Analysis on Lithic Remains from Tabuhan Cave:
A contribution to the chaîne opératoire study in the Preneolithic of
Gunung Sewu, East Java, Indonesia

Analisi sui Resti Litici dalla Grotta di Tabuhan:
Un contributo allo studio della catena operativa nel Preneolitico di
Gunung Sewu, Java orientale, Indonesia.

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Thesis

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Mohammad Ruly Fauzi
Dedicated to my Father

H. Nashadi bin H. Abdullah bin Tjaing

"It is not important to be the best, but it is important to do your best."
Ringkasan
Gua Tabuhan merupakan gua hunian masa prasejarah yang sedikit sekali di bahas dalam literatur. Tesis ini membahas posisi kronologis kultural dari temuan artefak litik di Gua Tabuhan. Analisis rantai-operasi yang diterapkan pada artefak batu dari Gua Tabuhan menunjukkan adanya kesamaan dimensi, asal, dan (yang terpenting) volume dari nodule rijang yang dieksploitasi di dalam gua. Analisis teknologis terhadap serpih juga menunjukkan adanya pemilahan jenis support yang digunakan lebih lanjut sebagai alat beretus (modifikasi lebih lanjut). Perbandingan antara Gua Song Terus, Song Keplek dan Gua Tabuhan dalam hal tipologi alat batu menunjukkan adanya suatu kesamaan ciri yang menegaskan karakter khas budaya Proneolitik Gunung Sewu (i.e. type mousteroid) serta posisi krono-kultural artefak batu Gua Tabuhan.

Abstract
Tabuhan Cave is a cave dwelling site which is rarely discussed in the literature. This thesis discusses the chrono-cultural position of the lithic artifacts found in this cave. Chaîne opératoire analysis of the stone artifacts from this cave shown that there is an indication of similar initial dimensions, origin, and (most importantly) the initial volume of chert nodules that have been exploited in this cave. The results of technological analyses taken on flakes described indication of selecting of the type of support that will be modified as retouched implements. Comparison between Song Terus, Song Keplek and Tabuhan cave in the typology of stone tools had shown common features that validate the characteristics Proneolithic in the Gunung Sewu Region (i.e. mousteroid like tools) and position lithic artifacts in the chrono-cultural of the Gunung Sewu Prehistory.

Sommario
La grotta di Tabuhan è un sito preistorico che viene raramente trattato in letteratura. Questa tesi discute la posizione cronoculturale delle industrie litiche che sono state rinvenute in questa grotta. L’analisi della catena operativa dei resti litici in questa grotta ha evidenziato una similitudine dei noduli di selce che sono stati utilizzati sulla base delle loro dimensioni, della provenienza, e (soprattutto) il loro volume iniziale. Le analisi tecnologiche sulle scheggie mostrano anche l’evidenza del comportamento umano nel selezionare il tipo di supporto, il quale sarà modificato successivamente per divenire uno strumento ritoccato. La comparazione sulla tipologia degli strumenti litici tra il sito di Song Terus, la grotta di Song Keplek e Tabuhan aveva mostrato elementi comuni che confermano caratteristiche del Proneolitico (i.e. gli strumenti musteriidi) e la sua posizione nel contesto cronoculturale della Preistoria di Gunung Sewu.
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Introduction

Lithic remains is one of the most conserved archaeological remains that can be found under excavation or natural exposure, no matter where and what kind of environment that present. Due to its physical characteristics, lithic remains are often shows clear traces of human modification bearing on its surfaces. This condition frequently allowed researcher to reach further explanation such as cultural development, adaptation, environment, trading, socio-economy or even prehistoric cognition rather than only in technological interpretation. Following this development, numerous series of methodology in lithic analysis were continued to develop for the sake of wider explanation that possible. This development in methodology and interpretation encourage me to be focused on a lithic material study.

Recent research collaboration involving French and Indonesian research institutions (Puslitbang Arkenas and MNHN) in Gunung Sewu region has brought many improvements in the study of Indonesian Prehistory. Indeed, this mutual collaboration provides opportunities for student and researchers from both countries to study the materials came from the excavation. Tabuhan cave site is one of many prehistoric sites that have been excavated by this team. Although there are already several results from lithic study have done by researchers and students from both countries, lithic remains from Tabuhan site are prospectively enriching the knowledge about cultural characteristic and its dynamic occurred in Tabuhan, exclusively during Holocene period. I am optimist that this study will have a significant contribution towards the explanation of Holocene lithic Industries in Gunung Sewu region.

This thesis will be divided into several chapter based on its major contents and the objectives. Introduction part will describe a general synthesis of South-East Asian prehistory which is related to this study. Chapter I is a presentation of the environmental background of Gunung Sewu area, exclusively Tabuhan Cave as the location of research. Chapter II will discuss the study of lithic remains from Tabuhan Site by means of several scientific methods and approaches. Chapter III will discuss several analyses have been done to Tabuhan cave lithic collection followed by its interpretation. The last part of this thesis is Conclusion and Perspectives which will discuss the explanation stage of the results and prospective research.

Human Settlements in the Insular Southeast Asia

The settlements of insular Southeast Asia cannot be separated from the role of abrupt changing of global climate that happen during Pleistocene. Sea level lowering allowed a shallow sea to be exposed and became land bridge for fauna and human migrated from Mainland Asia to the Insular (Sumatera, Java, and Borneo). Eustatic movement also alternates earliest human landscape from a shallow sea, swampy area into dry land or vice-versa, as an impact of changing in astronomic parameters (Hays et al., 1976: 1121; 1131; Simanjuntak and Sémah, 2005: 2).

Settlements of the Insular Southeast Asia have been ongoing since the earliest history of human migration out from Africa ca. 1,6 to 1,2 ma or even much more earlier (Grimaud-Hervé and Widianto, 1990: 332; Sémah et al., 2000; Dennell, 2009: 165; Manzi, 2007: 65-81). Land bridge that
connected Asia Mainland and Insular due to lowering of sea level happens during glaciations period allowed early humans to colonize the archipelago. The oldest evidence of hominid settlement came from a site in Perning, Java which is dated ca. 1.8 mya BP, but the date is controversial (Sémah et al., 2000: 767-768). Long term history of Homo erectus appearance in Insular Southeast Asia is likely ended ca. 100 ka BP based on the discovery of a progressive form of Homo erectus which is found in Ngandong (and later related also to H erectus fossil from Sambung Macan and Ngawi). Later they were replaced by Anatomically Modern Human which is came ca. 40 ka BP. However, some authors consider it to be earlier, based on the dating taken from AMH fossil in Australia, Phillipines, and East Java (See Bellwood, 1997: 49-52; Detroit et al., 2004: 710-711; Storm and de Vos, 2006: 279; Mijares et al., 2010: 128).

During Late Pleistocene or near the end of the upper Pleistocene (ca. 45-10 ka BP), the land bridge between mainland and Insular Southeast Asia reformed again because of global lowering sea level exposed shallow marine base located in a narrow sea between islands (Simanjuntak and Sémah, 2005: 2). This phenomenon allowed penetration of a new human species (i.e Homo sapiens) from mainland to insular and later replaced H. erectus. Several evidence related to the appearance of Homo sapiens in the Insular Southeast Asia are came from cave site, such as Niah Cave, Tabon Cave, Dawung, and Song Terus cave (in Holocene layer). Evidence of Homo sapiens earliest arrival in Australian continent also can be considered as the minimal age of their arrival at the Insular Southeast Asia (Simanjuntak and Sémah, 2005: 3; Smith and Sharp, 1993: 37-59).

In Niah cave Malaysia, a human fossil which is famous as “the Deep Skull” was discovered by Tom and Barbara Harrison in 1958 (Harison 1959 in Kennedy, 1977: 33). Fragment of charcoal which is associated in the same layer with this skull has been dated ca. 42 ka by means of radiocarbon dating method. Later, there is a possibility that this skull was a result of an intrusion from more recent burials found in this cave (Hunt et al., 2007: 1954). However, the new result in calibrated datation on the lowest occupation level that yielded date ca. 46,200±462 Cal BP seems has confirmed the age of the skull (Hunt, et al., 2007: 1960).

In Tabon cave Phillipines, a famous frontal bone of H sapiens found under excavation have a reliable datation ca. 16,5 ± 2,0 ka BP by U-Series dating method. Another human fossil from the same site, a diaphysis fragment of right tibia yielded older date, ca. 47±10-11 ka BP (Detroit et al., 2004: 710-711). Indeed, this old dated fossil more or less consistent with the earlier radiocarbon datation taken from occupation layer associated with flake assemblage IV in Tabon cave 30,5±1,1 ka uncal BP, and estimated 45-50 ka BP for the lowest layer (see Fox, 1970: 24).

New evidence of the oldest human fossil in the Phillipines came from a third metatarsal of human which is found in Callao cave and been dated ca. 66.7 ± 1 ka by means of U-Series ablation method. Provisionally this metatarsal attributed to a small bodied H. sapiens because its closest result in morphometric comparison studies (Mijares et al., 2010: 125-128). This specimen shows a clear evidence of human expansion by crossing an open sea as early as late Pleistocene.

In Purnung, East Java, the evidence of the earliest human settlement represented by a controversial upper left premolar tooth which is associated with extinct rainforest fauna (e.g. Pongo pygmeus and Hylobates). This tooth is one of five isolated hominin teeth which were discovered by Koenigswald in a fissure containing breccias sediments during his excavation in 1930’s. This isolated
tooth has been studied by Koenigswald himself (1939), Badoux (1959), Storm (2005) and de Vos (2005) after Koenigswald reported a primitive hominid tooth in his collection (Storm and de Vos 2006: 271). Later, in 2005 Paul Storm convinced that this premolar tooth is belong to a modern human *Homo sapiens* because its similarity in morphometric (Storm, 2005: 542-543).

Human remains from Song Terus Cave in a burial context were indirectly dated 9.330±90 BP using radiocarbon method applied to a shell (Sémah et al., 2004: 58). The skeletal features show clear characteristics of classic *Mongoloid* type. Other burials also been found in Song Keplek and have similar *Mongoloid* features (Widianto, 1993 and Détroit, 2002 in Forestier, 2007: 93-96). The oldest burial was dated by radiocarbon method and yielded age ca. 7.020±180 BP uncal.

Outside Java, the findings of old human fossils are somehow rare. In the eastern part of Indonesia, Flores, a particular form of hominin were lived during Upper Pleistocene ca. 18.000 BP, based on radiocarbon datation taken on a charcoal at the same layer (Robert et al., 2009: 492; Brown and Maeda, 2009: 575). This hominid later called as *Homo floresiensis* which is still disputed whether it is a new species of human or a result of a particular adaptation derived by isolated and small landscape.

Photo 01. Two photos above (scale are not available) are example of human remains found under excavation. Photo A is burial came from Keplek layer in Song Terus, photo B is occlusal view left P3 of *Hominid* which is identified belong to a modern human (*Homo sapiens*) in Koenigswald Punung Fauna collection (Detroit, 2002 in Sémah et al., *in prep*; Storm, 2005: 541).

Human settlement in Insular Southeast Asia has been going for a long time since the appearance of the first hominid outside Africa. This is based on *Homo erectus* remains that had been found mostly in Java. The appearance of *Homo sapiens* can be generally considered begin since ca. 120-40 ka BP (see Hunt, et al., 2007: 1960; Fox, 1970: 24; Detroit et al., 2004: 710-711 ; Storm, 2005: 541-543; Mijares et al., 2010: 125-128). However, lack of consistent datation and fragmented context of AMH remains in this area give us no clue to make a good model in order to explain hominid evolution or replacement. Until now there are two models available to explain existence of two hominid species in this area. The First is called regional continuity in evolution and the second one is replacement model (for further explanation see Bellwood, 2007: 82-92). Nevertheless, some paleoanthropologist today continues to believe that the present populations in Asia have distinctive morphological characteristics of Asian *H erectus* (Bellwood, 2007: 82).
Paleoenvironment of Insular Asia during Late Pleistocene towards Holocene Period

The climate and environment in Insular Southeast Asia has evolved and passed several changing events, mostly during the Pleistocene Period. The submerged and exposed land affected the changing of landscape from inland to coastal and vice-versa (Simanjuntak and Sémah, 2005: 1-2). This condition allowed the phenomena of endemism and particular adaptation in isolated island such represented by some species of island migrated fauna (e.g. Celebochoerus celebensis, Stegodon sondaari, Stegodon florisiensis, Stegodon luzonensis, Rhinoceros philippinensis, Hooijeromyx nusatenggara and Homo floresiensis?) (Hertler et al., 2007: 76).

The paleoenvironment reconstruction of the Insular Southeast Asia related with the dynamics of faunal and landscape evolution has been studied by several researchers based on faunal and vegetation remains. The oldest record of paleoenvironmental events in this area might be came from Sangiran Dome, a paleontological site located in Java, Indonesia. In this region, a continuous Pleistocene deposits exposed in separated formation called Kalibeng (ca. 2,6-1,8 ma BP); Pucangan (ca. 1,8 to 0,9 ma BP); Grenbank (ca. 0,9-0,8 ma BP); Kabuh (ca. 0,7 to 0,2 ma BP) and Notopuro (ca. 0.15 ma BP) (Sémah et al., 1990: 41-47). In this region, series evidence of paleoenvironment evolution from mangrove, rain forest to swampy estuary environment that probably as a habitat of early H. erectus until the appearance of drier open-woodland or savanna-like landscape towards the middle Pleistocene are well recorded (A-M Sémah, 2004: 250-252; Sémah and Djubiantono, 2007: 91). The impact of volcanic activity are strongly appear in a breccias limestone formation dated older than 1,8 ma BP which destroyed most of the vegetation during that time.

Meanwhile, the evidence of warmer and more humid climate presence during the MIS 5 in several deposits such as in Terus layer at Song Terus and Gunung Dawung fissure. In Song Terus, to be detailed in Terus cultural period, an episodic of stalagmite succession has been dated ca. 80-112 ka BP (Sémah and Falguères through personal communication). The evidence of rainforest appearance in Java represented by faunal remains from Punung (Punung I, II and Gunung Dawung) with the appearance of orang-utans (Pongo pygmaeus) and gibbons (Hylobates) (Storm and de Vos, 2006: 277). This faunal unit is so important because it marks the transitional between Homo erectus landscape and Homo sapiens. Evidence of modern human existence in this area was shown by isolated teeth in Koenigswald collection that had been found during his excavation in Punung (see Storm, 2005: 540-544; Storm and de Vos, 2006: 279). The age of this faunal unit is about 126-81 ka, based on logical comparison to Wajak Fauna (modern, dated ca. 10,5 ka) and Ngandong Fauna (extinct form, >125 ka) with paleoenvironmental setting came from palynological analysis of terrestrial pollen remains in Bandung from ca. 135-16 ka (Kaars and Dam 1997: 69-70). This is also means that the arrival of modern human in Insular Asia can be earlier than what we have concluded before; it can be reach as older as 125 ka BP.

Towards the late Pleistocene, the change of landscape in Insular Southeast Asia seems to be more clearly represented. Terrestrial pollen evidence from Bandung, west java shows the occurrence of lower precipitation rate with a cold and dryer climate during Glacial Period, exclusively ca. 81 ka until ca. 16 ka, represented by the presence of Gramineae, Compositae, Cyperaceae, Polygonum and Typha (Kaars, 1997: 68). However, the most representative paleovegetation reconstruction model near Punung area was came from Ambarawa Basin, respecting its near location and moderate
altitudes. This site shows that even during the Holocene period there is an evolution of vegetation and landscape (Sémah A-M et al., 1992: 904; Sémah A-M, 2004: 256-257).

Towards Holocene period, climate was become more humid and as a result, the forests were slowly expanded and replaced open woodland or savanna-like landscape which is common during LGP in Insular Southeast Asia. This situation represented by Holocene pollen remains which is extracted from South China Sea marine core, Pollen spectra from this core shows clear domination of pollen from trees and reduced amount of pollen from herbaceous plants (see Sun et al., 2000: 308). A sharp reducing in total pollen influx also characterized Holocene Period in South China Sea core 17962. This diminution of total pollen influx related to the landscape evolution influenced by eustatic movement because the rising of sea level add the distance between the river and the position of coring. River catchment also becoming narrower towards the Holocene period causing the reducing of pollen transported to South China Sea (Sun et al., 2000: 310).

Several studies in palinology related to global change of climate have been done in several sites in Indonesia. Pollen record from Ambarawa depression zone has shown a precipitation recrudescence and the new development of swamp and swampy forest with maximum peak at ca. 9000 and 7000 BP. After this event, decreasing of precipitation happen from ca. 4000 BP and becoming similar with actual condition (Sémah A-M, 2004: 257). Another sounding, still at Ambarawa depression, marked a forest regression ca. 2800, 1500, and 500 BP. The first stage represents drier climate, meanwhile the last two marking the impact of human activity in that region (Sémah A-M, 2004: 257). The rising of sea level also happen during the Holocene period, based on thick sea floor sediment which is studied by Tjia (1987). Rising of the thickness in marine deposits from Sunda shelf suggest that ca. 6000 and 3000 ka BP the sea level was 6 meters above actual position (Bellwood, 2007: 22).

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Figure 01. The dynamics of Southeast Asia coastlines during Late Pleistocene until Holocene (recent days). (A) since 40 ka BP until recent days; (B) -50 m during early Holocene (ca. 10 ka BP); (C) -100 m on ca. 14 ka BP; (D) -130 m on 16-20.000 BP (Gibbons and Clunie, 1986: 71).

**Synthesis of Lithic Industries in Indonesian Archipelago**

Compared to a lithic study in Europe the research related with lithic remains in Indonesia is still on its development because there are no good chronological continuities. Nevertheless, earliest development of a lithic study in Indonesia could not be separated from a contribution of European researchers who worked during colonization period. The discovery of Pacitanian Industry or sometimes in literatures mentioned as Patjitanian (caused by the differences between Indonesian
old and new spelling) along Terraces of Baksoko River by two europeans, GHR von Koenigswald and MWF Tweedie, on 1935 shows the terraces of this region in the Oldworld prehistory. This term was given by HG Movius in 1944 for thousands of artifacts from Baksoko based on his typo-technology classification (see Movius 1944: 1-125, Oakley 1949: 49; Sémah et al., 2008: 42; Simanjuntak et al., 2004: 7). After many controversy about its position and chronology, it is clear now that Pacitanian Culture have the same characteristic as Acheulean or Lower Paleolithic culture and can be considered belongs to Middle Pleistocene or at least not younger than Upper Pleistocene (see Gaillard et al. in Sémah 2007: 69-71 and Bartstra, 1983: 431). Similar artifacts also have been found at Ngebung, Sangiran which considered as Acheulian Large Flakes Assemblage (LFA). These artifacts found in alluvial sediment dated from Lower to Middle Pleistocene (Mishra et al., 2009: 268-269; Sémah et al., 2000: 763-769 in Moncel, 2010: 4).

Lithic artifact dated ca. 74 ka BP (Late Pleistocene) have been reported by Moore and Brumm (2006) and consist of flake tools which is attributed to Homo floresiensis at Liang Bua cave. Another site yield an older date for the flake tools assemblage that came from a site called Mata Menge in Central Flores, dated ca. 700 ka BP (Bellwood, 2007: 67). These two site outside Java show the evidences of Middle-Last Pleistocene Hominid expansion towards the eastern part of Archipelago which is never been connected during the lowering sea level. Flakes assemblage on those two sites show indication of direct débitage technique by using a hard hammer. Support for making tools was not only taken by débitage on a nucleus but also on executed on larger flakes (Moore and Brumm, 2006: 93-94).

