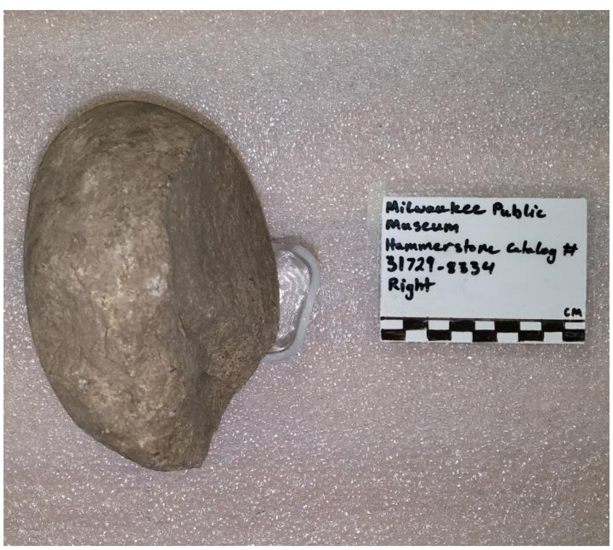
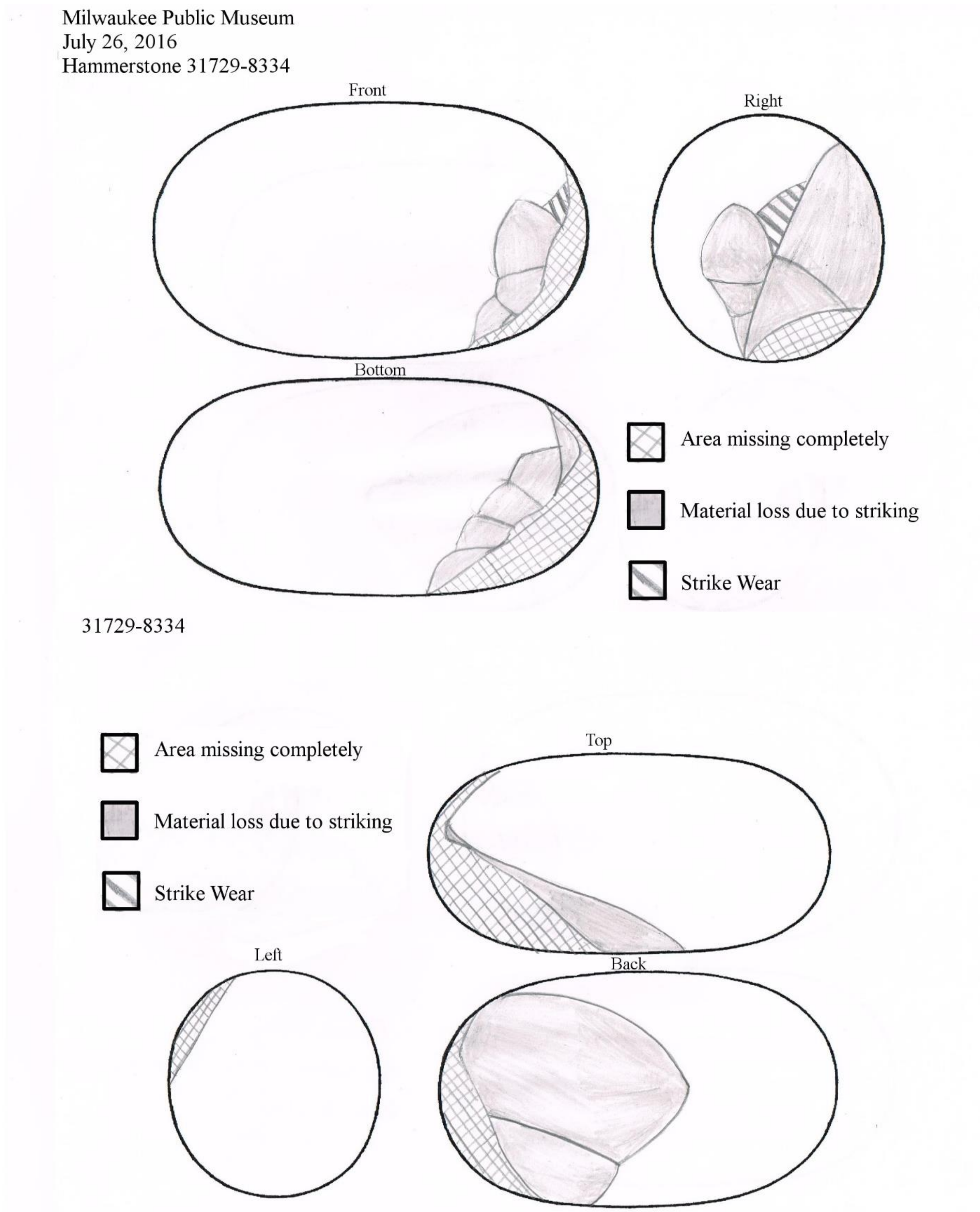
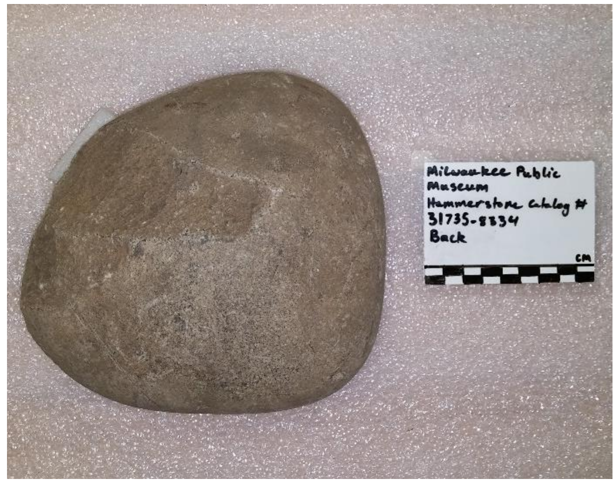


