The function of stone tools from Gua Arca Site, Kangean Island, East Java

Fungsi alat batu dari Situs Gua Arca, Pulau Kangean, Jawa Timur

Rahfi Muhammad
Alumni Department of Archeology, Faculty of Cultural Sciences, University of Indonesia
afiamat10@gmail.com

Kata Kunci:
Gua Arca;
alat batu;
jejak pakai;
fungsi

ABSTRAK

Gua Arca yang terletak di Pulau Kangean, Jawa Timur, merupakan situs gua prasejarah. Sejauh ini, penelitian tentang alat batu dari Situs Gua Arca masih pada tahap pengumpulan data, sedangkan fungsinya belum diketahui. Artikel ini membahas kemungkinan fungsi alat batu dari Gua Arca, berdasarkan hasil analisis tipe alat dan analisis mikroskopis jejak pakai yang dibandingkan dengan hasil penelitian eksperimental sebelumnya. Hasil analisis menjelaskan keterkaitan antara jejak pakai dengan penggunaan alat dan material yang dikerjakan. Kemiripan antara jejak pakai pada alat batu Situs Gua Arca dengan hasil eksperimen terdahulu menunjukan kemungkinan fungsi sebagai alat pengerjaan kayu dan pengolahan bahan makanan.

Keywords:
Gua Arca;
stone tool;
use-wear;
function

ABSTRACT

Gua Arca is a prehistoric cave site in Kangean Island, East Java. Stone tools found in this site has yet to be studied in terms of the function, merely being collected instead. This article discusses the possible function of the stone tools based on typological and microscopical use-wear analysis, compared to the results from previous experimental research. The results of the analysis show that use-wear is related to the tools' function and the material they worked on. The similarity between use-wear traces on stone tools from Gua Arca and the result from previous experimental research indicates the stone tools' function as wood-working tools and food-processing tools.

Article Submitted 18-04-2021
Article Accepted 06-10-2021
Article Published 30-11-2021

BERKALA ARKEOLOGI

VOLUME : 41 No. 2, November 2021, 137-158
DOI : 10.30883/jba.v41i2.855
VERSION : English (translated)
WEBSITE : https://berkalaarkeologi.kemdikbud.go.id

ISSN: 0216-1419 | E-ISSN: 2548-7132

INTRODUCTION

Human strive to fulfill their needs of life by producing technology, making, and using tools. These tools are used by humans to process natural resources around them. The tools variation of use and shape have continued to develop along with the advance of human mind (Soejono, 2010). The tools material come from the surrounding environment such as stone, wood, and bone (Crabtree, 1972). Stone tools are one of the artifacts found in large numbers at prehistoric sites in relatively good condition. It also have an important role to explore knowledge about prehistoric human behavior (O' Connor, 2013). Stone tools are rock materials used by humans by being shaped and modified for utilization. According to George H. Odell, the definition of stone tools in archeology includes:

> "1) *an object utilized by prehistoric people (i.e., possesing evidence of use modification)* 2) *an object secondarily modified through re-touch or grinding or one that has been manufactured through a specialized technique (e.g., blade)* 3) *a secondarily modified object whose technology and shape are consistent with a typology of stone types for that region"* (Odell, 2004)

In the beginning, stone tools were used incidentally, by utilizing nearby stones with sharp edges. Furthermore, along with the advancement of prehistoric human mind, the technology of stone tools making and uilization have developed with modifications to adapt tools shape to its function. According to William Andrefsky, stone tools are shaped through a series of processes according to the abilities and knowledge of humans at that time, then used according to necessities (Andrefsky, 2005).

Stone tools were generally used by prehistoric humans for daily activities such as chopping, scraping, sawing, and perforating. This activity produced certain traces on the sharp edge, due to friction between the sharp edge and the material being worked on. The traces generally formed are the sharp edge fractures, striations, blunt edges, and glosses (Kononenko, 2011). Thus, archaeologist began to observe and examine the use-wear to explain the function of stone tools in order to reconstruct prehistoric human life.

The research on function of stone tools was carried out through ethnographic and experimental analogies. Ethnographic analogies are carried out by comparing an artifact with objects that are still used by inland tribes (Sharer & Ahmore, 2003). Experimental analogy is carried out to test the hypothesis through a series of research stages which include replication and analysis (Olle & Verges, 2014).

One of the earliest published studies of the function of stone tools was a book entitled "Prehistoric Technology" by S.A Semenov. Semenov applied new microscopic research methods and collected various experimental studies on the producing and testing of stone tools, and used ethnographic data to explain prehistoric stone tools. The research conducted by Semenov seeks the correlation between the use-wear of stone tools and certain activities that can produce similar traces (Semenov, 1964). Furthermore, the use-wear analysis was also carried out through microscopic analysis. There are two microscopic scale used in the use-wear analysis, the low-power magnification <100x and the high-power magnification >100x. Low-power magnification microscopes focus on macro traces such as sharp edge fracture and macro blunting. This technique allows interpretation of the stone tools utilization and the material hardness being worked on. The high-power magnification microscope allows more detailed analysis of micro-traces such as gloss, micro-striation and micro-abrasion (Lemorini et al., 2006). Research on the function of stone tools have continued to be carried out through various approaches such as experiments, use-wear analysis, and ethnographic analogies (Banks, 2004).

In Indonesia, research on the function of stone tools is still rare. But there are some of the stone tool use-wear studies have been carried out including an article written by Katrynada Jauharatna entitled "*Kajian Mikroskopis Jejak Pakai Alat Serpih dengan Pembesaran Rendah: Studi Kasus Artefak Batu dari Ceruk Layah, Kecamatan Sampung, Kabupaten Ponorogo, Jawa Timur*". The microscopic approach used in this research is a low magnification microscope, the results explain the use of flakes for certain activities and also the resistance of the material being worked on (Jauharatna & ., 2019). In addition, there are also two other studies in the form of undergraduate thesis, the first was written by Bambang Sarkoro entitled "*Analisis Jejak Pakai pada Beliung Persegi dari Daerah Bogor*". This study contains an analysis of the relationship between the utilization and the damage of stone adzes (Sarkoro, 1990). The second was written by Irdiansyah entitled "*Fungsi Alat Batu Situs Gua Pandan*". Research conducted by Irdiansyah describes the function of stone tools at Pandan Cave site based on the results of classification and use-wear microscopic observations, then it was associated with ethnographic analogies and previous experimental results by the experts (Irdiansyah, 2008).