In the other locality, Sulawesi (Celebes) which considered separated by western Southeast Asia by Wallace line, another Paleolithic Industry was found. This industry named as Tjabenge (Cabenge Flake-Industry) characterized by flakes and other débitage product that reveal similar characteristic with Sangiran Flake-Industry (Heekeren, 1972: 69).

In Sumatera, another culture characterized by unifacial reduction of a river pebble tends to be appeared during Late Pleistocene to early Holocene. This culture called Hoabinhian, characterized by unifacial stone tools made by pebble or large flake (see Forestier et al., 2006: 69; 72). This culture seems to be specifically appeared in Sumatera, southeast of Mainland Asia, southeast of Australia, and New Guinea (Bowdler, 2006: 355). The context of this culture is a shell-midden that unfortunately are common to be found in open air site, suffered from erosion and other natural destruction. Hence there are no good datations or chronology from those sites. An exceptional to one site called Togi Ndrawa, in Nias Island, south of Sumatera, where the remains from excavation shows the oldest Hoabinhian culture found inside the cave dated to the transitional period from late Pleistocene to Holocene (Forestier et al., 2005: 730-732). The general chronology of this culture is between 16000 to 7000 BP (Bowdler, 2006: 355-356).

Toalian culture is a locality Holocene lithic industry appeared in southwest Sulawesi (Celebes) that tends to be appeared together with Sampung Bone Industry in Java. This lithic industry characterized by geometric microlithic tools obtained by blade as a support (Heekeren, 1972: 106). The appearances of bladelets, knives, points, and arrowheads also have an important contribution in this lithic industry (Heekeren, 1972: 108; 110-115). Heekeren (1972) was considered
this lithic industry belongs to Mesolithic period of eastern Indonesia with important contribution of the first recorded prehistoric arts.

In Bandung, West Java, obsidian has been used as raw material for making stone tools based on the findings at several numbers of sites around this basin area. De Jong and G.H.R. Koenigswald on 1930-1935 had collected a great numbers of obsidian tools around this area (Heekeren, 1972: 133). In Pawon cave site, a layer containing numerous artifacts made by obsidian was dated ca. 5500-9500 BP by using radiocarbon dating method (Yondri, 2005 in Chia et al., 2008: 452). It seems like this obsidian artifacts were clearly belong to a pre-Neolithic culture similar what have been suggested by van Hekereen (Hekereen, 1957: 102-104).

In Java, Holocene lithic industry represented by several archaeological remains found in caves and open air sites which situated particularly at Gunung Sewu Region. Recent result in a typo-technological study of Holocene lithic industry in Gunung Sewu (Song Keplek and Song Terus) shows that this industry has distinct feature compared with the Toalian lithic industry from southwest Sulawesi. This is based on domination of mousteroïd like tools and the appearance of lower Paleolithic tools in Holocene lithic assemblage on this Area (Forestier et al., 2000: 32; Forestier, 2008: 465). This is logic because Toalian lithic industry tends to be isolated, considering its geographical position and its esoteric character (Heekeren, 1972: 124). Truman Simanjuntak and Hubert Forestier have considered the Holocene lithic industry in Gunung Sewu belongs to Preneolithic culture, dated around 5.000-8.000 BP (Simanjuntak et al., 2004: 259; Forestier et al., 2000: 31-32). This concept of differentiation with the European system in chrono-technological terminology to describe flake implements from Late Pleistocene-Early Holocene was first proposed by Heekeren (1972), considering the important contribution of Lower Paleolithic and Neolithic implements in Late Pleistocene-Holocene lithic industry (Heekeren, 1972: 149-152). From the open sites in Punung area, East Java (e.g. Ngrijangan) bifacially retouched arrowheads tend to be appeared with Neolithic adzes (see Simanjuntak et al., 2004: 193-198). These arrowheads, together with Neolithic stone adzes, have characterized a Neolithic settlement in Java particularly surrounding Punung area. Considering a Preneolithic culture found in cave sites around Punung area, Neolithic era seems to be started not older than 5000 BP in Java, or particularly in this area.
Figure 02. Several examples of Indonesian Lithic Industry during Middle-Pleistocene and Holocene. I. Middle Pleistocene Implements (a. 
*nacreau* from Ngebung ca. 800 ka BP; b. Sangiran Flake Industry; c. Handaxe from Koboran; d. Handaxe from Baksoko); II. Late Pleistocene Implements (core-tool and *racloir*); III. Hoabinhian (unifacial tool); Southwest Toalian Industry (barbed arrowheads); IV. Preneolithic Holocene Industry with *Mousteroid* characteristic found under excavation in Song Terus and Song Keplek cave, Punung, East Java; V. Neolithic arrowheads from Punung.
Chapter I

Site Presentation

I. 1. Gunung Sewu Region of East Java

Gunung Sewu (Thousand Mountains in Javanese Language) of Java is located along the southern mountain of eastern Java, start from Kali (river) Oyo on the west until Pacitan Bay on the east. This line of anticline belonged to the southern mountain chain of Java that extended outward from the west to the east on of Java Island. This formation consisted of submarine succession interrupted with old andesit which is laid under the sea since the Miocene until Lower Pleistocene period and slowly uplifted during Middle Pleistocene epoch (see Bemmelen 1970: 591-592). Afterward, a chemical dissolution and mechanical erosion happened during Middle Pleistocene until Holocene has engraved this uplifted formation and as the results a stretch of thousands karst hills and narrow valley like we can see nowadays (Bartstra, 1949; Sartono 1964 in Gallet, 2004: 42). However, the actual pattern is somehow more complicated. Appearance of silicified woods which are found is very often in river banks around this area indicates presence of forest (Miocene?) which must be older than Pleistocene (Sémah, 2011 personal communication). This means that the landscape development might be have been started older than what we have thought before.

The name Gunung Sewu came from geomorphology of the landscape that covered by many small hills. The name Thousand Mountain itself is misleading, regarding that there are no high mountains in this area instead of limestone hills. Those hills are not really high, they are rose about 60 m above the land and its maximum height is only about 500 m asl (Bartstra, 1976: 6). Gunung Sewu consist of a wide area with a maximum long 85 km started from Kali Opak in the west to the bay of Pacitan on the East meanwhile its maximum width reach 30 km at the south of Gunung Panggung. The extent of karst area as a majority in this formation is approximately 1300 km² (Escher, 1931: 260 in Barstra, 1976: 3).

At the present time Gunung Sewu karstic formation is covering more or less 65% of the whole of this area. The rest is small alluvial plain and old igneous formation, such as andesit, basalt, and dasit (Intan, 2004 in Simanjuntak et al., 2004: 35-39). Cherts and others silicified stones are abundant in some parts of this area, especially near the river or another open location where erosion can uncovered them from the soil and formation. Some areas are well known with the abundance of silicified rocks (usually cherts) on its surface (outcrops), such as Ngrijangan, Ngrijang Sengon, Nglipar, Giriwoyo, Wonasari and almost all Punung area. A nodule form of chert, jasper or another silicified material (including fossil wood) that commonly used as raw material in lithic industries also can be found naturally laid on a river bed and its terraces (eg. River Maron, Baksoko, Kiyut, and Banjar).
I.1.1 Geomorphological Evolution

The very first geological description of Gunung Sewu was made by Franz Wilhelm Junghuhn in 1836 (Simanjuntak et al., 2004: 42). He is the first person who has described physical character of the Gunung Sewu in which he interested with. He described the landscape of Gunung Sewu consist of hemispherical and a conical shapes of the hills that surrounded by several narrow labyrinthine valley. He did not look further for the karstification and the question of how this kind of landscape was formed. He could only presume that those conical and hemispherical hills were formed by some special polyps when the formation was still under the sea (Junghuhn, 1945 in Bartstra, 1976: 6-7). Hereafter several advance and more complex hypotheses concerning this unique formation were completed what that he has done before.

![Image](image.png)

Figure 1.1. Photo on the left show satellite imagery part of Punung area located in Gunung Sewu. Picture on the right shows geomorphology around Punung area in Gunung Sewu which is dominated with numerous hills and narrow labyrinthine valley (Junghuhn, 1836) (Source data: Googlearth and Bakorsutanal Indonesia, 3D model: Fauzi, 2011).

Gunung Sewu formation has a structure relatively simple with a slightly southward regional dip and totally covered by a formation of limestone the southern part. Recent work by Westway et al. (2007) in paleontological site called Gunung Dawung, near Tabuhan cave shows that the uplift event of karst formation was happened before Middle Pleistocene, based U-series dating method applied on a sample of lower flowstone dated to 492±38 kya (Westaway et al., 2007: 715-716). This minimal age also confirmed a previous datation taken from several sites (such as Braholo cave, Tabuhan cave and Song Terus) which shows that the karstification in this area was started at minimal age around Middle Pleistocene (Hameau et al., 2006: 400-401; Sémah et al., 2004: 49-50). The chronology karstification in this region is important to understand the connection between human mobility and culture on their paleoenvironmental context.
Table 1.1. Several datation taken from samples in Punung Area showing the minimal age of landscape (karst environment) in that area (taken from *Sémah et al., 2004: 50; **Hameau et al., 2006: 401; ***Westaway et al., 2007: 715).

<table>
<thead>
<tr>
<th>Sites Location</th>
<th>Sample</th>
<th>Method</th>
<th>Result (kya)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tabuhan cave*</td>
<td>Stalagmitic floor (GT.TP.9907)</td>
<td>Alpha spectrometry (TIMS)</td>
<td>326±9</td>
</tr>
<tr>
<td>Braholo cave*</td>
<td>Stalagmitic floor</td>
<td>U/Th (U-series)</td>
<td>245±69/-40</td>
</tr>
<tr>
<td>Song Terus**</td>
<td>Tooth (ST.KII.3110)</td>
<td>ESR/U-Series</td>
<td>254±38</td>
</tr>
<tr>
<td>Song Terus**</td>
<td>Tooth <em>Tapirus</em> (ST.KI.4698)</td>
<td>ESR/U-Series</td>
<td>341±51</td>
</tr>
<tr>
<td>Dawung (5 08° 07' 33.5&quot;, E 110° 59' 15.1'&quot;***</td>
<td>Lowest flowstone (SPI8-DW)</td>
<td>U/Th (U-Series)</td>
<td>492±38</td>
</tr>
</tbody>
</table>

The section shows an interbedded position of old andesites and volcanic products with the massif limestone formation.

Figure 1.2. The stratigraphy section of Gunung Sewu made by Bartstra showing a difference successive and locality along south (Gunung Sewu) and North (Wonosari Basin) (Bartstra, 1976: 8).

The history of the karstification and the formation of the Gunung Sewu landscape like we can see nowadays has been disputed by several scientists in theirs papers and journals. According to J.V. Danes (1951), a Czech geographer, the landscape of Gunung Sewu is a result of both, mechanical and chemical erosion after a plateau of seafloor uplifted during Middle Miocene. Meanwhile, Van Vulkenburg and White concluded that the landscape in this area as a result of chemical dissolution, but they also agree that mechanical erosion also being a part in during the karstification but not significance (Intan, 2004 in Simanjuntak, 2004: 44). Herbert Lehmann, by the year 1936 mentioned that Thousand Mountain landscape was a result of humid phase during Holocene. An *epirogenetic* movement that forces the massif limestone formations in Thousand Mountains also took a part in the “engraving process” of this landscape. Lehmann called this conical and hemisphere karst formation in this area as *Kegelkarst* (Lehmann, 1936 in Haryono and Day, 2004: 1).
R. W. van Bemmelen (1970) in his dissertation provides a complete geological description of the Gunung Sewu area. He also compiled several previous result and description to enrich his observation. According to him, based on its lithology this area is dominated by Miocene limestone of the Wonosari Formation which was uplifted during Pliocene or Late Pleistocene epoch and then dip gently southwards about 2% gradient (Bemmelen, 1970). The thickness of this limestone formation is approximately 650 meters and mainly consists of massif coral limestone on the south and chalky bedded limestone in the north (Bemmelen, 1970; Balazs 1968, Waltham et al., 1983; Surono et al., 1992 in Haryono and Day, 2004: 62). From the grain size viewpoint, limestone lithology in this area are highly variable, but can be generally classified as rudstones, packstones and framestones\(^1\) (Waltham et al., 1983 in Haryono and Day, 2004: 63).

Some fissure and underground rivers are exists in this region due to the chemical dissolution process (e.g. Gunung Dawung and Banjar river near Tabuhan Cave). On those special features of this karstic area we could find a faunal remains and stone artifacts concreted in compacted and silicified clay (e.g. Kali Banjar and Sirikan) or even in a breccias with a clay matrix (Gunung Dawung), because according to Haryono and Day (2004), this kind of matrix are common to be found. From several excavations made in the cave sites around this area, some lenses of volcanic ashes are commonly presents and sometime purely undisturbed because it is covered by a block of limestone. The thickness of the volcanic ashes lenses which were found during excavation are varied from extremely thin until 30 cm thick, such as what we found in Song Terus cave (mixed with brown clay). These kinds of lenses of volcanic ashes are also occasionally come into sight on a carbonates on

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1 Based on Embry and Clovan classification of limestones. Rudstones are refers to a clast-suported limestone in which more than 10 % of the clast (particles of broken-down rocks) are coarser than 2 mm in size; packstones are refers to limestones with particles less than 2 mm in size; and framestones are refers to autochthonous limestone which original components were bound during deposition by organisms which built a rigid framework, e.g. corals (Anthozoa) in a reef structure (Allaby, 1999)
geological outcrops (Waltham et al., 1983 in Haryono and Day, 2004: 63). The volcanic ashes in this area represent the dynamics of volcanic activity around Thousand Mountains area and can be very useful to become an object to correlate the stratigraphy to obtain a relative chronology or to be better in tephrochronology.

Two geographers Eko Haryono and Mike Day who made more detailed surface and aerial description in 2004 found that Gunung Sewu which generally classified as Kegelkarst by Lehman (1936) actually consist of three landscape subsets (they divide it into cone, polygonal and residual cone karst) (for further explanation see Haryono and Day, 2004: 62-69). From the aerial documentation integrated with detailed surface description Haryono and Mike Day succeed to show the contribution of natural lineaments to the character of valleys and karst hills to the surface morphology of Thousand Mountains. Undoubtedly, this result is enriching our knowledge on the process in thousand mountains surface morphology formation and its connection with the lithology.

**Figure 1.4** Landform differentiation of Southern Mountain (Gunung Kidul in Javanese) based on Haryono and Day, 2004. A: Labyrinth Cone-Karst; B: Polygonal Karst; C. Residual Cone Karst. (Haryono and Day, 2004: 64-67)

### I.2 Tabuhan Cave Site Presentation

#### I.2.1 Location and Morphology of Tabuhan Cave

Tabuhan cave located on coordinates 8°07’32.33” South and 110°58’59.59” East. This site administratively belonged to Tabuhan village, Sub district of Punung under Pacitan Regency Province of East Java. This cave is one of the famous caves in Pacitan regency, because it is well known as tourism object. This cave situated on a karst hill at elevation about 350.32 m asl with it is entrance facing to the east. Tabuhan cave is an endogene cave because it pierces and deep penetrated into
the karst hill that caused the temperature inside more or less stable because the air is protected from external weather (Lowe and Walker, 1997: 127).

![Figure 1.5 Location of Tabuhan cave site together with nearby sites and topography of surrounding areas. Picture a shows common topography of Area around Tabuhan Cave from Northeast to Southwest, figure b shows surface of Tabuhan cave and location of excavation (3D model by Fauzi 2011; Source data Sémah et al., 2012 in prep; http://www.maporama.com/maps/asia/indonesia/java/Java_Top.jpg with modification).](image)

Tabuhan cave can be categorized as a big cave because it has an entrance about 35 m width with a cave ceiling approximately from 4 to 10 m high. This cave has two main chambers with orientation elongated to Southwest and the second one elongated to Northwest. The dimension of the first chamber is 63 m long and 33 m wide, meanwhile the second chamber is smaller with a dimension 42 m long and 18 m wide.

![Photo 1.1 Tabuhan cave view from east (left) and condition of its chamber near the entrance (right) (photos: excavation team, Punung 2007)](image)
I.2.2 Research History of Tabuhan Cave Site

Not many literatures discuss the quaternary and prehistory research on Tabuhan cave. Tabuhan cave is only mentioned as a place of interest or as a reference in the most literature related to Punung area. The very first scientific research that mentioned Tabuhan Cave was done by GHR von Koenigswald in 1930’s in a report describe his excavation at fissure located about 550 meters from Tabuhan cave (i.e. Punung 2 faunal unit). Later, in 1959 Badoux reported the list of taxonomic determination from his work on faunal remains that came from Koenigswald excavation in 1930’s (Badoux, 1959 in Storm and De Vos, 2006: 272; 276). Recently the location of this fissure was rediscovered by Storm and de Vos in 2003 and also mentioned in their article on 2006. Storm and de Vos also mentioned that they found fossils of extant mammals (e.g. muntjak, deer, bovid, and pig) on a surface of Tabuhan cave (Storm and de Vos, 2006: 276).

Another earliest work nearby Tabuhan was done by van Heekeren and Basoeki on 1953, but they only interested in series of stone tools discovered nearby this cave. It was mentioned that they found what they believed Pacitanian industries laid in a river named Sungai Gede which is located near the Tabuhan Cave. Tabuhan cave also been reported in the year of nineties when Truman Simanjuntak with his survey team were discovered that Tabuhan cave -together with another 70 caves- as a potential cave in prehistoric research concerning several ecological variables. They found that the dimension, humidity and other variables of microenvironment and its surrounding supports (e.g. water and sunlight) are quite the same like the other prehistoric cave that has been researched by them before.

The very first archaeological excavation at Tabuhan cave was conducted in 1998 by Puslitbang Arkenas and MNHN. The purpose is to get a stratigraphical overview and a sample of remains distribution inside the cave chamber. However, this test pit was more intended to understand the stratigraphy of the cave and defining the age of the karst system in this area. This excavation was not intended to discover and gather the samples of archaeological remains (Sémah et al., 2004: 48-51).

I.2.3 Paleoenvironmental

Condition of paleoenvironment in the Tabuhan cave surrounding area can be refer to the research results that have been done before in Song Terus cave and Gunung Dawung, two nearby sites. Paleoenvironment reconstruction from Song Terus cave gave us a presentation of environment since ca. 300 ka BP until ca. 5000 BP. Meanwhile faunal assemblage from Gunung Dawung fissure represents condition of environment during the MIS 5. During the middle Pleistocene the surrounding area of Tabuhan cave was characterized by a rainforest based on the findings of several arboreal fauna such as orang-utans (Pongo pygmaeus) and gibbons (Hylobates) (Storm and de Vos, 2006: 277).

From Song Terus cave, one archaeological layer called Tabuhan layer (named after the similarity with Tabuhan cave deposit on testpit). Tabuhan layer contained faunal assemblage which is dominated by open woodland faunas such as Bovidae (genus Bos and Bubalus) and Cervidae

Paleoenvironment on the beginning of the Holocene represents by Keplek layer in Song Terus cave. Towards the Holocene period environment was became more humid. This different environment was indicated by undisturbed lamination of carbonates and remains of rainforest and aquatic faunas (freshwater mollusks, Testudinidae, Trachypithecus). From pollen analysis, the presence of family Quercus, Podocarpus, Castanopsis, and Dipterocarpaceae represents rain forest vegetation (Sémah et al., 2004: 58).

I.2.4 Archaeological excavation at Tabuhan cave site

In year 2002 the other excavation was done in the other part of the cave with a position very near to the cave entrance. This excavation has successfully uncovered a dense archaeological layer dominated by lithics remains. One testpit called PSA square being excavated and gave 1432 pieces of remains. They recorded lithic artifacts, potsherds, faunal remains, and limestone. From the lithic remains they have collected hammerstone, cores, nodule, flakes and debris. Lithic collections from this excavation were the most pronounce artifacts respecting its percentage.

