The Adaptation Pattern as the Development of Lithic Technology in the Southern and Northern Mountains Areas of Java

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Abstract. In maintaining their lives, prehistoric humankind, especially in the Pleistocene up to the beginning of the Holocene era, were still highly dependent on the availability of natural surroundings. The cycles of nature, technology, and culture are inseparable because anything that changes nature will also affect subsystems and cultures. This process may form human intelligence level and adaptation patterns to sustain their lives, such as the development of stone tools technology. When raw material is unavailable in their surroundings, humans will substitute them with other materials for daily purposes. The results of research in the Baksoko River – Oyo River and Kidang Cave watersheds are examples of prehistoric human adaptation in sustaining their lives.

Keywords: Adaptation · Pleistocene · Paleolithic

1 Introduction

The condition of nature in the Mountain Sewu region as a part of the Southern Mountains of Java today differs significantly from the Pleistocene era. During the Pleistocene, inhabited by the genus Homo erectus, various types of trees lived and supported the existence of life for those who depended heavily on the availability of natural surroundings. Many environments have changed in Indonesia, particularly Mt Sewu, since the Pleistocene to the Early Holocene. In the Pleistocene Epoch, around 1.8 million to 11.8 thousand years ago [1], the glacial-interglacial period happened repeatedly and influenced the global climate. Glaciation Period is a condition in which the temperature earth decrease and forms ice at the earth's poles. Sea water surface decreases and forms new lands. Unlike the interglacial period, in this era, the earth's temperature became warm, the ice melted, sea levels rose, and plains were submerged in the sea surface. The sea level surface dynamics were caused by the glacial and interglaciation period and the tectonics movement. They triggered the change in the sea surface [2].

During the Pleistocene to the Early Holocene, Java, and Bali, it has indicated a lower sea level surface than it is today. This fact is indicated when Sunda was exposed down to

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150 m, and its mainland was three times wider. Even when the sea surface level is 40 m lower than today, there are possibilities of newly exposed land between Java, Sumatra, Borneo, and the Malay Peninsula. During lower sea surface periods, lower rainfall and humidity would happen. During that time, tropical forest rain became more prominent, and the exchange of many animal types through the forest corridor between Asia and Australia occurred [3].

Decreasing sea water surface allows humans and fauna to migrate to newly formed land. The change in the mainland dimensions would also affect the availability of natural resources and the natural environment, from the mainland to coastal nature and vice versa. The migration of humans and fauna, along with the change of environment, call the process of adaptation and finally impact humankind's process and cultural development. [4].

The environmental condition in Java Pleistocene Period (between 126,000 to 107,000 BP), based on results from Van der Kaars and Dam in Bandung [5], showed that freshwater swamp forests were humid. The temperature was warmer at about 81,000 BP; open swamps replaced the freshwater swamp forest. Next, on 47,000 to 20,000 BP, the climate was indicated as a drier condition. One significant change in this period was the Last Glaciation Maximum (GMT), and after 16,000 BP, the climate increased to a warmer temperature [5] (Fig. 1).

The rainforest on the island of Java seems affected by climate change during The Last Glaciation Maximum. This climate is characterized by a long and dry southeastern monsoon, a much more humid northwestern monsoon, and significant temperature decrease that affect the landscape throughout the region. The increasing of rainfall rate that would decrease the temperature was also stated by Westaway [6]. S*peleothem* Analysis from East Java and Flores has confirmed the increase in rainfall rate between 17–16.5 thousand years ago [6]. Most rainforests are covered by exposed vegetation and mainly consist of grasslands [7]. This temperature increase reached its maximum at 8,500 BP. At that time, the rainforest reached its highest development point; in Central Java, two phases of forest recession were recorded. Around 4,000 BP, there was grassland development; around

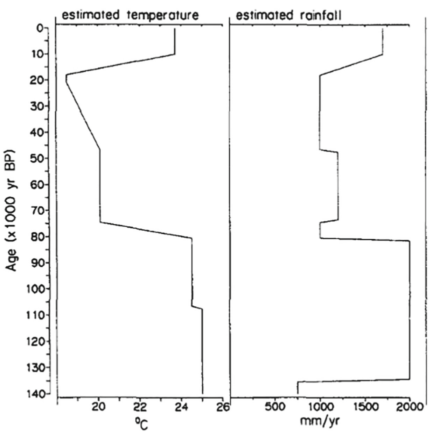

Fig. 1. Temperature and rainfall rate in Bandung for the last 135 thousand years [5]

2,800 BP, there was a rainforest recession with climate change. This also happened to the vegetation in the Central Java area around 1,500 BP. Around 4.000 BP, there was a savanna development; around 2.800 BP, a rainforest recession with climate change. This also occurs in vegetation in Central Java around 1.500 BP [7].