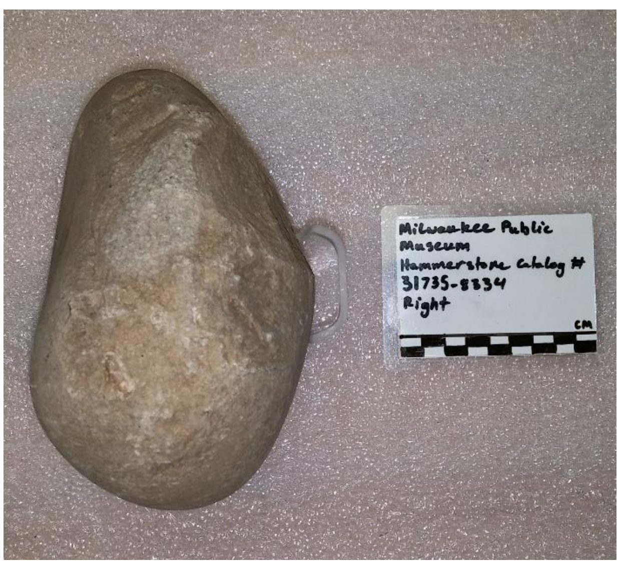


Massee Collection 31729-8334—MUH14

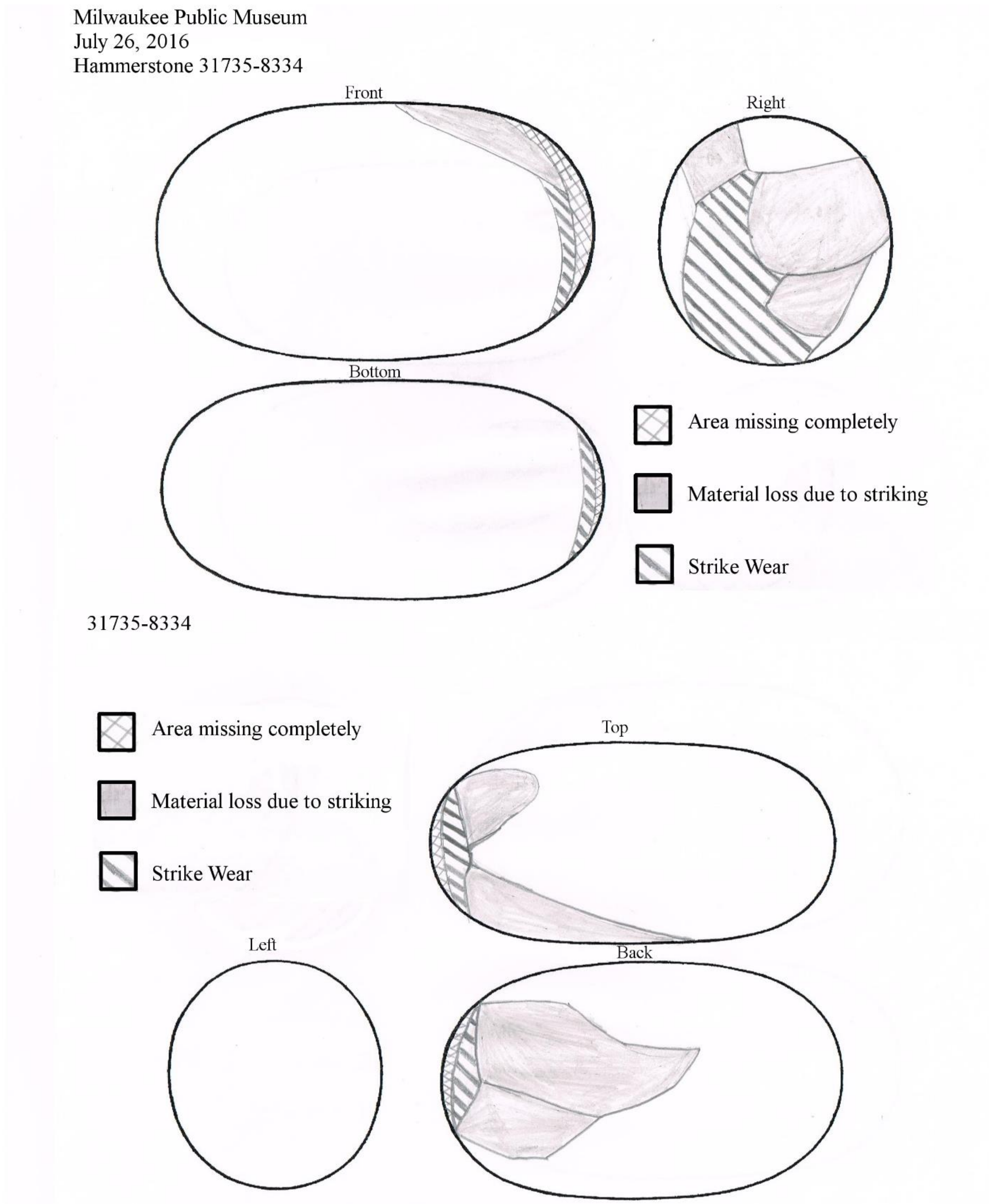


Massee Collection 31729-8334—MUH14



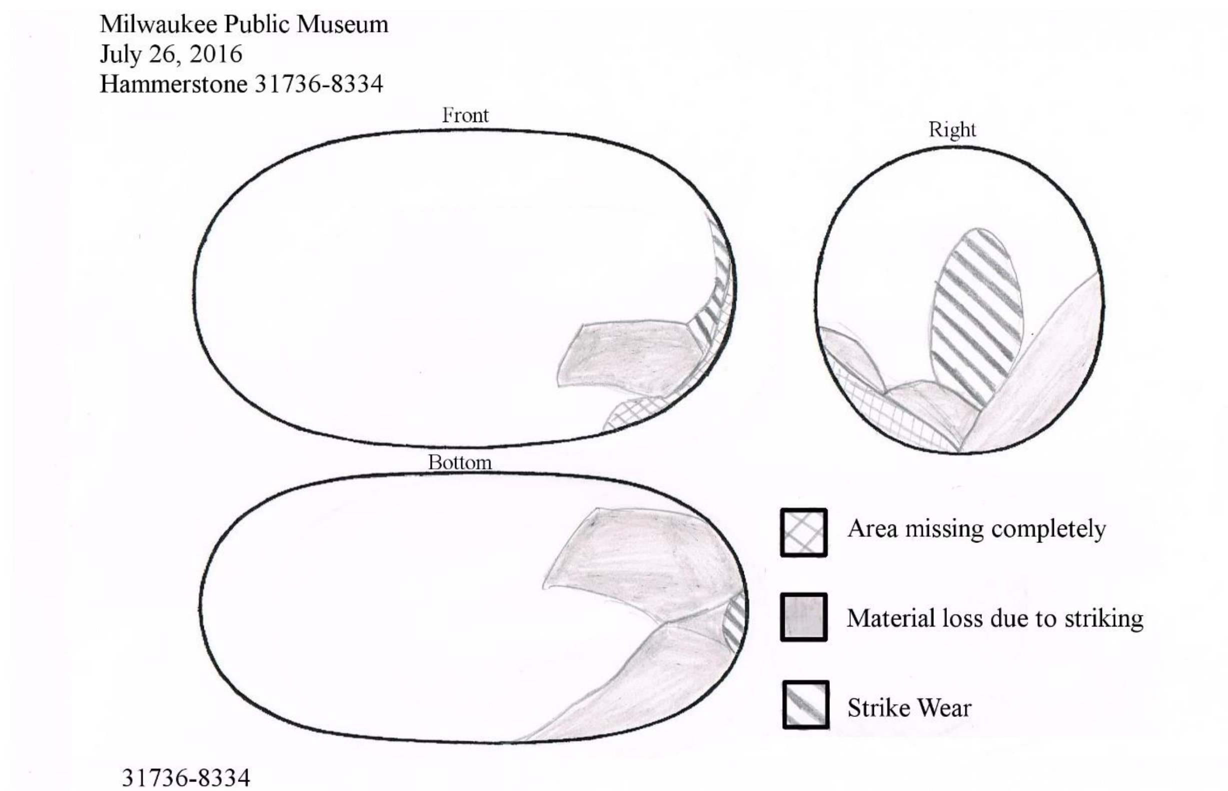


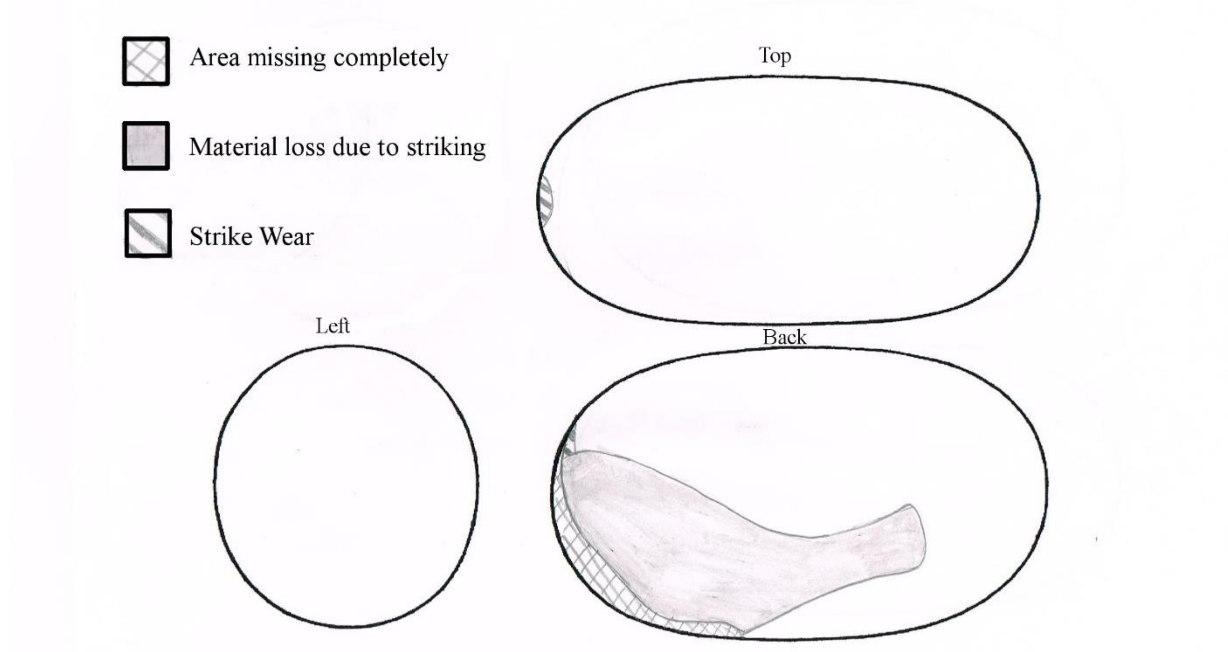
Massee Collection 31735-8334—MUH15



Massee Collection 31735-8334—MUH15

Massee Collection 31736-8334—MUH16