The excavation was taken later in order to enlarge the area of previous excavation and collecting more data with more advance recording system. By the year 2009 and 2010, another eight squares were opened surrounding the location 2002 excavation. From the excavation in 2009 a field work that have been done by cooperation between Puslitbang Arkenas and Muséum National d'Histoire Natural de Paris recorded 2.539 archaeological remains, not including the small remains that came from the sieving and sorting the sediments. The remains consist of limestone, speleothems, potsherds, mollusks, bones, teeth, and lithic remains.

I.2.5 Tabuhan Stratigraphy

Excavations undertake in 2002, 2009 and 2010 also yield a clear stratigraphical section of Tabuhan cave. Concerning the depth of the excavation which already reach more than 5 m, this cave contains at least two layers, Holocene and Pleistocene layer. Unfortunately, no datation has been done yet in the preliminary assumed as a Pleistocene layer to confirm it. Until recently, there is no specific archaeostratigraphical definition to divided cultural layer in Tabuhan cave, such what we have applied in Song Terus cave.

The beginning of sedimentation process or cave filling in Tabuhan can be shown by the age of material deposited inside the cave in the deepest level. A stalagmic floor located around -9.17 to -9.31 meters depth resulting age at least 326 kya by means alpha spectrometry (TIMS) method (Sémah et al., 2004: 50). This is means that the cave filling and the cavity was active at least during the late-middle Pleistocene. There are no reports of artifact deposit found in this layer at Tabuhan
site. At Song Terus site located about 200 meters from Tabuhan a deposit of archaeological remains was dated to the same period (see Hameau et al., 2006: 401-402).

From the archaeological remains, Tabuhan cave deposit can be separated in two layers, the lower layer the upper part (above one meter from ZTg) and the lower part which is located below. Upper part characterized by dense lithic remains associated with faunal remains (teeth, bones and shells). The most remarkable difference between upper and lower layer, beside its density, was the appearance of mollusk shells which is only found on the upper layer. Unfortunately, there are no identification have been done on the faunal remains of Tabuhan cave which might be helpful in determining the layers. One radiometric datation was taken on mollusk shell from this layer and gave us date ca. 10 ka BP (Sémah, 2011 personal communication).

1.2.6 General Sedimentary Context

The most upper part of cave stratification consists of several deposits of soils. Lower part started from ZTg -150 cm consists of clay mixed with small number of silt and fine sand, with some pebble size limestone. In this layer we can also find a very thin discontinues carbonates (CaCO$_3$) lamination, and most of it observed on the left side of the section (section D/E 4). These thin laminations of carbonate give us a clue about the presence of very humid condition inside the cave and its surrounding area which allowed a high rate of carbonate precipitation (for comparative description see Sémah et al., 2004: 54; 58 and Gallet, 2004: 297-299). Somehow the presence of this carbonates becoming more intense towards more recent time, as can be seen in the left part of D/E-4 at depth ZTg 110-95 cm. A small concentration of tuff layers also presence in this layer.

The following layer consists of clayish-silt with small quantity of sand. Pebble and gravel sized limestone presence in this layer as well as the previous layer. Somehow, this layer was cut by another layer in D/E3 which also covered the upper part of this layer. The following layer is thick clayish sand within relative coarse texture interrupted with a dense gravel and pebble size limestone. In some way the deposits of more coarse material were more observable in this layer because of its abundance. Archaeological remains were mostly found within these two layers in a very high density. The last following layer is a series of clayish-sand covered by compact sandy-clay as a recent cave floor.

Based on our grain size analysis of sediments in the upper layer from ZTg -150 to -50 cm there are no significant differences between the layers. All layers are mostly consist of sand size particles (coarse and fine size ranged from $\phi$ 40-2000 $\mu$m) with very small percentage of clay size ($\phi$ <2 $\mu$m) and silt ($\phi$ 2-40 $\mu$m). Decarbonatation which was applied to the samples shown that most of coarse particles are refers to detritus of calcium carbonates and aggregated particles. It means that the sedimentation is also have been influenced by detritus material originated from ceiling and the wall of the cave through disaggregation of calcium carbonates.
I.2.7 Archaeological Remains from Tabuhan cave

Excavations in 2002, 2009 and 2010 have successfully uncovered numerous numbers of remains both organic and inorganic. The most remarkable remains found in the excavation in 2002 and 2010 were lithic artifacts. Faunal remains are not common to be found in the excavation but some remarkable things are important to be noticed:

1. Archaeological layer was found approximately 5 cm below the surface. This surface characterized by flakes, potsherds, and several types of faunal remains.
2. Mollusks vertical repartitions were seem to be limited only in the upper layer (from ZTg -0.600 until -0.970 m) with the densest area between ZTg -0.60 to 0.907 m.
3. One bone tool which was uncovered in excavation in 2009 (No. GT09.C3.D1.1924) brings us evidence related to an exploitation of hard element from faunal resources. This bone tool clearly shows a modification of its natural form by means of shaping. Remarkable feature such as polishing and glossy traces are visible on its lateral surface. Preliminary taxonomic determination resulted that this bone tool is a diaphysis of a metacarpal bone from Bos javanicus (Fajar, 2011).
4. Presence of cortical flakes, flakes, stone tools, hammer stones, and débitage waste (chunks) found under excavation represent the characteristic of knapping on the site, henceforward it bring us to a preliminary assumption about the function of the cave as a workshop (atelier de taille).
5. Reddish color on the surface of several limestone and chert shows evidence of using fire which is confirmed by some fragments of charcoals found under excavation.
Archaeological remains distributions have shown that the upper layer is denser than the lower layer. This might be connected to the different type of dwelling during different period (see Simanjuntak et al., 2004: 81-91). Somehow, cave habitation in Gunung Sewu area seems being occupied gradually started from late Pleistocene or even earlier. However, intensive occupation was clearly shown by Upper Pleistocene and Holocene layer (Sémah et al, 2004: 56-60). This phenomenon might be used as an explanation of a quasi gradual augmentation of artifact density in Tabuhan cave. The upper layer up Tabuhan cave deposit above ZTg -100 cm probably refer to the Holocene occupation during Preneolithic period which has been characterized by more intensive cave occupation (see Simanjuntak and Sémah, 2005: 4).

Figure 1.7. Examples of Mollusk remains found under excavation of Tabuhan cave field campaign 2010 in Keplek horizon. Preliminary determinations resulting these two shells belongs to family Thyaridae (1) and Cyclotus (2) (identification by Budiman, 2011). Bellow vertical distribution of Mollusks (view from southeast excavation orientation or north in geographical orientation) compared to other kind of faunal remains (Photos and picture: Fauzi and Zanolli, 2010, Courtesy: Sémah et al., 2012 in prep).

Figure 1.8 Bone tool No. GT09.C3.D1.1924 from metacarpal of Bos javanicus with indication of shaping and some traces of utilization (abrasion, glossy and smoothed surface on its shaped edges) (Photos and pictures: Fajar, 2010, courtesy Sémah et al., 2012 in prep).
Chapter II
Proneolithic Industry from Gunung Sewu

II.1 Proneolithic industry from Gunung Sewu Region

Typo-technological approach in order to describe and characterize Holocene Lithic Industry from Keplek Horizon at Song Keplek and Song Terus was done by Hubert Forestier on 1998 for his dissertation. From Keplek Layer in Song Keplek, he studied not less than 3.664 lithic remains (dimension ≥20 mm) and some artifacts from KI and KII testpit at Song Terus (Forestier, 2007: 251). He has described and characterized lithic industry in Gunung Sewu region as separated culture with Toalian Mesolithic industry in southwest Sulawesi which is belong to the same period with Keplek culture (ca. 8.000-5.000 BP).

General character of Keplek lithic industry is the absence of blade, bladelets, point and geometrical tools which are common to be found in Mesolithic culture during the same period at Sulawesi (i.e. Toalian culture) (see Forestier, 2000: 546-547). To avoid misunderstanding with previous study in technology and chronology of Mesolithic tradition, he proposed the using of the word Proneolithic as a terminology to describe lithic assemblage from Song Keplek and for Gunung Sewu region in a broader sense (see also Simanjuntak et al., 2004: 259). For the moment, this terminology only refers to Gunung Sewu region including another studied site near Tabuhan, Song Terus. Typology of the stone tools in Song Terus site more or less the same with what Forestier (1998) described in his work (See, Forestier, 1998: 432 and 451; Forestier 2007: 160-203, and Reawaru, 2005: 80 as a comparison).

Proneolithic culture during the Holocene period in Gunung sewu region characterized by important contribution of Mousteroïd type tools (racloir, grattoir sensu lato, perçoir, and denticulé) among the lithic assemblage (Forestier, 2007: 254, 268; Forestier, 1998: 451; Forestier, 1999: 139). General morphology of the flakes produced were usually elongated (80% in Song Keplek collection) and shows the presence of cortex on its dorsal face. From the study on the nuclei and flakes, débitage method which commonly used to obtain support for tools and produce flakes is unipolar. Other methods presence on nucleus and flakes dorsal faces is bipolar and centripetal (Forestier, 2007: 254-258). Remarkable phenomena is the strong appearance of débitage type C (Boëda in Forestier, 2000: 539-544; 2007: 264-267). This method of débitage is using the algorithm A/B which is alternating each other that can be considered as a deformation of natural structure of an initial nodule shape and utilization of the alternated surface as the way of volume exploitation (see also McNabb, 2007: 319; Arzarello et al., 129-132).

The presence of core-tool like (chopper) is confusing in this assemblage. It is rather that this chopper shape is actually a core which has passed simple débitage method applied on a nodule. Forestier consider it as a simple exploitation of a nucleus based on an alternating knapping algorithm between plan de frapee and plan de débitage (see Forestier, 2007: 242-244). Nevertheless, activity
of using exhausted nucleus as a tool also presence in Song Keplek lithic collection, based on a retouched edges on a nucleus (Forestier, 2007: 240).

In Song Terus, Stevanus Reawaru (2005) has studied the technological characters on 5890 lithic remains. He comes to a conclusion that Song Terus lithic collection has a similar characteristic with Song Keplek based on the typology. But there is no further evidences of distinctive features except the presence of cortical flakes which is tend to be less than Song Keplek lithic collection. Reawaru studied Song Terus lithic collection in the frame of its each natural (?) sub-layer context. There are no significant features distinguishing those assemblages based on each different sub-layer, concerning its similarity in tool assemblage, débitage technology and metrical analyses (see Reawaru, 2005: 49-83). He also concludes that the removing of cortex and reducing dimension of support was happened since quarrying stage. It means that there was a preparation stage on the quarrying area (or somewhere else) before the support arrived at the cave. His study based on the presence of cortex on the dorsal face of the flakes.

Determinism of stone tools function in this area was carried out by Antony Borel’s works on lithic collection in Song Terus for his Ph.D. dissertation on 2011. From his study it seems that there is a relation from the outline shape of the flakes or tools and traces of utilization. The clearest trace left on the tools is the activity of scrapping graminae which is confirmed also by experimental studies (Borel, 2010).

II.2 Chaîne opératoire in Gunung Sewu Region (from Song Terus and Song Keplek lithic collections)

Preneolithic peoples in Gunung Sewu Region generally select chert as raw material for their tools. This is confirmed by most of the sites around Pacitan area which yielded numerous lithic artifact made by this silicified stone. In Braholo cave, situated at the same karstic formation (i.e. Wonesari) about 34 km to the northwest of Punung village, exploitation of chert was not really common instead of a limestone (see Simanjuntak et al., 2004: 155-156). In this cave site, bone industry was better developed along with limestone tools industry. Meanwhile in Punung area, a condition is vice-versa. Chert has become the major raw material in lithic industry. However, there is specific study in the raw material such as petrography or mineralogy characterization from this area yet available.

Evidences from Song Keplek shows there was selection during quarrying stage of raw material based on its locality (i.e. river). Raw material study in Song Keplek collection shows significant number of patination or reddish color on artifacts surface (Forestier called it neo-cortex). This is the base of his hypothesis that Preneolithic people in Song Keplek were prefer to collect chert nodule from the river bank rather than to extract it from a steeped cliffs or on the surface around the site (Forestier, 2007: 143-145). But the average volume or predicted dimension of chert nodule brought to the cave was not the concern of his research (i.e. typo-technological description) by that time. Forestier (1998) only conclude that the weights of nodule collected were very varied around 100 to 1000 g (Forestier, 2007: 144). Furthermore, there is no advance studies carried out to explain this quarrying stage.
Different case seems occurred in Song Terus site. There are only 22 % of lithic remains can be predicted came from river banks, meanwhile 44% are came from quarry extraction on a slope, outcrops or land surface (Reawaru, 2005: 53). There is no further information in procurement strategy yet available from previous research in Song Terus cave.

In Song Keplek, the presences of cortical flakes or partially have more than fifty percent of cortex are very common. Tool-supports with cortical back are common to be found, showing that the strategy in débitage process is an *expeditive-strategy* (Forestier, 2007:268-269). Different case once again happened for lithic remains from Song Terus. There are lots of flakes found without the presence of cortex on its dorsal face (66 %) (Reawaru, 2005: 57).

The evidence from Song Keplek shows that during the débitage process the form that have been intended by Preneolithic people was an elongated flake. This is also confirmed by the same characteristics found in Song Terus assemblage (Reawaru: 2005: 60). Remarkable feature is the presence of elongated flakes which does not have character of blades or bladelets implements (Forestier, 2007: 269; Reawaru, 2005: 60). Débitage techniques that have been used in Preneolithic culture at Gunung Sewu region is direct percussion by using hard-hammer (*e.g.* andesit, fossilized wood, or another relatively hard stone) (Forestier, 2007: 146). The presences of utilized flakes are shown again in the application of *expeditive-strategy* in achieving *support* for tools.

Investigation in débitage method that have used by Preneolithic peoples of Gunung Sewu was brought by morphological analyses of nucleus by Forestier (1998). Normally, volumetric reductions were followed by the initial shape of raw material (nodules). This is related with the intention to obtain elongated flake as a support for tools (see Forestier, 2007: 254-269; Forestier, 2000: 539-541). From his study on lithic remains from Song Keplek, particularly in nucleus, débitage methods which have been used in Gunung Sewu Region during Preneolithic period are:

- Unipolar orthogonal
- Bipolar orthogonal
- Centripetal

From the study that have been made by Forestier (1998) and Reawaru (2005), volumetric exploitation of a nucleus in Song Keplek do not characterized by a systematic volumetric reduction or *predetermined débitage* (Inizan and Tixier, 1999: 61). This is shown by the presence of lithic implements with cortical on its dorsal face. According to Forestier (1998) the presence of utilized flakes also show us that *expeditive-strategy* in obtaining support for tools are really common in Preneolithic culture in Gunung Sewu region. The appearance of these types of tools is questionable because in fact it is hard to determine between utilization and intentional retouch. Volumetric exploitation through débitage in order to obtain *support* for tools is following the initial (natural) shape of the nodule (Forestier, 2007: 258-259; 269-270).

Expeditive-strategy also represented by using form débitage type C (Boëda in Forestier 2000: 539) or *Système par surface de débitage alternée* (SSDA) (Forestier 1993 in Arzarello, 2011: 129-132). Fast exploitation by using a system of knapping the next flake by striking on the previous alternated surface. This type of débitage method normally will produce an elongated, thick, cortical flake with *unipolar negative-scar* on its dorsal face (see Forestier, 2000: 539-542).
II.3 Material studied from Tabuhan Lithic Collection

Lithic collections used in this thesis came from excavation campaigns on 2002 and 2009. These lithic collections originated from 5 excavation squares, which are GT.02.P5A, GT.09.C3, GT.09.C4, GT.09.D3, and GT.09.D4. The database in these five excavation squares are accessible but must be manipulated in order to match with the station total recording system which have been used in Tabuhan since the excavation of 2009. From these five excavation squares, not less than 1.580 lithic remains (in excavation database marked as rijang, a local name for chert) were found.

Due to the limitation on the access to the findings, (mostly by misplacement, errors in recording, and incorrect classification) the total number of data used for this research is 1.516 lithic remains (including 1.511 chert remains and 5 hammer stones). From sieving material there are 1.858 lithic remains have been collected. These sieving materials were only quantified and sorted in order to search findings that I consider as important for the study. Concerning the amount of materials available for this study, it can be considered that this amount of data is sufficient for characterizing Preneolithic industry of Tabuhan cave site.

II.4 Problematic Discussion and Background of the research

Several differences in raw material procurement during the quarrying stage between two sites in Gunung Sewu region are not allowing us to make a generalization. Tabuhan cave, as a new excavated site must be studied in order to complete the information about procurement strategy during Preneolithic period. This is important, regarding Tabuhan position which is not far from the river (e.g. Kali Banjar and Sirikan), but its neighboring site, Song Terus, shows a contrary result in procurement strategy (i.e. outcrops origins). Assessment in nodule volume was never been studied particularly. Until now, there is no synthesis available to explain the possibility of estimating the initial dimension or volume of raw material brought into the cave in Gunung Sewu Region.

Forestier has described clearly the exploitation of natural nodule or a block of raw material from the river by Preneolithic people of Song Keplek. Unfortunately he did not mention an exact standardized volume of a nodule brought to the cave and later exploited by using method débitage
type C, except a large variability ranged from 100 to 10 kilograms of \textit{nodule}. Logically, the presence of huge number cortical flakes will be directly related to the small or medium size nodule. From our experimental point of view, a big nodule will produce also a lot of non cortical flakes. Hence, in Song Keplek, there must be an average size of nodule which is exploited in the cave that makes such homogenous product of débitage \textit{(i.e. cortical flakes)}. Therefore, the question about human behavior during \textit{Preneolithic} period in selecting raw material is still incomplete and available for further explanation.

The positions of Tabuhan lithic collection in a chrono-cultural model in Gunung Sewu is still not clear until now, because it was never been studied. Nevertheless, as new excavated materials, study from a lithic collection from Tabuhan cave can be considered as a starter for further research. The result will enrich the data description and complete synthesis about Preneolithic culture in Gunung Sewu region, particularly around Punung area.

Tabuhan cave has been excavated with a good recording and well developed database system. These data mostly related to the position and form \textit{(space and form unit)} of the remains. These databases have to be accustomed in order to fit on the new recording system and for future fieldwork. Until now there is no well synthesis of the artifact distributions, especially lithic, from Tabuhan cave site. Thanks to the development of an informatics in archaeology, these three dimensional \((x,y,z)\) space unit can be utilized for making a repartition in three dimensional. However, availability of the exact provenience from each remains should be utilized as a substitute for the efforts of every people whom had worked hard for the field report.

As a new data, Tabuhan lithic collection will enhance information towards understanding the dynamics of Preneolithic culture and in making a better synthesis about prehistory of Gunung Sewu Region. The different function of a site might be observed during the building of a synthesis in order to have broader view in explanation stage. Unlike its neighboring site, Song Terus and Song Keplek, the function of Tabuhan cave during Late Pleistocene and Early Holocene is still remains unclear. Henceforth, this thesis will provide the first syntheses of a new prospective archaeological research which have been done recent years in Tabuhan cave.

\section{Aim of study}

General purpose of the study is to describe lithic collection from the excavation of Tabuhan cave. The study of technology and typology of Preneolithic implements to characterized Holocene lithic industry in Gunung Sewu region had been worked by two scholars, Hubert Forestier and Stevanus Reawaru. Hence, characterization of Tabuhan lithic collection is important to enrich our knowledge and information about Preneolithic culture during Holocene period.