The dynamic change of the climate from the dry climate of the Pleistocene to the wet of the Holocene would also change the type of animal that survived. A dry and exposed landscape would allow large animals like herbivores to breed. On the other hand, a wet and dense climate would support animals with mobile ability between trees (arboreal) to survive. Pleistocene Epoch Fauna in Java was found in several distinct stratigraphy layers. Their biostratigraphy can be easily specified and arranged. Biostratigraphy by von Koenigswald about fossils shows that they are part of the Malayan Sino fauna (from South China) and Siva Malaya (from India) [8]. In the 1980s, the biostratigraphic scheme in Java included faunas such as Satir (1.5 million years ago) - Ci Saat (1.2 million years ago) – Trinil Haupt- Knochenschicht (1 million years ago) - Kedung Brubus (0.8 million years ago) - Ngandong (100–300,000 years ago) - Punung Fauna (last interglacial period) - Wajak (Holocene) [9]. One of the extraordinary and spectacular discoveries was made by ITB (Institute Bandung Technology) cooperated with an American researcher who finally discovered the youngest Homo erectus, about 100,000 BP years old (Fig. 2).

Punung Fauna from Mountain Sewu has attracted enormous attention over the last two decades. Von Koenigswald discovered Punung faunal group in the 1930s in yellow-colored rocks breccias. The original site for this invention was not confirmed until 2003 when the Indonesian-Dutch team rediscovered it [12]. Based on the discovery of the Punung fauna location, the previous date was later detailed from the final interglacial period to 118 ± 3 thousand years ago [13].

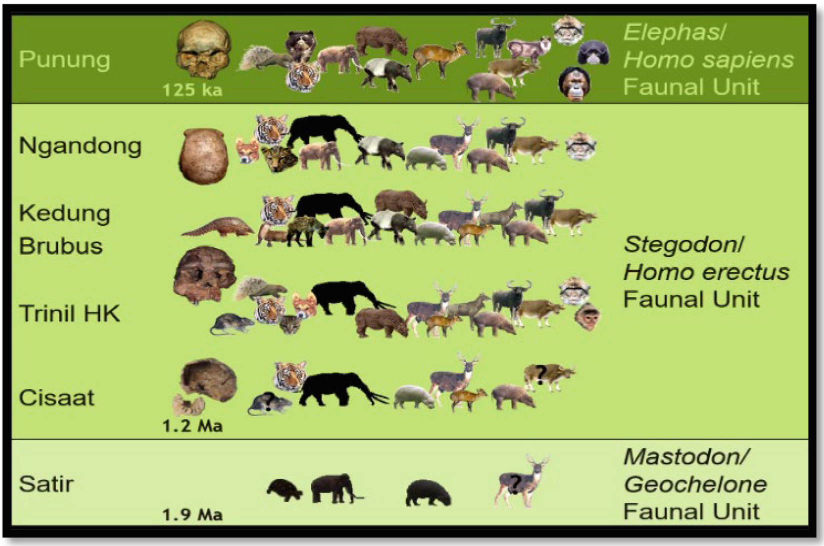

Fig. 2. Biostratigraphy Sequence of the Pleistocene with modification [10, 11].

Based on this biostratigraphy, it is interesting to trace how humans survived their life at that time. Humans from the Pleistocene to the Early Holocene depended on natural resource availability. Even the daily hunting equipment also depends on the availability of natural resources such as stone and food remains (bones and shells). This may cause adaptations pattern in the nature–technology–culture cycle.