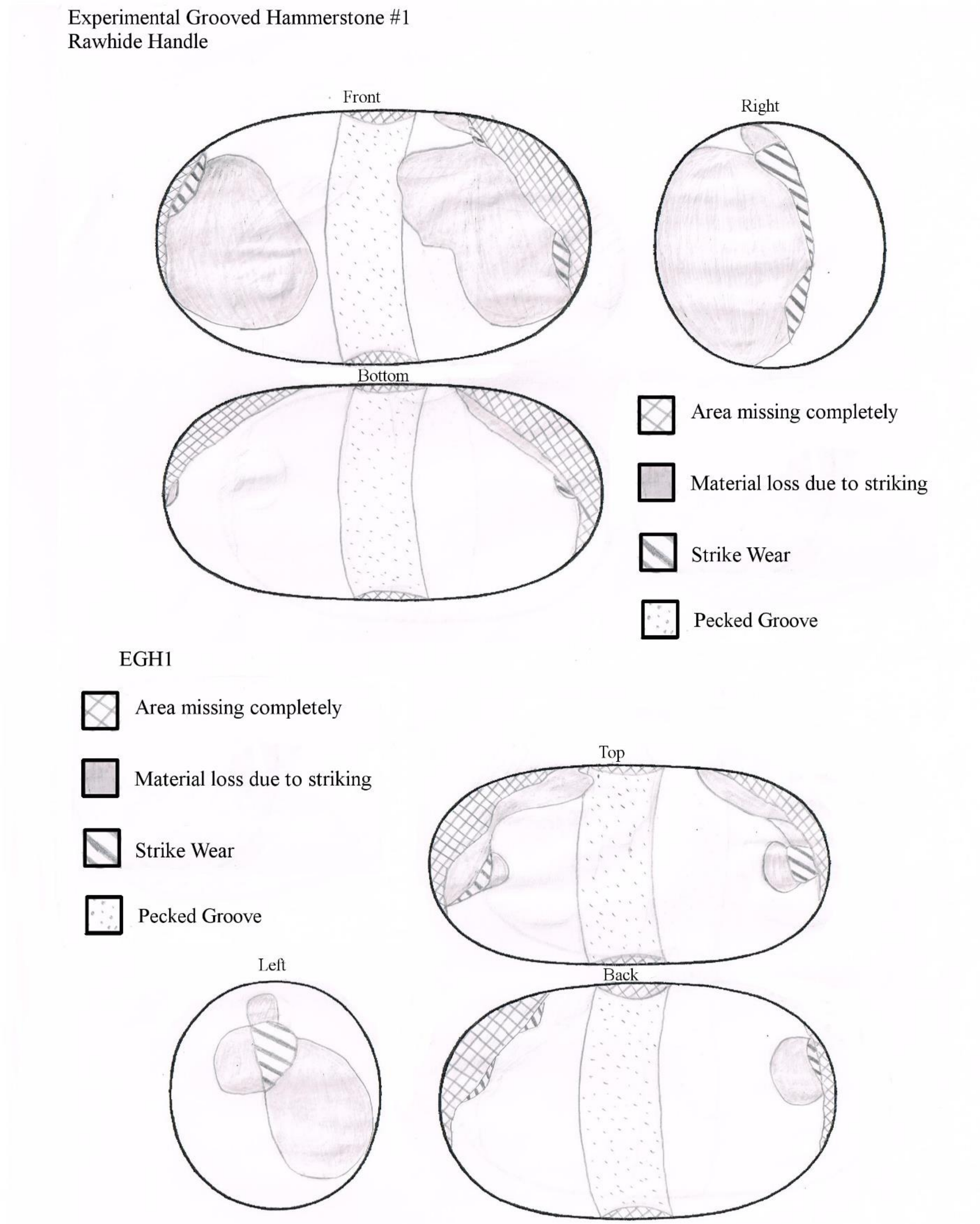


Massee Collection 31736-8334—MUH16

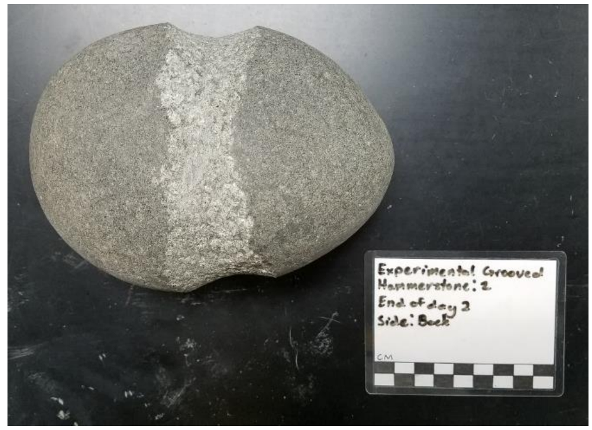
Appendix D: The Experimental Hammerstones

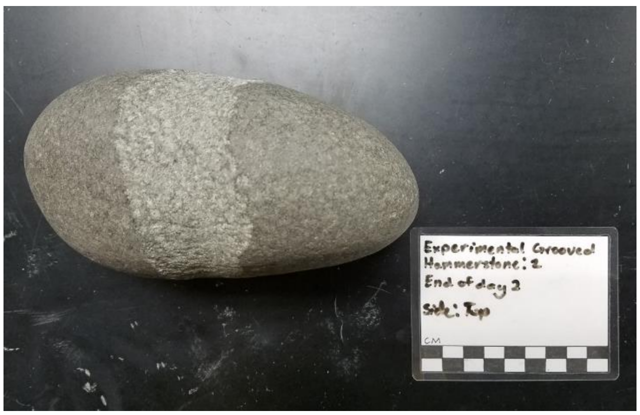
Experimental Grooved Hammerstone #1—EGH1

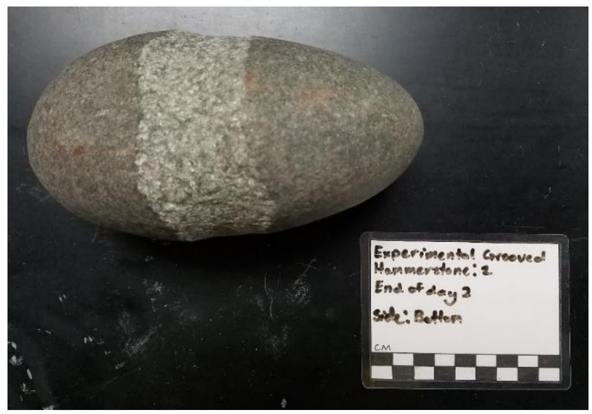
Experimental Grooved Hammerstone #1—EGH1