Beside the general purpose of the study mentioned above, this study also has several specific achievements intended with the purpose to complete information which is not available yet concerning \textit{Preneolithic} culture in Gunung Sewu region and Tabuhan cave. The explanations of specific purposes intended to be achieved from this study are:
1. To describe technological characters of the Tabuhan cave Lithic collection in the frame of its three dimensional spatial distribution.
2. To investigate several indicators that can be use as a hint in assessing average initial volume of support and débitage activity took place in the cave which has not been done yet in previous study.
3. To compare the technological character of Tabuhan Lithic collection with the results from previous studies and defines the function of Tabuhan site during Holocene period.
4. To understand the position of Tabuhan lithic collection in the chrono-cultural reconstruction of Gunung Sewu.
5. To provide basic starts in chaîne-opératoire study on Tabuhan Lithic collection for further study.

II.6 Method

This study will describe all information of Archaeological investigation that took place in Tabuhan cave, particularly on its lithic collection in order to have a clear vision on the nature of the data. The research on Tabuhan lithic collection in this thesis will be presented in general framework of archaeological investigation, observation, description and explanation as an addition (see Deetz, 1967: 8). Any interpretation based on analysis (description) will be put in a broader previous interpretation in order to have a regional based explanation.

II.6.1 Observation

The very first stage of this research is the materials that have to be excavated. This was done by 2009 excavation which purposed to record more detail about the stratification and remains repartition. Enlargement of the area already excavated in 2002 will bring a problem in database if there is no good control on the field reports. This research also purposed to build a well organize catalogue and database of lithic collection, integrated between 2002 and recent excavations.

During this stage, construction of a master database for all remains is done by integrating the points of remains positions (station total). This is need to be done and well controlled in order to diminish errors in recording, concerning this research also using a database as a basic for tri-dimensional repartition of the collection.

Another kind of non artifacts material also collected and being recorded its position. In this research, oolith or cave pearls were being collected because it can be an alternative way in observing the condition of the cave chamber, concerning its appearance only happens during the most humid period. This is important to explain taphonomical study of lithic remains.
II.6.2 Description stage

In description stage, this research entering the corridor of general description in lithic study including several particular categorizations has been made to simplify the data. Observation in this research includes general method in assessing morphological and metrical features bearing on lithic artifacts in technological context. Most of terminology being used in this thesis are based on methods and technique in lithic analysis proposed by Inizan et al. (1999); Andrefsky (2008); Odell (2004); Arzarello et al., (2011) and Hubert Forestier (1998 and 2007). Observation stage also being a tool to build a collection database and catalogue including verification of validity between remains, database, and the most important its provenience in station total system.

II.6.2.1 Spatial analyses on Lithic remain from Tabuhan cave

Spatial analysis of Tabuhan lithic collection using manipulated database to be compatible with the program used. In this stage, classification that has been made in the field and later in the database can be manipulated in dividing the layer based on gap between the remains. Afterward, distribution can be viewed based on every category made by further analysis in morphology (morphometry or typology). This analysis intended to get a full three dimensional distribution model that can be change according the result from further analysis.

Another database was needed to make density analyses and orientation of the object. This is important to describe taphonomy process of lithic artifacts during post depositional process. Density process was done by using Kernel Density Analyses 2D provided by PAST software v. 2.07 to measure and estimate the density of the object around circular area based on Gaussian Kernel Density Formula (Hammer and Harper, 2011: 166):

\[ f(x, y) = \frac{1}{\pi \sigma^2} \sum_i e^{-\frac{1}{2\sigma^2}[(x-x_i)^2 + (y-y_i)^2]} \]

Analysis in orientation of the object will show if there is any trend in artifacts orientation that will give a clue to the orientation in deposition or the post-depositional pattern. This work have been done by Sahnouni and Heinzelin (1998: 1093-1094) to make an assessment in the context of Aîn Hanech artifacts. Analysis were carried out by using Direction Analysis one sample, provided by PAST software version 2.07 which allowed us to make a rose diagram to show total orientation of particular remains. Shanon J. McPherron (2005: 1012-1013) was using this method in defining site formation process in Pech de l’Aze’ IV, southern France.

II.6.2.2 Classification of lithic collections

Related with the purpose of research which already described in this chapter, several categories have been applied to lithic remains from Tabuhan cave site during the observation stage. Category has been made are:
1. Flake
Refer to any lithic remain which shows characteristics or attributes of a flake. Flake attributes which were used in this research are presence of bulb of percussion, ripples, bulb scar, and lance on its ventral face, striking platform, and particular termination on its distal end. Several attributes on its dorsal face are also being observed to define the category of the flakes. Any flakes with less than 50 % of cortex appearance on its dorsal face will be grouped in flake. In general, these features will help in orienting and describing the flake itself. Regarding many flakes are broken, or not complete, another sub categories were made for fragmentary flakes as listed below:

a. Broken Flake
Any identified flake that lost its distal part (i.e. only proximal part is observable). This flake is easier to identify than fragment flake because most of the flake attributes located on proximal part of flake.

b. Flake Fragment
Any identified flake that lost its proximal part (in contrary with broken flake). This category is hard to identify, because only distal part with unclear marks on its ventral. However, presence of ripples and visible termination type of a flake can be observed and become the basic of identification. Sometimes, incomplete bulb of percussion also helped in observation and identification.

Categorizations of flake based on its degree of fragmentation have been done by Alan Sullivan and Ken Rozen in 1985 in order to categorizing all “artifactual” lithic remains (see Odell, 2003: 123). With this category, any broken or fragmented flake will have their particular place in classification, not going to be the same place with debris. Regarding there is no significant appearance of blade and bladellets in Punung area, no sub-category will be made. Verbal description will be included as a remarkable note.

2. Cortical Flake
This category based on the same attributes study on a flake. The differences is only located on dorsal face, a cortical flake refers to any flake with fully cortical back or at least with cortex appearance more than 50 percent. The same categorization based on localization of fragmentation also applied in this category, as listed below.

a. Broken cortical flake
This subcategory has the same manner in identification with broken flake in flake category.

b. Cortical flake fragment
This subcategory has the same manner of identification flake fragment in flake category.

3. Tool
This is category refers to any flake that undoubtedly have been intentionally retouched or any pieces of nodule that have been shaped (i.e. modified by knapping process by means of shaping or façonnage). This category shows every further modification of a flake (support)
which can be observed on its margin. Categorization based on typology of tools will be explained in the next chapter.

4. **Nucleus**
A block of raw material which suggested as the origin of flake has came from. Core can be identified by looking at its facetted surface as a result of *débitage* activity. In a cave, the presence of a block or nodule of *chert* and another silicified stone can be a basic in identifying an artifact or at least a result of *manuport*. This category of remains is important in order to describe the behavior in procurement or even their strategy in procurement.

5. **Debris**
Refer to any pieces from lithic collection which not shown any technological attributes. Basic identification of this category is experience in knapping experimentation and the location of the remains been found (i.e. a cave that usually occupied by human during prehistory period). Every knapping process will produce also debris (in some literature also called *chunk*, *waste*, or *shard*). In a cave site, this remain will be easier to be considered as a debris from knapping activity. In an open site, a more carefully observation must be done, even from the artifact association and context it was clear there was human activity on it.

6. **Hammerstone**
Since no organic hammer was found in Tabuhan collection, this category only refers to stone which shows clear marks of utilization as a hammer. Usually on a hammer stone some marks were left as a result of knapping activity, such as impact scars or breakages which are accumulated in one or two particular areas on a surface of a stone.
Attributes on lithic artifacts for identification and classification

(after Inizan et al., 1999: 33; 60; Crabtree, 1972; and Holmes, 1919)

Fig. 2.2 Flake identification and terminology has been used during description

Fig. 2.3 Fragmented flake identification

Fig. 2.4 Example of hammerstones being used in knapping process.

Fig. 2.5 Nucleus identification

Fig. 2.6 Terminology have been used in Tool identification
II.6.2.3 Morphological description and metrical measurements

After lithic collection classified based on its categories and subcategories, technological description was taken in verbal and pictorial form. Verbal description is including attributes, orientation and several remarkable alterations. Metrical information was taken based on technological orientation for flakes and cortical flakes. Technological orientation was using débitage axis as a reference. Meanwhile morphological measurement refers to morphological axis itself (maximum length, width, and thickness). Technological measurement only applied on intact flake. This measurement will be useful in investigating if there was any tendency for obtaining particular dimension occurred during débitage process. In this observation, particular description was applied on a core tool. Measurement was done by measuring its maximum length, width and thickness based on morphological axis. Concerning its scarcity appearance among the Tabuhan lithic assemblage, the descriptions undertake were only its dimension, alteration, and amount of removals.

Fig. 2.7 Technique in measuring flake length (L) and width (l) based on débitage axis (D), with comparison to the location of morphological axis (M). (after Inizan et al., 1999: 107).

II.6.2.3.1 General Description of flake, cortical flake, and tool morphologies

Morphological description was undertake particularly on a flake attributes as support for making tools. These attributes are bulb, striking platform, flaking angle, termination. Traces of alteration also recorded in description form as an information of condition of the object examined. Explanations about variables which have been observed in Tabuhan lithic collection are available in the following list below:

1. Bulb of percussion
   Bulb located on ventral face of a flake which usually (but not always) characterizes débitage technique that has been used to obtain that flake. In this research, bulb was divided based on the level of its elevation from ventral face:
   a. Well pronounced
   b. Pronounced
   c. Less Pronounced
31

3. Flaking angle
Flaking angle is an angle between striking platform and ventral face of a flake. This angle gives us information about débitage technique has been used to obtain a flake (Arzarello et al. 2011: 114-124)

4. Termination
Observation of flake termination on the distal part of a flake was done by evaluating its morphology. This observation was done in order to search a possibility if there was any connection between termination morphology and selection of further modification to obtain a specified tool.
II.6.2.3.2 General description on Nucleus

Description on nucleus was done by evaluating several parameters that have been shown. These parameters are geometrical form, number of striking platform(s), number of débitage removal(s), direction(s) of débitage, and assessment on the stage of exploitation. In order to simplify the data, several suitable categorizations were applied during description process as listed below:

a. Geometrical form (Nodule, Pyramidal, Polygonal, Rectangular and Amorphous)
b. Number of striking platform (Single, Double, Multiple)
c. Number of débitage removal
d. Direction of débitage (Unipolar, Bipolar, Centripetal)
e. Nucleus Exploitation stage (from I until IV), described as:
   - Unexploited nodule: Nodule of chert which only have one or two removals on its surface.
   - Minimum exploitation: Nucleus which have been less exploited, shown by the appearance of potential striking platform and débitage surface. Normally these nuleuses have fewer cortexes than unexploited one.
   - Medium exploitation: Nucleus which have been exploited but not maximal, shown by the appearance of potential striking platform and débitage surface but together with small dimension and open angle between striking platform(s) and débitage surface(s).
   - Maximum exploitation: Nucleus in small dimension which shows no potential striking platform, usually caused by open angle between striking platform(s) and débitage surface(s)

II.6.2.3.3 General Description on Debris

Descriptions on debris were based on their morphological dimension (i.e. maximum length, width and thickness) and alteration. This description also allowed us to verify the database and the provenience of the objects (x,y,z). Information of cortex appearance and alteration will enrich the data gathered from flake, cortical flake, and nucleus.
II.6.2.4 Observation on cortex appearance

Cortex appearances in lithic collection were divided in four categories, based on their percentage of appearance on surfaces and their general classification. Surface observed for flakes and cortical flakes for the percentage of cortex is on dorsal face. Meanwhile for the nucleus, percentage of cortex was considered its comparison with total surface. Cortex observation on debris was more complicated because it has no exact orientation and not possible to compare with its total surface like what applied on nucleus. To solve this problem, assessment of cortex appearance on debris was completed by comparison with its total visible surface in perpendicular view.

Categorizations of cortex appearance which applied on lithic collection from Tabuhan cave are listed below:

a. Non cortical (NC) : Zero appearance of cortex
b. Partially Cortical <50% (PC<50) : Less than 50 percent of cortex
c. Partially Cortical >50% (PC>50) : More than 50 percent of cortex
d. Totally Cortical (TC) : Fully cortical on its surface

To be noticed, the appearance of cortex on the surface are sometime has to be evaluated subjectively. Appearance of a small percentage of cortexes on a surface (e.g. less than 5 percent) will be considered as non cortical, the same assessment also applied on a condition vice-versa.

II.6.2.5 Raw material provenience assessment

Study in cortex appearance and surface of lithic collection and Tabuhan will bring us to an early assumption about the type of quarrying site. From the screening of lithic remains during excavation, we assume that the raw materials are mostly gathered along the river. This is shown by eroded surface or reddish color related to patination. Therefore, characteristic cortex and surface appearance were also being studied in Tabuhan lithic collection. To complete this study, three categories was made in order to speculate the environment of raw material provenience as listed below:

a. Origin river provenience. This category refers to raw material which is located in a secondary context and showing presence of alteration made by water transportation.
b. Origin surface site. This category refers to raw material came from outcrop site (primary context) where usually the chert block were being extracted from cliff or surface.
c. Unidentified. This category are usually appears on a remains with zero percentage of cortex which not allowed us to describe the alteration generally caused by river transportation.

Debris was also included in this categorization regarding its significant number among collection and to keep the composition in an ideal proportion.
II.6.2.6 Alteration

Alterations observed in this research were divided in three, *concretion*, *patination* and *burnt* traces. Concretion on a surface of an artifact will show us indirectly the variation on carbonate precipitation occurred inside the cave. Meanwhile *patination* is a variable that can show us the alteration related to rate of iron mineral activity and the presence of water. This observation allowed us to avoid mistakes if there was a *reuse* and *recycle* activity on old artifacts based on double patination or old patination which is very rare in Gunung Sewu Preneolithic artifacts.

II.6.2.7 Typological approach on retouch pieces

Retouch in this research refers to series or single intentional removal(s) which is applied on a flake (support) in order to obtain a specific shape on its edges. Basically, observation on retouched pieces in this research concerning several variables (according to Inizan *et al.*, 1999: 93) such as: position, localization, distribution, delineation, extent, angle, and morphology. Further information will be described in the next chapter together with the description result.

II.6.2.8 Raw material study

To have better knowledge about raw material diversity among the Tabuhan lithic collection, observation on raw material characteristic has been done. This observation was based on color, surface texture on altered/removed part (*i.e.* not on the cortex) and level in transparency. This observation was only taken on tools, with preliminary assumption that tool is the clearest evidence of further modification. Hence, intentionally retouched or shaped pieces are representing the real activity of human modification for utilization.

Categorizations have been made for surface texture and level of transparency. Surface texture related to the condition of non cortical surface and homogeneity of raw material. This observation was done by rubbing the surface of the lithic specimen. Transparency related directly to the contents of silica (Si) in the rock. This observation was done through evaluating the level of transparency on the border of the artifact. On nucleus the technique becoming tricky, because observation only taken by looking at surface transparency. Categories which have been applied in order to run this observation are listed below:

- **Surface texture**: - Smooth
  - Medium Smooth
  - Rough
- **Transparency**: - High
  - Medium
  - Low
The result of this observation did not only give a shallow interpretation such as the selection in kind of rock suitable for knapping (i.e. silicified rock or cryptocrystalline). This observation also meant to support the preliminary assumption about the provenience of major quarrying site. Logically, if most of the raw materials brought to the cave were originally come from the river, high diversity in macro characteristic of raw material will be very high. This condition directly related with river activity in eroding the landscape and collecting the stone from several sites and mixed them in one site (e.g. river bank deposition). If the quarrying site is an outcrop on the cliff or slope, the character of raw material in the collection will not show high variability. I realize that this interpretation can be biased by only observing tools. A further study will have to be done in order to confirm the results from this observation.

As preliminary study in raw material, several samples were taken to have a clear characterization from petrographic characteristics. Samples were taken from sorted sieving collections which were identified as chert. Four Thin sections 30 μm were taken as a sample in order to define the micromorphology under microscope. Several samples are also being collected from characterization in mineralogical composition by using Infrared spectroscopy.

### II.6.2.9 Study in estimation of average initial volume of nodule

This observation based on samples which were taken from the whole category in Tabuhan lithic collection except hammerstone. Sampling was based on category of raw material, which characterizes by yellowish brown color, medium smooth texture on surface and medium transparency. The total number of nucleus collected from this sampling are 4, and total débitage results are 105 (including flakes, cortical flakes, tools and debris). The most important in this observation are the volume of all products.

Measurements of volume were done by using a beakers volume measuring container filled by water. This method in measuring was chosen because its simplicity and efficiency. Samples were placed inside the container which already filled by water until its level reaching certain an even value (e.g. 1000 ml). Differences of value on scale bar before and after the samples were placed inside beakers glass became the value of samples volume. Reliability of this measurement can be considered until 10 ml.

After measurements, estimation of initial average volume of nodule was reconstructed. This volume compared also to the unexploited nucleus and minimal exploitation. The result will brought us to the conclusion about the average initial nodule brought to the cave which has a relation with human behavior in selecting raw material during procurement stage. Further discussion about this observation will be explained in the next chapter.

### II.6.3 Explanation

Every single observation including its each individual interpretations have been made in one complete research are mostly fragmented and not integrated each other. To accomplish the main
purpose in archaeology study (*i.e.* reconstruction of culture and its process) these fragmented information must be integrated towards more holistic explanation. In this thesis, each interpretation from every observations have been done were integrated and have their own part in explanation.

Explanation stage in this research will be consider the Preneolithic human behavior during Holocene in Tabuhan and its relation with the other site based on the previous result in archaeological research. I hope this thesis will give its particular contribution in the study about Prehistory of Gunung Sewu Region and enhance our knowledge in the future research perspectives, especially around Punung area.
Chapter III

Analysis on Tabuhan Lithic Collection

III.1 Spatial Analysis

Tabuhan cave site is surrounded by several near water sources, such as Kali Banjar and Kali Sirikan. These rivers not only provide water as the most important element in human life but also resource of lithic raw material. The distance between Tabuhan site and nearest river, Kali Banjar, is about 190 m to the south. Meanwhile another river which is located on the west of Tabuhan cave, Kali Sirikan, is only 200 m from this site to the west. This means that Tabuhan cave was supported by natural resources that situated not far from the site (see figure 3.1).

![Figure 3.1 View from southeast of Tabuhan Cave showing two rivers (Banjar and Sirikan) located not far from the site (data source: Sémah, 2012 in prep 3D modeling: Fauzi, 2011)](image-url)

III.1.1 Distribution of lithic remains

Three dimensional distributions provide us simplest way in observing archaeological remains distribution because it allowed us for viewing 360° on both side, vertical and horizontal, and also section plane whenever detail observation is needed. This analysis applied only on plotted remains. The purpose of this observation is to investigate if there is any particular distribution shown by three dimensional distributions of remains. To obtain this, only plotted lithic artifacts were being used in analysis. This strategy was applied to avoid mistakes in defining the layer based on gap among the remains. As a result three dimensional vertical distributions of lithic remains from Tabuhan show us some important information:
1. Presence of different artifact density within the densest layer (between ZTg -0.57 to -0.98 m). This layer can be considered as five different archaeological layers, named from upper to lower: sub-layer B1, B2, B3, B4 and C.
2. The densest layer among B layer is the layer B3 meanwhile the most scattered and scarce remains was found in layer C.
3. Almost all categories in lithic remains were found in all layers, except the hammerstones which only found in layer B3, B2, and B4.
4. Observable slopes in artifact position are clearly shown from excavation data 2009 as well the gap between sub-layers. This phenomenon sometimes cannot be seen from excavation data 2002 due to different method in recording system.