Based on previous studies on the function of stone tools that have been carried out in Indonesia, this paper raises the topic on the function of stone tools using microscope at Arca Cave site. Arca Cave site is a prehistoric site located on Kangean Island, East Java. Research at Arca Cave has been carried out since 2018. It comprises archaeological and geological survey data collection, test-pits sequences, excavation sequences, and preliminary analysis of excavation findings by the Regional Agency for Archaeological Research in D.I. Yogyakarta Province (Balar DIY) (Alifah et al., 2018). The excavation was carried out in two boxes, S6T1 and B11S4. S6T1 is located on the west side of the fourth mouth/entrance of Arca Cave, while B11S4 is located on the floor of the main cave of Arca Cave.

Excavations carried out in 2019 unearthed several findings of stone artifacts (Figure 1). It is found along with other findings such as charcoal, sea shells, animal bones (*bovidae* and *cervidae*), and human bones (S6T1 and B11S4) (Alifah et al., 2019). Among the findings, the stone artifacts from the S6T1 selected as research data in this paper. The total number of stone artifacts from S6T1 are 3,251. The number are much more than the five stone artifacts from B11S4.

The excavation at S6T1 revealed two stratigraphic layers, the first layer is a layer of dark brown soil with a soft texture and contains sand. It covers 41 cm soil thickness from spits 1 to 8. The second layer is a layer of dark brown soil slightly darker than the first layer, coarse textured, and contains limestone grains. It covers 54 cm soil thickness from spits 9 to 17(Alifah et al., 2019). Based on the stratigraphy, stone artifacts in S6T1 were found in both layers, 131 stone artifacts from the first layer and 3,390 stone artifacts from the second layer.

Figure 1. Some stone artifacts from box S6T1.
(Source: Rahfi M., 2021))

Stone tools from sites on small islands have also been found in Madura and Bawean Island. In Madura, the stone tools obtained through excavations at two sites, Toroan Cave (Pamekasan) and Delubang Cave (Sumenep). Stone tool from the two sites were concluded by Khadijah Thahir Muda (2017) as stone tools of two different technologies, pre-neolithic and neolithic. In Bawean, excavations in several rivers close to settlements and caves yielded a number of stone artifacts with the type of square stone adzes. It is an indications of prehistoric life on the island (Alifah, 2020).

Absolute dating at Arca Cave was carried out on three samples in the form of two shells and one animal tooth taken from spit 4, spit 8, and spit 17. The dating analysis for samples was carried out in two laboratories, Waikato Laboratory (New Zealand) for the first and second samples, and Beta Analytic Laboratory (United States) for the third sample. The selection of the three samples was based on the context of archaeological findings. The first sample was the illustration of the latest use of the Arca Cave as a settlement. The second sample was in a context with very densely found shells fragments. It is hoped to provide a time-span of the marine resource exploitation in the Arca Cave. The third sample was in a context with densely found chert stone artifacts and animal bone fragments. The absolute dating results showed that the first sample was 1.416±25 BP and the second sample was 5,850±44 BP. The third sample could not be analyzed because the sample conditions is not adequate for dating analysis. However, based on the stratigraphy, the third sample was estimated to have a time span close with from the second sample (Alifah et al., 2019).

Stone tools in the Arca Cave, are the most common findings compared to other types of findings from excavation and are in relatively good condition. Therefore, research on stone tools is an important thing to reconstruct prehistoric human behavior in Arca Cave. Stone tools are relics of prehistoric times that can be viewed from various perspectives to get an illustration of prehistoric human behavior. An indication of prehistoric human behavior can be seen from the relationship between attributes on artifacts used for certain functions (Grace, 2012).

Basic knowledge of tools functions begins with observing and recording the morphology of stone tools, especially the attributes attached to the sharp edge (Grace, 2012). Observation and recording of the sharp edge attributes on stone tools are used as the basis for classifying stone tools into types, lead to the possible function of the tool. Furthermore, the use-wear analysis was carried out through microscopic observations to examine the traces found on stone tools due to certain activities. The possible function of stone tools in the Arca Cave can be explained based on the relationship between stone tool typology and use-wear analysis followed by experimental result from previous studies. Thus, the identification of tool types is carried out to see the relationship between stone tools and their functions. The identification of stone tool typology is carried out by describing the shape of use-wear found on the sharp edge, therefore the functions and activities of prehistoric humans in the Arca Cave can be explained.

METHOD

The research carried out in three stages namely, data collection, data processing, and interpretation. First stage, books and articles on stone tool research in general and specifically on the analysis of stone tool functions was collected, as well as research reports that became the basis of knowledge for conducting research. Next is re-checking the Arca Cave archaeological excavation result as the data source. Re-checking is carried out to verify the data amount and availability, also to determine the data limitation. In addition, sorting process of stone artifacts assemblage is also carried out to classify stone artifacts into tool and non-tool categories. The sorting process is carried out by observing the sharp edge of stone artifacts. Determination of an artifact as a tool, refers to the presence of intensive use-wear on its surface and the presence of re-touching or resharpening (scars) on the sharp edge. Sorting process of stone artifacts is done macroscopically, by observing with the naked eye. Then, the tools category obtained through sorting process used as data.

Second, data processing by classifying the tools category. The data was divided into certain classes based on function attributes. The type resulting from this classification indicates an efficient tool used in an activity. This type refers to the classification model which includes the attributes of sharp edge position, the angle of sharp edge, and the shape of sharp edge (Bandy, 1995) The position of sharp edge was the placement of re-touch and use-wear on the stone tool surface. The position of sharp edge was divided into unimarginal and bimarginal which refers to the position of re-touch and use-wear on one surface (unimarginal) and on both surfaces (bimarginal). The angle of sharp edge was the meeting angle between ventral and dorsal sides on the presumed sharp edge of stone tools. The edges form a certain angle measured using a protractor/goniometry.

The angles of sharp edge were divided into three classes based on their inclination towards certain activities. The angle of 26-35 degrees was classified as a gently sloping angle, 46-55 degrees was a steep angle, and 66-75 degrees was a very steep angle. The angle of sharp edge was measured using a protractor/goniometry. The shape of sharp edge was the cross-sectional shape of the part that has re-touch or use-wear. According to Marie-Louise Inizan, the shape of sharp edges were generally divided into straight, convex, concave, serrated, notched, and tapered (Figure 2) (Inizan et al., 1999a).