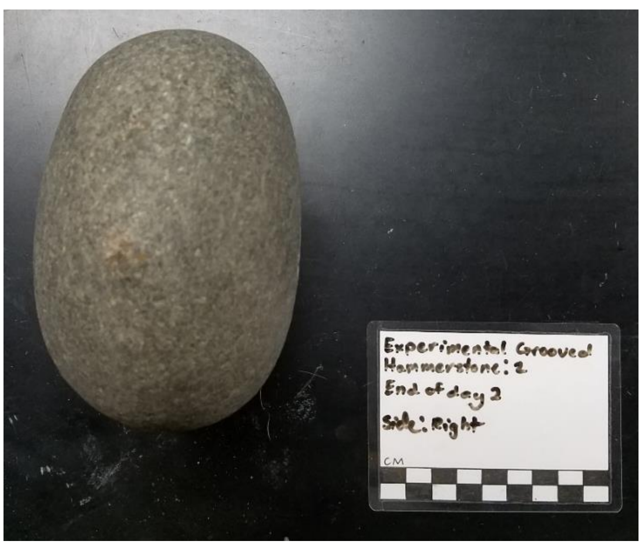


Experimental Grooved Hammerstone #1—EGH1

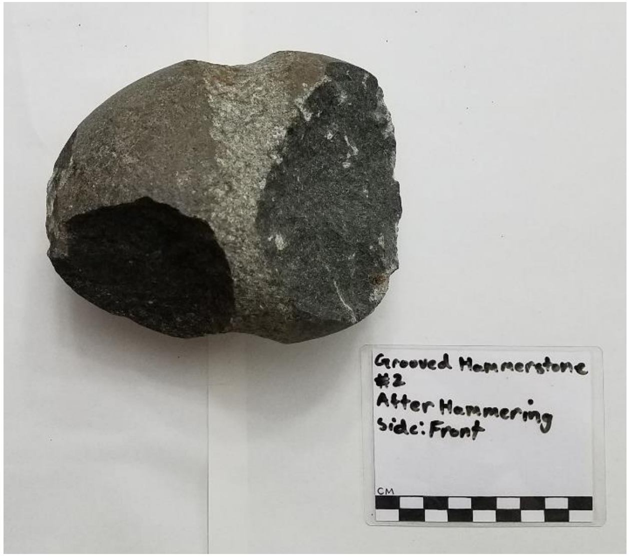




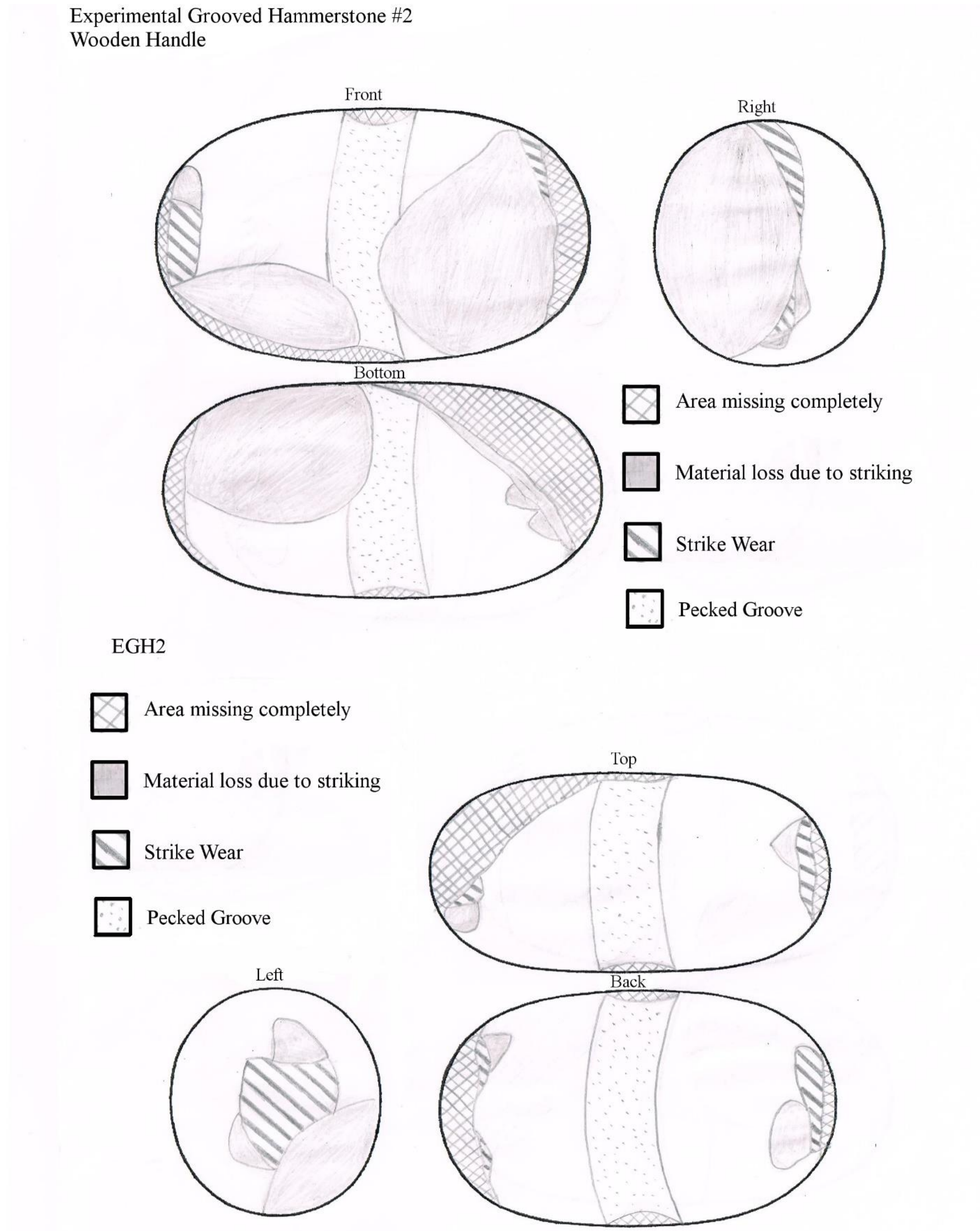




Experimental Grooved Hammerstone #2—EGH2



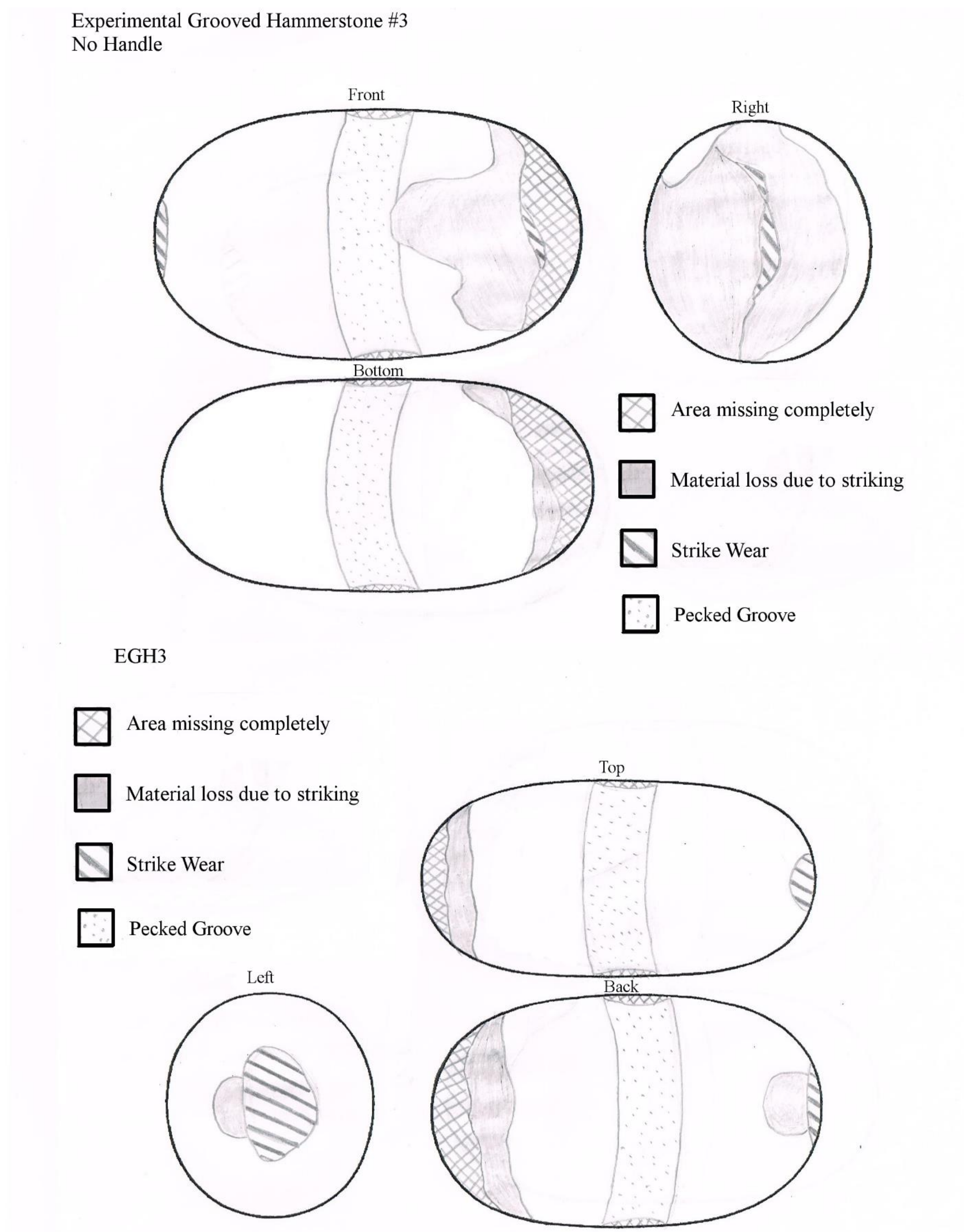
Experimental Grooved Hammerstone #2—EGH2