2 Rationale of the Study

The daily equipment tends to be based on prey during hunting and gathering food. The development of prehistoric stone technology in Indonesia is similar to the development of stone technology general context, from simple to complex and perfect form. The development of this process happens over a long evolution; they are paleolithic (old stone), Mesolithic (middle stone), and neolithic (young stone). The terminology used is not referred to a period but more to technological terminology instead [14].

One of the famous sites in Java with paleolithic culture is the remaining Pacitanian culture found separately in Kali Oyo, Gunungkidul, and Kali Baksoko, Pacitan. These rivers are located in the Gunung Sewu, part of the Southern Mountains in Java. The research on Baksoko River and Oyo River shows material raw to create paleolithic stone tools from volcanic andesitic rock type, chert (silicified limestone*)*, and chalcedony [15]. Rock type contains high silica, and its rate is usually 7 Mohs. Based on observation of rocks type in the Mountain Sewu Region, it shows that downstream material is rock chert or chocolate reddish colored silicification limestone (*reddish brown)* both in the core and the rock surface (*cortex).* While upstream, the raw material found is volcanic andesite. Volcanic andesite rock indicates a color of chocolate reddish on the surface part (cortex), while the stone core is gray. This may be caused by breakthrough intrusion experienced by andesitic volcanic rock (*volcanic intrusion)* in a dominated karst environment with limestone rock type. Weathering and dissolving the carbonate limestone rock will coat the existing andesite volcanic rock. This will turn the surface of the colored stone similar to rock chert. However, the inner part, after the trimming process, turns gray [15].

Early Holocene development of stone tools technology was more complex with the trimming and retouched stage or secondary processing after they were released from the parent or core stone. Stone tools processed with this technique tend to be applied on small or called non-massive, using flakes blade and scrape tool type. This is based on the different types of animals that lived during the late Pleistocene [11, 16]. Humans existed at that time as Homo sapiens and already starting to occupy caves or niches as a place to stay. Even though there are many cave occupancy areas in the Mountain Sewu, the discussion of this article will study the research in the Rembang Zone Area of the North Mountains of Java. This is applied to measure the differences and similarities between adaptation patterns and technology in both areas. Research carried out in the Rembang Zone Area provides a different picture related to the application of stone tools technology—the differences in natural resources available in the Rembang Zone, and Mountain Sewu Area base this. Rembang Zone has ramps, cave morphology, or niche below the land surface or dolina.

3 Materials and Methods

Research conducted by geoarchaeology approach. The study combines archaeological and geological data. The study expects to reveal human occupation in Pleistocene epoch until beginning Holocene to survive their lives. [15]. Technology development is strongly influenced by the availability of surrounding natural resources, especially raw materials (stones, shells, bones). Humans at that time only depend on the availability of surrounding natural sources by taking and utilizing what is available in nature. They modify what is available in nature simply to comply with their needs. This study indicates close relationship between the availability of resources and the location where human do their activity [17] (Fig. 3).

The Mount Sewu area (Oyo and Baksoko rivers) shows many traces and archaeological remains from the Pleistocene to the Holocene Epoch, especially in the river banks, slopes, and hills. It differs from the condition found in the site in the Rembang Zone Area, in North Java Mountains. In some sites, some discovery was not as complete as in the Southern Mountains of Java. Apart from the fact that only a few sites are found, the natural conditions and the archeological findings are very different. Sites in the North Mountains of Java, both on Pleistocene culture and Early Holocene, are similar to those in the Southern Mountains of Java. The main difference is that although many caves or niches are found in the North Mountains of Java, they are not inhabitable. Morphology cave existed in the North Mountains of Java; part large is a dolina below the surface. That is exciting to study how humans adapt to survive.