![Figure 3.2 Lithic artifact repartition (from southeast of excavation orientation) shows arbitrary layering based on gap between remains (from below to top: layer C red, layer B4 orange, layer B3 blue, layer B2 green and layer B4 rose). The separation stage between each layers need to be done by making section plans in certain location. This strategy was applied due to the inconsistency of artifact positions within the layers (picture: Fauzi, 2011).](image)

Classification has been made on both plotted and unplotted lithic remains in order to simplify the analytical process (see section III.2). Furthermore, the result of plotted lithic remains classification was integrated into a spatial analysis to get the information about the distribution of each category in every layer. Our observation on the result given by categorization and three dimensional distribution shows that each layer have similar distribution of each lithic category based on its quantity (debris always appear to be dominant, followed by flakes, cortical flakes, tools, and nuclei). The result of lithic artifacts distributions in each layer is available in table 3.1 and figure 3.3.
Table 3.1 Distribution of each category of plotted remains on each layer.

<table>
<thead>
<tr>
<th>Layer</th>
<th>Flakes</th>
<th>Cortical Flakes</th>
<th>Tools*</th>
<th>Nucleus</th>
<th>Debris</th>
<th>Hammerstones</th>
</tr>
</thead>
<tbody>
<tr>
<td>B1</td>
<td>87</td>
<td>28</td>
<td>28</td>
<td>9</td>
<td>127</td>
<td>-</td>
</tr>
<tr>
<td>B2</td>
<td>89</td>
<td>34</td>
<td>24</td>
<td>13</td>
<td>93</td>
<td>1</td>
</tr>
<tr>
<td>B3</td>
<td>275</td>
<td>112</td>
<td>82</td>
<td>41</td>
<td>346</td>
<td>3</td>
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<td>2</td>
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<td>13</td>
<td>2</td>
<td>2</td>
<td>4</td>
<td>5</td>
<td>-</td>
</tr>
<tr>
<td>Total</td>
<td>492</td>
<td>192</td>
<td>144</td>
<td>69</td>
<td>612</td>
<td>5</td>
</tr>
</tbody>
</table>

*Not including two tools from sieving because position could not be traced.

Figure 3.3 Distribution of lithic remains based on classification and layers show the same normal distribution between débitage products. Notice the different proportion of the nucleus and other débitage products in layer C and other layer B.

Compared to the total distribution of class, there are no significant differences, except in layer C, where nuclei were found with a larger proportion than the products. To explain this, I would rather to say that this layer represent a knapping site where the products were taken out after the activity was done. Meanwhile in layer all layer B, the knapping process was taken on the site and represent also habitation on the site, because the proportion between nuclei and the others débitage products are in normal proportion.

III.1.2 Site Formation Process

Two analytical methods were used in order to have a description of formation process that probably has occurred to Tabuhan site, especially in the upper layer where the lithic artifacts are abundance. Methods have been use to investigate this phenomenon are Kernel density analysis and single variable in direction pattern analysis.

III.1.2.1 Density analysis

Even though by only observing points of plotted artifact we can see difference density, Kernel density provide us a better view by making an estimated density (number of points per areas)
because it shows by colored contour. The picture produced by Kernel Density analysis shows that the majority of the artifacts are distributed on the northeast of excavation orientation. Regarding the position of excavated area which is near to the cave entrance this formation process might be a result of natural form of the cave floor. Our observation on the cave entrance revealed a position of cave wall which is oriented the same direction with the artifact distribution (i.e. northeast orientation and inclination towards the inner cave. The result of this analysis can be considered as the representation of position and orientation of the occupation levels in Tabuhan cave during the Preneolithic cultural period.

![Figure 3.4](image1.png)

**Figure 3.4** Density appearance of each sub-layer and layer C, color related to density estimation in points per area (meters) which is presented graduated from the lowest in blue and the highest in red. Notice that this view is taken from northeast to east-west on excavation orientation in purpose of better presentation.

![Figure 3.5](image2.png)

**Figure 3.5** Three dimensional plotting system illustrates lithic remains from Tabuhan have been slightly oriented towards northeast (view from northwest excavation orientation). Small box on bottom left show orientation and horizontal distribution of total lithic remains (picture: Fauzi, 2011).
III.1.2.2 One sample Direction Analysis

Analysis undertakes on the database of Tabuhan cave remains direction has confirmed the density analysis and the observation on the tri-dimensional remains distribution. Unfortunately, there were only 666 lithic remains can show their direction meanwhile the rest of them are listed have no direction or not recorded. To solve this problem, their direction of all categories of remains except stone (bone, tooth, jaw, charcoal, potsherd, mollusk, and chert) with maximum length 10 cm were plotted in rose diagram. This diagram shows us the higher presence of remains to be oriented to north-south and northeast-southwest.

Even it very weak, indeed there is a pattern in artifact orientation. This phenomenon might be related to the initial morphology of the occupation floor. This condition confirmed with the general inclination of the cave floor in recent days which is slightly dip into inner part of the cave (north of excavation orientation). Unfortunately, only one sample (horizontal) directions were recorded. Combination of artifacts direction and recording of vertical orientation (the direction of inclination) in the future field research will give extra information concerning the site formation process in Tabuhan cave.

![Rose diagram showing weak pattern in archaeological remains direction](image)

Figure 3.6 Rose diagram showing weak pattern in archaeological remains direction (refer to excavation direction). Right picture show no significant pattern on lithic artifacts direction. Concerning only 666 data available in the database this diagram is cannot represent the population. In the other side, data from the direction of total remains shows there is weak appearance of pattern. Majority of the remains have directions towards NS and NESW (Data: Sémah et al., 2012 in prep; picture: Fauzi, 2011).

III.2 Classification of lithic remains

Total numbers of lithic artifact being analyzed during excavation campaign 2010 to support this research are 1.516 lithic remains (including 1.511 rijang and 5 hammerstones) from recorded pieces and from sieving material there are 1.858 pieces. Recorded artifacts (i.e. being plotted during excavation) were divided in several categories, meanwhile observation on sieving objects only add
negligible number in this category. Description of the classification has been made are listed in a table 3.2 below:

Tabel 3.2 Distribution of artifact category based on classification of artifact type

<table>
<thead>
<tr>
<th>Category</th>
<th>Number of remains</th>
<th>% among collection</th>
<th>Weight (grams)</th>
<th>% among collection</th>
<th>Note</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flake</td>
<td>492</td>
<td>32.6</td>
<td>5915</td>
<td>22.4</td>
<td></td>
</tr>
<tr>
<td>Cortical Flake</td>
<td>192</td>
<td>12.7</td>
<td>3558</td>
<td>13.5</td>
<td></td>
</tr>
<tr>
<td>Tool</td>
<td>146</td>
<td>9.7</td>
<td>3562</td>
<td>13.5</td>
<td>Two flake tools taken from sieving GT.09.D3 and C3, layer not found</td>
</tr>
<tr>
<td>Nucleus</td>
<td>69</td>
<td>4.6</td>
<td>8051</td>
<td>30.5</td>
<td>One nucleus from sieving No. GT.09.D3.D1</td>
</tr>
<tr>
<td>Debris</td>
<td>612</td>
<td>40.5</td>
<td>5310</td>
<td>20.1</td>
<td></td>
</tr>
<tr>
<td>Hammerstone</td>
<td>5</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>Not included in percentage of débitage products</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>1516</strong></td>
<td><strong>100</strong></td>
<td><strong>26396</strong></td>
<td><strong>100</strong></td>
<td></td>
</tr>
</tbody>
</table>

Figure 3.7 Distribution of Tabuhan cave lithic artifact based on classification in type of débitage products. Proportion between each category is an evidence of a workshop site where the knapping activity occurred on the place. Usually debris is the most numerous remains, meanwhile nucleus is the lowest. Significant appearance of cortical flakes among the assemblage (13%) allowed us to make a hypothesis that the full débitage activity was occurred on the place.

Interpretation from this categorization is there is a normal distribution of each débitage activity which is usually produces a lot of debris, followed with flakes, cortical flakes and nucleus. Tools refer to a intentionally retouched pieces (can be came from flake or debris) also show a normal appearance in their number because indeed, using of a stone implements are not only provide by retouched pieces, but also a direct using. This result can be biased by this view (see Forestier 1998 & 2007) because he already describe the “utilized flakes” based on macroscopic analysis. However, it
was very difficult to observe and determine the utilization traces on the lithic collection only by macroscopic observation.

From the cortical flakes, 13 % (n=1.511) of their appearance can be considered as a significant number. Indeed I arrive in a conclusion that the débitage was happen on the site including decortications of nodule. To be noticed, we not suggest the using of term decortication in the Gunung Sewu Preneolithic industry because from my observation, this activity is not clearly appeared. This is because Preneolithic peoples also utilize cortical flakes directly or as a support of retouched pieces. This phenomenon will be completely described in the next part in this chapter.

III.3 Chaîne Opératoire Study

Regarding the appearance of all similar elements of lithic assemblage that can be brought from experimental knapping and in addition the proportion of each débitage products, it is possible to investigate nearly complete information of the chaîne opératoire from Tabuhan caves lithic collection. To describe the information we have acquired through several analyses I will describe the character and information in systematic order from the earliest stage, from procurement stage until further modification which will be represented by retouched pieces in tool typology. I realize that it is not fully complete explanation of human behavior in lithic industry, but I believe that the information I gathered and synthesized will give a big contribution in the study of chaîne opératoire.

III.3.1 Raw material procurement

Raw materials that had been used in Tabuhan cave to support débitage activity are mostly chert with a high diversity based on its color and texture (macro characteristics). This diversity reflects the type of major quarrying site which is probably a river. River is a natural reservoir of varied eroded material including nodules from bedded chert in the surrounding area (see Odell, 2003: 21). To test this preliminary hypothesis I use several ways in order to explain the nature of the raw material and its connection with human behavior. Cortex appearance, macro-characteristic, and micro-characteristic of raw material have become the parameters we chose to gain the information from Tabuhan lithic collection.

Figure 3.8 George H. Odell originally describe three possible localities of chert which I simplified as two, surface outcrops and river quarrying site. River quarrying site usually result of a mixed localities of a chert pebbles (taken from Odell, 2004: 22-23).
III.3.1.1 Type of rocks used

Classification of rock type from archaeological sites is often not practical because the artifacts in one assemblage are usually very homogeneity based on its general type of rock (e.g. chert, obsidian, sandstone etc). Indeed it is already clear by sort of previous research that during the prehistory chert was a preferable raw material to supports knapping activities in Gunung Sewu area, exclusively Punung Region (see Simanjuntak et al., 2004: 153-156; Simanjuntak, 2001: 154; Simanjuntak and Sémah, 2005: 6; Simanjuntak and Asikin, 2004: 16-17; Forestier, 1997: 142-145; 1999: 139; 2000: 539-544; Semah et al., 2004: 47; Reawaru, 2005: 52). Regarding all of previous research have already explained that chert is the most used material in lithic industry of Punung area, I will not pointing this analysis to the same subject. For me characterization among chert itself will give information about the type of quarrying site where the raw material were originally came from.

The very first stage of analysis in raw materials was done by macroscopic observation based on four parameters: color, surface texture, glassiness (luster), and relative homogeneity. This observation was applied only on Tool category with a reason that retouched implements are the clearest evidence of human modification on lithic materials and its utilization. However, limited observation on retouched implements is also reflecting the whole assemblage in more narrow scopes and efficient time consumption.

This analysis resulting that it is very difficult to make a general category with such have been done by Hubert Forestier and Stevanus Reawaru based on color and texture. Categorization based on color resulting nine groups. Meanwhile three classifications based on texture of raw material shows that most of them having a smooth surface, with low to absent transparency on its edge, and average homogeneity (figure 3.9 and 3.10 below). We can consider the general overview of the raw materials that have been used in Tabuhan cave is a siliceous rock with a high variability on its physical characteristics. This result shows that raw materials were brought from a quarrying site that contained high variability of silicified rocks. This kind of quarrying site is the character of secondary geological position site which is usually can be found in a river or colluviums deposits.

![Classification of raw material by color](image)

Figure 3.9 Histogram above shows us a variety in raw material colors appear in tool category (notice that population not including tools from layer C).
III.3.1.2 Characteristic of mineralogy

Fifteen samples were collected from the debris category to characterize the mineralogy and characteristics of the raw material of Tabuhan lithic collection. Because of the limitation on its dimensions, only four of them were taken for a thin section in order to have a petrographic description. Eleven samples which is the rest were analyzed by infrared spectrometry to obtain mineralogical characteristics. The descriptions of macroscopic characters of the samples are listed in table 3.3 below.

Table 3.3 Description of the samples of lithic remains from Tabuhan Cave

<table>
<thead>
<tr>
<th>No</th>
<th>Sample box number</th>
<th>Color (munsell rock color chart 2010)</th>
<th>SURFACE</th>
<th>Transparency (related to silica contained)</th>
<th>note</th>
<th>History of Analysis</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>GT.10.1 A</td>
<td>5R 4/6 MODERATE RED</td>
<td>Smooth</td>
<td>Low</td>
<td></td>
<td>Thin section &amp; infrared</td>
</tr>
<tr>
<td>2</td>
<td>GT.10.2 B</td>
<td>10YR 8/4 PALE YELLOWISH ORANGE</td>
<td>Smooth</td>
<td>Medium</td>
<td></td>
<td>Infrared</td>
</tr>
<tr>
<td>3</td>
<td>GT.10.2 C</td>
<td>5Y 7/2 GREYISH YELLOW GREEN</td>
<td>Smooth</td>
<td>Medium</td>
<td></td>
<td>Infrared</td>
</tr>
<tr>
<td>4</td>
<td>GT.10.3 A</td>
<td>10GY DUSTY YELLOWISH GREEN</td>
<td>Rough</td>
<td>Low</td>
<td></td>
<td>Infrared</td>
</tr>
<tr>
<td>5</td>
<td>GT.10.3 B</td>
<td>5Y 3/2 OLIVE GREY</td>
<td>Medium</td>
<td>Smooth</td>
<td></td>
<td>Infrared</td>
</tr>
<tr>
<td>6</td>
<td>GT.10.3 C</td>
<td>NB VERY LIGHT GREY</td>
<td>Smooth</td>
<td>Low</td>
<td></td>
<td>Infrared</td>
</tr>
<tr>
<td>7</td>
<td>GT.10.3 D</td>
<td>N3 WHITE</td>
<td>Smooth</td>
<td>Medium</td>
<td></td>
<td>Infrared</td>
</tr>
<tr>
<td>8</td>
<td>GT.10.4 A</td>
<td>10YR DARK YELLOWISH ORANGE</td>
<td>Rough</td>
<td>Low</td>
<td></td>
<td>Thin section</td>
</tr>
<tr>
<td>9</td>
<td>GT.10.4 B</td>
<td>5R 4/6 MODERATE RED</td>
<td>Smooth</td>
<td>Medium</td>
<td></td>
<td>Infrared</td>
</tr>
<tr>
<td>10</td>
<td>GT.10.4 C</td>
<td>10YR 3/2 GREYISH BROWN</td>
<td>Smooth</td>
<td>High</td>
<td></td>
<td>Infrared</td>
</tr>
<tr>
<td>11</td>
<td>GT.10.4 D</td>
<td>N3 DARK GREY</td>
<td>Smooth</td>
<td>Medium</td>
<td></td>
<td>Infrared</td>
</tr>
<tr>
<td>12</td>
<td>GT.10.5 A</td>
<td>10R 3/4 DARK REDDISH BROWN</td>
<td>Rough</td>
<td>Low</td>
<td></td>
<td>Thin section</td>
</tr>
<tr>
<td>13</td>
<td>GT.10.5 B</td>
<td>10YR 5/4 DARK YELLOWISH BROWN</td>
<td>Smooth</td>
<td>Low</td>
<td></td>
<td>Infrared</td>
</tr>
<tr>
<td>14</td>
<td>GT.10.5 C</td>
<td>5Y 6/2 GREENISH GRAY</td>
<td>Smooth</td>
<td>Medium</td>
<td></td>
<td>Thin section</td>
</tr>
<tr>
<td>15</td>
<td>GT.10.5 D</td>
<td>10YR 4/6 DARK YELLOWISH ORANGE</td>
<td>Smooth</td>
<td>Medium</td>
<td></td>
<td>Infrared</td>
</tr>
</tbody>
</table>
III.3.1.2.1 Petrography description

Several microscopic characteristics of raw material in Tabuhan lithic collection were identified on four thin sections (30 µm). All of the materials that were cut into thin sections have preliminarily been identified as chert (containing one piece of jasper). Quartz, in the form of micro-chalcedony, is the major mineral phase of this kind of rocks (Odell, 2003: 19; Rapp, 2009: 76). The description of the content of auxiliary minerals appears to be useful for distinguishing different chert which is not only limited on Tabuhan lithic collection but also from Gunung Sewu.

Sample no GT.09.A5 (layer GT.09.C4.F1, ZTg 0.85 to -0.91 cm) shows impurities of a siliceous rock (chert) by appearance of feldspar (KAlSi3O8) and hematite (Fe2O3) (photo 3.1). Feldspar mineral in this sample represents by crystals with simple twining under microscope observation (MacKenzie and Guilford, 1986: 126; van Deer Plas, 1966: 145-167). The presence of feldspar within this chert was ascertained through non destructive infrared reflection spectroscopy. The spectra of the chert GT.09.A5 show the typical quartz bands (Spitzer, 1961) and a relatively strong band at 580 cm⁻¹, indicating feldspar within the quartz matrix (Farmer, 1974). The appearance of this mineral (photo 3.1) indicates volcanic activity, because feldspar commonly crystallizes in magma. However its appearance can also be associated with metamorphic rocks (i.e. as a “daughter” in the rock cycle). Its appearance within limestone formations (in this sense Wonosari formation) appears uncommon. However Rapp (2009: 79) has mentioned that feldspar and the other minerals (e.g. clays and iron oxide) can be presented in a chert due to its impurities. Hence, I can only assume that the occurrence of K-feldspar is connected with volcanic activity nearby the area, creating a useful indicator for this particular type of chert. The presence of the iron oxide hematite (Fe2O3) is suggested by the cubic shape of some of the opaque minerals on the section of sample GT.09.A5. The presence of iron oxide is also probably due to alteration of pyrite (FeS₂, crystallizing in cubic system) (Puaud, 2011 personal communication).

Photo 3.1 Two microphotographs from the same thin section (GT.09.A5) show a crystal of K-feldspar (a) and opaque iron oxide (b) in a chalcedony matrix (chert).

The appearance of silicified micro-organisms is common in chert from marine limestone host rocks (Selley et al., 2005: 54-55). Several fossils were observed in the thin sections from sample GT.09.5C and 4A (both from layer GT.02.P5A.16EAF1 within depth ZTg -0.85 to -0.90 m) that have not been identified yet (except one which is probably a foraminifer). It was only two samples from
Tabuhan cave that shown the appearance of microorganism fossils. These fossils can be used as indicator in the finding of the origin of the raw material from this limestone formation.

Jasper is a red opaque massive form of chalcedony in which a type of chert that characterized by its reddish color caused by hematite (Trewin and Fayers, 2005: 51; Trendall, 2005: 37). Clay minerals make up a significant part of this deep sea sedimentary rock (Rapp, 2009: 55). These rocks, originally formed on the sea floor (i.e. ophiolithic suite), commonly show traces of tectonic activity, due to the uplift event they experienced (Metcalfe, 2005: 169). The jasper sample GT.02.A1, which was found in layer GT.02.PSA.16EAG1 at a depth of -0.90 to -1 m (figure 13) also shows red color and indications of tectonic deformation. The heterogeneity of the reddish color seems to be the result of the differential abundance of iron oxides in the sub-cortical area and the inner part of the rock. This sample shows a high level of homogeneity without any radiolarian fossils which would usually be the case for jasper.
III.3.1.2.2 Mineralogy description

Analysis of mineralogy was done by using Fourier Transform mid-Infrared (400-4000 cm\(^{-1}\)) Spectroscopy, Attenuated Total Reflection with 60 repetition of measurements for each sample. Eleven samples of raw material from Tabuhan lithic collection are showing a similar shape of spectrum between the frequencies 400-4000 cm\(^{-1}\), especially between frequencies 400-1200 cm\(^{-1}\). One remarkable character observed is the absorption band peak around 555-510 cm\(^{-1}\) in all samples which is fitted to the character of chalcedony absorption band (see Schmidt and Fröhlich, 2011: 1476). Even though not all samples are showing their peak around those frequencies, most of them are having a weak signal at the same frequency (see figure 3.11). This mineralogical characteristic can be used as identification of Tabuhan lithic collection and Gunung Sewu in more general scope.