Experimental Grooved Hammerstone #2—EGH2

Experimental Grooved Hammerstone #3—EGH3

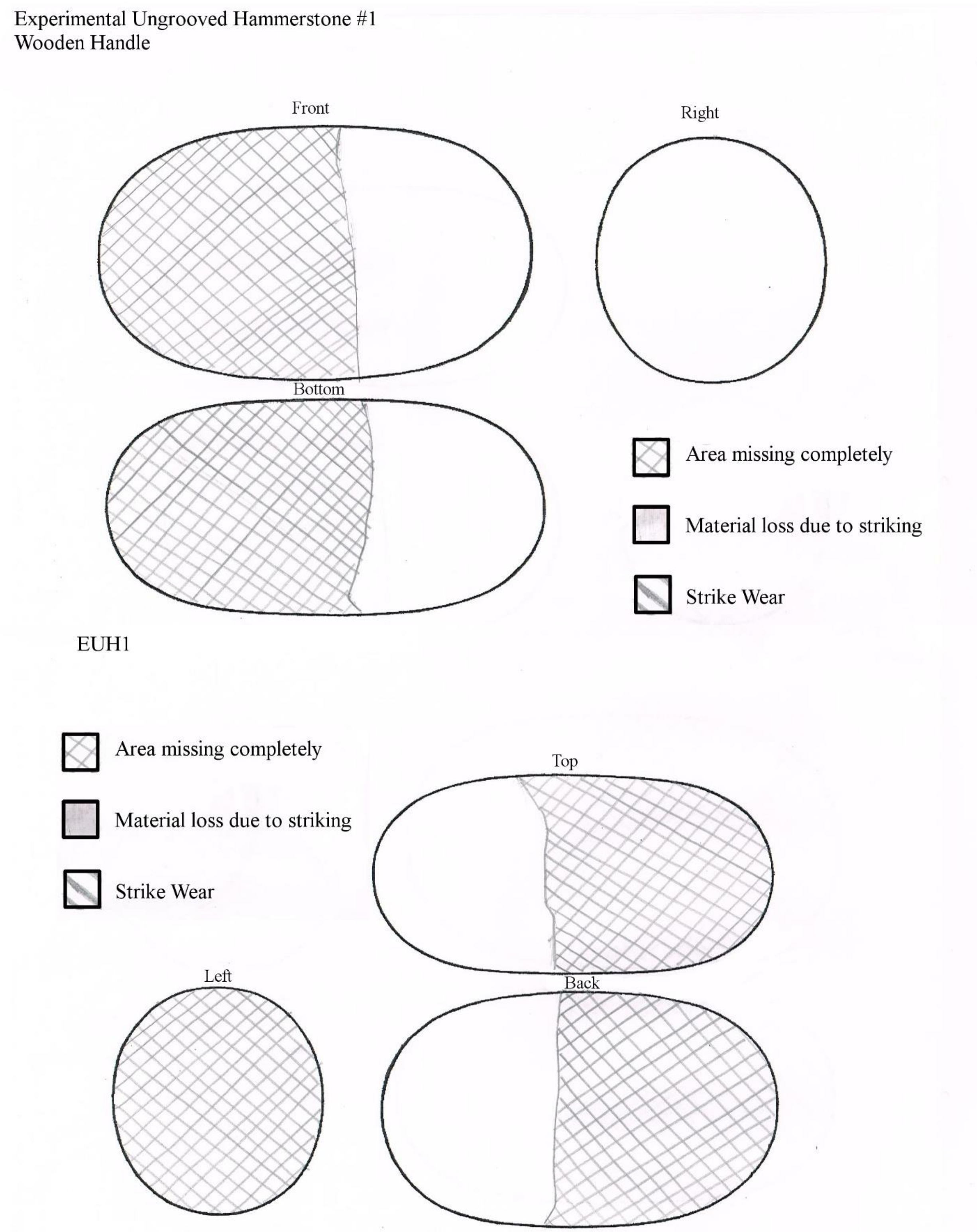
Experimental Grooved Hammerstone #3—EGH3



Experimental Grooved Hammerstone #3—EGH3

Experimental Ungrooved Hammerstone #1—EUH1

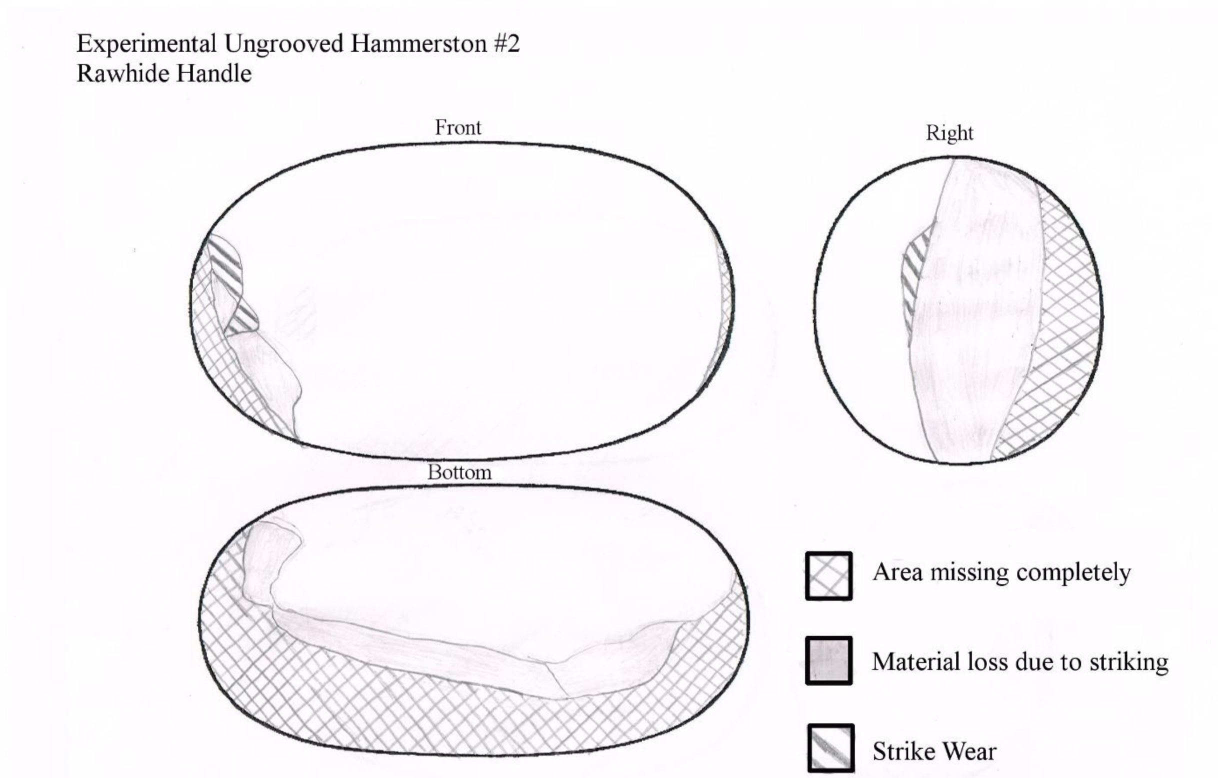
Experimental Ungrooved Hammerstone #1—EUH1