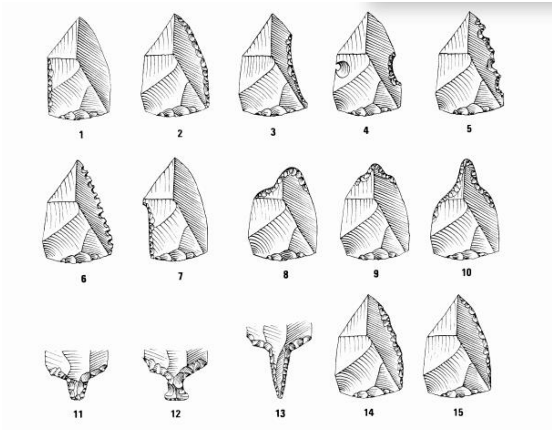

Figure 2. The shape of sharp edges.
(Source: Inizan et al., 1999)

The measurement and weighing of stone tools were carried out based on the classes of their sharpness. Measurements were made by measuring the longest dimension of the stone tool using a circle determined by the size class. Weighing was done to get the size of stone tools maximum dimension. Therefore, the overall shape of stone tool was obtained. Weighing was done using a digital scale. Measurement and weighing can give an idea of the stone tool efficiency value based on the specific way of hand holding.

The use-wear analysis in this study refers to the forms of use-wear proposed by several researchers, such as R. Tringham (1974), G.H. Odell (1981), L. Keeley (1980), dan J. Kamminga (1982). Based on that, the tools determined as sample by identifying the sharp edges. Microscopic identification was done to see the use-wear that indicate the tool is being used. Microscopic analysis was carried out with a low and high magnification microscope, then pictorially recorded and verbally described. The recording and description results were then analyzed further by comparing the types of tools.

Third, the interpretation based on the analysis of the sharp edge morphology and use-wear was eventually still not strong enough to explain the function. It needs a separate experiment to prove the function accurately. However, experimental research in this study was not possible because the condition to conduct experiments could not be met. Experiments can be carried out if certain conditions are met, including the type of raw material and the same level of hardness as the samples as well as special skills for replicating stone tools. Therefore, what was done to explain the function of stone tools in this study was a comparison using the experimental results of previous studies. These comparisons were made to help estimate the function of stone tools from the Arca Cave site. The experimental comparison used in this study was taken from the results of Tringham experiment (1974), Odell (1981), Kamminga (1982), and Keeley (1980).

RESEARCH RESULTS

Stone Tool Classification

Before the classification of stone tools was made, the stone artifacts assemblage was firstly sorted macroscopically. Stone tools was identified using the naked eye or with a magnifying glass. Then, sorting process was done to divide stone artifacts into two major category, tools and non-tools. The tool category characterized by the presence of intensive work indication on the surface, intentionally made fracture on the sharp edge (re-touch), and fractures with suspected use-wear that can be seen macroscopically. The non-tool category are debitages from the stone tool-making process and did not have the characteristics of further processing. The non-tool category was divided into two types, non-tool flakes (artifacts with flakes attributes but are not used as tools) and unidentified artifacts.

Sorting process of the 3,521 stone artifacts from S6T1 yielded 142 tools, while the rest were non-tool artifacts consisting of non-tool flakes and debitages. A total of 142 of these tools were classified based on the sharp edge attribute as an attribute that strike directly to the material being made, to produce a type associated with an approximate function. The variables that were used as the basis for the classification are:

a. Sharp edge position: identification on the sharp edge position based on the placement of the re-touch or use-wear on one side of the stone tool (unimarginal) or both sides (bimarginal).
b. Sharp edge angle: The angle of sharp edge was measured using a protractor on the part of the stone tool that was suspected to be a sharp edge.
c. Shape of the sharp edge: the shape was identified by looking at the margin on the presence re-touch or use-wear in the form of macro edge-damage on the sharp edge. The forms of sharp edge that become the reference proposed by (Inizan et al., 1999b) i.e., straight, convex, concave, serrated, and tapered.

Based on the attribute characteristics that have been recorded, stone tools were then classified into several types from the position of sharp edge and the angle of the sharp edge. Each type of tool was named by the code for each attribute. The position of sharp edge was divided into two types, the code uses Roman numerals I for the unimarginal and II for the bimarginal. The sharp edge angles were coded as 1 for gently sloping angles, 2 for steep angles, and 3 for very steep angles. There were also sub-types of tools based on the shape of sharp edge which were coded with letters, “A” for straight, “B” for convex, “C” for concave, “D” for serrated, and “E” for tapered. This classification produced four types of tools based on the position of sharp edge and the angle of sharp edge. Then, each type of tool was divided into several sub-types based on the shape of sharp edge.

Type I1 was a tool with an unimarginal sharp edge and a gentle slope angle. Type I1 was divided into four sub-types based on the shape of sharp edge. Sub-type A with straight sharp edge has 31 tools, sub-type B with convex shape has 35 tools, sub-type C with concave shape has 1 tool, and sub-type E with tapered shape has 14 tools.

Type I2 was a tool with an unimarginal sharp edge and a steep angle. Type I2 was divided into five sub-types based on the shape of sharp edge, sub-type A with straight sharp edge has 22 tools, sub-type B with convex shape has 12 tools, sub-type C with concave shape has six (6) tools, sub-type D with serrated shape has two (2) tools, sub-type E with tapered shape consists of seven (7) tools.

Type I3 was a tool with an unimarginal sharp edge and a very steep angle. Type I3 was divided into two sub-types based on the shape of sharp edge, sub-type A with straight shape has six (6) tools and sub-type B with convex shape has three (3) tools.

Type II1 was a tool with a bimarginal sharp edge and gentle slope angle. Type II1 was divided into two sub-types based on the shape of sharp edge, sub-type B with a convex shape has two (2) tools and sub-type C with a concave shape has one (1) tool. These types of tools were integrated with the size and weight attributes of each tool to get an overall shape of stone tools.

The classification type of stone tool based on the size was done to find out the pattern and trend between the type and size. This classification produced three size classes based on measurements of the maximum length of all stone tools. The result was that all types of stone tools are dominated by medium size (64%), except Type II1 which had only large size and the least number (2%). Type I3 tools were also few in number and only have medium (4%) and large (2%). Meanwhile, tools with small sizes were only found in Type I1 (14%) and Type I2 (2%) (Table 1).

Table 1. Grouping of tool types by size.

Type	Size						Total	
	Small		Medium		Large			
	Total	%	Total	%	Total	%	Total	%
I1	20	14,08%	56	39,44%	5	3,52%	81	57,04%
I2	3	2,11%	29	20,42%	17	11,97%	49	34,51%
I3	-	-	6	4,23%	3	2,11%	9	6,34%
II1	-	-	-	-	3	2,11%	3	2,11%
Total	**23**	16,20%	91	64,08%	28	19,72%	142	100,00%
Small: 1,5 - 3,0 cm			Medium: 3,1 - 5,0 cm			Big: 5,1 - 7,6 cm		

(Source: Rahfi M., 2021)

The classification of stone tool types based on weight was carried out to know the pattern and trend between each type of tool and weight of tool. The types of tools were classified into heavy class based on the weighing result. Based on the analysis of the weight, it can be seen that Type I1 and I2 were dominated by light weight (42%), Type I was dominated by medium weight (4%), and Type II1 with the least number of tools and only had medium weight (2%) (Table 2).