This paper will examine significant natural changes between the Pleistocene epoch by developing paleolithic technology and the Holocene epoch, which applied mesolithic/pre neolithic - neolithic technology. To survive, humans need to develop their level of technology in making daily equipment. This is because they are still dependent on the availability of flora and fauna as food sources. Technology development in the making

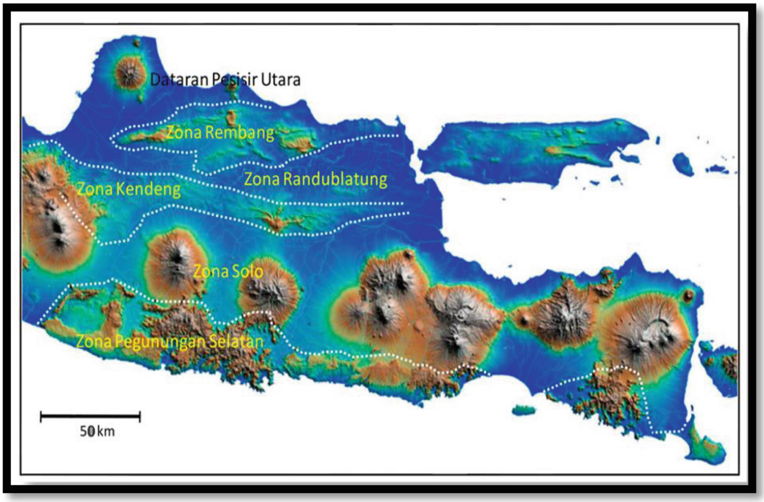

Fig. 3. Zoning physiography in Java [18]

has to go on a long journey. This process correlates with the human intelligence level in utilizing natural resources. Based on this fact, it needs to review techonomic data since the technology is closely related to natural changes. In other words, culture is human adaptation effort to their environment because different natures will produce different cultures.

Theory about the system in culture consists of subsystems, which are inseparable from one another. They are subsystems in technology, society, and ideological [19]. Any external factor entering the system will create changes [19]. Changes in the natural environment will significantly affect and quickly react to the technology subsystem. Since the subsystem technology is directly related to the surrounding nature (flora-fauna and geography) [20]. Apart from that, subsystem technology is a kind of artifact needed in hunting and gathering food. Studying these artifacts would expose the background behind human pattern change.

4 Data and Discussion

Research results related to findings of stone artifacts from Pleistocene Epoch sites to the Early Holocene in the Southern Mountains of Java and the Northern Mountains of Java show a striking difference. It is based on the natural environment's condition and the artifacts and Eco facts findings.

Stone tools (lithic) became the most dominant since it is a durable material found in a relatively complete shape with several traces of the trimming process. This can be understood since most results of stone technology are the most enduring evidence from the destruction process, so most parts can still be found [15]. Stone artifacts or raw material discovery are widely spread and considered an indicator of the culture's long period. From the Pleistocene to the Holocene Epoch or stone age, the remaining culture is dominated by artifacts and stone tools. Mountain Sewu Area, a prehistoric metropolis, is rich with stone tools from the paleolithic until the neolithic [21]. Based on this fact, the study will explain the Pleistocene, namely in the Oyo River Watershed (DAS) [22]and the Baksoko River Watershed [23]in the Mountain Sewu region. The research is also based on relatively recent sites in the Rembang Zone Area, namely in Kidang Cave, Blora [24].

4.1 Analysis Macroscopic Artifacts Litic

The stone tools analyzed result from research on Pleistocene sites with paleolithic stone tools. From the previous research done in Mountain Sewu since the 1930s, and various interpretation produced, analysis is applied through adequate and representative sample findings and specific locations from upstream until downstream of the river. This is applied in a manner qualitative Good from facet technology nor type material raw the stone.

Macroscopic Analysis is applied to identify the type of rock material through its lithology characteristic. The technical analysis identifies the technology used in making stone tools to specify any processing technique applied in creating stone tools. The artistry technique covers chipping, cutting, flaking, abrasive, and drilling, often combined to produce the tool mentioned. Based on research throughout Oyo River, Gunungkidul (2016), and Baksoka River (2019), many Paleolithic stone tools are found. The analysis results about stone tools indicate that the technology used are methods and techniques. The method resides in mind, while the technique is skills of the human body part, in this case, their hands. Creating tools is a systematically regular pattern (method) that results in a similar final shape. In general, the technology used in making stone tools is strike-platform (*striking-platform*), *bulb* (*bulb of percussion*), *former flaking* (*bulbar scar*), and flake grooves (*ripples*), both in the parent rock nor the resulting rock shaped (Crabtree in [25]) (Fig. 4).