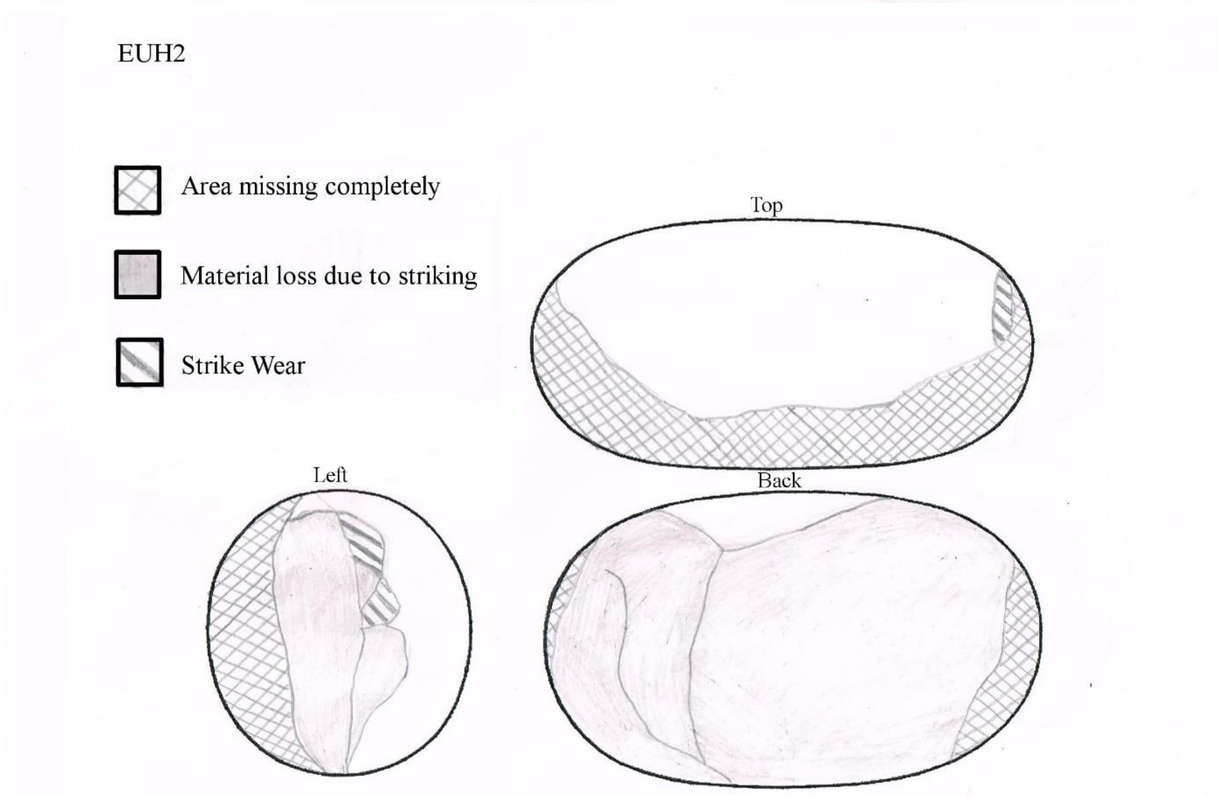


Experimental Ungrooved Hammerstone #1—EUH1

Experimental Ungrooved Hammerstone #2—EUH2

Experimental Ungrooved Hammerstone #2—EUH2

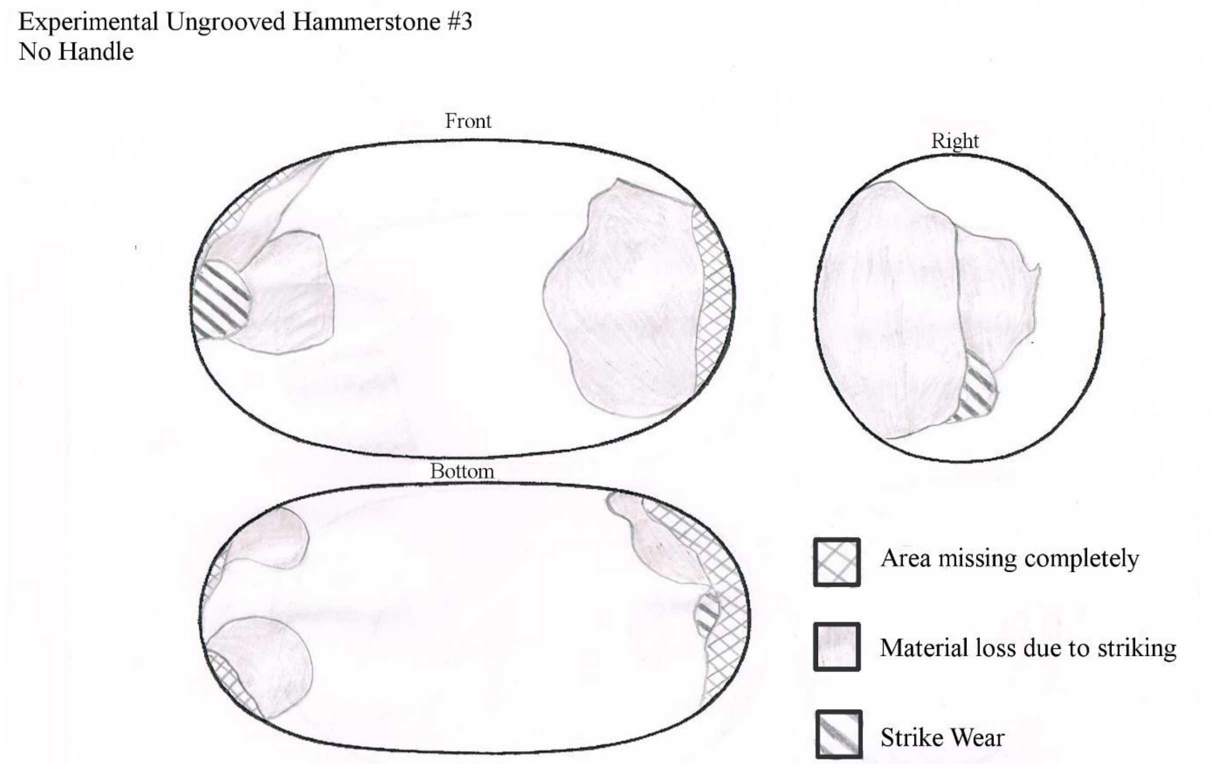


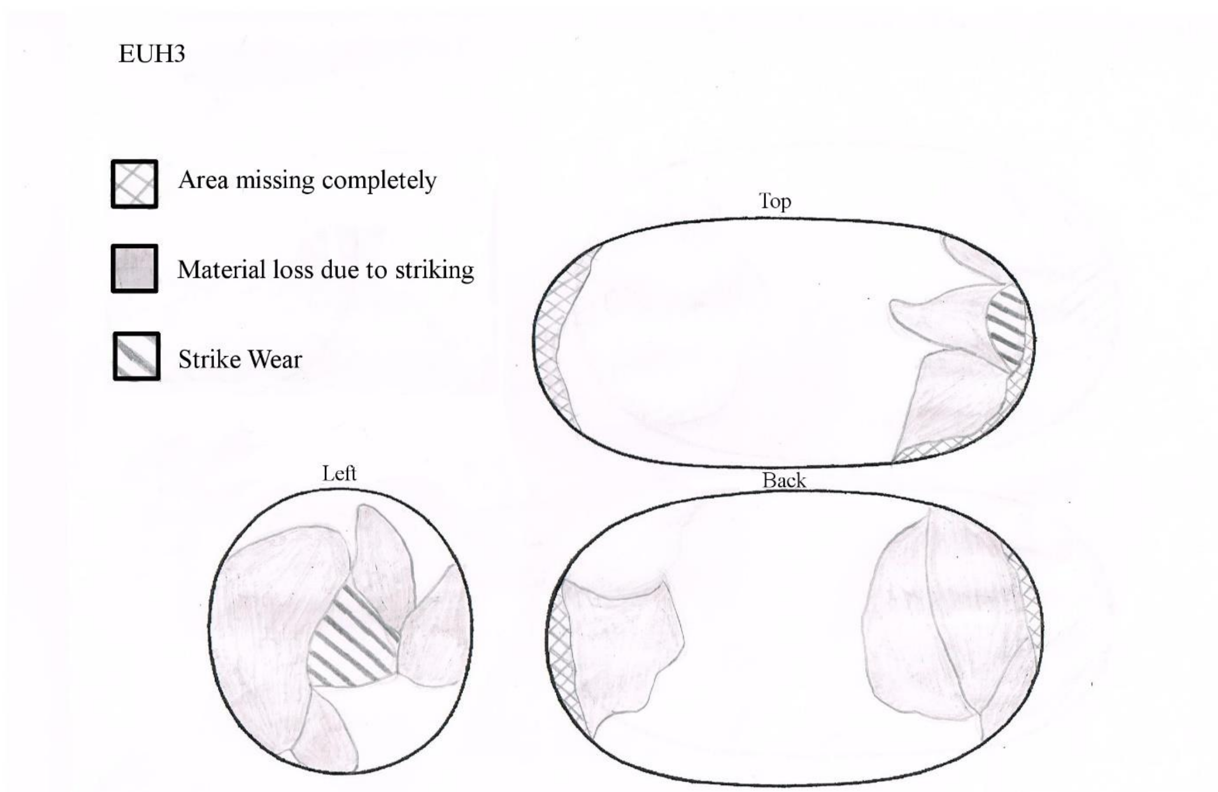


Experimental Ungrooved Hammerstone #2—EUH2

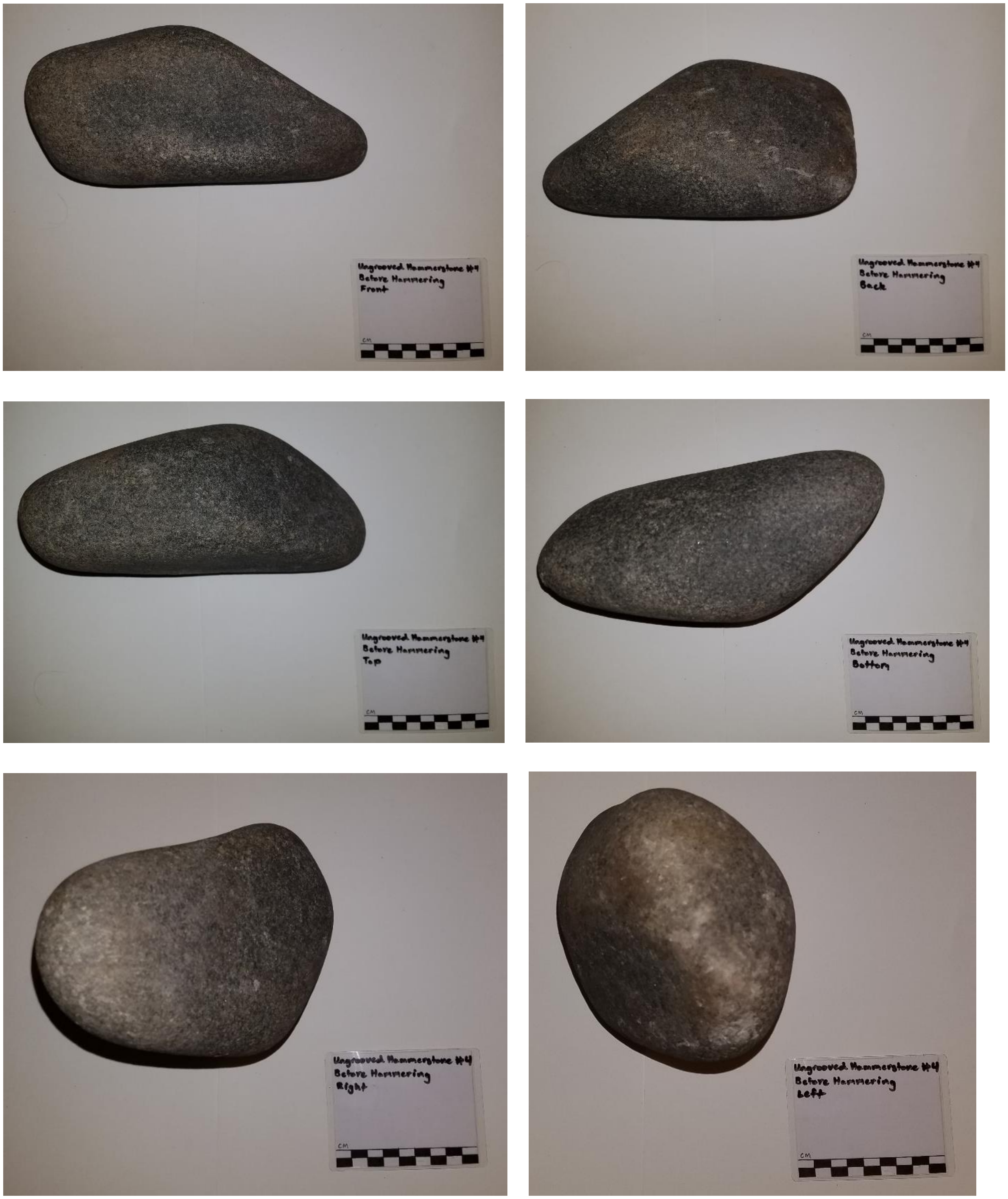