Table 2. Classification of tool types by weight.

Type	Weight						Total	
	Light		Medium		Heavy			
	Total	%	Total	%	Total	%	Total	%
I1	60	42,25%	21	14,79%	-	-	81	57,04%
I2	23	16,20%	21	14,79%	5	3,52%	49	34,51%
I3	1	0,70%	7	4,93%	1	0,70%	9	6,34%
II1	-	-	3	2,11%	-	-	3	2,11%
Total	84	59,15%	52	36,62%	6	4,23%	142	100,00%

Light: 0 - 10 gram Medium: 11 - 40 gram Heavy: 41 - 100

(Source: Rahfi M., 2021)

Next, the types of tools were classified by size and weight. Classification of stone tool types by size and weight was done to make prediction of how to handle the tool. This prediction was determined from the researcher perspectives on the tendency of the tool comfortability when held by hand. Based on its size and weight, there were three possible ways of holding the tool. The first method was clamped using the tips of the fingers (thumb, index, and middle fingers), the second method was clamped using the fingertips to the base of the finger, and the third method was gripped by hand (Table 3).

Table 3. Grouping of tool types by size and weight.

Type		Small		Medium		Large			Total
		1	2	1	2	1	2	3	
I1	**Total**	18	2	42	14	-	5	-	81
	%	12,68%	1,41%	29,58%	9,86%	-	3,52%	-	57,04%
I2	**Total**	3	-	17	12	3	9	5	49
	%	2,11%	-	11,97%	8,45%	2,11%	6,34%	3,52%	34,51%
I3	**Total**	-	-	1	5	-	2	1	9
	%	-	-	0,70%	3,52%	-	1,41%	0,70%	6,34%
II1	**Total**	-	-	-	-	-	3	-	3
	%	-	-	-	-	-	2,11%	-	2,11%
Total	**Total**	21	2	60	31	3	19	6	142
	%	14,79%	1,41%	42,25%	21,83%	2,11%	13,38%	4,23%	100,00%

Note: 1: Light 2: Medium 3: Heavy

(Source: Rahfi M., 2021)

Use-wear Analysis

Before the use-wear of stone tools is being analyzed, first the stone tools were sorted. The tools that being used has the characteristics of use-wear on the sharp edge. The sorting process began with the characteristics of use-wear on stone tools, such as sharp edge fracture, striations, gloss, and blunting. The stone tools were sorted using an Olympus Tokyo microscope with magnification 7x – 40x, inventory of the Balar DIY. The sorting was carried out by observing the sharp edge of stone tools assemblage consisting 142 tools.

Based on the sorting, it can be seen that Type I1 had five (5) tools, Type I2 had three (3) tools, Type II1 had two (2) tools, and none of the Type I3 (Table 4). This number was not the exact number of tools found at Arca Cave Site. There are several factors that cause the researcher to be limited in determining the tools, including the difficulty of observing use-wear on the sharp edges covered by soil concretion. There is also possibility of tools that being used, but leaving no traces of use-wear due to the short duration of usage or the materials being worked on had soft resistance. As much as ten (10) stone tools resulted by sorting process have visible and clear use-wear and will described further.

The microscope used for photomicrograph observation and recording was Dino-Lite AF 3113 Microscope, 20x - 230x magnification, inventory of the Archaeological Laboratory of the University of Indonesia which is connected to a computer with Dino Capture software. Therefore, the use-wear observations and photo shoots were carried out via a computer and photo data can be directly stored in the digital form. This microscope allowed the researcher to observe and record use-wear of stone tools through low and high magnification, with adjustments to visible symptoms. The sharp edge with indications of use-wear was first observed using a low magnification microscope (50x). Then, a microscope with a high magnification (200x) was used to further observe or clarify the use-wear seen at low magnification. The photographing process of use-wear was carried out on a microscope display which showed significant traces. Thus, the use-wear photos that appear refer to the significance of use-wear in a low or high magnification microscopes.

Table 4. Stone tool type.

Type	Tool Name	Sharp edge Position	Sharp edge Angle	Sharp edge Form	Size	Weight	Material
I1A	(KGNARC/2019/S6T1/12/11)	*Unimarginal*	Sloping	Straight	Small	Light	Chert
I1A	(KGN/ARC/2019/S6T1/8/3)	*Unimarginal*	Sloping	Straight	Medium	Light	Chert
I1B	(KGN/ARC/2019/S6T1/11/4)	*Unimarginal*	Sloping	Convex	Small	Light	Chert
I1B	(KGN/ARC/2019/S6T1/10/6)	*Unimarginal*	Sloping	Convex	Medium	Medium	Chert
I1E	(KGN/ARC/2019/S6T1/17/2)	*Unimarginal*	Sloping	Pointy	Medium	Light	Chert
I2A	(KGN/ARC/2019/S6T1/12/16)	*Unimarginal*	Lerjal	Straight	Medium	Medium	Chert
I2B	(KGN/ARC/2019/S6T1/16/10)	*Unimarginal*	Steep	Convex	Large	Medium	Chert
I2E	(KGN/ARC/2019/S6T1/10/3)	*Unimarginal*	Steep	Pointy	Small	Light	Chert
II1B	(KGN/ARC/S6T1/2019/9/1)	*Bimarginal*	Sloping	Convex	Large	Light	Chert
II1C	(KGN/ARC/2019/S6T1/8/1)	*Bimarginal*	Sloping	Concave	Large	Medium	Chert

(Source: Rahfi M., 2021)

Type I1

Type I1 is a stone tool with a unimarginal sharp edge and a gentle slope angle (26-35°). Type I1 tools have five (5) tools, sub-type A (Figure 3) the straight shape (two tools), sub-type B the convex shape (two tools), and sub-type E the tapered shape (one tool) (Table 5).

Type I2

Type I2 is a stone tool with an unimarginal sharp edge and a steep angle (36˚-60˚), and consists of three (3) tools, sub type A (Figure 4) the straight shape (one tool), sub-type B the convex shape (one tool), and sub-type E tapered shape (one tool) (Table 6).