Chopper. Choppers are included as hand-handheld axes using paleolithic technology made from natural boulders and then finished with monofacial trim (one side) to create a short side. Its function is to cut relatively big and long wood and bone. This axe was mostly found around the Pacitan area, associated with chopping, the *Pacitan chopper chopping tools complex* [26].

The cropping process in making an axe can be applied by directly striking the stone or using an intermediary tool made from bone or wood to create a short side. Most crusher axes found still leave some cortex or stone skin as the technique only applies on one side. The Crusher axe found in Oyo River is created from andesite stone and only trimmed on one side. The Crusher axe found seems to apply Paleolithic technology where the rock is directly trimmed in one face. Another crusher axe found is made from rock clay silica. The cropping process is done in an expansive and intensive method that leaves only a few cortexes. It is also done by transversal/wide method with trimmed part from lower to upper part in a macro scale. Another side of the natural rock became the characteristic of a hand axe. The study indicates that this crusher axe has been used

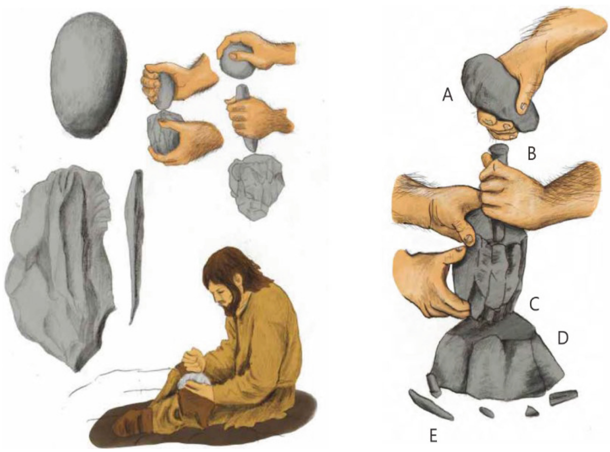

Fig. 4. Manufacturing techniques stone tool type axe through trim straight (left) and use an anvil or intermediary [16]

intensively, seen from the *primping* on the side part of the tool. This chopper is specific to the horseshoe chopper type. (Fig. 5).

Chopping. Despite their similar processing method, chopping differs slightly from the crusher axe. Chopping is done by intensively trimming two sides of the stone, as seen from the more detailed result of the chopping axe than the crushing axe. Most chopping axes leave no cortex, as it would produce sharp areas on both surfaces. The technology used in creating a chopping axe is more complex than crushing axes, which were only trimmed on one side and still left the cortex. [26].

The discovery of a chopping axe in Oyo River includes an axe made from yellow and clear flintstone. To create a sharp edge, this stone is trimmed on two sides, both on a macro and micro scale. Cropping in a macro scale is done, and the sequence is trimmed in a micro-scale to create a sharp edge. This tool is used intensively and was proved by the *primping* on its sharp part, although several cortexes are still found. The stone may have been processed several times with various directions through longitudinal trim and retouched (= *retouched).* On its narrow part, a more-intensive process is seen on the edge of the stone. The proof of its application is easily seen on various sides of the tool. Interestingly, the upper part is shaped into a handle (*handle*) and applied throughout all edges with retouches. This axe is known as the iron type (Fig. 6).

Flakes. Flakes tools are included in non-massive stone tools and are created from a rock into several tools. This is marked and characterized by humans' release from its parent stone. One of the technological characteristics of human creation is negative bulbs

Fig. 5. Chopper of horses shoe type from Oyo River, Gunungkidul [15]

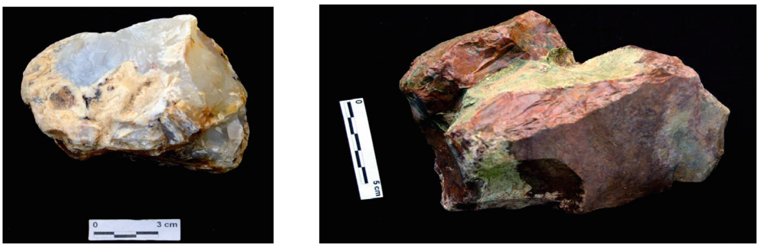

Fig. 6. Chopping the iron type from Kali Oyo [27]

Fig. 7. Illustration technique for making pre-neolithic stone tools (source: Pinterest, 2017).

on the dorsal side, on the ventral side without any facets, and there is a striking plain. These characteristics happen due to the variety and types of rocks impact on the strikes done by humans, which creates cones of percussion, bulbar scars, and ripples. The last characteristic will appear in the high-quality material; some are rocks with an advanced siliceous process. Apart from being caused by suitable quality materials, flaking marks and cracks are caused by the hard blows when the flake tool is released from the core stone [28] (Fig. 7).