Experimental Ungrooved Hammerstone #3—EUH3

Experimental Ungrooved Hammerstone #3—EUH3

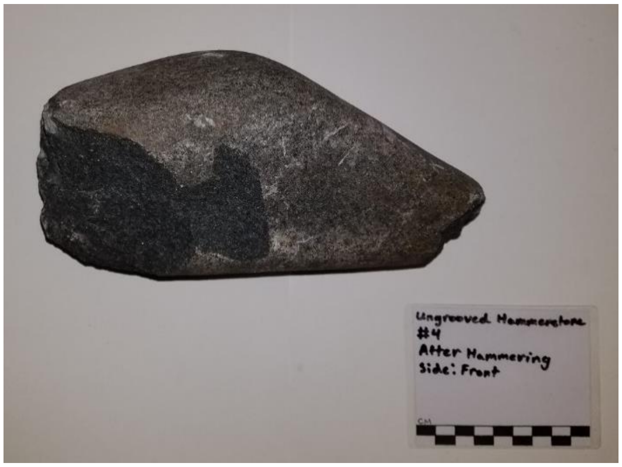


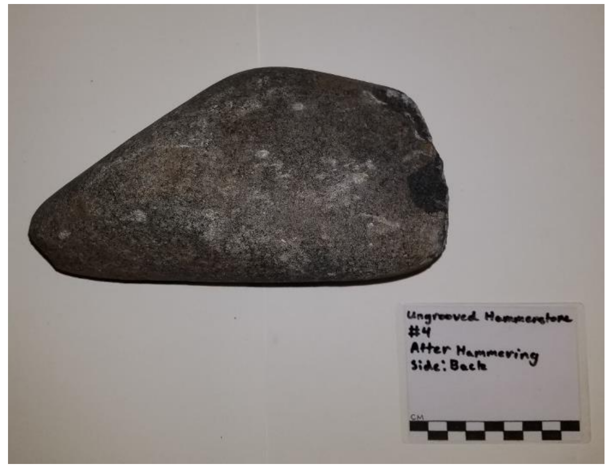


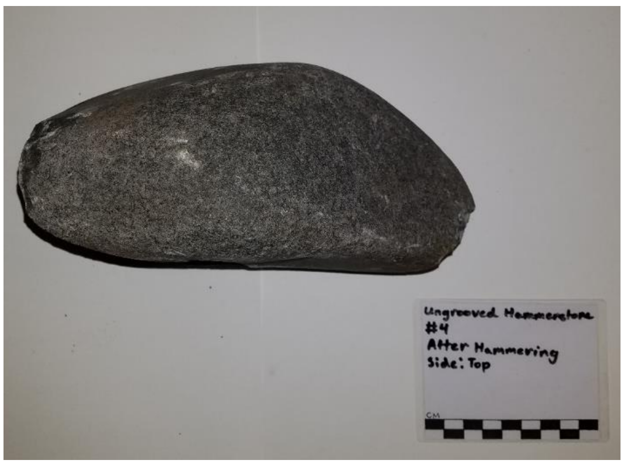
Experimental Ungrooved Hammerstone #3—EUH3

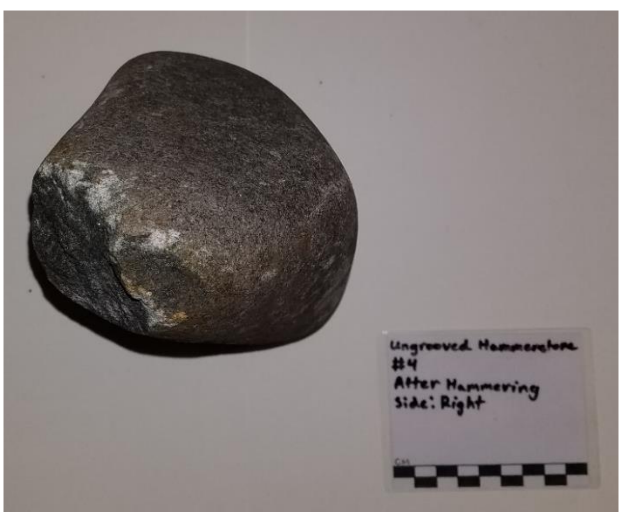


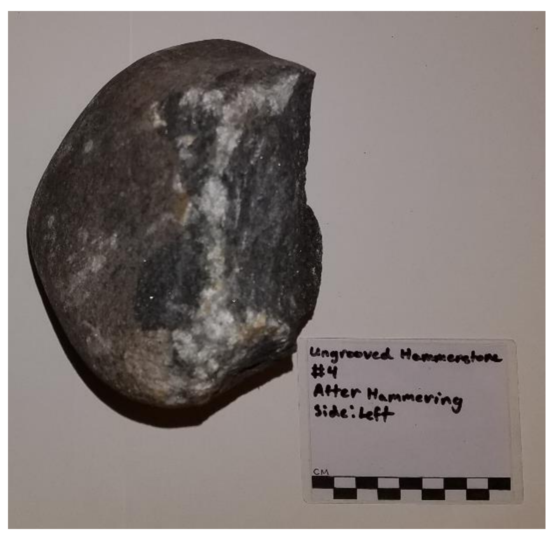
Experimental Ungrooved Hammerstone #4—EUH4