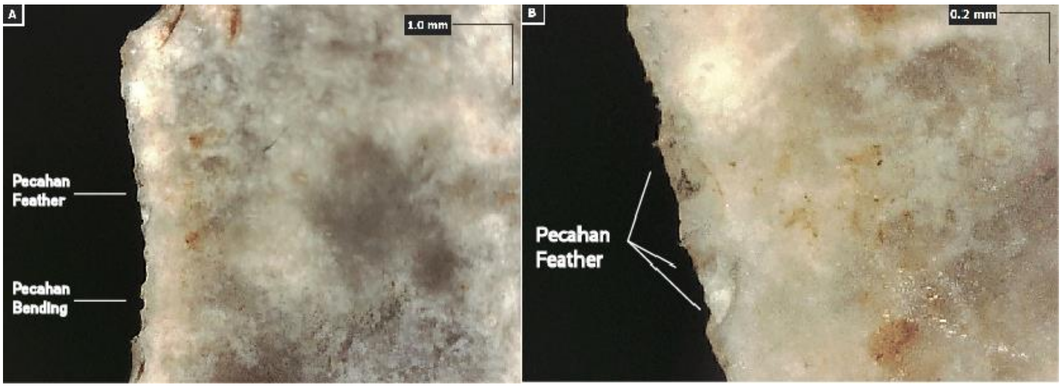

Figure 3. Magnification of 50x and 200x on type I1A tools.
(Source: Rahfi M., 2021)

Table 5. Use-wear on tool Type I1.

Type	Magnification	The form of use-wear	Position	Distribution
I1A (KGN/ARC/2019/S6T 1/12/11)	50x	fine fracture	dorsal	partial and adjacent
	200x	Feather fracture	dorsal	
		gloss	dorsal	
		bending fracture	ventral	
I1A (KGN/ARC/2019/S6T 1/8/3)	50x	fine and glossy fracture	ventral	discontinuous along the sharp edge
	200x	feather and step fracture	ventral	
		gloss (greasy polish)	ventral and dorsal	
I1B (KGN/ARC/2019/11/ 4)	50x	fine fracture	dorsal	partial and adjacent
	200x	feather and step fracture	dorsal	
I1B (KGN/ARC/2019/S6T 1/10/6)	50x	feather fracture	dorsal	partial and adjacent
		smoothing	dorsal	Partial
		feather fracture	ventral	Partial
		blunt	ventral and dorsal	Partial
	200x	no new characteristic	-	-
I1E(KGN/ARC/2019/S 6T1/17/2)	50x	step fracture	dorsal	along the sharp edge
		feather and step fracture	ventral	along the sharp edge
		feather fracture	distal	partial and adjacent
		gloss	ventral	along the sharp edge

(Source: Rahfi M., 2021)

Type II1

Type II1 is a stone tool with a bimarginal sharp edge and a gentle slope angle (26˚-35˚), and cosist of two (2) tools, sub-type B (Figure 5) the convex shape of one (1) tool and the concave shape of one (1) tool (Table 7).

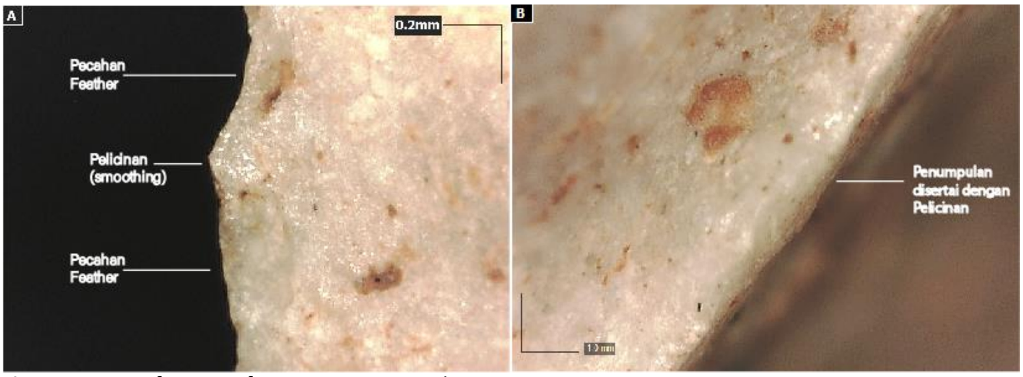

Figure 4. Magnification of 200 x on a type I2 device.
(Source: author's documentation*)*

Table 6. Use-wear on tool Type I2.

Type	Magnification	The shape of use-wear	Location	Distribution
I2A (KGN/ARC/2019/S 6T1/12/16)	50x	fine fracture	dorsal	along the sharp edge
	200x	feather fracture	dorsal	along the sharp edge
	200x	blunt and smoothing	ventral and dorsal	along the sharp edge
I2B (KGN/ARC/2019/S 6T1/16/10)	50x	feather fracture	dorsal	partial and adjacent
	50x	feather fracture	ventral	discontinuous at some part
	200x	no new characteristic	-	-
I2E (KGN/ARC/2019/S 6T1/10/3)	50x	feather fracture	ventral	discontinuous along the sharp edge
	200x	bending fracture	ventral and dorsal	intensive along the sharp edge

(Source: Rahfi M., 2021)

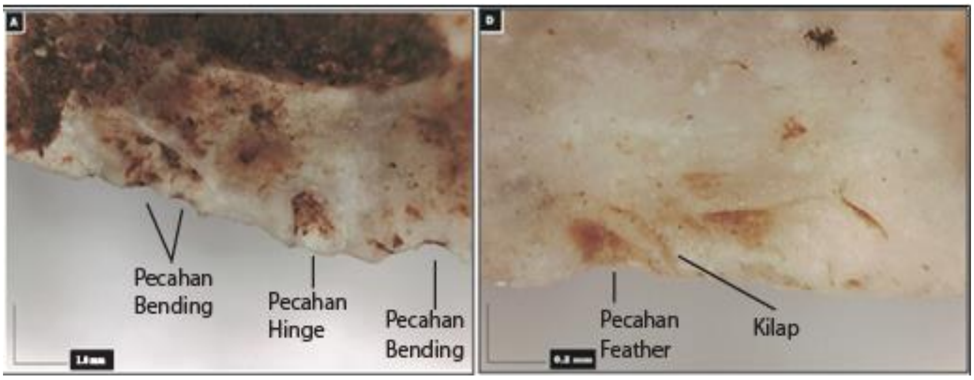

Figure 4. Magnification of 50 x and 200 x on tool type II1B.
(Source: Rahfi M., 2021)

Table 7. Use-wear on tool Type II1.

Type	Magnification	The shape of Use-wear	Location	Distribution
II1B (KGN/ARC/2019/S 6T1/9/1)	50x	bending and step fracture	dorsal	along the sharpness
		smoothing	dorsal	
		blunt	ventral and dorsal	
	200x	feather and bending fracture	ventral and dorsal	
		gloss	ventral	
II1C (KGN/ARC/2019/S 6T1/8/1)	50x	feather fracture and additive polish	dorsal	partial and near
		blunt	ventral and dorsal	partial
	200x	no new characteristic	-	-

(Source: Rahfi M., 2021)

DISCUSSION

Identification of use-wear in this study is certainly not strong enough to explain the function of a stone tool. Experimental comparisons are needed to estimate the function of stone tools based on their use-wear. However, specific experiments for this study were difficult to carry out due to the limitations of the researcher and the availability of research instruments. Therefore, the experiment used as a comparison was the result of previous experiments from experts. Comparisons with experiments from different studies certainly have many gaps to criticize, for example, the differences in the rock types of the stone tools in this study with the rock types in the previous experiments. Different types of rock can result in different forms of fracture, even though they are produced by the same activity. It is realized that the previous experiment will not produce a truly similar use-wear. However, this comparison can at least give an idea on the possible function of the stone tool.