Figure 3.11 Superimposed spectrum of absorption band within the sample from Tabuhan lithic collection. Specified character of chalcedony absorption band at around 555 cm\(^{-1}\) (Schmidt and Fröhlich, 2011: 1476) is shows by arrow.

Table 3.4 Distribution of peak absorption band within Tabuhan lithic collection samples

<table>
<thead>
<tr>
<th>Sample</th>
<th>Peak 1</th>
<th>Peak 2</th>
<th>Peak 3</th>
<th>Peak 4</th>
<th>Peak 5</th>
<th>Peak 6</th>
<th>Peak 7</th>
</tr>
</thead>
<tbody>
<tr>
<td>GT.10.2B</td>
<td>1161.75</td>
<td>1064.49</td>
<td>794.24</td>
<td>776.8</td>
<td>694.58</td>
<td>weak</td>
<td>448.94</td>
</tr>
<tr>
<td>GT.10.2C</td>
<td>1161.95</td>
<td>1051.2</td>
<td>794.17</td>
<td>775.95</td>
<td>694.49</td>
<td>514.8</td>
<td>449.82</td>
</tr>
<tr>
<td>GT.10.4B</td>
<td>1161.8</td>
<td>1054.16</td>
<td>793.97</td>
<td>776.39</td>
<td>694.34</td>
<td>556.26</td>
<td>451.84</td>
</tr>
<tr>
<td>GT.10.4C</td>
<td>1161.86</td>
<td>1055.85</td>
<td>794.25</td>
<td>776.65</td>
<td>694.52</td>
<td>weak</td>
<td>449.42</td>
</tr>
<tr>
<td>GT.10.4D</td>
<td>1161.71</td>
<td>1054.71</td>
<td>794.22</td>
<td>776.47</td>
<td>694.37</td>
<td>weak</td>
<td>450.91</td>
</tr>
<tr>
<td>GT.10.3A</td>
<td>1161.91</td>
<td>1057.52</td>
<td>795.02</td>
<td>776.98</td>
<td>694.45</td>
<td>510.67</td>
<td>450.5</td>
</tr>
<tr>
<td>GT.10.3B</td>
<td>1161.7</td>
<td>1054.78</td>
<td>794.53</td>
<td>776.57</td>
<td>694.69</td>
<td>weak</td>
<td>448.91</td>
</tr>
<tr>
<td>GT.10.3C</td>
<td>1161.75</td>
<td>1050.87</td>
<td>794.1</td>
<td>776.04</td>
<td>694.5</td>
<td>weak</td>
<td>449.65</td>
</tr>
<tr>
<td>GT.10.3D</td>
<td>1161.78</td>
<td>1055.04</td>
<td>794.04</td>
<td>776.83</td>
<td>694.65</td>
<td>weak</td>
<td>448.22</td>
</tr>
<tr>
<td>GT.10.5B</td>
<td>1161.74</td>
<td>1055.58</td>
<td>793.55</td>
<td>776.75</td>
<td>694.55</td>
<td>weak</td>
<td>446.72</td>
</tr>
<tr>
<td>GT.10.5D</td>
<td>1161.73</td>
<td>1052.91</td>
<td>793.55</td>
<td>776.13</td>
<td>694.43</td>
<td>weak</td>
<td>447.34</td>
</tr>
</tbody>
</table>
III.3.1.3 Raw material provenience

The appearance of cortex and old weathered surface (archaeologist often classify it as neo-cortex) among lithic assemblage can show us more or less type of the original quarrying site. The same analysis has been done by Hubert Forestier and Stevanus Reawaru on the lithic collection from Song Keplek and Song Terus (see Forestier, 1998; 2007; Reawaru, 2005). As a summary, Song Terus shown a strong indication of raw material quarrying at outcrops or surface site indicated by very low appearance of old patination and less eroded cortical surface among the collection (Reawaru, 1997: 52-57). Result from macro observation on the surface of among the lithic collection from Tabuhan cave gave us interesting differences as shown in figure 3.12 below.

![Figure 3.12 Chart on the left shows the global percentage of raw material provenience by assessing the cortex appearance. Histogram on the right describes more specific distribution of raw material provenience within the category of lithic artifacts (Note: population not including layer C).](image)

The results of this analysis showing that the majority of the raw materials are came from the river quarrying site (64%), meanwhile the pieces have been identified to be originated from outcrops is only 24 % or approximately one third of which came from the river (3.12 for the complete result). This is an interesting subject to discuss; regarding different results was carried out by same analysis on a neighboring site, Song Terus. The appearance several old artifacts that have been modified (see section 3.3.1.5 in this chapter) supporting hypothesis that the prehistoric people of Tabuhan cave quarrying most of their raw materials for débitage activity from river or its terraces.

Concerning the location of two nearest river is only 190-200 m (Kali Banjar and Sirikan, this result is not strange but indeed, the different result carried out from nearby site, Song Terus, can provide further interpretation. From the previous research made by Reawaru (2005: 57) it is clear that Preneolithic people of Song Terus brought the most of raw material from an outcrops or surface...
quarrying site. Near this cave there are two locations where the abundant block of chert can be found, Ngrijang Sengon and Ngrijangan, situated at 1.76 km from Song Terus. Meanwhile the evidences from Tabuhan cave shows that the raw materials are mostly came from the river.

III.3.1.4 The cortical face appearance

Significant appearance of cortical part on the dorsal face of a flake and surface of the debris will give us information related with the strategy of exploitation. Significant percentages of cortical face also show that the débitage process was completely done on the site from the initial form of raw material (nodule or block).

![Figure 3.13 Cortex appearance within the category in Tabuhan lithic collection (note: population not including objects from layer c)](image)

Interesting result was shown on the percentage of cortex appearance within tools category with a flake or debris as a support. It was more than a half or to be precise 47% are showing varied percentage of cortical appearance on its dorsal face. From this result, it is clear that there was no indication of decortications or intentional activity of removing cortex to obtain non cortical flakes as a support for making retouched implements. This result is in contrary with the result of lithic analysis from song Terus, where it seems that there was decortications activity outside the site (represents by 66% of non cortical flakes), most probably on the quarrying site (see Reawaru 2005: 58-59; see also Kesar et al. in Adams and Blades, 2009: 146). Nevertheless, this result confirms the similarity between Holocene lithic assemblages from Song Keplek and Tabuhan cave where a lot of retouched implements showing cortical back. Tabuhan cave lithic collection is showing as well the expeditive strategy in lithic materials exploitation.
III.3.1.5 Scavenging Behavior (Reuse and Recycle activity)

Five artifacts from Tabuhan lithic collection were identified as old artifacts which are clearly must have been originated from river, shows by eroded surface and thick patina. Two artifacts are shown no further modification on its surface (GT.02.P5A.16EAC1.31 and GT.02.P5A.16EAD1.405) but several relatively new alterations (chipped?) were observed on its margins. This alteration represents direct using of these the old artifacts without any further modification (e.g. retouching). The appearance on relatively older artifacts among Tabuhan Lithic collection is an evidence of scavenging of stone tools artifacts by prehistoric man (see Camilli and Ebert, 1992: 120 in Rossignol and Wandsnider, 1992: 113-133).

Further modification was observed on three old artifacts which are shown by fresh retouch (non-patina surface and sharp angle on its margin). Specimen number GT.02.P5A.16EAE1.567 shows total retouching its lateral left by direct position, short extent, stepped morphology, and low angle with delineation rectilinear. Artifacts no GT.09.D4.F1.2936 shows new retouch on lateral right respecting another retouch on the left side. The retouches are distributed totally on lateral right, in alternating position, short extent, parallel morphology with semi abrupt angle and form a denticulate delineation. Another old artifact (GT.09.C3.G1.2462) shows retouch located totally on all edges, on direct position, invasive extent, sub-parallel morphology with abrupt angle and denticulate delineation. These three artifacts show the recycling behavior (see Schiffer, 1976: 38) by modifying and/or utilizing old artifacts which probably have been found together with nodule of chert on the river. The appearance of five old artifacts with clear evidence of transportation by water stream supporting our hypothesis in deciding river location of major quarrying site.
III.3.1.6 Characteristics in raw material exploitation behavior

The main purpose for this observation is to categorizing the stage of nucleus exploitation based on dimension and the availability of striking platform. Four categories have been made for 65 nuclei (including 7 nodule of chert) in Tabuhan lithic collection.

1. Nucleus stage 1
   Nodule of raw material which has been tested shows by only less than 5 facets and left the whole cortex or old patination on its surface. This type of nucleus was 11% from total nucleus.

2. Nucleus stage 2
   Nucleus which already has been exploited shows by more than five facets but still show availability of the striking platform for the successive débitage. This type of nucleus contributes 12% in total nucleus collection.

3. Nucleus stage 3
   Exhausted nucleus with no striking platform but its dimension is still give an opportunity for further exploitation by rejuvenation or bipolar knapping method (breaking). This type of nucleus contributes 31% among the total nucleus collection.

4. Nucleus stage 4
   This category refers to exhausted nucleus with very small dimension which is impossible for further exploitation. This nucleus similar to debris but oriented facets indicates clear marks of intentional removal such we found on the other nucleus. This type of nucleus contributes 46% among the total nucleus collection.

The most of nuclei have found are already exploited, which is described by domination from nucleus stage 3 and 4. It means that the exploitation of raw material was maximal until the nucleus...
becoming exhausted. The appearance of several tested nodule of chert also gave us an opportunity to understand the initial dimension of chert nodule have been exploited in the cave. Comparison between measurements of the exploited and unexploited nuclei can be used as a base in reconstructing the average size of the initial nodule being transported into the cave.

III.3.2 Reconstruction of initial dimension and volume of Raw Material brought into Tabuhan cave

Categorization of nucleus from Tabuhan lithic collection allowed us to separate the nucleus with small stage of exploitation (nodule of chert) and the exploited (faceted bolas) (see previous section in this chapter). This separation was showing that five nucleus has been exploited on minimal stage which is allowing us to observed its initial shape and dimension. Five objects have been identified as a minimal exploited nodule of chert (one among these nodule probably quartzite) which can be divided by two based on their shape rounded nodule and slab (flattened) nodule.

Two nodule of chert among Tabuhan lithic collection are showing slab form which is minimally exploited by utilizing natural flattened surface as a striking platform. Objects number GT.02.PSA.16EAD1.157 found in layer B1 is showing a thick reddish brown patina on its surface suggest that it was came from the river. Objects number GT.02.PSA.16EAF1.837 has no patina on its surface. However, eroded surface on its cortex also indicates that it was originated from the river.
Three minimal exploited nucleus which is appear as a nodule were found under excavation at layer B3 (no GT.02.P5A.16EAD1.451; GT.02.P5A.16EAF1.982 and GT.02.P5A.16EAF1.1147). These nodules have varied number of facets (two facets and five facets) and have been identified as a result of anthropic activity based on the morphology of negative bulb and position of the striking platform that has been used. These nodules represented the form and initial volume of the raw materials which were brought into Tabuhan cave in a natural nodular form. Another important issue is these three chert nodules are showing characteristics of raw material originated from the river.

From measurements three nodules found in Layer B3 did not have significant differences because the maximum value of standard deviation is only 5.67 mm which is appear on maximum width measurements (see table 3.5). This is the first indication of the nearly similar dimension of the nodule shape raw materials which were collected from the river. This similarity can be a result of natural sorting by geological processes or anthropic activity (i.e. standardization).

<table>
<thead>
<tr>
<th>Notes</th>
<th>Max Lenght</th>
<th>Max Width</th>
<th>Max Thickness</th>
</tr>
</thead>
<tbody>
<tr>
<td>GT.02.P5A.16EAD1.451</td>
<td>97.8</td>
<td>81.6</td>
<td>71.5</td>
</tr>
<tr>
<td>GT.02.P5A.16EAF1.982</td>
<td>101.5</td>
<td>86.5</td>
<td>65.3</td>
</tr>
<tr>
<td>GT.02.P5A.16EAF1.1147</td>
<td>104.8</td>
<td>75.2</td>
<td>67.2</td>
</tr>
<tr>
<td>Mean</td>
<td>101.4</td>
<td>81.1</td>
<td>68</td>
</tr>
<tr>
<td>SD</td>
<td>3.50</td>
<td>5.67</td>
<td>3.18</td>
</tr>
</tbody>
</table>

These three nodules are minimal exploited nucleus which makes it possible to measure its maximum volume in spherical form that can be considered nearly the exact volume before it was knapped. Knowing the approximate volume of these three nodules can be used as a reference in correlating the débitage products and the nucleus. From the experimental point of view, the value of real volume which is measured by scaled glass gave us nearly the same value with measuring volume of nodule by using volume equation of sphere. This calculated volume was carried out by using equation $V = \frac{4}{3}\pi r^3$, where $r$ (radius) were using the mean of maximum tri dimensional measurements (length, width, thickness).

Calculation of the volume of spherical model will also provide us the other important information. Reversed equation of spherical volume can give us the radius and diameter of the reconstructed initial nodule. Applying the volume of reconstructed nodule ($cm^3$) in reversed density (grams/cm$^3$) equation will provide us the approximate initial mass (in grams).
Diameter of the initial spherical chert nodule can be calculated by using equation

\[ r = \sqrt[3]{\frac{V}{4\pi}} \].

This reversed mathematic equation of volume will give us the mean of diameter nodular chert or the diameter on its spherical form. The result of reconstructed volume of spherical form can be used as a reference in calculating the approximate initial mass of chert nodule that has been brought into the cave by using mass (grams) = Volume (in cm\(^3\)) \times \rho\) (density) where \(\rho\) is using the density of quartz (±2.65 grams/cm\(^3\)) mineral because chert is primary composed by this silicate mineral (see Rapp, 2009: 63; Odell, 2004: 19).

Two chert nodules from Tabuhan lithic collection number GT.02.P5A.16EAD1.451 and GT.02.P5A.16EAF1.982 were measured its volume by using a beaker glass and water gave us the \textit{real volume ca.} 200 and 265 cm\(^3\). Meanwhile measurements by using spherical volume equation give the \textit{calculated volume} 305.68 and 313.84 cm\(^3\) or 52.8% and 18.4% larger than the \textit{real volume} we have measured. These two calculated volume can be considered as the \textit{maximum volume} of the two nodules in a spherical form. Meanwhile the same compared measurements applied on four nuclei found in Tabuhan lithic collection gave difference volume between 3 to 18% except for nucleus number GT.02.P5A.16EAF1.1089 which gave unacceptable difference about 95%. Nevertheless, four measurements is giving a nearly exact volume compared by two measurements that giving higher difference means that the method of \textit{volume calculation} in spherical form is trustworthy.

Table 3.6 Results of Measurement and Calculations of the Nodules volume from Tabuhan cave lithic collection.

<table>
<thead>
<tr>
<th>Notes</th>
<th>Max Lenght (cm)</th>
<th>Max Width (cm)</th>
<th>Max Thickness (cm)</th>
<th>Mean of dimension (cm)</th>
<th>(r = \frac{1}{2} \text{mean of dimensions}) cm</th>
<th>Volume (4/3 (\pi r^3)) cm(^3)/ml</th>
<th>Real Volume cc/ml</th>
<th>Percentage of difference (real volume to calculated volume)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GT.02.P5A.16EAD1.451</td>
<td>9.78</td>
<td>8.16</td>
<td>7.15</td>
<td>8.36</td>
<td>4.18</td>
<td>305.68</td>
<td>200</td>
<td>52.8</td>
</tr>
<tr>
<td>GT.02.P5A.16EAF1.982</td>
<td>10.15</td>
<td>8.63</td>
<td>6.33</td>
<td>8.44</td>
<td>4.22</td>
<td>313.84</td>
<td>265</td>
<td>18.4</td>
</tr>
<tr>
<td>GT.02.P5A.16EAF1.1147</td>
<td>10.44</td>
<td>7.52</td>
<td>6.72</td>
<td>8.24</td>
<td>4.12</td>
<td>292.70</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean</td>
<td>10.14</td>
<td>8.11</td>
<td>6.80</td>
<td>8.35</td>
<td>4.17</td>
<td>304.07</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>0.35</td>
<td>0.57</td>
<td>0.32</td>
<td>0.10</td>
<td>0.05</td>
<td>10.66</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 3.7 Results of Measurements and Calculations of the nuclei volume from Tabuhan cave lithic collection.

<table>
<thead>
<tr>
<th>Notes</th>
<th>Max Lenght (cm)</th>
<th>Max Width (cm)</th>
<th>Max Thickness (cm)</th>
<th>Mean of dimension (cm)</th>
<th>(r = \frac{1}{2} \text{mean of dimensions}) cm</th>
<th>Volume (4/3 (\pi r^3)) cm(^3)/ml</th>
<th>Real volume in cm(^3)/ml</th>
<th>Percentage of difference (real volume to calculated volume)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GT.09.D4.F1.2507</td>
<td>7.18</td>
<td>6.56</td>
<td>4.37</td>
<td>6.04</td>
<td>3.00</td>
<td>115.27</td>
<td>98</td>
<td>17.6</td>
</tr>
<tr>
<td>GT.09.D4.F1.2486</td>
<td>5.23</td>
<td>4.61</td>
<td>3.66</td>
<td>4.50</td>
<td>2.25</td>
<td>47.67</td>
<td>45</td>
<td>5.9</td>
</tr>
<tr>
<td>GT.02.P5A.16EAF1.1176</td>
<td>4.50</td>
<td>3.13</td>
<td>3.53</td>
<td>3.53</td>
<td>1.77</td>
<td>20.51</td>
<td>20</td>
<td>2.6</td>
</tr>
<tr>
<td>GT.02.P5A.16EAF1.1089</td>
<td>7.18</td>
<td>6.87</td>
<td>3.73</td>
<td>5.90</td>
<td>2.95</td>
<td>107.44</td>
<td>55</td>
<td>95.34 (l)</td>
</tr>
<tr>
<td>mean</td>
<td>6.00</td>
<td>5.29</td>
<td>3.69</td>
<td>4.99</td>
<td>2.50</td>
<td>72.71</td>
<td>54.90</td>
<td>30.35</td>
</tr>
<tr>
<td>SD</td>
<td>1.35</td>
<td>1.77</td>
<td>0.56</td>
<td>1.20</td>
<td>0.60</td>
<td>46.08</td>
<td>32.32</td>
<td>43.83</td>
</tr>
</tbody>
</table>

In making the reconstruction model we choose one sample of raw material which has the same macromorphological characteristics, such as color and texture. This separation was done in order to limiting the scope of the analysis, concerning high variability in raw materials from Tabuhan.
lithic collection. From the separation we observed four nuclei and hundred and five débitage products (including flakes, tools, debris) which have the same character on its raw materials. Four nuclei that we chose have varied volumes and forms. Volumes of these four nuclei were measured and calculated by spherical volume equations (see table 3.7).

Direct measurement of débitage products gave us a total volume ca. 700 cm³. This volume can be distributed proportionally into four nuclei we have measured before. Proportional distribution of débitage products volume was made by predicting the volume loss. This calculation is based on assumption that each nucleus was came from different nodule which has volume ca. 265 cm³ (taken from measured volume of the biggest nodule no. GT.02.PSA.16EAF1.982). Calculation we have made resulting an average volume of nodule ca. 229.5 cm³ (based on measurement) and 247.72 cm³ (based on calculation). These two average volumes are only 13% and 6.5% smaller than the biggest nodule found under excavation. Smaller volume in the reconstruction can be caused by the nature of archaeological data itself (not all remains were successfully collected) and volume loss that happen after knapping process (many small debris are scattered and lost). This reconstruction of volume gave us information about the similarity in volume of chert nodules which also related directly with their dimension (diameter and weight).