Before separating from the parent stone, humans will prepare the stone surface with several pruning and determine the tool's shapes later (Fig. 8). This side is called the dorsal section. The characteristic point (*point of percussion)* is bruises that form on the strike plains, which is the exact point that receives the strike's strongest power. A strike plain is where collisions happen between striking tools with stone material. Once it is released less from its parent rock, the striking plain will remain in the upper part of the flakes. The thickness of these striking plains is limited between marked hits area and facets on the rock surface. Bulbus is a lateral surface where the flakes are removed from the parent stone. The part of the original bulbs attached to the rock is called the ventral. Bulbus is when the flakes are released from the parent stone, while the bulbous negative is traced when released from the parent stone. The pruning process produces a thin, sharp side, usually on both sides. Flake tool consists of two types, one-sided sharp-edge and two-sided sharp-edge. [29, p. 6].

4.2 The Raw Material Difference Between Paleolithic and Pre-neolithic Technology in Mountain Sewu Region.

The result of the research in raw material findings in Kali Oyo and Kali Baksoko and the discovery of stone tools in the Mountain Sewu area caves show a significant difference. The material used is a rock with a high silica level, and it is seen that the trimming

Fig. 8. Found flakes from Kali Oyo. [22]

process does exist. The level of rock hardness rate is generally above the 7 Mohs scale. Furthermore, observations of stone tools found in Kali Oyo caves, including Sengok Cave, Getas, and Lawa Cave, District Ponjong, indicated that they do not originate from Kali Oyo. This is based on a different level of silica content. The raw material in the Gunungkidul residential cave contains a lower silica level than in Kali Oyo. Besides that, the comparison between lytic tools findings at Song Tritis and Braholo Caves [30] with lytic artifacts in Kali Oyo shows different raw materials.

Furthermore, the analysis of raw material artifacts in Baksoko River shows different point locations between one another. In the upstream area (center of Paleolithic tool products), the raw material available is chert (silicified limestone) which contains a gray inner part (RA). The downstream areas are dominated by yellow chert (RK). Petrography Analysis proves the difference between the raw materials of Paleolithic and Pre-neolithic tools. The raw material from this petrography analysis is made from the silicification of tuf, limestone, volcanic breccias, and tuff glass.

4.3 Insufficient Raw Material in the Karst Area of the Rembang Zone: An Adaptation Pattern.

The technology used in making stone, developed during the occupancy in caves, is pre-neolitic technology which was more advanced than the paleolithic. The techniques and variations used in pre-neolitic technology are more careful than in paleolithic technology, as shown on the trim and second prominence flakiness (*secondary-retouched)* to create a sharp edge. The technology used in the pre-neolithic varies from its types, such as flakes, blades, and shave tools. Besides that, another tool is microliths sharps and simple arrows.

The technology from bones and shell material is less varied and primarily focuses on trimming and polishing. Any tools or jewelry made from bones usually choose the long part of bone as its material, where one or two parts are trimmed to make it sharp and polished until it is shiny [31]. The technique used to create jewelry from sea shells is much more straightforward than one made from bone. It is because the shell has a line structure suitable for trimming its sharp edges. The cropping process in the shells tool includes micro-fracturing, striations and linear features, polish, impact pits, and *lunging* (*edge rounding)* [28].