The activity of using stone tools generally produces three main movements, namely transverse, longitudinal, and perforating movements. The three movements were then subdivided into more specific usage activities. In addition, these movements also tend to be related to certain materials, for example, sharpening movements were generally only carried out on materials with medium to hard resistance, such as wood and bone. (Odell, 1981).

Transverse motions such as sharpening and scraping carried out by applying pressure to the sharp edge (Figure 6). Then the stone tool was pulled or pushed transversely on the material being worked. Gentle working angle on the scraping activity and a steep working angle on the sharpening activity. Activities with transverse movement generally result in adjacent feather fracture on the sharp edge surface which are in direct contact with the material (Odell, 1981). The morphology of the tool used for sharpening activity varies depending on the material being worked on. The use-wear resulting from this activity are generally feather-shaped fracture that are adjacent to some of the sharp edge areas and are located on one side (Odell, 1981).

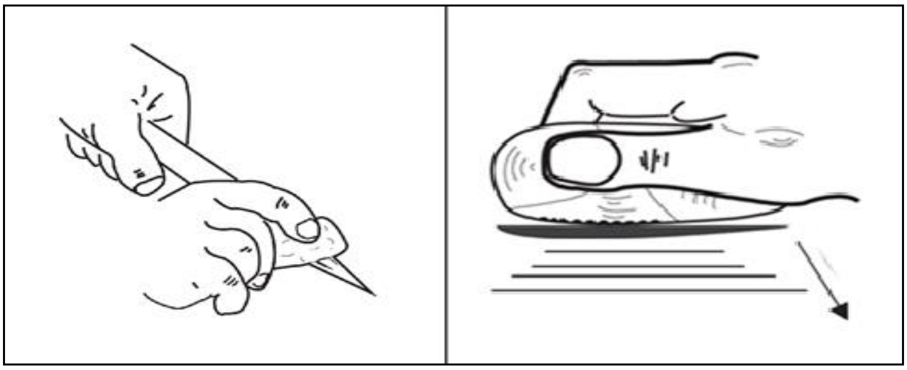

Figure 5. Illustration of sharpening activity (left) and scraping activity (right)
(Source: Rahfi M., 2021)

The materials used in this activity are generally wood, bones, and dried animal skins. In woodworking, the intensive use of tools can create a gloss due to the smoothing of sharp edge, thereby increasing light reflection. Smoothing is usually found together with blunting and striation (Kamminga, 1982). On bone work, Keeley found a very bright polish and sometimes accompanied by furrow striation (scar to the stone surface in the form of rough lines) with a transverse orientation. In the activity of scraping dry animal skin, Keeley found a dull polish with a slight greasy appearance that protrudes on one side of the sharp edge and striations with a transverse orientation. (Keeley, 1980).

Longitudinal movement is an activity such as chopping or sawing defined as a longitudinal or bidirectional movement with a vertical working angle to the material being worked (Figure 7). The sharp edge position in this activity is parallel to the direction of use, therefore both sides of the sharp edge surface are in contact with the material being worked on. Chopping activities are generally carried out on soft materials such as meat and hard materials for sawing (Grace, 2012). Use-wear that generally appear due to chopping activities are generally in the form of feather fracture that are discontinues along the sharp edge and are on both sides or dominant on one side of the tool with slightly tilted use. (Tringham et al., 1974). However, the use-wear of sawing activity are almost similar to chopping activity but generally have a larger size.

Materials that are usually used in chopping activities are animal skin and fresh meat. Through experimental research, Keeley discovered the presence of a greasy gloss/polish with a longitudinal orientation on meat and skin processing (Keeley, 1980). In sawing, Keeley found that bone tool making can produce traces of gloss on both sides of the sharp edges and striations with a longitudinal orientation (Keeley, 1980). In woodworking, Kamminga explained that it usually causes smoothing of the sharp edge surface and is sometimes accompanied by furrow striation (Kamminga, 1982).

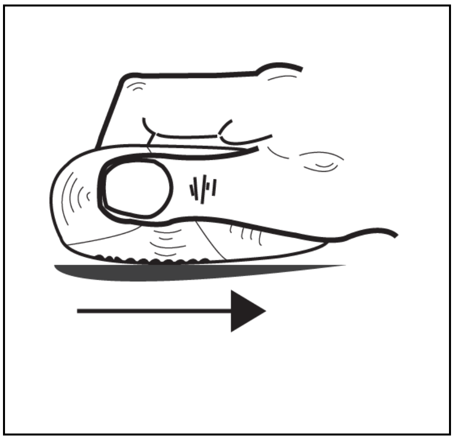

Figure 6. Illustration of chopping activity. *(Source: Rahfi M., 2021)*

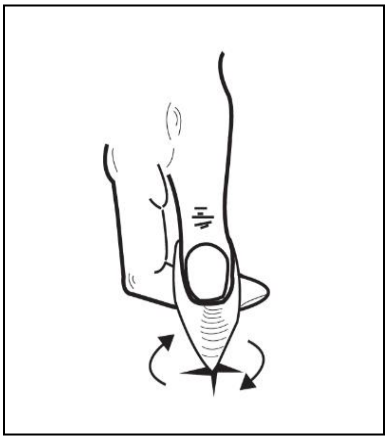

Figure 7. Illustration of perforating activity. *(Rahfi M., 2021)*

The activity of perforating or drilling (Figure 8) This is done by pressing the sharp edge on the material being worked on, then turning it right and left, therefore a hole is formed on the surface of the material being worked on (Grace, 2012). Fractures that may be formed from this activity are bending fractures. The mechanism for the formation of fractures in the perforating activity is the result of a circular motion, the position of the sharp edge is perpendicular to the sides of the hole, therefore when the tool is moved by rotating it causes the sharp edge to come into contact transversely with the material being worked on. Odell then compared the sharp edge position perpendicular to the hole of the material in the perforating activity, with the sharpening motion transversely in the scraping activity. Odell explained that there are two types of tools commonly used for scraping activities, tools with planar-convex and concavo-convex surfaces. The movement of the transverse sharp edge with a planar-convex surface as the sharp edge in contact with the material has more traces of fracture and larger size, compared to the concavo-convex surface as the sharp edge in contact with the material (Odell, 1981).