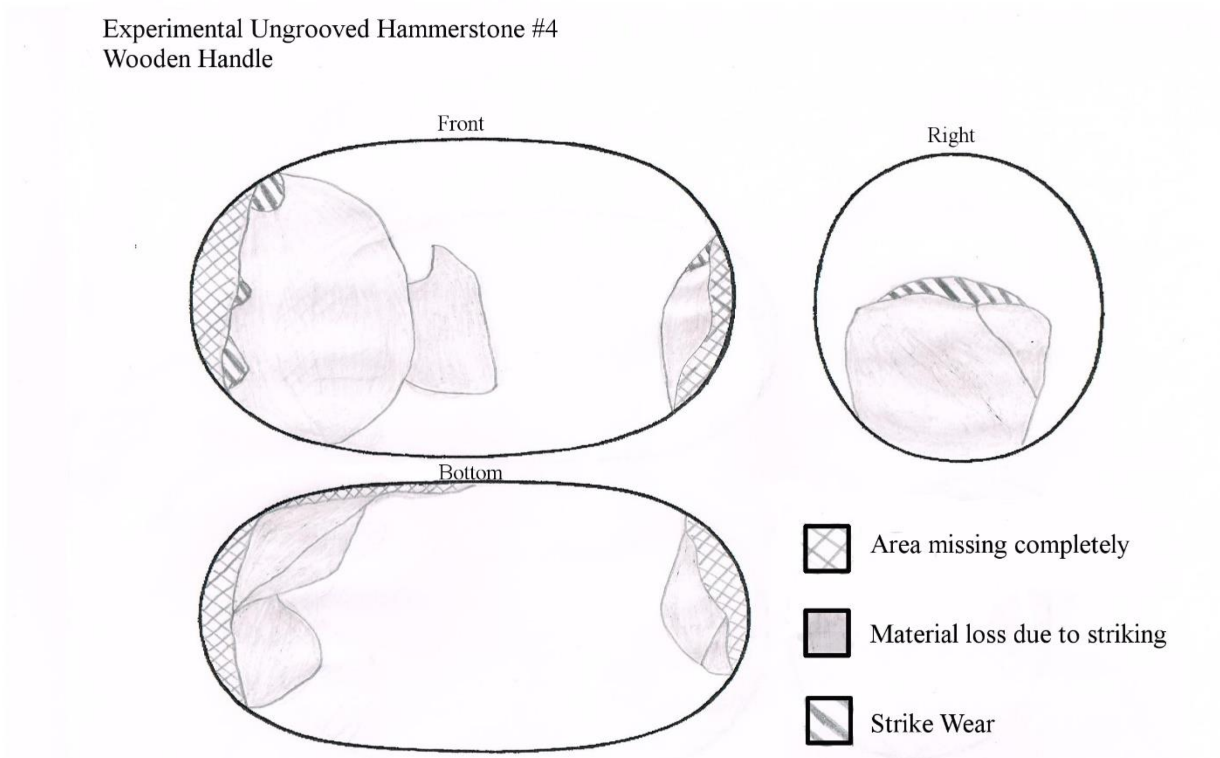


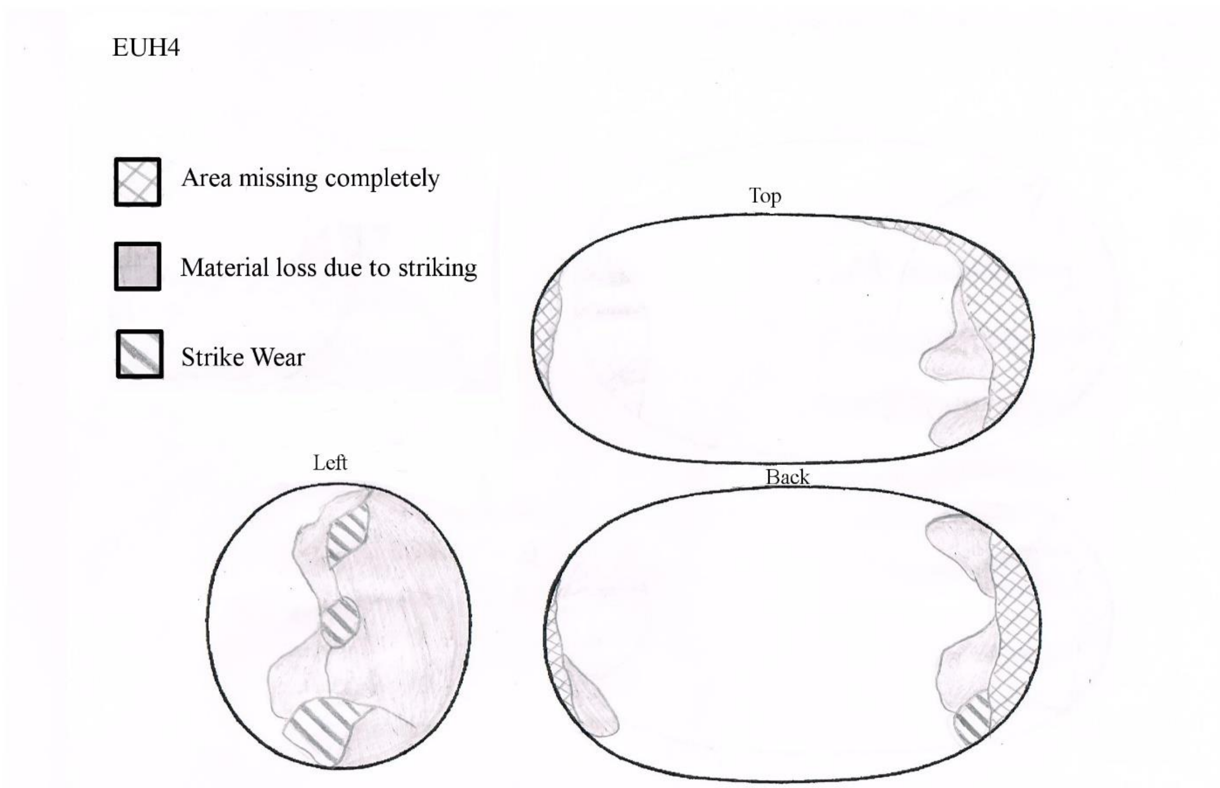






Experimental Ungrooved Hammerstone #4—EUH4

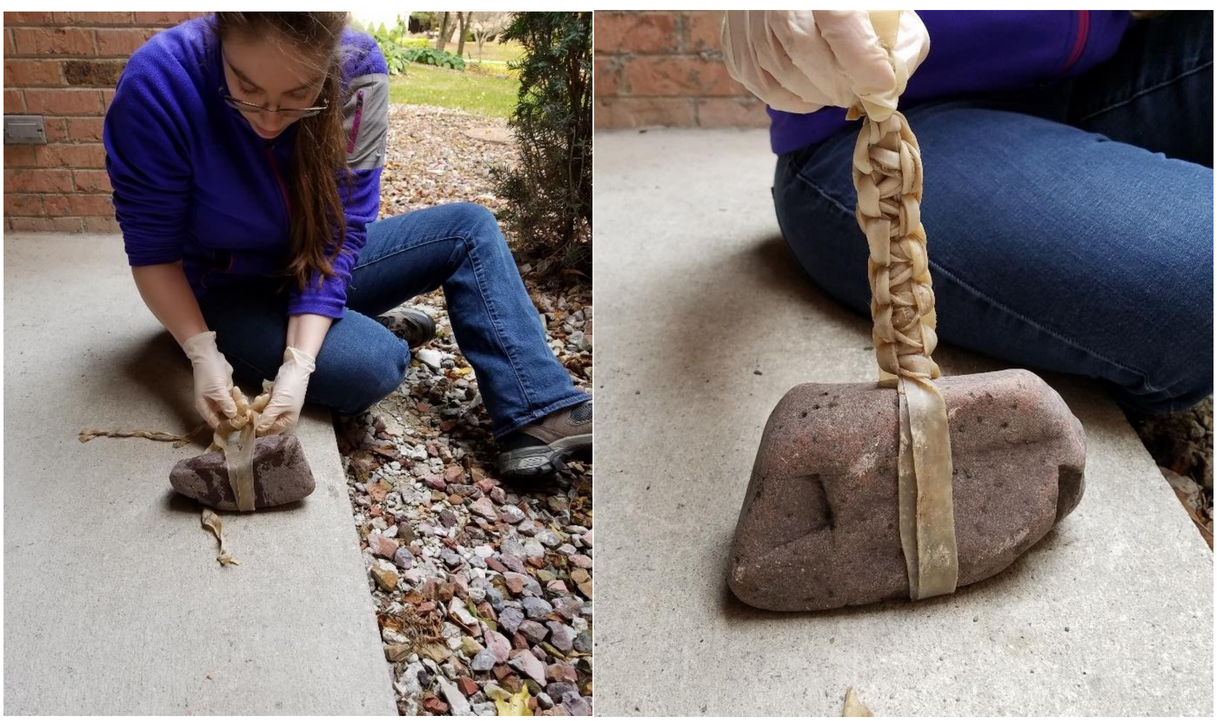




Experimental Ungrooved Hammerstone #4—EUH4

Appendix E: Miscellaneous Images

Process of making the wooden handles



Process of making the rawhide handles

Hammering with a handheld hammer