Table 3.8 Reconstruction of initial nodule based on sample(s) nuclei, débitage products, and biggest nodule from Tabuhan cave lithic collection.

<table>
<thead>
<tr>
<th>Reconstructed model</th>
<th>A</th>
<th>B</th>
<th>C</th>
<th>D</th>
<th>E</th>
<th>F</th>
<th>G</th>
<th>H</th>
<th>I</th>
<th>J</th>
</tr>
</thead>
<tbody>
<tr>
<td>Notes</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>GT.02.D8.1.5604</td>
<td>131.27</td>
<td>98</td>
<td>265</td>
<td>147</td>
<td>20</td>
<td>700</td>
<td>198.80</td>
<td>236.40</td>
<td>254.12</td>
<td>7.29</td>
</tr>
<tr>
<td>GT.02.D8.1.2486</td>
<td>47.67</td>
<td>45</td>
<td>263</td>
<td>120</td>
<td>26</td>
<td>700</td>
<td>182.90</td>
<td>227.50</td>
<td>238.17</td>
<td>1.17</td>
</tr>
<tr>
<td>GT.02.PSA.16EAF1.1276</td>
<td>20.51</td>
<td>20</td>
<td>265</td>
<td>247</td>
<td>29</td>
<td>700</td>
<td>203.68</td>
<td>227.90</td>
<td>230.19</td>
<td>0.22</td>
</tr>
<tr>
<td>GT.02.PSA.16EAF1.1089</td>
<td>107.44</td>
<td>53</td>
<td>263</td>
<td>210</td>
<td>25</td>
<td>700</td>
<td>174.50</td>
<td>229.50</td>
<td>228.02</td>
<td>2.84</td>
</tr>
<tr>
<td>Total</td>
<td>218</td>
<td>100</td>
<td></td>
<td>700</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mean</td>
<td>72.72</td>
<td>54.92</td>
<td>210.50</td>
<td>25.40</td>
<td>175.89</td>
<td>227.50</td>
<td>247.71</td>
<td>7.88</td>
<td></td>
<td></td>
</tr>
<tr>
<td>SD</td>
<td>46.08</td>
<td>32.32</td>
<td>32.32</td>
<td>3.36</td>
<td>27.69</td>
<td>5.40</td>
<td>25.14</td>
<td>10.45</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Reversed equation of spherical volume formula provides us the diameters of every calculation we have made. Our calculation resulting that the initial reconstructed nodules have a diameter ranged from 7 to 8 cm. This result is strongly supported by the dimension of flake and cortical flake which is the maximum length we found is only 7.6 cm in very small numbers, compared to another dimension. Meanwhile the calculation of nodules weight based on chert density and nodules volume resulting range of weight from 520 to 760 grams or less than one kilogram. The reconstructed weights have no significant differences with the weight of the biggest nodule we found under excavation which is about 750 grams. These reconstructions of volume, dimension and weight of initial nodule in summary showing that there is similarity on physical characteristic of nodule that have been exploited by prehistoric peoples of Tabuhan cave.
Figure 3.16 The box plot above show similarity of several dimensional parameters taken from initial nodule reconstruction, (from left to right): volume (bellow 300 ml), diameter (bellow 9 cm), and mass (bellow 1 kilogram).

Figure 3.17 Histogram (normal distribution fit shows by line) above shows that maximum length (cm) of the total débitage products are less than 8 cm. This histogram supported our reconstruction of initial nodule dimension with diameter ca. 7-8 cm.

III.3.3 Débitage

From the presences of all elements can be resulted from knapping process in Tabuhan cave, we can make a conclusion that the débitage activity was happened on the site. Very initial stage is characterized by cortex presence among the assemblage. Meanwhile the final stage in débitage activity shown by the presence of retouched implements. Varied kinds of hammerstones, both dimension and weight, also supported our preliminary assumption that Tabuhan cave is a workshop site where the full activity of knapping process was occurred inside the cave.
III.3.3.1 Technique

Until the last excavation (field work 2010) there are no organic materials which shown indication of utilization as an *indenter* (hammer) (Odell, 2003: 46). Based on this information, we consider that the débitage activity was supported only by hard hammers or hammerstone (Inizan et al., 1999: 142). From excavation 2002 and 2009 we have collected five stones (pebble and fossilized wood) which shown traces of utilization as a hard hammer (Inizan et al., 1999: 148). Hammerstones from Tabuhan lithic collection came from layer B2, B3, and B4. However, layer B3 seems contained more hammer stones (three objects) compare to another layer. The other remarks we found is almost all hammer stone located at D4 square. Variation of hammerstone dimension is related to their function, whether it was used for retouching or knapping. Large hammerstones seem being used in débitage activity; meanwhile smaller hammerstone was used for retouching (see Torre et al., 2008: 261-262).

Percussion tools which is only limited to stones in the Tabuhan lithic collection brought us to a conclusion that the technique that have been used is direct percussion with hard material (*i.e.* hard hammer or hammerstone). Our hypothesis is also supported by the characteristics of débitage products from Tabuhan lithic collection especially from *butt* and features on the ventral face.

<table>
<thead>
<tr>
<th>No</th>
<th>Artifact no.</th>
<th>Raw material</th>
<th>Dimension (max) in mm</th>
<th>Layer</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>Lenght</td>
<td>Width</td>
</tr>
<tr>
<td>1</td>
<td>GT.09.D4.NON.2532</td>
<td>Chert (nodule)</td>
<td>50.8</td>
<td>39</td>
</tr>
<tr>
<td>2</td>
<td>GT.09.D4.E1.2355</td>
<td>Andesite</td>
<td>86.8</td>
<td>69.9</td>
</tr>
<tr>
<td>3</td>
<td>GT.09.D4.C1.1740</td>
<td>Chert (nodule)</td>
<td>38.8</td>
<td>33.6</td>
</tr>
<tr>
<td>4</td>
<td>GT.09.D4.E1.2336</td>
<td>Chert (nodule)</td>
<td>105.2</td>
<td>85.5</td>
</tr>
<tr>
<td>5</td>
<td>GT.09.C4.E1.2210</td>
<td>Fossil wood</td>
<td>81.4</td>
<td>60.4</td>
</tr>
</tbody>
</table>

Table 3.9 Hammer stones from Tabuhan lithic collection

Photo 3.6 Example of two hard hammers (andesite and chert) in different dimension that found under excavation (photo and drawing: fauzi, 2010).
III.3.2 Débitage methods

Investigation on débitage method from Tabuhan cave lithic collection was carried out by observation on technological features in nuclei. This method of observation also done by Hubert Forestier and Stevanus Reawaru on Preneolithic remains from Song Keplek and Song Terus. Total numbers of nuclei that have been found in Tabuhan cave are 65 nuclei including 5 nodules of chert and 2 oblate spherical form of a pebble size chert. The observation was only taken on 58 nuclei which shows further modification of its form which is related directly to the exploitation of nucleus volume. This strategy of observation was done in order to have a better description on débitage method which is impossible to obtain from minimal exploited nodule or pebble of chert.

Variables that been used in this observation is the direction of débitage, location and numbers of striking platform(s). This observation resulted typology of the nuclei which is related directly to the method of débitage. Investigation on the débitage method also carried out by observation on several flake that show characteristic of Kombewa (janus flake) method. We included this method because of it was never been reported in previous research on Gunung Sewu Preneolithic culture.

<table>
<thead>
<tr>
<th>Striking Platform</th>
<th>Direction</th>
<th>Geometric form</th>
<th>Layer B1</th>
<th>Layer B2</th>
<th>Layer B3</th>
<th>Layer B4</th>
<th>Layer C</th>
<th>I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Single</td>
<td>Unidirectional</td>
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<td>1</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>8</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Amorphous</td>
<td>4</td>
<td>1</td>
<td>3</td>
<td>8</td>
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<td>10</td>
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<td>Opposed (bipolar)</td>
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<tr>
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<td>Amorphous</td>
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<td>11</td>
<td>37</td>
<td>2</td>
<td>58</td>
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</tr>
</tbody>
</table>

Table 3.10 Typology of nucleus from Tabuhan cave lithic collection

Figure 3.18 Histogram of nucleus typology based on direction of débitage and striking platform.
From the observation all of nuclei have the same algorithm of débitage which have already been described by Hubert Forestier (2007: 259). This algorithm is based on utilization of previous removal (A) as striking platform in the successive débitage (B) or in simple way formed as A/B algorithm. Inizan and Tixier (1999: 61) classify this method as a simple débitage because it does not have any preparation stage such as shaping the core as been found in predetermined débitage (e.g. levallois and blade). This method in detaching a flakes was also described by John Mcnabb (2007: 319-322) and given name as alternate flaking. He have described the varieties can be carried out by simple algorithm which is the most efficient way in exploitation volume of a core or block of raw material.

Nevertheless, the second most prominent method appeared is centripetal direction of débitage which represented by 14 nuclei (ca. 24%). The direction of débitage was unipolar along the edges of one striking platform which resulting pyramidal form of a core. However, volume exploitation of a nodule of raw material was dominated also by multidirectional débitage by using multiple striking platforms (c.a. 39%).

Several flakes are showing characteristic of Kombewa débitage method. The appearance of this method is not too significant among the flake category. We identified the flakes that were produced by this method by observing biconvexity on two flake faces (upper and lower) that have
the attributes of ventral face of a flake. Two striking platforms were also shown as well on the Kombewa flake that we have observed.

Kombewa method in Tabuhan cave lithic collection is not strictly connected to the Kombewa in 
\textit{sensu stricto}, a method that aimed specifically to obtain a regular circle, semi-circular or oval flake. Nevertheless, Kombewa flakes found in Tabuhan cave might be a result of removal a large flake which not intended to produce a Kombewa flake. Inizan and Tixier already explain the chance of producing unintentional Kombewa flakes which they have described as “Kombewa waste product” (see Inizan and Tixier, 1999: 71).

<table>
<thead>
<tr>
<th>Category</th>
<th>Layer B1</th>
<th>Layer B2</th>
<th>Layer B3</th>
<th>Layer B4</th>
<th>Layer C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flake</td>
<td>1</td>
<td>1</td>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Tool</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

Table 3.11 Distribution of kambewa flakes in Tabuhan cave lithic collection

III.3.3.3 General Characteristics of débitage products

Observation on the lithic collection from Tabuhan cave also being focused in the characterization of débitage products. Several characteristics we have been observed are technological characteristics of features on débitage products which in this analysis includes flakes, cortical flakes, and tools, especially on dimension and morphology.

III.3.3.3.1 Technological characteristics

Technological characteristic of débitage products is carried out by measurement and morphology of some features on flake and cortical flakes. From the measurement in technological orientation (see Inizan and Tixier 1999: 107) on débitage products we found out that there is weak sign of a tendency in producing elongated flakes. This is shown by more or less scattered points
between two area (x>y and x<y). However, from the point interpolation we can know that most of the points are scattered under line y=x, $R^2=1$. This is mean that indeed the technological length from most of the flakes have a bigger value than the width which also meaning an elongated flakes are more common in Tabuhan lithic collection.

![Figure 3.19 Plotted length/width of débitage products shows that there is tendency of producing elongated flakes but in a very weak sign. Point interpolation (r=1) shows that the points more scattered under y=x, $R^2=1$ or in area where length > width.]

Butt width in Tabuhan lithic collection is ranging from 0.5 to 25 millimeters with the most dominant group is which is between 5 to 7 centimeters. This characteristic can support our hypothesis in the direct débitage technique by using hard hammer (see Pelegrin 2000: 75). The butt width distribution of Tabuhan lithic collection is relatively thick which is related to the hard hammer has been used during the débitage.

![Figure 3.20 Histogram of butt width in Tabuhan lithic collection.](image)
Our observation also being focused in the characterization of the *tool-support* came from flake. We found that within the tool category, the percentage of a thick butt width was very common. This phenomenon is occurred in the box plot and percentile graph of comparison between tool, flake and cortical flake category. The thickness of butt might be related directly with the thickness of the flake. This is means that there was a selecting behavior in determining the support for a flake tool. Thick flake probably have been selected as support in retouch implements to avoid the flakes to be broken during the retouching.

Figure 3.21 Superimposed curves on the left side shows percentile distribution of butt width between flake (a), cortical flake (b), and tools (c). Comparative result of butt width among the category shows by box plot on the right side. Indeed, in both figure we found significant differences between tools and the other two categories. It is clear that retouched implements in Tabuhan cave have slightly thicker butt than cortical flakes and flakes.

Figure 3.22 Percentile of the thickness is also given the same result with comparison from butt width.
Our observation on butt morphology have resulted varied type of butt form. The most prominent category is plain striking platform. Meanwhile the second is facetted but and cortical butt. Our interest is the presence of cortical butt which is tends to be quite significant. The presence of cortical butt is an evidence of the first product of débitage which is taken on a complete form of nodule. This is mean that the full exploitations of raw material in a nodule form have been done totally inside the Tabuhan cave.

Flaking angle can provide the information of knapping technique have been used to obtain the flakes in knapping and débitage activity. Flakes made with a hard hammer can be separated from those made with a soft hammer. The depth of scar produce by hard hammer usually deeper than the scar produces by soft hammer (Drewet, 2011: 43). This condition must have affected the flaking angle located on lower face (ventral) of a flake. The flaking angle produced by hard hammer will be much wider than the one that produce by soft hammer.

Our observation on the variation of flaking angle shows a significant numbers of flakes (including tools and cortical flakes) that much wider than 95 degree angle and even more higher around 120-125 degree. This can be an evidence of the using hard hammer in the débitage activity during Preneolithic period in Tabuhan cave. Meanwhile the presence of narrower flaking angle is negligible concerning its quantity.
Technological characterization is also being carried out by describing the level of bulb of percussion prominence. Our observation shows that most of the specimen came from flake, cortical flake and tools have a prominent or very prominent bulb of percussion (about 58%). Meanwhile the less prominent bulb of percussion is about 39% among the observable specimen. It means that the presence of bulb of percussion is very common within the assemblage. Once again this observation also supports our hypothesis in determining the using of technique direct percussion with hard hammer in Tabuhan lithic collection.

Several knapping accident were observed among Tabuhan lithic collection. These knapping accidents have been identified as breaks (siret fracture and clean breaks) and peculiar termination (plunging or outrepassé termination) (see Inizan and Tixier, 1999: 34-36). Because of knapping accident usually produce unintended form of flake, it can be use as reflection of the level in controlling débitage process and the quality of the raw material has been used.
III.3.3.3 Alteration

Our observation on Tabuhan lithic collection was resulting two major types of alteration which we have identified by macroscopic observation. These alterations are thermal damage and concretion on several objects among the collection. Characteristic of thermal damage caused by fire already describe by Inizan and Tixier (1999: 92; 94). This alteration can be identified by reddish color and glossy-look on surface of the stone artifacts. Moreover, “pod-lid” fractures also become a character of thermal damage on siliceous rock (Inizan and Tixier, 1999: 92).

1. Burnt pieces

Not less than 141 remains from Tabuhan lithic collection have been identified as burnt artifacts. This alteration is shown by reddish color, glossy surface, and sometimes pod-lid fractures. The most numerous burnt pieces are came from debris category. Meanwhile layer B3 have been the most contributed layer where the burnt lithic remains came from (see figure 3.36). From our observation, reddish and glossy surface became the main characteristics of burnt lithic remains. Meanwhile fractures with pod-lid morphology are very rare among burnt lithic collection. Regarding significant number of burnt artifacts came from debris category; we conclude that
these burnt lithic remains are results of unintentional burning. Regarding the appearance of color change and luster, these remains might be exposed on a temperature exceeds 250° Celsius (see Inizan and Tixier, 1999: 92).

Figure 3.27 Histogram and table above shows the distribution of burnt remains that have been identified in Tabuhan cave lithic collection.

Photo 3.10 Burnt remains from Tabuhan lithic collection shows reddish color and thermal damage on its surface. Glossy and reddish color on surface became the most prominent evidence. Meanwhile pod-lid fractures like shown by remains no. GT.09.C3.D1.1902 are rarely found.

2. **Concretion of calcium carbonates (CaCO3)**

In Song Terus, the presence of calcium carbonates in the sediment can be use as indirect evidence of more humid phase in the cave and surrounding environment (see Sémah et al., 2004: 58). We can use this from other evidence such as concretion on artifacts. From our observation the concretion stage can be divided by 3 category based on the area covered by concretion itself compared to the surface area on the artifacts. Concretion stage one (low) was appeared to be the majority in all layer compared to concretion stage 2 (medium), and
concretion stage 3 (high). Most of the remains with carbonates concretion came from layer B3 (see figure 3.28). If we compare this data with the vertical distribution of oolith in the cave sediment there is accordance between the appearance of concretion on the remains and oolith. Indeed concretion on the surface of the remains can be related to more humid phase during the Holocene period in Tabuhan cave. However, this observation could not give any suggestion in defining the boundary between early Holocene and late Pleistocene layer like in Song Terus cave.

Photo 3.11 Oolith and heavy concretion of calcium carbonates on the surface of artifacts from Tabuhan cave found at depth ZTg - 0.8 m (photos: Fauzi & Purnomo, 2011).

Figure 3.28 Histogram and table above describe the distribution of concretion appearance on the Tabuhan lithic remains in each layer.

III.3.4. General Typology of Tools

General typology of tools is needed to confirm the similarity of Tabuhan lithic collection and the moustertoid type of tools from Preneolithic period of Gunung Sewu (see Forestier, 2007: 268). Our observations are including only retouched implements which are aimed to describe the position of cultural chronology of Tabuhan lithic collection. From tool category (144 pieces) we have
separated 140 tools which are supported by flakes (including broken and fragment of flakes) debris, and old artifacts. This separation was made in order to not mixing the old artifacts with no visible modification (2 specimen) (intentional retouch) and core tools (2 specimen).

Based on our categorization, the types of tool supports are very varied. Flake is the most dominant support type for retouched implements. Meanwhile, another type of support is dominated by fragmented flakes. We also found out that the fragments of a distal part of flakes (flake fragment) are more dominant than proximal part (broken flake). This is related to the character of a distal part which usually slightly thinner than the proximal part. This pattern shows the selection of distal part on fragmented flakes as support of tools beside the flakes. Other types of support also have been observed in tools category, such as debris, old artifacts and pebbles.

Based on our observation, indeed the similarity between Tabuhan lithic collection and the retouched assemblage from Song Terus and Song Keplek are very similar. The significant appearance of side scrapper, denticulate, and perçoir, and notch indicates the same technological aspect between Tabuhan cave and the other two neighboring sites, Song Keplek and Song Terus. The only difference in the typology is no occurrence of limace (Forestier, 1998; 2007: 196), an extremely thick flake with several removals on its edges.

Figure 3.29 Distribution of tools supports in Tabuhan lithic collections.
Table 3.12 General Typology of Stone Tools in Tabuhan lithic collection.