Through the previous experimental research by experts, it can be seen the similarities between the shapes, position, and distribution of the use-wear of Arca Cave stone tools. Therefore, the prediction of the stone tools function can be taken.

Stone tool Type I1A (KGN/ARC/2019/S6T1/12/11), I1B (KGN/ARC/2019/S6T1/11/4, and KGN/ARC/2019/S6T1/10/6) have a unimarginal sharp edge with a gentle angle. Those three have traces of use-wear in the shape of feather and step fractures distributed adjacently on some sharp edge and protruding on one side. In addition, there are traces of smoothing that can only be seen on the I1B (KGN/ARC/2019/S6T1/10/6) which is suspected to be traces of woodworking. Based on the types of tools and traces of use-wear and comparison with the previous experiments, it can be estimated that those three are used for wood sharpening activities.

Stone tool Type I1A (KGN/ARC/2019/S6T1/8/3) and I1E (KGN/ARC/2019/S6T1/17/2) have traces of feather and step fractures distributed discontinuously along the sharp edge and dominant on one side and a greasy gloss/polish that is distributed along the sharp edge. Based on the use-wear, these two are estimated to be used for chopping meat activities with a slightly inclined angle of work, so that the traces of use-wear are dominant on one side of the sharp edge.

Stone tool Type I2A (KGN/ARC/2019/S6T1/12/16) and I2B (KGN/ARC/2019/S6T1/16/10) have unimarginal sharp edge with steep angles. The traces of use-wear are in the form of feather fractures that are adjacent, dominant on one side, and distributed over some areas of the sharp edge. In addition, there are also traces of smoothing and blunting, so it can be estimated that this tool was used for wood scraping activities.

Stone tool Type I2E (KGN/ARC/2019/S6T1/10/3) have traces of bending fractures distributed along the sharp edge (right lateral, left lateral, and distal) and feather fragments distributed discontinuously, so it can be estimated that this tool is functioning for perforating in medium hardness materials (perhaps softwood/dry leather).

Stone tool Type II1B (KGN/ARC/S6T1/2019/9/1) has a bimarginal sharp edge with a gentle slope angle and has traces of use-wear in the form of feathers and steps fractures distributed discontinuously along the sharp edge on both sides. In addition, there is also a bright gloss with a slight greasy appearance in a longitudinal orientation accompanied by dulling of the sharp edge. Based on the morphology of the sharp edge and the trace of use-wear, this tool is estimated to be used for longitudinal movement activities, perhaps chopping/skinning the meat/animal skin with a working angle perpendicular to the material being worked on.

Stone tool Type II1C (KGN/ARC/2019/S6T1/8/1) has a feather fracture distributed over some of the sharp edge and is visible on both sides. In addition, there are also traces of smoothing accompanied by a bright gloss that coats the surface of the tool (additive polish) which is only found on one side of the sharp edge. This indicates that only part of the sharp edge is in contact with the material being worked and is intensive on one side. Based on the morphology of the sharp edge and the trace of use-wear, this tool is estimated to be used for transverse movement activities such as scraping/sharpening. Meanwhile, the traces of smoothing and gloss on this tool are thought to be traces of woodworking (Table 8).

Table 8. Estimated activities performed using the tool.

Tool Name	Sharpness Position	Sharpness Angle	Sharpness Form	Size	Weight	Activity	Material	Holding Technique
(KGN/ARC/2019/S6T1/12/11)	Unimarginal	Sloping	Straight	Small	Light	Whittle	Wood	1
(KGN/ARC/2019/S6T1/8/3)	Unimarginal	Sloping	Straight	Small	Light	Cut	Meat	1
(KGN/ARC/2019/S6T1/11/4)	Unimarginal	Sloping	Convex	Small	Light	Whittle	Wood	1
(KGN/ARC/2019/S6T1/10/6)	Unimarginal	Sloping	Convex	Medium	Medium	Whittle	Wood	2
(KGN/ARC/2019/S6T1/17/2)	Unimarginal	Sloping	tapered	Medium	Medium	Cut	Meat/Leather	2
(KGN/ARC/2019/S6T1/12/16)	Unimarginal	Steep	Straight	Medium	Medium	Shredding	Wood	2
(KGN/ARC/2019/S6T1/16/10)	Unimarginal	Steep	Convex	Medium	Medium	Shredding	Wood	2
(KGN/ARC/2019/S6T1/10/3)	Unimarginal	Steep	Tapered	Small	Light	Hollow out	Wood	1
KGN/ARC/S6T1/2019/9/1)	Bimarginal	Sloping	Convex	Big	Medium	Cut	Meat/Leather	2
(KGN/ARC/2019/S6T1/8/1)	Bimarginal	Sloping	Sunken	Big	Medium	Shredding	Wood	2

1: Clamped using fingertips 3: Gripped by hand

2: Clamped using the tip of the finger to the base of the finger

(Source: Rahfi.M, 2021)

CONCLUSION

A series of research stages that have been carried out and described above are an attempt to explain the function of stone tools from Arca Cave Site. Based on the classification of stone tools at Arca Cave Site, it can be seen that the majority of tools have unifacial (unimarginal) sharp edge and a gentle slope angle (I1), followed by tools with unifacial sharp edge with steep angles (I2), unifacial sharp edge with very steep angles (I3), and bifacial (bimarginal) sharp edge with gently slope angles (II1). Based on the sorting process, the majority of stone tools that have traces of use-wear are type I1, followed by type I2, and type II1. The sorting process of stone tools assemblage shows that the number of tools that have traces of use-wear is very small. This can be attributed to the possibility that stone tools have not been used for a long time, therefore most do not leave traces of use-wear on the sharp edge. In addition, the absence of traces of resharpening on the sharp edge of the tool strengthens the notion that stone tools were used for single-use purposes.

Overall, these stone tools have traces of use-wear in the form of fractures (feather, bending, hinge, and step), gloss (greasy polish and abrasive smoothing), and blunting. Traces of striation also commonly found in use-wear were not identified on microscopic observation in this study. Based on the relationship between the type of tools and the use-wear, accompanied by comparisons of the previous experimental research, stone tools from Arca Cave are estimated into two types of activities. The first is activities related to the production process, activities lead to the tool making made from other raw materials, especially wood. Activities in the wooden tools making are included in the process of finishing stage. This can be seen from all the tools with traces of use-wear refer to the activity of sharpening and scraping wood, generally it carried out in the tool making at the finishing stage. So far, no tools have been found with traces of use-wear that are thought to be used for activities in the material procurement or in early-stage tool making, such as cleaving or sawing. The second is food processing activities that can be seen from the tools used for meat chopping. Similar to the activity of wooden tools making, food processing also shows that the activities carried out tend to refer to advanced food processing processes. There are no tools with indications of use-wear that can be associated with food gathering activities.