Stone artifacts in the Gunung Sewu region differ significantly from those in the Rembang Zone area, especially in Kidang Cave, Blora. This is based on the different material sources unavailable to make stone tools. The research in the Blora karst area, especially the Todanan karst, indicate that environmental condition does not provide raw stone with the high silica level needed to create any tool [32]. Nevertheless, the excavation at Kidang Cave found stone artifacts made from chert and andesite material as supporting equipment and not primary tools. This is based on the absence of any artifacts technology and the stone artifacts used as a hitting rock to make tools and whetstone to sharpen them [33]. Striking stone is found almost in all digging areas formed in andesite and limestone silica materials. Its intense application is directly shown in the peeled-off stone cortex on its side. One stone found is made from base gravel andesite material and is oval-shaped. The whole side has lost the cortex because of its intensive usage. Another artifact found is a whetstone indicated by horizontal step strokes on either part and forms a basin. This stone is later used to sharpen tools from seas shells and bone [33]. The materials used are limestone silica, primarily red and yellow rock in pebble size (Fig. 9).

Shells and bones mostly dominate the findings of artifacts from shells, bones, and teeth. Interestingly, the technology used in making tool shells and bones applies the pre-neolitic technique by applying secondary trimming (rethoused) to sharpen the tool (Fig. 10). Several tools made from bone apply pre-neolithic technology with the application of dorsal and ventral and similar to flakes tool. Besides that, researchers have found a spatula remodeled to become similar to secondary trim in the lateral [33].

The application of shells and bones to create tools with pre-neolithic technology seems caused by the unavailability of stone as raw material. The researchers predict that human life in Kidang Cave has adapted to its natural surroundings. The caveman who lived in the early Holocene tended to develop pre-neolithic technology. However, the research on cave sites, especially in the Rembang Zone, Kidang Cave, and caves in the Rembang Regency [35], show no source of raw stone to create any available tools. They should overcome this by using leftover food from bones, teeth, and shells to make equipment. The technique applied in making tools is more advanced than the tool that uses shells and bones in most discoveries in cave sites around Java. Men living in caves around Rembang Zone were tech-savvy pre-neolithic, which later applied to the material made from shells and bones. It indicates that humans living in caves around

Fig. 9. Whetstone (left) and whetstone (right) Source: [34]

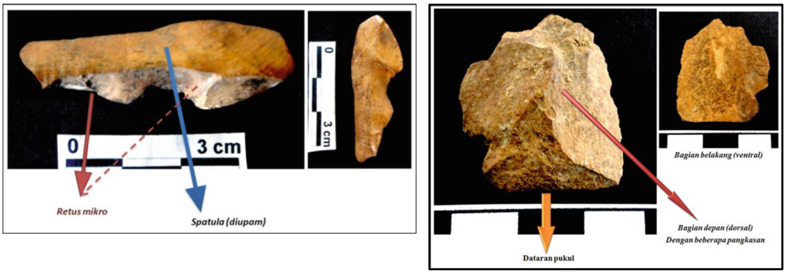

Fig. 10. Tools from bone apply trimming secondary like pre-neolithic technology Source: [24, 33].

the Rembang Zone are much superior since the nature of bones and shells is relatively softer than stones. This may result from more varied products and processing compared to a tool made from bones and shells at others cave sites in Java.

5 Conclusion

Culture will develop based on the natural environment around human surviving their life. Close relations transform into cycles and ecosystems between natural resources and humans, forming culture and technology to survive their lives. A mutual ecosystem is where one is attached to others and becomes inseparable. When nature changes, the rest of them will also experience it.

The creation of the culture is based on the adaptation process between man and the natural environment surrounding him, which later will create a character in each other's culture. The study results on stone tools technology development in the karst region of the Southern and Northern Mountains of Java show each character. This is mainly caused by the different natural conditions, which would later demand specific survival adaptations. All the sites in Pleistocene Epoch to the Early Holocene in the second area indicate the adaptation in stone tools technology development. In the Mountain Sewu Area, the development of stone tools technology is completely starting the paleolithic until neolithic technology; the differences are based on various raw material resources. The raw material used in paleolithic technology primarily uses raw volcanic limestone with intruded silicification andesitic, while pre-neolithic technology uses yellow chert. Meanwhile, in the North Mountains of Java area, particularly in the Rembang Zone, silicification stone technology is applied to the shells and bones as its raw materials. This is because no stone with high silica content is available as its natural resources. Product tools and shells and bones artifacts in the Rembang Zone area become more varied compared to shells and bones artifacts in the Southern Mountains of Java area, specifically Mountain Sewu.

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