<table>
<thead>
<tr>
<th>Type</th>
<th>Sub-type</th>
<th>Varian</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Side Scraper (Racloir) (30)</td>
<td>Single</td>
<td>Rectilinear</td>
<td>19</td>
</tr>
<tr>
<td></td>
<td>Concave</td>
<td>2</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Convex</td>
<td>3</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Shoulder</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Double</td>
<td>Straight</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>Concave</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td>Notch (Coche) (40)</td>
<td>Single</td>
<td></td>
<td>27</td>
</tr>
<tr>
<td></td>
<td>Double</td>
<td></td>
<td>13</td>
</tr>
<tr>
<td>Denticulated (Denticulée)</td>
<td></td>
<td></td>
<td>41</td>
</tr>
<tr>
<td>Transversal scrapper (11)</td>
<td>Distal</td>
<td>Rectilinear</td>
<td>2</td>
</tr>
<tr>
<td></td>
<td>Concave</td>
<td>1</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Convex</td>
<td>6</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Proximal</td>
<td>Convex</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rectilinear</td>
<td>1</td>
</tr>
<tr>
<td>Perçoir-Beak (Bec)</td>
<td></td>
<td></td>
<td>8</td>
</tr>
<tr>
<td>Multi-Tool</td>
<td></td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Core-Tool</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td>Unmodified old Artifacts</td>
<td></td>
<td></td>
<td>2</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>144</td>
</tr>
</tbody>
</table>

### III.3.4.1 Side Scraper

Side scrapers have been observed composed of single and double side scraper with delineation rectilinear, concave, convex, and shouldered. Supports of this type of tools are come from flakes, fragmented flakes (distal and proximal), and debris. On the flakes, positions of retouches are usually bifacial, direct, and, inverse with short extent whether it is distributed total or partial along the edges.

### III.3.4.2 Notch

Notch is the most frequently found type of tools among the other type. Notch in the Tabuhan lithic collection characterize by a deep single or multiple removal which its diameter ranged from 0.80-120 mm. Several chipping are found in this single removal that might be related to utilization (?). Notch can be easily distinguished from concave scrapper because the distribution is always partially or discontinue with a very small area respecting the whole length of edges. This type of tools consist of two sub-type, single and double which characterized by single or multiple removal distributed partially or discontinue on the edges of the support. Supports of this tool type are come from flake, fragmented flake, and debris. The positions of removals have been observed in this type of tool are mostly direct, inversed, or alternate.

### III.3.4.3 Transversal scrapper

Transversal scrapper (grattoir sensu lato) is a tool type which shows transversal removals located on a distal or proximal part of a flake. Eleven transversal scrappers were identified among the collection and most of its have been retouched on the distal part. Convex and rectilinear
delineation of retouch is very common in this tool type. Angle of retouch is dominated with *semi-abrupt* with very few appearances of *abrupt* and *low* angles. Indeed, abrupt and semi abrupt angle are characterized this type of tool.

III.3.4.4 Denticulate

*Denticulated* were also the most frequently found type of tool beside notch. This type of tool characterized by denticulated delineation of retouches which is distributed partially, total, or discontinue along the edges. The positions of retouch are varied from *alternating, bifacial, direct or inverse*. Angles of retouch are also varied from low, semi abrupt and several abrupt angles. Concerning the very high variety of retouch morphology and characteristics it was hard to divide this tool type category into a sub-type.

III.3.4.5 *Perçoir-Bec*

*Perçoir-Bec* is type of tools which made by several removals along the edges which delineated a point in one location. This point can form a straight point or bended point which called also *beak*. The removals characterized by partial or total distribution along the edges which delineated a point in one part of the edges. Positions of the removals observed are varied from bifacial, direct or invasive.

III.3.4.6 Multi-tool

Multi tool is a type of tool which shown different type of delineation and position of the retouch. This type of tools is very varied which make it hard to divide it into several sub-types. However, scrapper with varied delineation becomes the most frequently found element inside this tool category. The rest of the tool-type appear in this category are denticulate, beak, and notch.

III.3.4.7 Core-tool (?)

This type of tools is a big question, not because it is low appearance but also its existence in the collection. Nevertheless, Forestier (1998; 2007) also mentioned this type of tools but consider it as a core, rather than include it inside the tool assemblage. In Tabuhan lithic collection, the shaping of the initial form of nodule to obtain sharp edges was very clearly found in two artifacts. Artifacts number GT.D4.E1.2161 was the clearest evidence of *shaping* activity instead of débitage during the Preneolithic period. This artifact came from a small pebble which has removals along its edge on bifacial position.
III.4 Comparison on tools typology within the layers (sub-layer B)

Comparison of the tools assemblage on each layer was done by superimposed cumulative graph. Some differences appear but in general the shapes of curves are shown the same pattern. The differences are mostly caused by sample numbers which is not proportional especially for layer B4. This comparison shows that the cultural characteristic based on type of tools between each layer are similar. This is also mean that sub-layers in layer B as our preliminary assumption consisted of the same cultural period (i.e. Preneolithic)
III.5 Comparison study with Song Terus and Song Keplek

Based on our observation on the retouched implements, indeed it is clear that there is a similarity in general type of tools typology. This is mean that the position of Tabuhan lithic collection is in the same chrono-cultural with Preneolithic culture of Gunung Sewu which is previously represented by Song Keplek and Song Terus remains. This is also confirm the relative datation of the site, especially layer B1, B2, B3 and B4 which can be consider have the same date with Song Terus and Song Keplek, ca. 8000-5000 BP. Comparison between the typology carried out by cumulative graphs or Bordian type system (1961) (see Odell, 2003: 112) shows there are no significant differences in the tools assemblages albeit small number of types are different (e.g. multi tools and limace).

Figure 3.30 Cumulative graphic of tool types between four layers show only little differences.

Figure 3.31 Superimposed cumulative graph (Bordes, 1959) of the general tools types between three cave sites around Punung Area, Gunung Sewu. Two data of typology distribution in Song Keplek and Song Terus were taken from Forestier, 2007: 160-202, Reawaru, 2002: 68-80).
III.6  Interpretation

Observation on the Tabuhan lithic collection has provided an example of specific raw material exploitation behavior in the Preneolithic period of Gunung Sewu region. The quarrying site which is located on the river deposit which is tend to be secondary geological context of chert nodule was shown very clearly by the appearance of heavy weathered and patinated cortical surface. This type of quarrying site provided nodular form of chert and several artifacts that came from older archaeological deposits. The exploitation might be also affected not only the form of nodule, but also the size. Hence, the reconstruction of the calculated nodule and the nodule brought the quasi-similar results. The nodules of chert have a volume less than 300 cm³ (in spherical form) or average diameter ca. 9 cm, with a mass between 700-800 grams for each nodule.

Knapping technique have been used during débitage process was direct percussion with hard hammer, based on the type of indenter (percuteur) found and the characteristic of débitage products (well marked bulb of percussion and wide striking angles). Débitage method which is described by the varieties of striking platforms been used and the direction of débitage on the nuclei shows similarity with Preneolithic assemblage of Song Keplek and Song Terus. This method was classified as a simple débitage method (Inizan and Tixier, 1999: 61) or type C (Boëda in Forestier 2000: 539) or alternate (McNabb, 2007: 309-322). The occurrence of this method is a clear evidence of a simple and relatively faster exploitation of a nodule of raw material to obtain a ready to use flakes tools (even without retouching) (for example see utilized flakes or serpih pakai defined by Forestier, 2007: 269; Reawaru, 2005: 78). Retouched implements shows also characteristic of moustéroid (Forestier, 2007: 268) which has become a characters of Preneolithic lithic assemblage from Gunung Sewu. This is mean the position of Tabuhan lithic assemblage in belong to the Preneolithic period.

Technological description on the débitage products shows that there is a selection in tool making which is based on the thick of the flakes which is has been mentioned by Forestier in his dissertation on 1998 (Forestier, 2007: 254). In Tabuhan tool assemblage this selection also shown as well in the width or thickness of the butt (talon). Our analysis also shows us the positive linear correlation between butt thickness and flake thickness. This method can be helpful on the analysis of fragmented flake such as what we have got in Tabuhan lithic collection.
Conclusion and Perspectives

Status and chronological position of Tabuhan Lithic Collection

As we mentioned in the previous chapter the position of Tabuhan lithic collection is clearly belong to the Preneolithic period of Gunung Sewu. This is mean that the relative chronology of this culture can be taken from previous datation have been done at the other site (Song Keplek and Song Terus) ca. 5000-8000 BP (Simanjuntak et al., 2004: 107). Mollusk shell GT.09.C4.F1.3267 that was found at depth Ztg -0.904 m gave us a date ca. 10 ka BP (10.030 ±70 14C years BP unCal) (Sémah 2011, personal communication). This date considered to be older than the other Preneolithic site in Gunung Sewu area. Indeed, the reliability of this date can be criticize since there is a probability of contaminated sample or the changing on the amount of dated isotopes in the reservoir (see Walker, 2005: 24-29). Database and tridimensional plotting of all remains which became a part of this thesis can help in deciding which remains can be dated based on significance of its position.

Occurrence of core tools is also an important subject. This core tool have been shaped through the same method of knapping which is characterized by the using of previous removals scar as striking platform in alternated direction (A/B) (Boëda in Forestier, 2000: 539; Forestier, 2007: 265; McNabb, 2009: 319-322). This method provides faster and more efficient way in obtaining a ready to used flakes than the other predetermined débitage (e.g. Kombewa and Levallois) (see Inizan and Tixier, 1999: 61-73).

Table 1. Position of the Tabuhan lithic collection in the chrono-cultural period of the Gunung Sewu prehistory (compiled from Simanjuntak et al., 2004: 261; Westaway et al., 2007: 709-711; Sémah et al., in press)

<table>
<thead>
<tr>
<th>Dating</th>
<th>Site(s)</th>
<th>Cultural Period</th>
<th>Characters</th>
<th>Human and Faunal Assemblage</th>
</tr>
</thead>
<tbody>
<tr>
<td>640±110 BP 5th Period</td>
<td>Klepu open air site habitation</td>
<td>Paleometalic</td>
<td>Iron, beads, ceramic, and small contribution of stone tools (?).</td>
<td>H. sapiens Recent fauna</td>
</tr>
<tr>
<td>1100±120 BP 2100±220 BP</td>
<td>Padangan open air site habitation</td>
<td>Neolithic</td>
<td>Polished stone adzes, typical Punung arrow heads</td>
<td>H. sapiens Recent fauna</td>
</tr>
<tr>
<td>730±100 BP 3260±110 BP</td>
<td>Song Keplek Braholo cave</td>
<td>Early Neolithic (?) in cave</td>
<td>Ceramics, proto stone adze, stone tools (flakes), burial in cave.</td>
<td>H. sapiens Recent fauna</td>
</tr>
<tr>
<td>5th Period (early-middle)</td>
<td>Braholo cave</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4510±90 BP 8870±2210 BP</td>
<td>Song Keplek Tabuhan cave</td>
<td>Proneolithic Keplek Period</td>
<td>flake tools, core tools (?) and river quarrying site, bone tools, shell tools, shell and teeth ornaments, and human burial in cave.</td>
<td>H. sapiens Wajak fauna (recent)</td>
</tr>
<tr>
<td>10030±70 BP 3rd Period</td>
<td>Song Terus Cave habitation</td>
<td>Middle Paleolithic (?) Terus Period</td>
<td>First evidence of cave habitation (?), oldest flake industry (non big-flakes)</td>
<td>H. erectus (?) H. sapiens Punung Fauna</td>
</tr>
<tr>
<td>180000-600000 BP 2nd Period</td>
<td>Song Terus Open air site and cave (?) site</td>
<td>Paleolithic</td>
<td>Big flakes, core tools, biface, chopper-chopping tools, cleavers, and bolas.</td>
<td>H. erectus (?) Ngandong fauna (?)</td>
</tr>
<tr>
<td>Older than 180000 BP (relative date by comparison to Terus Flake Industry) 1st Period</td>
<td>Baksoko River Open air site</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Procurement strategy and human behavior in the selection of raw material

The ‘standardization’ based on the dimension of nodules is possible as a reflection of human behavior in raw material selection (see chapter III). The reconstruction of volume and dimension of the initial nodule had clearly shows the similarity of tridimensional dimension (volume unit), which is also confirmed by the maximum dimension of débitage products (see chapter III). However, it cannot be simply conclude as traces of human behavior on the selection of nodule dimension during procurement stage. Natural processes can cause homogeneity on the granulometry of the river including chert nodules. Hence the similarity of nodules sizes have been exploited is also possible caused by the nature of the deposits itself.

Our field observation shows that Banjar River is the most probably quarrying site for the raw material of Tabuhan lithic collection. Our background reason is the location of River Banjar which is very near to the cave and the nearly abundant deposits of old artifacts and nodules of chert. This river is an underground river with numerous deposits of pebble size stones which is mixed and very varied based on its morphological point of view. This river is one of the main sources of water in Tabuhan and Wareng village until recent days. We have observed this river and found many artifacts have been cemented on the ceiling and cave walls. Numerous nodule or stones such as quartzite, chert, and andesit are also found on the bed of this river and surrounding walls. These nodules have been disaggregated and eroded by flooding water during rainy season (December-Mars). During this rainy season water stream also wash away the artifacts and other disaggregated material which might be simplify as an accumulation-purge cycle. It is very logic that the Preneolithic people of Tabuhan cave collecting the nodule and scavenging the old artifacts from this river, because of its availability on raw materials and relatively near location.

Utilization of cortical flakes and debris as a support for retouched tools is not a strange thing because the thickness is the main considered variable in the selection for tool supports. This can be considered as characteristic of Tabuhan cave lithic collection. We also observed that the linear

Figure 03 Location of Banjar River (the most probable quarrying site) near Tabuhan cave (ca. 300 meters) Photos on the right show several nodules of siliceous (?) rocks cemented in a underground cave wall and ceiling. Those nodules is can be easily eroded by periodic flood, deposited and then washed away. (map after Reawaru, 2005: 15 with modification, photos: Shadust, 2008, all materials are courtesy of Sémah et al., in preparation).
positive correlation between butt thicknesses with flake thickness can help to determine the
selection of support for tools where the fragmented flake is more or less abundant. People of
Tabuhan cave also scavenging the old artifacts which is varied from flake tools to unexhausted
nucleuses.

Function of Tabuhan cave site

Defining a site function based on lithic products and its related have been discussed by several
researchers in a wider context of explanation (see Odell, 1981: 319-342; Sullivan and Rozen, 1985:
775-779; Andrefsky, 1994: 21-34; 2005: 201-221). This kind of explanatory method in lithic studies
usually utilizes more than one parameters and several comparison with concerning possibly related
variables (spatial, raw material, technological variation within the assemblage, tool function,
association, etc.). In this thesis we might discuss briefly the investigation of site function based on
the raw material provenance and the characteristic of the débitage products.

Tabuhan site gave us evidences of several layers based on the lithic remains vertical distribution.
This might be a result of several occupational stages in this cave. However, no significant differences
between the assemblage on these levels, especially between layer B (B1, B2, B3, and B4) indicate a
similar site functions through the multiple occupation periods during Holocene. Complete finding
based on the appearance of all débitage products and its association together with the hammer
stones in varied dimension indicates a special function of a site as a workshop of tool making
activities. Hence, its association with the bone tool, traces of fire and faunal exploitation (?) is also
describe a common function of a cave site as a dwelling place. Nevertheless, the observed area
which is situated near the cave entrance shows more particular function as a place of débitage
activities. Appearance of retouched implements might be related to the working of organics element
in this cave. The appearance of a bone tool in Preneolithic layer of Tabuhan cave (see figure 1.13)
can be used as an evidence of working on bones.

The most important question is why there is a difference on raw material provenance during the
same period between Song Terus and Tabuhan cave though both of it located in very near. Both
sites are also located very near to the two rivers where the siliceous rocks are quite abundant (i.e.
Banjar and Sirikan river). The answer we proposed here is a different kind of dwelling type on the
both of sites. Song Terus site shows a different and more complex history of the raw material
through preparation. This was shown by decortications of the raw material outside the cave which
probably have been done on the outcrops as the major of quarrying site (possibly Ngrijangan or
Ngrijang Sengon) (see Reawaru, 2005: 52-57).

Meanwhile in Tabuhan cave, raw materials which are collected from river are more abundant than
the one that came from outcrops. Lithic remains from Tabuhan cave shows significant number of
cortical flakes which indicates the first flakes with cortical back and butt (talon) were detached in the
cave. The using of cortical flakes as a support for retouched implements shows that decortications
probably not happened during the débitage process. Débitage in Tabuhan cave is a simple volume
exploitation of a chert nodule to obtain débitage products in rapid and efficient way even for the
very first débitage. This strategy might be related to the average volume of nodule (reconstructed
and original) which is only less than 300 cm$^3$ (average diameters $\leq$ 8 cm). Concerning all of those variables in raw material provenance and débitage products we made a conclusion that Tabuhan cave is particular site which was functioned as a workshop (atelier de taille) of particular kind of raw material, in this case chert nodule from the river.

**Perspectives**

Our research in Tabuhan cave has enriched our knowledge in the Gunung Sewu Preneolithic culture through lithic analysis. Application of reconstruction model of the initial dimension of nodule is for the first time applied in Tabuhan cave. However, this analysis is more suitable on the observation of lithic assemblage which the initial nodule of raw material is in a quasi-spherical form. The calculated volume in a spherical form on a nucleus or nodule must be considered as a maximum volume. Meanwhile the reconstructed volume based on the calculation is a minimum size of volume (real volume of exploited nucleus + débitage products + waste). It was considered as a minimal volume because we believe also lost of volume total before and after débitage (from our experiment 5-8 % volume lost) and the nature of archaeological data which is conceptually act as a sample only.

This research have completed the previous research related to the Preneolithic of Gunung Sewu at once as a starter for the future research in more specified study on Tabuhan cave lithic collection. Our comparative studies has confirmed the appearance of mousterial type of retouched implements as a characteristics of Preneolithic in Gunung Sewu together with the appearance of core-tool which usually related to the Paleolithic culture (e.g. Pacitanian). Abundance of raw materials which is suitable for débitage and knapping in the surrounding areas probably has a role in the exploitation behavior. Simple method of débitage to produce ready to use flake and cortical flake which is also used as a support for a tool is a reflection of expeditive strategy in volume exploitation and tool production (see Forestier, 2005: 269).

**Prospective future research**

For the future, this research can be continued into a larger scope of research. Refitting and mass analysis on the Tabuhan lithic remains related to the reconstruction of the raw material dimension and volume must be done by using more samples. This is important because the signal of standardization in the nodule dimension is still weak and only based on the hypothesis supported by our analysis in reconstruction initial volume of nodule and measurement of the débitage products. Application of station total in recording system, instead of manual measurement with a tape measure, has demonstrated more accurate positioning of the remains. This method must be continued in the future fieldwork on this site regarding the important of understanding site formation process happened in Tabuhan cave.

Specific analysis in the study of raw material must be taken in order to confirm the provenance of the raw materials which is never been confirm and compared directly with the assumed quarrying sites. This study has to be done in a geological and mineralogical research context as the only studies
that can confirm the raw material provenance based on microstructure and mineralogical component or the raw material itself.
Bibliography


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Abbreviations used in text

ATR  Attenuated Total Reflection
asl.  Above sea level
BP  Before Present
ca.  circa
Cal  Calibrated datation
cc  centimeter cubic
cm  centimeter(s)
\text{cm}^1  reciprocal centimeter (wave length)
\text{cm}^2  square centimeters
\text{cm}^3  see cc
\text{eds.}  editors
\text{e.g.}  exempli gratiā
\text{et al.}  et alii
\text{g}  gram(s)
id  idem
\text{i.e.}  id est
IPH  Institute Paléontologie et Humaine
ka  kilo years ago
m  meter(s)
m²  square meters
ma  million years ago
ml  milliliter(s)
mm  millimeter(s)
MNHN  Museum National Histoire Naturelle
No.  Number
p.  page of a book
pp.  page of an article
Puslitbang Arkenas  (Pusat Penelitian dan Pengembangan Arkeologi Nasional)
unCal  Un-calibrated datation
Vol.  Volume
ZTg  Datum point of depth reference in Tabuhan cave.