The discussion of stone tools functional context can be seen from the relationship between the results of research results and other findings from the excavation. The findings of faunal remains in the form of terrestrial animal bones (*bovidae* and *cervidae*), sea shells, and fish bones indicate the use of terrestrial and aquatic animals for subsistence processed using stone tools. This explanation is reinforced by the environmental conditions of the site which are close to food sources such as forests, fresh water, and the sea.

The discussion above is a small attempt to explain the position of stone tools in prehistoric human activities, especially in Arca Cave. Further research is needed on this site considering that there has not been much excavation data and analysis of the findings used in this study. Excavations at this site need to be carried out by opening several pits in the cave room. It can develop research in terms of the variety of findings and the pattern of distribution of archaeological finds in the cave, which is then followed up with a specific analysis. Regarding this research, it is necessary to conduct research with experiments to find out an overview on stone tools function as a whole which includes the process of tool making, the material being worked on, and the length of time the tool is used. In addition, residual analysis on stone tools also needs to be carried out to see residual traces that may be related to certain materials and the possibility of using the handle of the tool.

AUTHOR DECLARATION

Author contributed to the creation of this manuscript. The manuscript has been read and approved by author. Author did not receive funding for the creation of this manuscript. Author confirm that there are no known conflicts of interest associated with this publication and there has been no significant financial support for this work that could have influenced its outcome. Author adhered to the Copyright Notice set by Berkala Arkeologi.

ACKNOLEDGEMENT

The effort to complete this research certainly involves support from many people. Thank you to all the lecturers and staffs at FIB UI, especially Departmenet of Archaeology, who have given me knowledge and opened my mind to the world of archeology. Thank you to Regional Agency for Archaeological Research in D.I. Yogyakarta Province for giving me access and the opportunity to conduct research. Special thanks to Alifah, M.A. who had given input on this research and are willing to be bothered while I collect research data. Thanks to the honorable Karina Arifin, Ph.D. who in the midst of her busy life patiently guided me during this research. The knowledge and passion given has motivated me to keep learning and not easily give up.

REFERENCES

Alifah. (2020). The contribution of recent data from islands in the north java sea on Indonesian prehistoric archaeology. *Wallenae*, *18*(2), 65–72.

Alifah, Gunadi, Taniardi, P., Pratama, A., Nugraha, S., & Anwar, M. . (2018). *Laporan penelitian arkeologi: Pulau kecil di utara Jawa dalam arus migrasi masa prasejarah*.

Alifah, Nugraha, S., Taniardi, P., Purnamasari, R., Suryono, T., Ardiyanto, L., Anwar, M. ., Ramdhan, L., & Abdurahman, F. (2019). *Laporan penelitian arkeologi: pulau kecil di utara Jawa dalam Arus migrasi masa prasejarah*.

Andrefsky, W. (2005). *Lithics: Macroscopic approaches to analysis: second edition* (second). Cambridge University Press.

Bandy, M. S. (1995). Functional analysis of flake tools from Chiripa, Bolivia. In *Taraco Archaeological Project*.

Banks, W. E. (2004). *Toolkit and site use: Result of a high power use-wear analysis of lithic assamblages from Solutre*. Faculty of Graduated School of the University of Kansas.

Crabtree, D. . (1972). *An introduction to flintworking* (first). Idaho State University.

Grace, R. (2012). Interpreting the function of stone tools. In *Interpreting the Function of Stone Tools* (second). Ikarus Book.

Inizan, M.-L., Reduron-Ballinger, M., & Tixier, J. (1999a). *Technology and terminology of knapped stone*. Cercle de recherches et d'études préhistoriques. https://www.researchgate.net/publication/241685228_Technology_and_Terminology_of_Knapped_Stone

Inizan, M.-L., Reduron-Ballinger, M., & Tixier, J. (1999b). *Technology and terminology of knnaped stone* (first). ercle de Reserches et d'Estudes Prehistoriques Maison de I'Ethnologie.

Irdiansyah. (2008). *Fungsi alat batu dari situs gua pandan, Padang bindu, Sumatera selatan*. University of Indonesia.

Jauharatna, K., & . A. (2019). Kajian mikroskopis jejak pakai alat serpih dengan perbesaran rendah: studi kasus artefak batu dari Ceruk Layah, Kecamatan Sampung, Kabupaten Ponorogo. *Panalungtik*, 2(1), 59–75. https://doi.org/10.24164/pnk.v2i1.21

Kamminga, J. (1982). *Over the edge: Functional analysis of Australian stone tools* (first). University of Queensland.

Keeley, L. (1980). *Experimental determination of dtone tools uses: A microwear analysis* (first). University of Chicago Press.

Kononenko, N. (2011). Experimental and archaeological studies of use-wear and residues on obsidian artifacts from Papua New Guinea. In *Technical Reports of the Australian Museum online* (Vol. 21, Issue February).

Lemorini, C., Stiner, M. C., Gopher, A., Shimelmitz, R., & Barkai, R. (2006). Use-wear analysis of an Amudian laminar assemblage from the Acheuleo-Yabrudian of Qesem Cave, Israel. *Journal of Archaeological Science*, *33*(7), 921–934.

Muda, K. . (2017). *Prasejarah situs Delubang dan Toroan, Pulau Madura, Indonesia*. Universitas Gadjah Mada.

O' Connor, S. (2013). Archaeology in practice. *John Willey & Sons Inc*.

Odell, G. H. (1981). The mechanic of use-breakage of stone tools: Some testable hypotheses. *Journal of Field Archaeology, 8*(2), 197–209.
Odell, G. H. (2004). *Lithic analysis* (first). University of Tulsa.
Olle, A., & Verges, J. (2014). The use of sequential experiments and SEM in documenting stone tool microwear. *Journal of Arcaheological Science*, *28*, 60–72.
Sarkoro, B. (1990). *Analisis jejak pakai beliung persegi dari daerah Bogor*. University of Indonesia.
Semenov, S. A. (1964). *Prehistoric Technology*. Adams and Dart.
Sharer, R. ., & Ahmore, W. (2003). *Discovering our past* (third). Mc Graw-Hill Higher Education.
Soejono (Ed.). (2010). *Sejarah nasional indonesia jilid I* (fifth). Balai Pustaka.
Tringham, R., Cooper, G., Odell, G., Voytek, B., & Whitman, A. (1974). Experimentation in the formation of edge damage: a new approach to lithic analysis. *Journal of Field Archaeology*, *1*(1–2), 171–196.

This page was intentionally blank